MEETING PROGRAM & ABSTRACTS

SVP 2016

SVP 76TH ANNUAL MEETING

SVP
SOCIETY OF VERTEBRATE PALEONTOLOGY

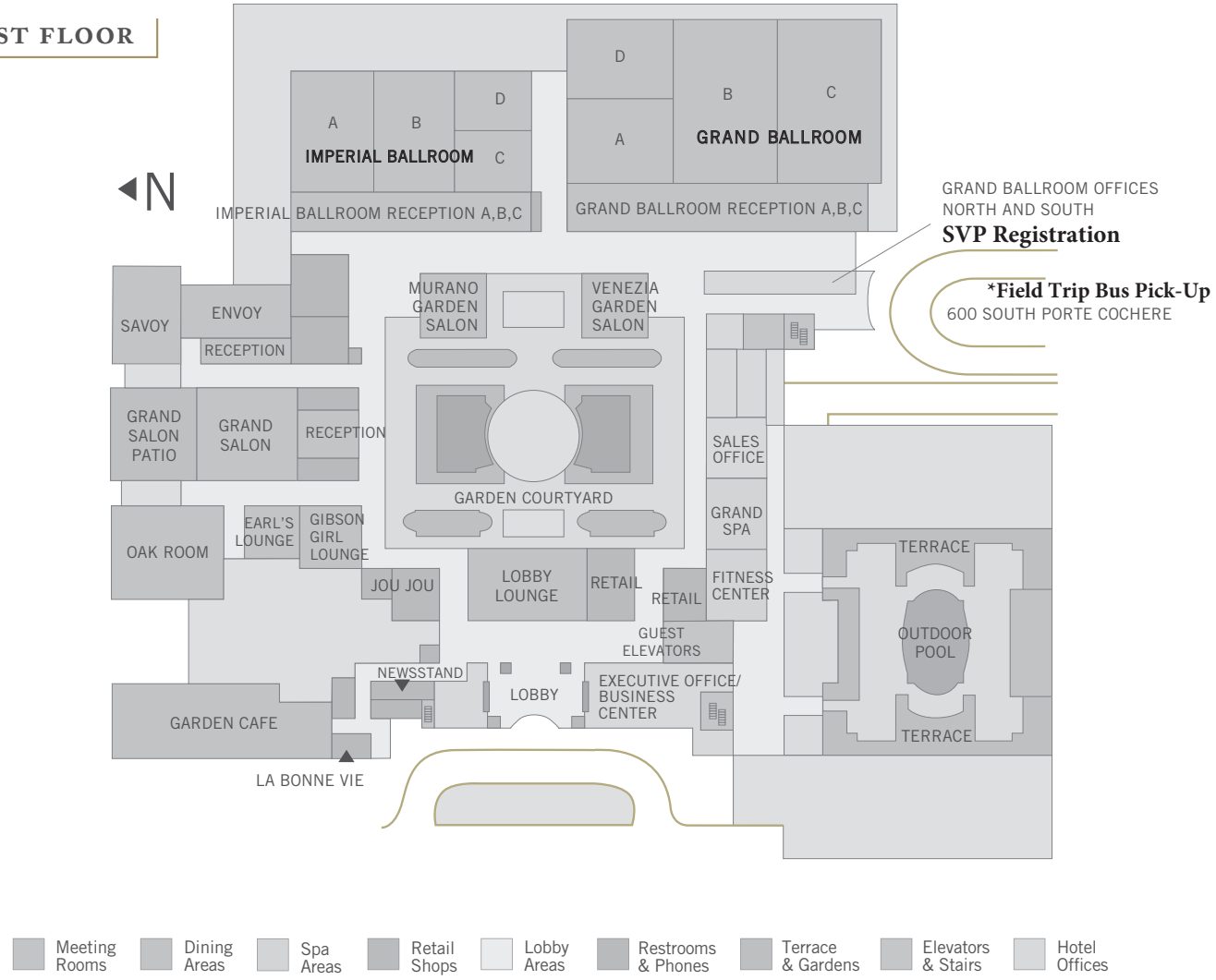
October 26–29, 2016 · Grand America Hotel · Salt Lake City, Utah, USA

SOCIETY OF VERTEBRATE PALEONTOLOGY
OCTOBER 2016
ABSTRACTS OF PAPERS
76th ANNUAL MEETING

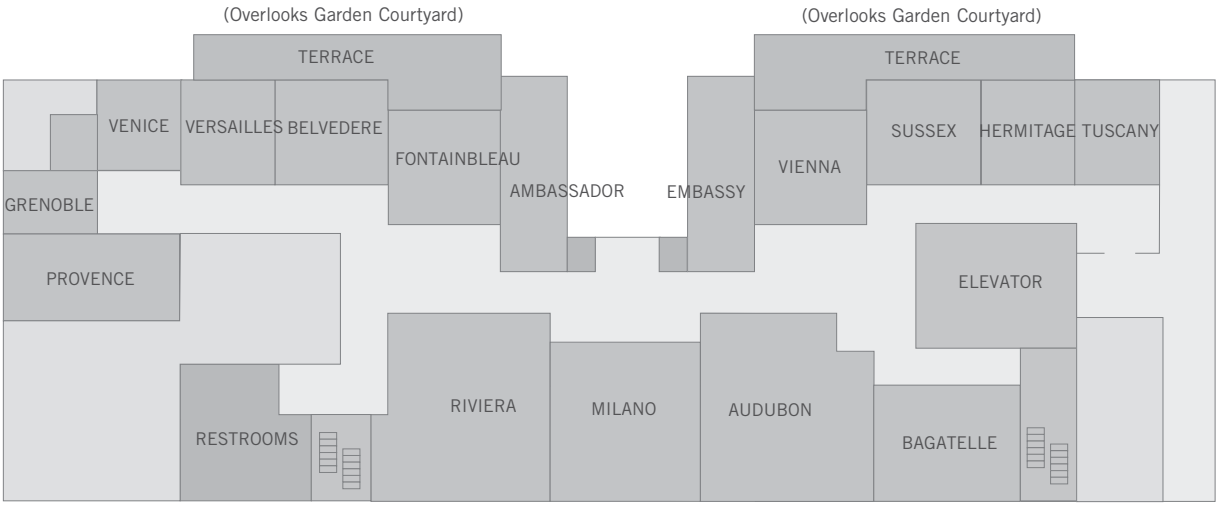
Grand America Hotel
Salt Lake City, Utah, USA
October 26–29, 2016

HOTEL MAP

FIRST FLOOR



THIRD FLOOR



WELCOME TO SALT LAKE CITY


Salt Lake City has changed a lot since SVP met at Snowbird Ski and Summer Resort in the fall of 1998. After hosting the Olympic XIX Winter Games in 2002 the city has become much more modern. Liquor laws are in line with the rest of the country (*private clubs for members only* are a relic of the past and there are at least eight commercial breweries in Salt Lake County alone), public transit is one of the best in the nation (buses, trains, and bicycle lanes connect the entire city), and nearly every museum in the state has been remodeled or completely rebuilt (including the Natural History Museum of Utah, Brigham Young University's Museum of Paleontology, the Utah Field House Museum of Natural History State Park, the Bureau of Land Management's Cleveland-Lloyd Dinosaur Quarry, the BLM's Bigwater Visitor Center at Grand Staircase-Escalante National Monument, and the famous quarry and visitor center at Dinosaur National Monument).

With 12 museums containing paleontological resources that can be reached within 4 hours, Salt Lake City rests at the center of North America's fossil bearing landscape. This will result in the most field trip opportunities ever offered to annual meeting attendees. Even if you do not take advantage of a field trip, be sure to spend extra time visiting one or more of the many museums in the region, take a bike ride in the city or on one of the world class mountain bike trails that lead right into the city, enjoy the views, or visit one of the many National Parks that are located around the state.

2016 is also an important year for the public land managing agencies that are associated with SVP, including the Bureau of Land Management, which is celebrating 70/40 – the seventieth anniversary of the bureau and 40 year anniversary of the Federal Land Policy and Management Act (FLPMA), and the National Park Service, which is celebrating its centennial. Of special importance is Dinosaur National Monument, which is only 3 hours east of Salt Lake City and celebrated its centennial in 2015. If you have not visited Dinosaur National Monument, this will be your opportunity.

Scott Foss, SVP 76th Annual Meeting Host Committee Co-Chair
Randall Irmis, SVP 76th Annual Meeting Host Committee Co-Chair

PRESENTATION POLICIES

SVP Abstracts are reviewed by the Program Committee and occasionally by outside reviewers. Authors are responsible for the technical content of their articles.

Unless specified otherwise, coverage of abstracts presented orally at the Annual Meeting is strictly prohibited until the start time of the presentation, and coverage of poster presentations is prohibited until the relevant poster session opens for viewing. As defined here, "coverage" includes all types of electronic and print media; this includes blogging, tweeting, advanced online publication, and other intent to communicate or disseminate results or discussion presented at the SVP Annual Meeting.

Still photography, video and/or audio taping, or any other electronic recording at the SVP Annual Meeting is strictly prohibited, with the exception of the designated SVP press event. The SVP reserves the right to engage professional photographers or audio/videotape professionals to archive sections of the Meeting for the Society's use.

Editorial policies of Science and Nature magazines: If you are planning to submit, or have submitted, your publication to Science or Nature, be sure you are familiar with their embargo policies.

Please address any questions about program practices to the Program Committee or to the Executive Committee.

Citing an Abstract in the 2016 SVP Program and Abstracts Book

This Program and Abstracts Book is an official supplement to the online version of the *Journal of Vertebrate Paleontology.* The citation format for an abstract printed in this book is: *Journal of Vertebrate Paleontology*, Program and Abstracts, 2016, <insert page number here>.

CODE OF CONDUCT

The Society of Vertebrate Paleontology expects meeting attendees to behave in a courteous, collegial, and respectful fashion to each other, student volunteers, SVP staff, and convention center staff. Attendees should respect common sense rules for professional and personal interactions, public behavior (including behavior in public electronic communications), common courtesy, respect for private property, and respect for intellectual property of presenters. Demeaning, abusive, harassing, or threatening behavior towards other attendees or towards volunteers, SVP staff, convention center staff, or security staff is not permitted, either in personal or electronic interactions.

SOCIAL MEDIA GUIDELINES

Please Read Before You Tweet (Or Blog, Or Facebook, Or Instagram…)

The Society of Vertebrate Paleontology encourages open discussion on social media and other outlets at our annual meeting. In order to find a balance between embracing social media and protecting authors' work, we set forth the following guidelines:

- SVP has an embargo in place on discussing presentations until the beginning of the talk or poster session. Please do not discuss presentations until this time if you do not have the authors' permission to do so.

- This embargo exists to protect the authors. As an author, you have permission to break your own embargo or permit someone else to do the same. This includes discussing your own presentation online, posting slides or posters, etc. However, to protect yourself, make sure you are aware of any potential future publisher's policies about early dissemination of work.

- Do not photograph or video tape a talk or poster without the authors' express permission. Never post any images or video without the authors' permission.

- While the default assumption is to allow open discussion of SVP presentations on social media, please respect any request by an author to not disseminate the contents of their talk. The following icon may be downloaded from the SVP website for inclusion on slides or posters to clearly express when an author does not want their results posted:

We want to thank everyone for following these basic guidelines for online posts of all kinds. As a reminder, the official hashtag of the meeting is #2016SVP. We look forward to seeing your thoughts and discussion online!

2016 SVP Schedule of Events (subject to change)
All events are held at the Grand America Hotel unless otherwise noted with an **

Tuesday, October 25

3:00pm–7:00pm	**Registration Open**	Grand Ballroom Offices
4:00 pm–6:00 pm	**Women in Science Social**	Grand Ballroom A

Wednesday, October 26

7:00am–7:30pm	**Registration Open**	Grand Ballroom Offices
8:00am–12:15pm	**Podium Symposium I:** Molecular Preservation in the Fossil Record: Evidence, Analyses, Applications, and Challenges	Imperial Ballroom AB
	Technical Session I	Imperial Ballroom CD
	Technical Session II	Grand Ballroom A
9:30am–6:15 pm	**Exhibit and Poster Viewing Hours** **Posters associated with Podium Symposium I "Molecular Preservation in the Fossil Record: Evidence, Analyses, Applications and Challenges"** (IB1–IB2) **Colbert Prize Competition Posters** (B1–B50) **Colbert Prize posters will be on display Wednesday through Saturday.* **Poster Symposium I "Advances in Middle Eocene Paleoecology: Evolutionary and Ecological Dynamics in a Post-Greenhouse World" Posters** (B51–B75) **Poster Symposium I posters will be on display Wednesday and Thursday.* **Regular Session Posters** (B76–B181)	Exhibit Hall, Grand Ballroom Imperial Ballroom Foyer Exhibit Hall, Grand Ballroom Exhibit Hall, Grand Ballroom
1:45pm–4:15pm	**Technical Session III**	Imperial Ballroom AB
	Technical Session IV	Imperial Ballroom CD
	Technical Session V	Grand Ballroom A
4:15pm–6:15pm	**Poster Session I (Regular Session Posters,** B76–B181**)** **Poster Session I authors will be present at their posters.* **Posters associated with Podium Symposium I "Molecular Preservation in the Fossil Record: Evidence, Analyses, Applications and Challenges"** (IB1–IB2) **Authors will be present at their posters.* **Poster Symposium I: Advances in Middle Eocene Paleoecology: Evolutionary and Ecological Dynamics in a Post-Greenhouse World** (B51–B75) **Authors will be present at their posters.*	Exhibit Hall, Grand Ballroom Imperial Ballroom Foyer Exhibit Hall, Grand Ballroom
7:30pm–10:30pm	**Welcome Reception**	**Natural History Museum of Utah

Thursday, October 27

7:00am–6:15pm	**Registration Open**	Grand Ballroom Offices
8:00am–12:15pm	**Romer Prize Session**	Imperial Ballroom AB
	Preparators' Session	Imperial Ballroom CD
	Technical Session VI	Grand Ballroom A
9:30am–6:15pm	**Exhibit and Poster Viewing Hours** **Posters associated with Preparators' Session** (IB1–IB7) **Colbert Prize Competition Posters** **Colbert Prize posters (B1–B50) will be on display Wednesday through Saturday.* **Poster Symposium I "Advances in Middle Eocene Paleoecology: Evolutionary and Ecological Dynamics in a Post-Greenhouse World" Posters** (B51–B75) **Poster Symposium I posters will be on display Wednesday and Thursday.* **Regular Session Posters** (B76–B166)	Exhibit Hall, Grand Ballroom Imperial Ballroom Foyer Exhibit Hall, Grand Ballroom Exhibit Hall, Grand Ballroom
12:30pm–1:30pm	**SVP Business Meeting and Open Forum** An opportunity to bring your questions to SVP leadership!	Imperial Ballroom AB
1:45pm–4:15pm	**Technical Session VII**	Imperial Ballroom AB
	Technical Session VIII	Imperial Ballroom CD
	Technical Session IX	Grand Ballroom A
2:00pm–3:30pm	**Preparators' Meeting**	Savoy
4:15pm–6:15pm	**Poster Session II (Regular Session Posters,** B76–B166**)** **Poster Session II authors will be present at their posters.* **Posters associated with Preparators' Session** (IB1–IB7) **Authors will be present at their posters.* **Colbert Prize Competition Posters** (B1–B50) **Authors will be present at their posters.*	Exhibit Hall, Grand Ballroom Imperial Ballroom Foyer Exhibit Hall, Grand Ballroom
6:30pm–7:30pm	**iDigBio: An Initiative to Make Millions of Paleontological Specimens Available in an Electronic Format**	Grand Ballroom A
7:30pm–9:30pm	**Organizational Meeting for Register of Professional Paleontologists**	Imperial Ballroom CD
7:30pm–11:30pm	**Student and Postdoc Roundtable and Reprint Exchange**	Imperial Ballroom AB

Friday, October 28

7:00am–5:00pm	**Registration Open**	Grand Ballroom Offices
8:00am–12:15pm	**Podium Symposium II:** Paleo Evo-Devo: The New Science of the Very Old	Imperial Ballroom AB
	Technical Session X	Imperial Ballroom CD
	Technical Session XI	Grand Ballroom A
9:30am–6:15pm	**Exhibit and Poster Viewing Hours** **Colbert Prize Competition Posters** **Colbert Prize posters (B1–B50) will be on display Wednesday through Saturday.* **Poster Symposium II "An Ecosystem We Thought We Knew: The Emerging Complexities of the Morrison Formation" Posters** (B51–B69) **Poster Symposium II posters will be on display Friday and Saturday.* **Regular Session Posters** (B70–B167)	Exhibit Hall, Grand Ballroom Exhibit Hall, Grand Ballroom Exhibit Hall, Grand Ballroom
1:45pm–4:15pm	**Technical Session XII**	Imperial Ballroom AB
	Technical Session XIII	Imperial Ballroom CD
	Technical Session XIV	Grand Ballroom A
4:15pm–6:15pm	**Poster Session III (Regular Session Posters,** B70–B167**)** **Poster Session III authors will be present at their posters.* **Poster Symposium II: An Ecosystem We Thought We Knew: The Emerging Complexities of the Morrison Formation** (B51–B69) **Authors will be present at their posters.*	Exhibit Hall, Grand Ballroom Exhibit Hall, Grand Ballroom
6:30pm–11:30pm	**Auction**	**Little America Hotel, Grand Ballroom

Saturday, October 29

7:00am–4:00pm	**Registration Open**	Grand Ballroom Offices
8:00am–12:15pm	8:00am–10:00am **Podium Symposium III:** Recent Advances in Understanding the Origins and Evolution of Tetrapod Endothermy 10:15am–12:15pm **Technical Session XV**	Imperial Ballroom AB
	Technical Session XVI	Imperial Ballroom CD
	Technical Session XVII	Grand Ballroom A
9:30am–6:15pm	**Exhibit and Poster Viewing Hours** **Posters associated with Podium Symposium III "Recent Advances in Understanding the Origins and Evolution of Tetrapod Endothermy" Posters** (IB1–IB2) **Colbert Prize Competition Posters** **Colbert Prize posters (B1–B50) will be on display Wednesday through Saturday.* **Poster Symposium II "An Ecosystem We Thought We Knew: The Emerging Complexities of the Morrison Formation" Posters** (B51–B69) **Poster Symposium II posters will be on display Friday and Saturday.* **Regular Session Posters** (B70–B164**)** **E&O Posters** (B165–B187)	Exhibit Hall, Grand Ballroom Imperial Ballroom Foyer Exhibit Hall, Grand Ballroom Exhibit Hall, Grand Ballroom Exhibit Hall, Grand Ballroom
1:45pm–4:15pm	**Technical Session XVIII**	Imperial Ballroom AB
	Technical Session XIX	Imperial Ballroom CD
	Technical Session XX	Grand Ballroom A
4:15pm–6:15pm	**Poster Session IV (Regular Session Posters,** B70–B164**)** **Poster Session IV authors will be present at their posters.* **E&O Poster Session** (B165–B187) **Authors will be present at their posters.* **Posters associated with Podium Symposium III "Recent Advances in Understanding the Origins and Evolution of Tetrapod Endothermy"** (IB1–IB2) **Authors will be present at their posters.*	Exhibit Hall, Grand Ballroom Exhibit Hall, Grand Ballroom Imperial Ballroom Foyer
7:30pm–10:00pm	**Awards Banquet** **Ticket required for admittance*	Imperial Ballroom ABCD
10:00pm–1:00am	**After Hours Party**	**Little America Hotel, Grand Ballroom

2016 SVP Workshops

**For Pre-registered Attendees*

TUE, October 25 9:00am–4:00pm	**Photogrammetry: Efficient Use of Digital Photography for 3D Data Collection in the Lab, Collections, and Field**	Grand America Hotel, Murano
TUE, October 25 9:00am–4:00pm	**Filling the Expectation Gap: Paleontologists as Teaching Professors—Professional Development for Paleontologists Working Outside of Research-Intensive Universities**	Grand America Hotel, Milano
TUE, October 25 9:00am–5:00pm	**Air Abrasion—Preserving the Smallest Details**	**Natural History Museum of Utah, Paleo Prep Lab
TUE, October 25 9:30am–4:30pm	**Archiving and Analyzing Vertebrate Paleoecological Data: Best Practices and Current Resources**	Grand America Hotel, Riviera
TUE, October 25 11:00am–5:00pm	**Morphological Evolution in Deep Time: Calculating Disparity and Rates from Discrete Phenotypic Data**	Grand America Hotel, Audubon
TUE, October 25 1:00pm–4:00pm	**Diverse Approaches to Paleo Outreach Programs: Ideas, Strategies, and Logistics**	**Natural History Museum of Utah

2016 SVP Field Trips

**For Pre-registered Attendees*

**All Field Trips pick up and drop off locations are at the Grand America Hotel*

Day/Time	
SUN, October 23 – TUE, October 25 **Time:** Begins Sunday, October 23, at 7:30am. Ends Tuesday, October 25, at 6:00pm.	**Mid Mesozoic Dinosaur Faunas of Central Utah**
SUN, October 23 – TUE, October 25 **Time:** Begins Sunday, October 23, at 5:00pm. Ends Tuesday, October 25, at 7:00pm.	**Rise of the Erg: Paleontology & Paleoenvironments of the Triassic-Jurassic Transition in Northeastern Utah**
MON, October 24 – TUE, October 25 **Time:** Begins Monday, October 24, at 7:30am. Ends Tuesday, October 25, at 7:30pm.	**Fossil Lake Deposits of the Green River Formation: Not All Fish Are Preserved Equal**
MON, October 24 – TUE, October 25 **Time:** Begins Monday, October 24, at 7:30am. Ends Tuesday, October 25, at 8:30pm.	**Bonebeds of the Morrison Formation**
TUE, October 25 **Time:** 8:30am – 4:30pm	**Brigham Young University Earth Science Museum and North American Museum of Ancient Life**
SUN, October 30 **Time:** 8:00am – 4:00pm	**Shorelines of Pleistocene Lake Bonneville**
SUN, October 30 – TUE, November 1 **Time:** Begins Sunday, October 30, at 8:00am. Ends Tuesday, November 1, at 7:00pm.	**Late Cretaceous Stratigraphy and Vertebrate Faunas of Southern Utah**
SUN, October 30 – TUE, November 1 **Time:** Begins Sunday, October 30, at 8:00am. Ends Tuesday, November 1, at 8:00pm.	**Vertebrate Paleontology, Stratigraphy, Biochronology, and Paleoecology of Middle Eocene Rock Units in the Green River and Uinta Basins, Wyoming and Utah**
SUN, October 30 – WED, November 2 **Time:** Begins Sunday, October 30, at 7:00am. Ends Wednesday, November 2, at 7:00pm.	**The Upper Triassic Chinle Formation of Southern Utah**

PROGRAM AT A GLANCE

	Imperial Ballroom AB	Imperial Ballroom CD	Grand Ballroom A	Imperial Ballroom AB	Imperial Ballroom CD	Grand Ballroom A
	Podium Symposium I: Molecular Preservation in the Fossil Record: Evidence, Analyses, Applications and Challenges	**Technical Session I**	**Technical Session II**	**Romer Prize Session**	**Preparator's Session**	**Technical Session VI**
	WED	**WED**	**WED**	**THUR**	**THUR**	**THUR**
8:00 am	SCHWEITZER	VON KOENIGSWALD	KLIGMAN	CHEN	BUGBEE	RANDAU
8:15 am	SCHROETER	DEWAR	SIMOES	TENNANT	SAWCHUK	BALISI
8:30 am	PRESSLEE	CAMMIDGE	DONG	LEMBERG	KLINE	PRYBYLA
8:45 am	CLELAND	HEDBERG	CONRAD	CHEN	BALCARCEL	BOESSENECKER
9:00 am	SJÖVALL	WINKLER	KEMP	WATANABE	HECK	WANG
9:15 am	LINDGREN	DESANTIS	PETERMANN	SALAS-GISMONDI	SMITH	O'KEEFE
9:30 am	WIEMANN	MIHLBACHLER	LAFUMA	MORHARDT	BROWNE	MEACHEN
9:45 am	PETEYA	KUHN-HENDRICKS	GELNAW	FIELD	SANTELLA	MONTANARI
10:00 am	COFFEE					
10:15 am	BOATMAN	BAI	HENRY	CARNEY	MALLISON	WILLS
10:30 am	ANNE	MACFADDEN	STREET	COUZENS	PRUITT	MOORE
10:45 am	MOYER	SCOTT	LIVELY	O'BRIEN	SHELBURNE	CARPENTER
11:00 am	PAN	WALLETT	KONISHI	BARRON-ORTIZ	BERNARD	BADER
11:15 am	CADENA	MARCOT	CALDWELL	SMILEY	MILES	SAITTA
11:30 am	ULLMANN	EMERY	CAMPBELL	BERTRAND	BROWN	ROY
11:45 am	HEINTZMAN	CALAMARI	GARBEROGLIO	DAVIS	BARNETT	TURNER
12:00 pm	JONES	BORMET	FOLIE	CHRITZ	GETTY	ALLENSACK
12:15 pm	**BREAK**					
1:30 pm						
	Imperial Ballroom AB	**Imperial Ballroom CD**	**Grand Ballroom A**	**Imperial Ballroom AB**	**Imperial Ballroom CD**	**Grand Ballroom A**
	Technical Session III	**Technical Session IV**	**Technical Session V**	**Technical Session VII**	**Technical Session VIII**	**Technical Session IX**
1:45 pm	HABIB	BEBEJ	BUTTON	BROWN	WILSON	AHLBERG
2:00 pm	GOLD	ZOUHRI	VAVREK	EVANS	LÓPEZ-TORRES	MIN ZHU
2:15 pm	VARRICCHIO	CORRIE	MALLON	GOODWIN	MORSE	PAN
2:30 pm	KING	CHURCHILL	CLOSE	HOBE	RANKIN	YOU-AN ZHU
2:45 pm	STRUBLE	LANZETTI	DEMAR	FREEDMAN	HOFFMAN	SCOTT
3:00 pm	M. WANG	PEREDO	MITCHELL	WOSIK	GARRETT	LU
3:15 pm	HANSON	FORDYCE	GARDNER	NORMAN	FOX	CLOUTIER
3:30 pm	KSEPKA	CLEMENTZ	HALLIDAY	ERICKSON	BURROUGHS	WILHELM
3:45 pm	THOMSON	SULSER	TOTH	WIERSMA	CASANOVAS-VILAR	BLOB
4:00 pm	CLAESSONS	TEJADA-LARA	POLLY	ARBOUR	MARCY	MACIVER
4:15 pm	*Poster Session I*			*Poster Session II*		
6:15 pm						

	Imperial Ballroom AB	Imperial Ballroom CD	Grand Ballroom A	Imperial Ballroom AB	Imperial Ballroom CD	Grand Ballroom A
	Podium Symposium II: Paleo Evo-Devo: The New Science of the Very Old	**Technical Session X**	**Technical Session XI**	**Podium Symposium III: Recent Advances in Understanding the Origins and Evolution of Tetrapod Endothermy**	**Technical Session XVI**	**Technical Session XVII**
	FRI	**FRI**	**FRI**	**SAT**	**SAT**	**SAT**
8:00 am	GOSWAMI	FORD	SNYDER	BAKKER	HOPKINS	METZ
8:15 am	WEISBECKER	ELSLER	JOHANSON	KNAUS	BADGLEY	DRUCKENMILLER
8:30 am	URBAN	ANDRUS	BRONSON	SHELTON	CALEDE	JIANG
8:45 am	LUO	PRITCHARD	STILSON	SEYMOUR	FAMOSO	ZHOU
9:00 am	JERNVALL	PARKER	ARGYRIOU	CROMPTON	MANTHI	WOLNIEWICZ
9:15 am	EVANS	LESSNER	LATIMER	SANDER	VILLASEÑOR	KELLEY
9:30 am	BOISVERT	MELSTROM	MALTESE	LEGENDRE	DU	LAWRENCE
9:45 am	SEARS	HASTINGS	ITANO	TATTERSALL	DUMOUCHEL	MASSARE
10:00 am	COFFEE					
				Technical Session XV		
10:15 am	BHULLAR	CLARK	CAMPIONE	MCPHEE	BEHRENSMEYER	STUBBS
10:30 am	COATES	TURNER	LIU	LAMANNA	ROBINSON	W. WANG
10:45 am	HIRASAWA	MILLER-CAMP	GOTTFRIED	FRONIMOS	JUKAR	MOTANI
11:00 am	BELL	BOLES	WU	GORSCAK	DENG	ROBERTS
11:15 am	HEAD	MYERS	ABDELGAWAD	UPCHURCH	MCLAUGHLIN	MUSCUTT
11:30 am	KAVANAGH	EVERS	CLAESON	BARRETT	ZAZULA	WINTRICH
11:45 am	FELICE	RABI	CARRILLO BRICEÑO	YANG	STEGNER	NEENAN
12:00 pm	LARSSON	VERMILLION	DENTON	GRIFFIN	PINEDA-MUNOZ	DRISCOL
12:15 pm	**BREAK**					
1:30 pm						
	Imperial Ballroom AB	**Imperial Ballroom CD**	**Grand Ballroom A**	**Imperial Ballroom AB**	**Imperial Ballroom CD**	**Grand Ballroom A**
	Technical Session XII	**Technical Session XIII**	**Technical Session XIV**	**Technical Session XVIII**	**Technical Session XIX**	**Technical Session XX**
1:45 pm	SOBRAL	HOVATTER	BRINK	FABBRI	SCHULTZ	MADDIN
2:00 pm	TSAI	S.SMITH	LUNGMUS	MARSH	BRANNICK	RASMUSSEN
2:15 pm	MANAFZAD	SECORD	SIDOR	CARRANO	GROSSNICKLE	ATKINS
2:30 pm	SULLIVAN	SHELLEY	KAMMERER	S. WANG	JÄGER	CARTER
2:45 pm	HOLLIDAY	SOLÉ	BENDEL	D. SMITH	MAO	PARDO
3:00 pm	LEBLANC	VITEK	VIGLIETTI	CHOINIERE	HUTTENLOCKER	MARJANOVIC
3:15 pm	REISZ	FRASER	SMITH	HOLTZ	COHEN	TARAILO
3:30 pm	COST	T.SMITH	ANGIELCZYK	DECECCHI	SPAULDING	BEIGHTOL
3:45 pm	KAYE	BEARD	NABAVIZADEH	BYKOWSKI	BONNAN	MERCIER
4:00 pm	ORGAN	POUST	ARAUJO	LARSON	WEBB	HENRICI
4:15 pm	*Poster Session III*			*Poster Session IV*		
6:15 pm						

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PALEONTOLOGY

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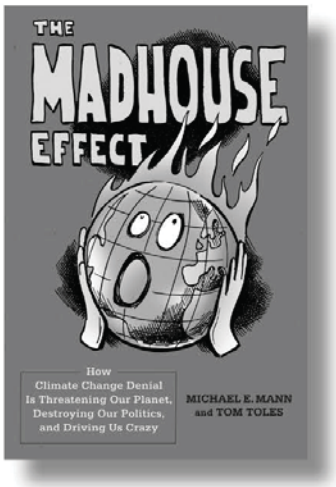

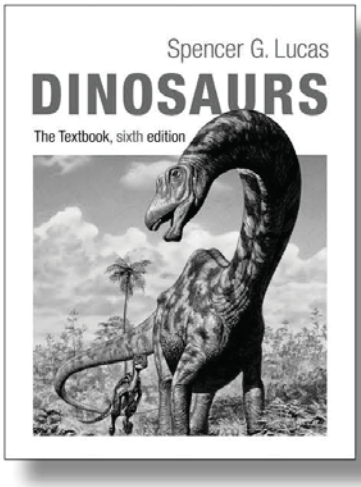

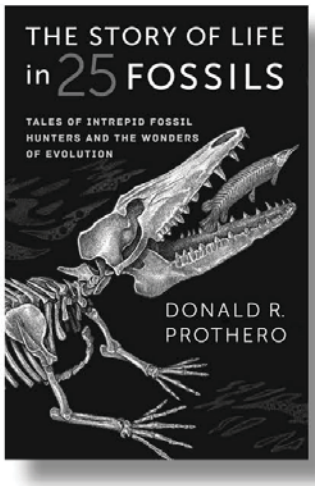

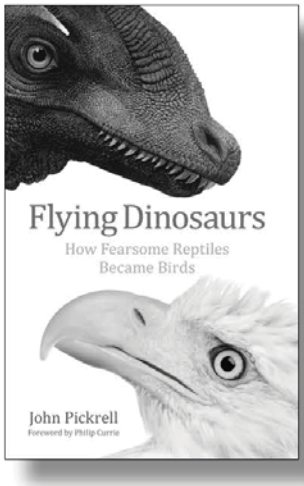

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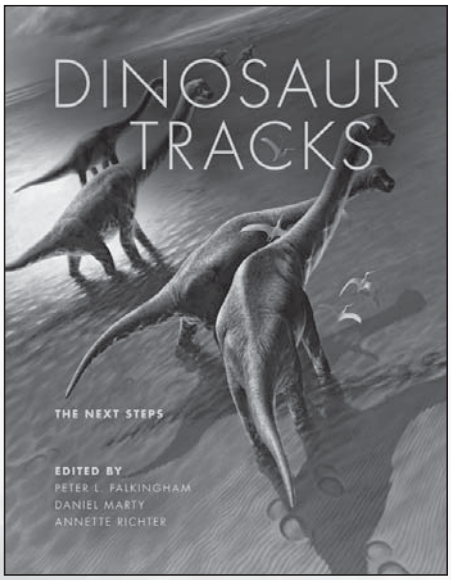

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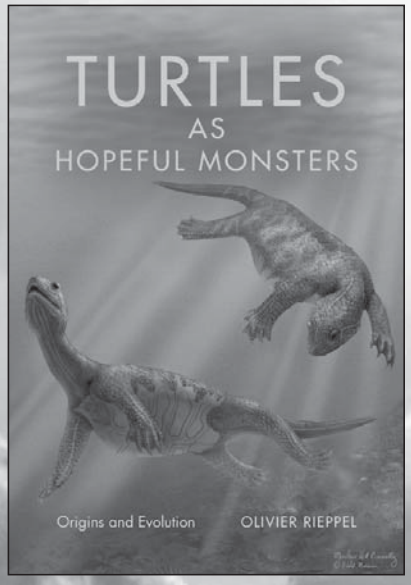

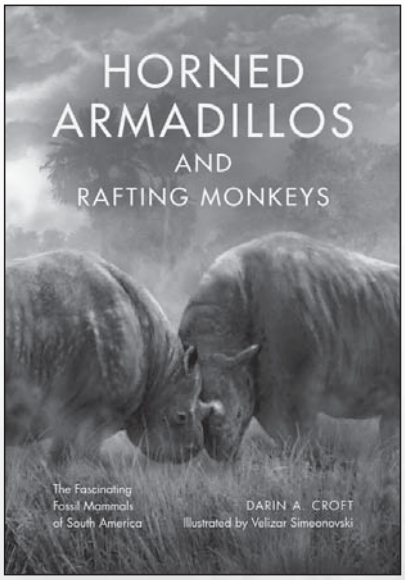

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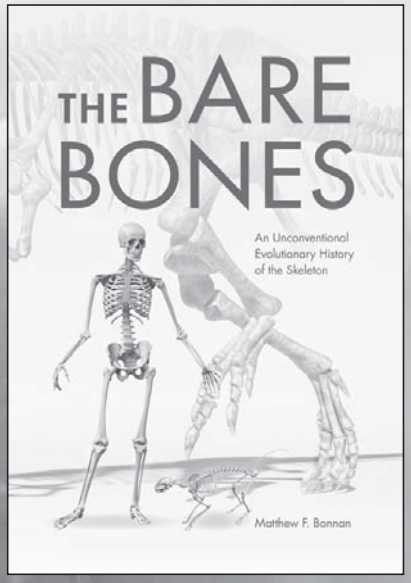

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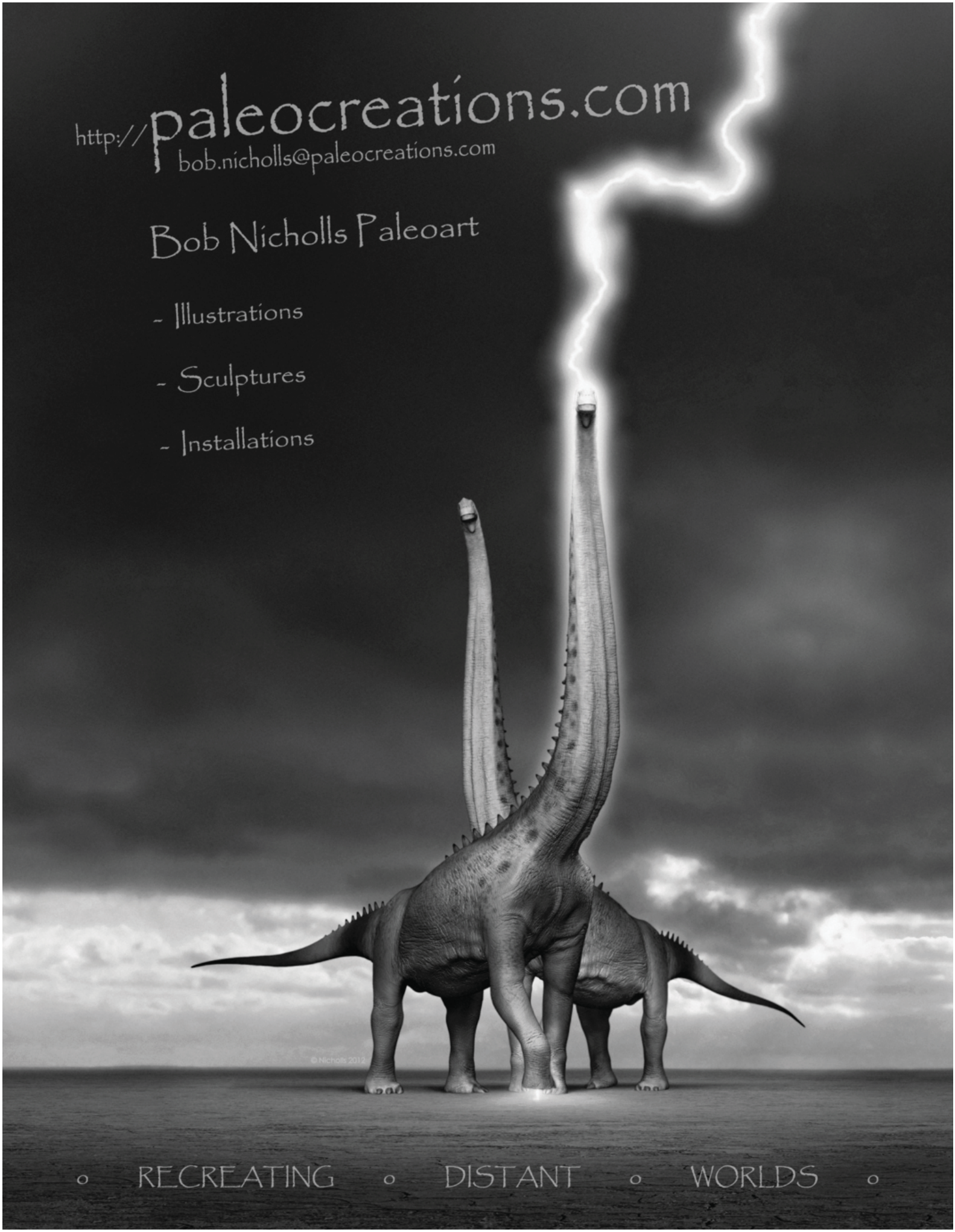
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WEDNESDAY MORNING, OCTOBER 26, 2016

PODIUM SYMPOSIUM I: MOLECULAR PRESERVATION IN THE FOSSIL RECORD: EVIDENCE, ANALYSES, APPLICATIONS, AND CHALLENGES

GRAND AMERICA HOTEL, IMPERIAL BALLROOM AB

MODERATORS: Mary Schweitzer and Johan Lindgren

8:00 **Schweitzer, M. H., Zheng, W.** "PROVE TO ME THEY'RE NOT": MOLECULAR CHEMISTRY AS A TOOL FOR HYPOTHESES TESTING

8:15 **Schroeter, E. R., Cleland, T. P., Schweitzer, M. H.** PALEOPROTEOMICS: THE BENEFITS AND CHALLENGES OF USING TANDEM MASS SPECTROMETRY TO INVESTIGATE EXTINCT PROTEOMES DERIVED FROM SOFT-TISSUES PRESERVED IN FOSSIL REMAINS

8:30 **Presslee, S., Macphee, R. D., Collins, M., Southon, J., Holden, A., Farrell, A.** RADIOCARBON DATING AND PROTEOMIC ANALYSIS OF HIGHLY PURIFIED BONE COLLAGEN DERIVED FROM RANCHO LA BREA MAMMAL FOSSILS

8:45 **Cleland, T. P., Schroeter, E. R., Feranec, R. S., Vashishth, D., Schweitzer, M. H.** BEYOND THE SEQUENCE: UTILITY OF PROTEIN MODIFICATIONS IN FOSSILS

9:00 **Sjövall, P., Jarenmark, M., Uvdal, P., Carney, R., Lindgren, J.** TOF-SIMS AS A TOOL FOR MOLECULAR IDENTIFICATION IN VERTEBRATE FOSSILS—CAPABILITIES AND LIMITATIONS

9:15 **Lindgren, J., Ito, S., Wakamatsu, K., Hauff, R., Sjövall, P., Uvdal, P., Schweitzer, M. H.** SKIN PRESERVATION AND TAPHONOMY ELUCIDATED BY INTEGRATED MOLECULAR, ULTRASTRUCTURAL, AND EXPERIMENTAL APPROACHES

9:30 **Wiemann, J., Fabbri, M., Yang, T., Stein, K., Vinther, J., Geisler-Wierwille, T., Norell, M., Sander, M. P.** FROM WHITE TO BLACK: MAILLARD REACTION PRODUCTS AND ENDOGENOUS PORPHYRINS STAIN FOSSIL HARD TISSUES

9:45 **Peteya, J. A., Gao, K., Li, Q., Clarke, J. A., D'Alba, L., Shawkey, M. D.** RAMAN SPECTROSCOPY OF EUMELANIN PRESERVED IN MID–LATE JURASSIC AND EARLY CRETACEOUS VERTEBRATES FROM NORTHEASTERN CHINA

10:00 **BREAK**

10:15 **Boatman, E. M., Goodwin, M. B., Holman, H. N., Fakra, S., Schweitzer, M. H.** CHARACTERIZATION OF *TYRANNOSAURUS* STRUCTURAL PROTEINS USING SYNCHROTRON X-RAY AND INFRARED MICRO-BEAM TECHNIQUES

10:30 **Anne, J., Wogelius, R., Edwards, N., Manning, P.** IMAGING THE CHEMISTRY OF LIFE: INTERPRETING EXTINCT VERTEBRATE PHYSIOLOGY USING SYNCHROTRON X-RAY ANALYSES

10:45 **Moyer, A.** MICROSCOPIC AND MOLECULAR PRESERVATION OF EPIDERMALLY DERIVED FOSSILS

11:00 **Pan, Y., Zheng, W., Moyer, A., O'Connor, J., Wang, M., Zheng, X., Schroeter, E., Schweitzer, M. H., Zhou, Z.** MOLECULAR ANALYSES OF *EOCONFUCIUSORNIS* (BIRD) FEATHERS SUPPORT THE PRESENCE OF ORIGINAL KERATIN PROTEINS AND MELANOSOMES FOR AT LEAST 130 MA

11:15 **Cadena, E.** OSTEOCYTES AND BLOOD VESSEL-LIKE MICROSTRUCTURES FROM THE EOCENE, MESSEL PIT LOCALITY, GERMANY. INSIGHTS IN TERMS OF THEIR MORPHOLOGICAL AND CHEMICAL CHARACTERIZATION

WEDNESDAY MORNING, OCTOBER 26, 2016
PODIUM SYMPOSIUM I (CONTINUED)

11:30 **Ullmann, P., Voegele, K., Grandstaff, D., Ash, R., Schroeter, E., Lacovara, K. J., Schweitzer, M. H.** EVALUATING THE UTILITY OF RARE EARTH ELEMENT PROFILES AS A PROXY FOR SOFT TISSUE AND BIOMOLECULAR PRESERVATION POTENTIAL IN FOSSIL BONE

11:45 **Heintzman, P. D., Zazula, G. D., Cahill, J. A., Mchorse, B. K., Kapp, J. D., Stiller, M., Scott, E., Macphee, R. D., Shapiro, B.** PALEOGENOMICS RESOLVES THE TAXONOMY AND SYSTEMATICS OF LATE PLEISTOCENE STILT-LEGGED EQUIDS FROM NORTH AMERICA

12:00 **Jones, E.** PUSHING NEW PERSPECTIVES: LESSONS LEARNED FROM THE HISTORY OF MOLECULAR PALEONTOLOGY

WEDNESDAY MORNING, OCTOBER 26, 2016
TECHNICAL SESSION I
GRAND AMERICA HOTEL, IMPERIAL BALLROOM CD
MODERATORS: Larisa DeSantis and Matthew Mihlbachler

8:00 **Withdrawn**

8:15 **Dewar, E. W., Osimanti, C. E.** BODY SIZE AFFECTS DIETARY INTERPRETATIONS BASED ON MESOWEAR OR STEREOSCOPIC MICROWEAR IN MAMMALS

8:30 **Cammidge, T. S., Kooyman, B., Theodor, J. M.** DIETARY RECONSTRUCTIONS OF *MAMMUTHUS* AND *MAMMUT* SPECIES USING DENTAL TARTAR AND MESOWEAR ANALYSES

8:45 **Hedberg, C., Desantis, L.** CLARIFYING CAUSAL AGENTS OF DENTAL MICROWEAR FORMATION AS REVEALED BY KOALAS

9:00 **Winkler, D. E.** FUNCTIONAL MORPHOLOGY OF MOLARS IN UNGULATES: CONSTRAINTS AND COMMON FEATURES

9:15 **Desantis, L., Sharp, A. C., Schubert, B. W., Colbert, M. W.** TAPIRS AS MODEL ORGANISMS FOR UNDERSTANDING HOMINID EVOLUTION: THE FUNCTIONAL SIGNIFICANCE OF THE SAGITTAL CREST AS REVEALED FROM DENTAL MICROWEAR TEXTURE ANALYSIS AND FINITE ELEMENT ANALYSIS

9:30 **Mihlbachler, M. C., Kaur, P., Beatty, B. L.** IS DENTAL WEAR 'TAXON-FREE'? DIET, DENTAL WEAR, AND HUNTER-SHREGER BAND ORIENTATION IN RHINOCEROTIDAE

9:45 **Kuhn-Hendricks, S. M., Erickson, G. M., Norell, M.** THE EVOLUTION OF MODIFIED RADIAL ENAMEL IN EQUIDS CONFERED DAMAGE TOLERANCE THROUGH CONTROLLED FRACTURE AND DAMAGE LOCALIZATION

10:00 **BREAK**

10:15 **Bai, B., Wang, Y., Meng, J.** ORIGIN AND CRANIODENTAL EVOLUTION OF DEPERETELLIDAE (MAMMALIA, PERISSODACTYLA)

10:30 **Macfadden, B. J., Guralnick, R. J.** HORSES IN THE CLOUD: BIG DATA EXPLORATION, MINING, AND INTEGRATION FOR *EQUUS* (MAMMALIA, EQUIDAE)

10:45 **Scott, E.** WHAT'S IN A NAME? RESOLVING THE TAXONOMY OF PLEISTOCENE LARGE *EQUUS* FROM THE NORTHERN GREAT BASIN OF NEVADA AND OREGON

WEDNESDAY MORNING, OCTOBER 26, 2016
TECHNICAL SESSION I (CONTINUED)

11:00 **Wallett, L. A.** THE PALEOPATHOLOGY OF CHRONIC LAMINITIS: GROSS LESIONS AND CT-BASED EVIDENCE FROM THE FOSSIL RECORD OF *EQUUS*

11:15 **Marcot, J. D., Maier, J. A.** RATES AND PATTERNS OF LIMB EVOLUTION OF NORTH AMERICAN EQUIDAE

11:30 **Emery, M.** CRANIAL MORPHOMETRICS AND DENTAL MEASUREMENTS CRITICALLY UNDERESTIMATE THE DIVERSITY OF FOSSIL ARTIODACTYL SPECIES

11:45 **Calamari, Z.** BENEATH THE SHEATHS: DO HORN CORES OF BOVIDS (ARTIODACTYLA, MAMMALIA) REPRESENT LIVING HORN SHAPE IN GEOMETRIC MORPHOMETRIC ANALYSES?

12:00 **Bormet, A. K., Polly, P.** SUBSTRATE AND LIMB EVOLUTION: A GLOBAL ECOMORPHOLOGICAL ANALYSIS OF RUMINANT UNGUALS

WEDNESDAY MORNING, OCTOBER 26, 2016
TECHNICAL SESSION II
GRAND AMERICA HOTEL, GRAND BALLROOM A
MODERATORS: Annelise Folie and Joshua Lively

8:00 **Kligman, B., Pritchard, A. C.** EARLIEST STEM-SQUAMATE (LEPIDOSAURIA) FROM THE LATE TRIASSIC OF ARIZONA

8:15 **Simoes, T. R., Caldwell, M. W., Nydam, R. L., Jimenez Huidobro, P.** OSTEOLOGY, PHYLOGENY AND FUNCTIONAL MORPHOLOGY OF TWO JURASSIC LIZARD SPECIES INDICATE THE EARLY EVOLUTION OF SCANSORIALITY IN GECKOES

8:30 **Dong, L., Evans, S. E., Wang, Y., Wang, Y., Chen, L.** A DIVERSE SQUAMATE ASSEMBLAGE FROM THE PALEOCENE DEPOSITS OF QIANSHAN BASIN, CHINA

8:45 **Conrad, J. L., Montanari, S., Ast, J. C., Wasserman, D. S., Norell, M.** FRAGMENTARY (AND COMPLETE) FOSSILS HELP RECONSTRUCT MONITOR LIZARD (SQUAMATA, VARANIFORMES) BIOLOGY AND EVOLUTION

9:00 **Kemp, M. E., Bochaton, C.** OUT WITH THE OLD AND IN WITH THE NEW: A NEW SET OF BODY SIZE ESTIMATION EQUATIONS FOR *ANOLIS* AND THEIR IMPLICATIONS FOR MACROEVOLUTION

9:15 **Petermann, H., Gauthier, J. A.** GROWTH RINGS AND SUTURE FUSIONS REVEAL COMPLEX ORGANISM-ENVIRONMENT INTERACTION IN LIZARDS: NEW INSIGHTS FOR INFERENCES ABOUT SIZE, AGE, AND DEVELOPMENTAL STAGE IN FOSSILS

9:30 **Lafuma, F. O., Clavel, J., Di-Poi, N.** MULTIPLE ORIGINS OF MULTICUSPID TEETH IN SQUAMATE REPTILES

9:45 **Gelnaw, W.** EVOLUTIONARY INSIGHTS FROM THE PINEAL FORAMEN

10:00 **BREAK**

10:15 **Henry, J. B., Gelnaw, W.** PHYLOGENETICALLY INFORMED DISCRIMINANT FUNCTION ANALYSIS AIDS FOSSIL IDENTIFICATION

10:30 **Street, H. P.** A SYSTEMATIC AND TAXONOMIC REVISION OF *MOSASAURUS* AND A GLOBAL MOSASAURINI

WEDNESDAY MORNING, OCTOBER 26, 2016
TECHNICAL SESSION II (CONTINUED)

10:45 **Lively, J. R.** THE EVOLUTION AND VARIATION OF BASAL MOSASAURINAE BASED ON A SPECIMEN-LEVEL PHYLOGENY OF "*CLIDASTES*": IMPLICATIONS FOR MOSASAUR MACROEVOLUTION

11:00 **Konishi, T., Brinkman, D.** NON-LETHAL FACE BITING BETWEEN MOSASAURS (SQUAMATA: MOSASAURIDAE): THE FIRST UNEQUIVOCAL EVIDENCE FROM AN EXCEPTIONAL SKELETON OF *MOSASAURUS* SP. FROM SOUTHERN ALBERTA, CANADA

11:15 **Caldwell, M. W., Reisz, R. R., Nydam, R. L., Palci, A., Simoes, T. R.** *TETRAPODOPHIS AMPLECTUS* (CRATO FORMATION, LOWER CRETACEOUS, BRAZIL) IS NOT A SNAKE

11:30 **Campbell, M., Caldwell, M. W.** A REVIEW OF SPATIAL AND TEMPORAL DISTRIBUTIONS FOR NON-OPHIDIAN OPHIDIOMORPHS

11:45 **Garberoglio, F. F., Caldwell, M. W., Apesteguía, S., Nydam, R. L.** MORE THAN ONE? THE HIDDEN DIVERSITY OF THE LIMBED SNAKES OF LA BUITRERA (CANDELEROS FORMATION, EARLY LATE CRETACEOUS), ARGENTINA

12:00 **Folie, A., Mees, F., De Putter, T., Smith, T.** A NEW LARGE SPECIES OF THE SNAKE *PALAEOPHIS* FROM THE LUTETIAN MARINE MARGIN OF THE CONGO BASIN, CABINDA, ANGOLA

WEDNESDAY AFTERNOON, OCTOBER 26, 2016
TECHNICAL SESSION III
GRAND AMERICA HOTEL, IMPERIAL BALLROOM AB
MODERATORS: Daniel Ksepka and Michael Habib

1:45 **Habib, M., Dececchi, A., Dufault, D., Larsson, H. C.** UP, UP AND AWAY: TERRESTRIAL LAUNCHING IN THEROPODS

2:00 **Gold, M. L., Norell, M., Smaers, J. B., Balanoff, A. M.** CHANGES IN BRAIN SHAPE ACROSS THE THEROPOD-BIRD TRANSITION

2:15 **Varricchio, D. J., Jackson, F. D.** EVOLUTIONARY TRANSITIONS IN REPRODUCTION FROM NON-AVIAN THEROPODS TO NEORNITHINE BIRDS: THE ENANTIORNITHINE RECORD

2:30 **King, J. L.** SEMICIRCULAR CANAL SHAPE WITHIN AVES AND NON-AVIAN THEROPODA: UTILIZING GEOMETRIC MORPHOMETRICS TO CORRELATE LIFE HISTORY WITH CANAL CROSS-SECTIONAL SHAPE

2:45 **Struble, M., Organ, C.** CONVERGENT EVOLUTION AND BIOMECHANICS OF THE RAPTORIAL FOOT

3:00 **Wang, M., Zhou, Z., Sullivan, C.** THE OLDEST KNOWN AVIAN GASTRIC PELLET FROM A FISH-EATING ENANTIORNITHINE, WITH IMPLICATIONS FOR THE DIGESTIVE SYSTEM IN EARLY BIRDS

3:15 **Hanson, M., Burnham, D. A., Bhullar, B. S.** RECONSTRUCTING THE SKULL OF *HESPERORNIS REGALIS*: THE FIRST THREE-DIMENSIONAL MODEL OF A CRETACEOUS STEM BIRD WITH INSIGHTS INTO EARLY AVIAN FUNCTIONAL MORPHOLOGY, PLESIOMORPHY, AND CONVERGENCE

3:30 **Ksepka, D., Gavryushkina, A., Heath, T., Stadler, T., Welch, D., Drummond, A.** NEW EVIDENCE FOR THE TIMING AND PATTERN OF PENGUIN EVOLUTION

3:45 **Thomson, V. A., Cooper, A.** AUSTRALIAN ISLAND EMUS ARE HOLOCENE DWARFS

WEDNESDAY AFTERNOON, OCTOBER 26, 2016
TECHNICAL SESSION III (CONTINUED)

4:00 **Claessens, L. P., Van Heteren, A. H., De Louw, P. G., Meijer, H. J., De Boer, E. J., De Vos, J., Janoo, A., Van Der Plicht, J., Soares, E. J., Rijsdijk, K. F.** IMMINENT COLLAPSE RESOURCE RELEASE HYPOTHESIS—EVIDENCE FOR A RAPID PRE-EXTINCTION PHENOTYPIC SHIFT IN BODY SIZE IN THE DODO

WEDNESDAY AFTERNOON, OCTOBER 26, 2016
TECHNICAL SESSION IV
GRAND AMERICA HOTEL, IMPERIAL BALLROOM CD
MODERATORS: Ryan Bebej and Mark Clementz

1:45 **Bebej, R. M., Smith, K. M.** ASSESSMENT OF LUMBAR MOBILITY IN ARCHAEOCETES (MAMMALIA, CETACEA): INSIGHTS INTO THE EVOLUTION OF AQUATIC LOCOMOTION IN THE EARLIEST WHALES

2:00 **Zouhri, S., Mhaidrat, L., Gingerich, P. D.** NEW SKELETON OF *PLATYOSPHYS AITHAI* (CETACEA) FROM THE LATE MIDDLE EOCENE OF GUERAN IN SOUTHWESTERN MOROCCO

2:15 **Corrie, J. E., Fordyce, R. E.** HETERODONT CONFUSION: A LATE OLIGOCENE PUTATIVE KEKENODONTID FROM NEW ZEALAND WITH COMMENTS ON THE TAXONOMY OF *SQUALODON GAMBIERENSIS*

2:30 **Churchill, M., Geisler, J., Beatty, B. L.** DIVERSITY OF CRANIAL TELESCOPING IN OLIGOCENE WHALES OF THE CHANDLER BRIDGE AND ASHLEY FORMATIONS OF SOUTH CAROLINA

2:45 **Lanzetti, A., Berta, A., Ekdale, E. G., Deméré, T. A.** LOST IN TRANSITION: DEVELOPMENTAL PATTERNS OF TOOTH FORMATION AND LOSS IN FETAL BALEEN WHALES AND IMPLICATIONS FOR MYSTICETE EVOLUTION

3:00 **Peredo, C. M., Pyenson, N., Uhen, M. D.** MORPHOLOGICAL CONSEQUENCES OF TOOTH LOSS: A COMPARISON OF THE COURSE OF THE MANDIBULAR CANAL IN MYSTICETE CETACEANS USING 3D MODELS

3:15 **Fordyce, R. E., Viglino, M., Buono, M. R., Cuitiño, J. I., Fitzgerald, E. M.** EARLY MIOCENE SQUALODONTID *PHOBERODON ARCTIROSTRIS* (ODONTOCETI, PLATANISTOIDEA) FROM PATAGONIA AND PHYLOGENETICS OF THE PLATANISTOIDEA

3:30 **Clementz, M. T., Larsen, T.** HOW MUCH KELP COULD A SEA COW EAT? IDENTIFYING CARBON SOURCES TO SIRENIAN DIETS THROUGH AMINO ACID STABLE ISOTOPE FINGERPRINTING

3:45 **Sulser, R. B., Luo, Z.** TESTING COMPETING MORPHOLOGICAL AND MOLECULAR PHYLOGENIES OF CHIROPTERA WITH MORPHOLOGICAL FEATURES OF THE INNER EAR COCHLEA

4:00 **Tejada-Lara, J. V., Flynn, J. J., Antoine, P., Salas-Gismondi, R.** MYLODONTID SLOTHS OF THE MIDDLE MIOCENE PEBAS MEGA-WETLANDS SYSTEM (WESTERN AMAZONIA, NORTHEASTERN PERU)

WEDNESDAY AFTERNOON, OCTOBER 26, 2016

TECHNICAL SESSION V

GRAND AMERICA HOTEL, GRAND BALLROOM A

MODERATORS: Jordan Mallon and David Demar

1:45 **Button, D. J., Butler, R. J., Lloyd, G. T., Ezcurra, M. D.** THE FIRST GLOBAL-SCALE PHYLOGENETIC NETWORK BIOGEOGRAPHY ANALYSIS OF LATE PALEOZOIC AND EARLY MESOZOIC TERRESTRIAL VERTEBRATES AND THE INFLUENCE OF MASS EXTINCTIONS ON ANIMAL DISTRIBUTION

2:00 **Vavrek, M. J.** THE MESOZOIC BREAKUP OF PANGAEA AND TERRESTRIAL VERTEBRATE BIODIVERSITY

2:15 **Mallon, J., Fraser, D. L., Brinkman, D. B., Nydam, R. L., Scott, C.** TERRESTRIAL VERTEBRATE DIVERSITY IN LATE CRETACEOUS NORTH AMERICA

2:30 **Close, R. A., Benson, R. B., Butler, R. J.** CONTROLLING FOR THE SPECIES-AREA EFFECT REMOVES LONG-TERM DIVERSITY TRENDS IN MESOZOIC TERRESTRIAL VERTEBRATES

2:45 **Demar, D. G., Wilson, G. P., Brinkman, D. B., Holroyd, P. A., Smith, S. M., Mercier, G. K.** VERTEBRATE FAUNAL DYNAMICS DURING THE END-CRETACEOUS MASS EXTINCTION: A SYNTHESIS FROM THE FOSSIL RECORD OF NORTHEASTERN MONTANA, USA

3:00 **Mitchell, J. S., Benson, R., Rabosky, D.** DYNAMIC RATES OF DINOSAUR EVOLUTION THROUGH THE MESOZOIC

3:15 **Gardner, J., Organ, C.** DISCRETE MODELS OF CORRELATED EVOLUTION ARE PRONE TO FALSE POSITIVE RESULTS

3:30 **Halliday, T. J., Goswami, A.** PHYLOGENETIC DATING METHOD CRITICALLY AFFECTS INTERPRETATION OF CONTINUOUS TRAIT EVOLUTION

3:45 **Toth, A., Soul, L., Eronen, J. T., Lyons, S. K., Behrensmeyer, A. K., Pineda-Munoz, S.** STABILITY OF EMPIRICAL MAMMAL CO-OCCURRENCE NETWORKS OVER PALEONTOLOGICAL TIMESCALES

4:00 **Polly, P., Schnitzler, J., Eronen, J. T., Lawing, A.** LONG-TERM DIRECTIONAL TRANSITIONS IN GLOBAL CLIMATE RATHER THAN SHORT-TERM FLUCTUATIONS DRIVE CHANGES IN VERTEBRATE DIVERSITY

WEDNESDAY, OCTOBER 26 THROUGH SATURDAY OCTOBER 29, 2016

SVP 2016 EDWIN H. AND MARGARET M. COLBERT PRIZE COMPETITION POSTERS

GRAND AMERICA HOTEL, EXHIBIT HALL GRAND BALLROOM

Authors must be present from 4:15 – 6:15 p.m., Thursday, October 27

Posters must be removed by 6:30 p.m., Saturday, October 29

B1 **Ni, P., Sun, Z., Lombardo, C., Tintori, A., Jiang, D.** REVISION OF *KYPHOSICHTHYS GRANDEI* FROM THE MIDDLE TRIASSIC OF YUNNAN PROVINCE, SOUTH CHINA: IMPLICATIONS FOR PHYLOGENETIC INTERRELATIONSHIPS OF GINGLYMODIAN FISHES

B2 **Coats, J. G., Noto, C. R.** MORPHOMETRICS ON A SMALL SCALE: USING SHAPE TO ASSIGN ISOLATED FOSSIL GAR SCALES TO SPECIFIC BODY REGIONS

*Numbers beginning with “B” represent the poster board number in Exhibit Hall Grand Ballroom

*Numbers beginning with “IB” represent the poster board number in Imperial Ballroom Foyer.

B3 **Voris, J., Heckert, A. B., Martin, L.** ONTOGENETIC HETERODONTY IN *RETICULODUS SYNERGUS* (HYBODONTIDAE, ACRODONTINAE), A FRESHWATER SHARK FROM THE UPPER TRIASSIC OF THE AMERICAN SOUTHWEST

B4 **Hodnett, J. M., Grogan, E. D., Lund, R.** A SMALL CTENACANTHIFORM SHARK FROM THE LATEST MISSISSIPPIAN (SERPUKHOVIAN) BEAR GULCH LIMESTONE OF MONTANA

B5 **Bardua, C., Evans, S. E., Goswami, A.** PHYLOGENY, ECOLOGY, AND TIME: 2D OUTLINE ANALYSIS OF ANURAN SKULLS FROM THE EARLY CRETACEOUS TO RECENT

B6 **Paparella, I., Caldwell, M. W., Nicosia, U.** A COMPARATIVE AND MORPHOMETRIC APPROACH TO THE INVESTIGATION OF THE CONVERGENT ADAPTATIONS IN SECONDARY AQUATIC AMNIOTES

B7 **Campbell, J. A., Sato, T., Tokaryk, T. T., Anderson, J. S.** AN UNUSUAL ELASMOSAURID (SAUROPTERYGIA, PLESIOSAURIA) FROM THE UPPER CRETACEOUS (UPPER CAMPANIAN–LOWER MAASTRICHTIAN) BEARPAW FORMATION OF SASKATCHEWAN

B8 **Foffa, D., Brusatte, S., Young, M. T., Dexter, K. G.** THE ECOLOGY AND EVOLUTION OF JURASSIC MARINE REPTILES

B9 **Chapman, B. R., Lively, J. R.** A NEW ASSEMBLAGE OF MOSASAURS FROM THE UPPER CRETACEOUS SAVOY PIT, AUSTIN CHALK, NORTH TEXAS

B10 **Vernygora, O. V., Simoes, T. R., Paparella, I. V., Jimenez Huidobro, P., Caldwell, M. W.** MOSASAUROID PHYLOGENY UNDER MULTIPLE PHYLOGENETIC METHODS

B11 **Herrera-Flores, J. A., Benton, M. J.** EXPLORING MACROEVOLUTION OF MESOZOIC LEPIDOSAURS

B12 **Rej, J., Mead, J. I.** MORPHOMETRIC COMPARISON WITH IMPLICATIONS FOR THE FOSSIL RECORD OF TWO LIZARDS (PHRYNOSOMATIDAE, SQUAMATA), WESTERN USA: *UTA STANSBURIANA* AND *UROSAURUS ORNATUS*

B13 **Ong, N. S., Irmis, R., Levitt-Bussian, C.** A HISTOLOGICAL STUDY OF ONTOGENETIC AND TAXONOMIC VARIATION IN SHELL ORNAMENTATION OF TRIONYCHOID TURTLES FROM THE UPPER CRETACEOUS (CAMPANIAN) KAIPAROWITS FORMATION OF UTAH

B14 **Syromyatnikova, E., Scheyer, T., Danilov, I. G.** BONE HISTOLOGY OF ADOCUSIAN TURTLES FROM ASIA AND NORTH AMERICA

B15 **Lawver, D., Jackson, F.** A FOSSIL EGG CLUTCH FROM THE STEM TURTLE *MEIOLANIA PLATYCEPS*: IMPLICATIONS FOR THE EVOLUTION OF TURTLE REPRODUCTIVE BIOLOGY

B16 **Olroyd, S. L., Sidor, C. A., Angielczyk, K. D., Nesbitt, S. J., Smith, R., Steyer, J., Tabor, N. J., Tolan, S.** RECENT TETRAPOD DISCOVERIES FROM THE MIDDLE PERMIAN (GUADALUPIAN) OF TANZANIA AND ZAMBIA, WITH BIOGEOGRAPHIC CONSIDERATIONS

B17 **Datta, D., Mukherjee, D., Ray, S.** A NEW PHYTOSAUR (DIAPSIDA, ARCHOSAURIFORMES) BONEBED FROM THE LATE TRIASSIC OF INDIA: TAPHONOMIC SIGNATURES AND BIOSTRATIGRAPHIC IMPLICATIONS

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B18 **Dollman, K. N., Choiniere, J. N.** INVESTIGATING THE CRANIAL ANATOMY AND PARATYMPANIC SINUS SYSTEMS OF LOWER JURASSIC CROCODYLOMORPHA USING COMPUTED TOMOGRAPHY AND 3D DIGITAL MODELLING

B19 **Sellers, K. C., Davis, J. L., Middleton, K. M., Holliday, C. M.** BIOMECHANICS AND THE EVOLUTION OF THE CROCODYLIFORM SKULL

B20 **Cerio, D., Witmer, L. M.** SOFT TISSUE RECONSTRUCTION AND VISUAL FIELDS OF DINOSAURS AND THEIR EXTANT RELATIVES

B21 **Läbe, S.** VERTICAL EXAGGERATION OF 3D SURFACE MODELS REVEALS ADDITIONAL DETAIL IN SAUROPOD TRACKWAYS

B22 **Barta, D. E., Nesbitt, S. J., Norell, M.** THE MANUS OF EARLY THEROPOD DINOSAURS: DIGITAL RECONSTRUCTIONS OF ARTICULATED SPECIMENS REVEAL A COMPLEX EVOLUTIONARY PATTERN OF DIGIT REDUCTION

B23 **Moore, A. J., Clark, J. M.** A COMPREHENSIVE, TIME-CALIBRATED PHYLOGENY OF THE DIVERSE 'WATERBIRD' ASSEMBLAGE INFERRED USING BAYESIAN TOTAL EVIDENCE METHODS

B24 **Wynd, B. M., Sidor, C. A., Peecook, B. R., Whitney, M., Smith, R., Nesbitt, S. J., Angielczyk, K. D., Tabor, N. J.** FIRST OCCURRENCE OF *CYNOGNATHUS* IN TANZANIA AND ZAMBIA, WITH BIOSTRATIGRAPHIC IMPLICATIONS FOR THE AGE OF TRIASSIC STRATA IN SOUTHERN PANGEA.

B25 **Weaver, L. N., Sargis, E. J., Wilson, G. P., Varricchio, D. J.** THE FIRST POSTCRANIAL SKELETON OF *CIMEXOMYS JUDITHAE* AND IMPLICATIONS FOR LOCOMOTOR DIVERSITY IN LATE CRETACEOUS CIMOLODONTAN MULTITUBERCULATES

B26 **Hoffmann, S., Krause, D. W., Hu, Y.** THE FIRST POSTCRANIAL REMAINS OF A GONDWANATHERIAN MAMMAL

B27 **Widlansky, S. J., Clyde, W. C., O'Connor, P. M., Roberts, E. M., Stevens, N. J.** CRETACEOUS MAGNETOSTRATIGRAPHY IN SOUTHWESTERN TANZANIA AND IMPLICATIONS FOR VERTEBRATE PALEOBIOGEOGRAPHY

B28 **Chen, M., Carrano, M. T.** ECOLOGICAL DYNAMICS OF MESOZOIC MAMMALIAN COMMUNITIES IN RESPONSE TO ABIOTIC AND BIOTIC CHANGES

B29 **Kristjanson, H. L., Silcox, M. T., Perry, J.** A NEW PARTIAL CRANIUM OF *PLESIADAPIS TRICUSPIDENS* AND INSIGHTS INTO PLESIADAPIFORM CRANIAL ANATOMY

B30 **Locke, E. M., Rowan, J., Reed, K. E.** SEXUAL DIMORPHISM IN PLIOCENE *GAZELLA* (MAMMALIA, ARTIODACTYLA) FROM MAKAPANSGAT LIMEWORKS CAVE, SOUTH AFRICA

B31 **Matsui, K.** RE-EXAMINATION OF DESMOSTYLIAN PHYLOGENETIC RELATIONSHIPS

B32 **Kerr, T. J., Clementz, M.** COMPOSITIONAL PROFILES OF TYMPANIC BULLAE OF MODERN BALAENOPTERIDS AND BALAENIDS (CETACEA, MYSTICETI): IMPLICATIONS FOR FOSSILIZATION AND CETACEAN PALEOECOLOGY

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B33 **Moroz, M. J., Smiley, T., Badgley, C.** ECOLOGICAL RESPONSE OF SMALL-MAMMAL ASSEMBLAGES TO ENVIRONMENTAL CHANGE OVER THE MIOCENE CLIMATIC OPTIMUM IN SOUTHERN CALIFORNIA

B34 **Cotte, M., Soibelzon, L., Prevosti, F. J., Vizcaíno, S. F., Bocherens, H.** INSIGHTS INTO THE PALAEOECOLOGY OF SOUTHERN SOUTH AMERICA DURING THE NEOGENE USING THE STABLE ISOTOPE ANALYSIS OF MAMMALIAN TOOTH ENAMEL AND DENTINE CARBONATE

B35 **Haupt, R. J., Mcdonald, H., Clementz, M.** DIETARY PREFERENCES OF THE SHASTA GROUND SLOTH (*NOTHROTHERIOPS SHASTENSIS*) INFERRED FROM STABLE ISOTOPE ANALYSIS OF COPROLITES

B36 **Mychajliw, A. M., Cooke, S. B., Almonte, J., Feliz, G., Gibson, L., Hadly, E. A.** WHAT IS 'NATURAL' AFTER 10,000 YEARS OF EXTINCTIONS AND INVASIONS? CONSERVATION PALEOBIOLOGICAL APPROACHES IN PARQUE NACIONAL JARAGUA, DOMINICAN REPUBLIC

B37 **Suraprasit, K., Chaimanee, Y., Bocherens, H., Jaeger, J.** MIDDLE MIOCENE SYMPATRIC TRAGULIDS IN C3-DOMINATED GRASSLANDS OF MAE MOH (LAMPANG PROVINCE, NORTHERN THAILAND): THE FIRST RECORD OF THE GENUS *DORCATHERIUM* FROM SOUTHEAST ASIA

B38 **Catena, A. M., Saylor, B. Z., Croft, D. A.** USING ICHNOFOSSILS AND PALEOSOLS TO RECONSTRUCT THE MIDDLE MIOCENE PALEOENVIRONMENT OF QUEBRADA HONDA, BOLIVIA

B39 **Colleary, C., Dolocan, A., Nesbitt, S. J.** CHEMICALLY CHARACTERIZING THE DIAGENETIC ALTERATION OF BIOMOLECULES IN PROBOSCIDEANS

B40 **Gerwitz, A., Green, J. L.** BONE HISTOLOGY REVEALS A DECREASE IN GROWTH RATE OF FLORIDA *ODOCOILEUS VIRGINIANUS* (MAMMALIA, CERVIDAE) OVER THE PAST 2 MILLION YEARS

B41 **Smail, I. E., Rector, A. L., Garello, D. I., Locke, E., Campisano, C. J., Arrowsmith, J., Reed, K. E.** PLEISTOCENE PRIMATES AND RODENTIA FROM MARKAYTOLI, LOWER AWASH VALLEY, ETHIOPIA: TAPHONOMIC AND PALEOENVIRONMENTAL IMPLICATIONS

B42 **Hensley-Marschand, B., Polly, P.** ECOMETRIC INDICATORS DEMONSTRATE SEASONALLY WARM AND ARID ENVIRONMENTS IN THE EARLY PLEISTOCENE OF NORTHERN EAST ASIA

B43 **Holt, E. M., Zhang, Z., Spano, N., Blake, S. E., Garcialuna, P., Sysiong, P., Rasco, J.** RELATIVE ABUNDANCE IN THE MAMMALIAN FAUNA OF FOSSIL LAKE, OREGON, WITH IMPLICATIONS FOR UNDERSTANDING COMMUNITY COMPOSITION IN THE REGION

B44 **Ferguson, K. J., Price, G. J., Webb, G. E., Feng, Y.** GEOCHEMICAL 'FINGERPRINTING' OF LATE PLEISTOCENE AGE VERTEBRATE FOSSIL REMAINS FROM KINGS CREEK, DARLING DOWNS, QUEENSLAND, AUSTRALIA

B45 **Peters, B. J., Schwermann, A. H., Martin, T.** MORPHOLOGICAL DIVERSITY OF THE ZALAMBDODONT MOLARS OF GOLDEN MOLES (MAMMALIA, CHRYSOCHLORIDAE) WITH INDICATION FOR DIFFERENT FOOD TEXTURE

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WEDNESDAY, OCTOBER 26 THROUGH SATURDAY OCTOBER 29, 2016
SVP 2016 EDWIN H. AND MARGARET M. COLBERT PRIZE COMPETITION POSTERS (CONTINUED)

B46 **Cherney, M. D., Fisher, D. C., Rountrey, A. N.** SEASON OF BIRTH AND TIMING OF EARLY DENTAL DEVELOPMENT IN AMERICAN MASTODONS (*MAMMUT AMERICANUM*)

B47 **Oberg, D., Hopkins, S. S.** RECONSTRUCTING BODY MASS FROM MARSUPIAL DENTAL DIMENSIONS

B48 **Kay, D. I., Kuhn-Hendricks, S. M., Erickson, G. M.** EVOLUTION OF MINERALIZED DENTAL TISSUE MATERIAL PROPERTIES IN GNATHOSTOMATA

B49 **Hielscher, R. C., Martin, T.** MOLAR RELIEF INDEX OF EXTANT AND FOSSIL BATS WITH APPLICATION TO DIETARY HABITS

B50 **Trayler, R. B., Kohn, M. J.** ENAMEL MATURATION IS INDEPENDENT OF APPOSITIONAL GEOMETRY

WEDNESDAY, OCTOBER 26 THROUGH THURSDAY OCTOBER 27, 2016
POSTER SYMPOSIUM I: ADVANCES IN MIDDLE EOCENE PALEOECOLOGY: EVOLUTIONARY AND ECOLOGICAL DYNAMICS IN A POST-GREENHOUSE WORLD
GRAND AMERICA HOTEL, EXHIBIT HALL GRAND BALLROOM
Authors must be present from 4:15 – 6:15 p.m., Wednesday, October 26
Posters must be removed by 6:30 p.m., Thursday, October 27

B51 **Smith, H. F., Hutchison, J., Jager, D. M., Adrian, B., Townsend, K.** NEWLY DISCOVERED CRANIAL, POSTCRANIAL, AND SHELL SPECIMENS OF *BAENA ARENOSA* AND *CHISTERNON UNDATUM* FROM THE UINTA FORMATION, UINTA BASIN, UTAH, USA: INSIGHTS INTO MORPHOLOGICAL VARIATION AT THE END OF THE BAENID RADIATION

B52 **Adrian, B., Hutchison, J., Townsend, K.** NEW REPORTS AND DISTRIBUTION OF RARE TURTLES IN THE UINTA FORMATION, INCLUDING SPECIMENS FROM CARETTOCHELYIDAE, PLANETOCHELYIDAE, TESTUDINIDAE, GEOEMYDIDAE, AND BAENIDAE

B53 **Elshafie, S. J.** CAN INFERRED ECOLOGY ELUCIDATE DRIVERS OF LIZARD EVOLUTION THROUGH EOCENE CLIMATIC TRANSITIONS OF THE WESTERN INTERIOR?

B54 **Hutchison, J., Holroyd, P. A., Westgate, J. W.** CARETTOCHELYINES FROM THE MIDDLE EOCENE OF COASTAL TEXAS: COSMOPOLITAN DISPERSERS IN A TIME OF GLOBAL WARMTH

B55 **Jager, D. M., Smith, H. F., Hutchison, J., Jorge, K., Adrian, B., Townsend, K.** 3D EPIPLASTRAL, GEOGRAPHIC, AND BODY SIZE VARIATION IN *ECHMATEMYS*, A GEOEMYDID TURTLE FROM THE UINTA FORMATION, UINTA BASIN, UTAH, USA

B56 **Muldoon, K. M., Jager, D. M., Zonneveld, J., Bartels, W. S., Gunnell, G. F.** GEOGRAPHIC PATTERNING IN MAMMAL COMMUNITY DYNAMICS ACROSS THE WASATCHIAN–BRIDGERIAN BOUNDARY AT SOUTH PASS, WYOMING

B57 **Tomiya, S., Spaulding, M., Zack, S. P.** DIVERSITY AND TURNOVER OF MAMMALIAN CARNIVORES FROM THE MIDDLE EOCENE WASHAKIE FORMATION, WYOMING, USA

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B58 **Higgins, P., Townsend, K., Rosenstein, D.** COLOR AND CHEMISTRY AS PROXIES FOR ENVIRONMENTAL CHANGE DURING THE UINTAN NORTH AMERICAN LAND MAMMAL 'AGE' (NALMA) AND AT THE BOUNDARY BETWEEN THE UINTAN AND DUCHESNEAN NALMAS

B59 **Stroik, L. K., Townsend, K.** THE EVOLUTION OF ECOLOGICAL NICHE STRUCTURE IN NORTH AMERICAN MIDDLE EOCENE UNGULATES

B60 **Yapuncich, G. S., Harrington, A. R., Bloch, J. I., Gunnell, G. F., Boyer, D. M.** ECOLOGICAL INFERENCES OF EARLY EUPRIMATES OF THE BRIDGER BASIN: AN EVALUATION OF CRANIODENTAL AND POSTCRANIAL BODY MASS PREDICTORS FROM ASSOCIATED SKELETONS

B61 **Perchalski, B. A., Gonzales, L. A., Gunnell, G. F., Bloch, J. I., Boyer, D. M.** MORPHOLOGICAL VARIATION AND SEXUAL DIMORPHISM IN SYMPATRIC NOTHARCTINE (EUPRIMATES, ADAPIFORMES) SPECIES

B62 **Boyer, D. M., Gunnell, G. F., Gonzales, L., Alexander, J. P., Dunn, R. H., Bloch, J. I.** EXCEPTIONALLY COMPLETE IN SITU SKELETON OF AN ADULT EARLY EOCENE NOTHARCTINE EUPRIMATE

B63 **Atwater, A., Kirk, E. C.** NEW UINTAN OMOMYOIDS (PRIMATES, HAPLORHINI) FROM SOUTHERN CALIFORNIA AND THE IMPLICATIONS FOR NORTH AMERICAN PRIMATE RICHNESS DURING THE MIDDLE EOCENE

B64 **Kirk, E., Atwater, A., Campisano, C., Egberts, S., Lundeen, I.** A NEW PRIMATE PARTIAL CRANIAL SPECIMEN FROM THE LATE MIDDLE EOCENE OF THE TORNILLO BASIN, TEXAS

B65 **Lundeen, I. K., Kirk, E.** REDUCTION OF THE OLFACTORY SYSTEM IN PRIMATES: NEW INSIGHTS FROM THE NASAL FOSSA OF THE DUCHESNEAN PRIMATE *ROONEYIA VIEJAENSIS*

B66 **Mattingly, S. G., Beard, K.** A NEW CARPOLESTID FROM SOUTHWESTERN WYOMING AND ITS PHYLOGENETIC IMPLICATIONS

B67 **Fulwood, E. L., Gunnell, G. F., Perchalski, B. A., Harrington, A., Gonzales, L., Alexander, J. P., Bloch, J. I., Boyer, D. M.** REVISED HIGH RESOLUTION STRATIGRAPHY OF BRIDGER FORMATION IN GRIZZLY BUTTES AREA OF SOUTHWEST WYOMING

B68 **Theodor, J. M., Dutchak, A., Perry, J. M.** UPDATE ON THE CYPRESS HILLS FORMATION FAUNAS OF SASKATCHEWAN (EOCENE–OLIGOCENE): NEW LOCALITIES AND NEW FOSSILS

B69 **Dunn, R. H.** REVISED MAMMALIAN FAUNA FROM THE SAND WASH BASIN AND ASSESSMENT OF AN EARLIEST UINTAN AGE

B70 **Westgate, J. W., Townsend, B.** A COMPARISON OF TWO LATE UINTAN (LATE MIDDLE EOCENE) MICRO-MAMMAL FAUNAS FROM THE CENTRAL ROCKY MOUNTAINS AND TEXAS COASTAL PLAIN AND THEIR PALEOECOLOGIC IMPLICATIONS

B71 **Li, Q., Meng, J., Wang, Y.** NEW RODENT ASSEMBLAGE FROM STRATA NEAR THE EOCENE–OLIGOCENE BOUNDARY IN ERDEN OBO SECTION (NEI MONGOL, CHINA)

B72 **Friscia, A. R., Dunn, R. H.** UINTAN CREODONTS FROM THE UINTA BASIN WITH A DESCRIPTION OF THE POST-CRANIAL SKELETON OF *OXYAENODON*

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POSTER SYMPOSIUM I: ADVANCES IN MIDDLE EOCENE PALEOECOLOGY: EVOLUTIONARY AND ECOLOGICAL DYNAMICS IN A POST-GREENHOUSE WORLD (CONTINUED)

B73 **Townsend, K. E., Hutchison, J., Ryan, M. J.** NEW SPECIMENS OF *HARPAGOLESTES* (MESONYCHIA, MESONYCHIDAE) FROM THE UINTA FORMATION, UINTA BASIN, UTAH

B74 **Holroyd, P. A., Townsend, K.** *PROTOREODON* AND THE DIVERSIFICATION OF BASAL RUMINANTS

B75 **Burger, B. J.** *HYRACHYUS EXIMIUS* FROM THE MIDDLE EOCENE LOWER WASHAKIE FORMATION ABODE TOWN MEMBER OF WYOMING AND ITS BEARING ON THE ORIGIN AND EARLY DIVERSIFICATION OF RHINOCEROSES

WEDNESDAY, OCTOBER 26, 2016
POSTER SESSION I
GRAND AMERICA HOTEL, IMPERIAL BALLROOM FOYER
Authors must be present from 4:15 – 6:15 p.m.
Posters must be removed by 6:30 p.m.

Posters Associated with Symposium I: Molecular Preservation in the Fossil Record: Evidence, Analyses, Applications and Challenges

IB1 **Uvdal, P., Sigfridsson Clauss, K., Carlson, S., Heimdal, J., Engdahl, A., Sjövall, P., Lindgren, J.** NEW LIGHT ON VERTEBRATE FOSSILS: HOW SYNCHROTRONS CAN CONTRIBUTE

IB2 **Van Der Reest, A. J., Currie, P. J.** FACTORS INFLUENCING MACROSCOPIC AND BIOMOLECULAR FEATHER PRESERVATION ON A SPECIMEN OF *ORNITHOMIMUS* (DINOSAURIA, THEROPODA) FROM DINOSAUR PROVINCIAL PARK, ALBERTA

EXHIBIT HALL GRAND BALLROOM

Regular Session Posters

B76 **Forir, M.** PLEISTOCENE ICHNOFOSSILS AND THEIR IMPORTANCE IN RECONSTRUCTING MAMMALIAN HABITUAL CAVE USE

B77 **Anglen, J. J., Chatters, J. C., Dundas, R. G., Hertfelder, S. E.** AN ATTRITIONAL ASSEMBLAGE TAPHONOMIC MODEL FOR THE FAIRMEAD LANDFILL FOSSIL LOCALITY (PLEISTOCENE, IRVINGTONIAN), MADERA COUNTY, CALIFORNIA

B78 **Spano, N. G., Zhang, Z., Holt, E., Blake, S. E., Garcialuna, P., Sysiong, P.** MAMMALIAN TAPHONOMIC ENVIRONMENT OF PLEISTOCENE FOSSIL LAKE, OREGON

B79 **Fox, N., Blois, J., Farrell, A., Takeuchi, G.** INITIAL ASSESSMENT OF PROJECT 23 SMALL MAMMAL DIVERSITY AND TAPHONOMY AT RANCHO LA BREA

B80 **Madan, M. A., Prothero, D. R., Syverson, V.** SIZE AND SHAPE STASIS IN RANCHO LA BREA BARN OWLS OVER THE LAST GLACIAL-INTERGLACIAL CYCLE

B81 **Long, K. L., Prothero, D. R.** STASIS IN RANCHO LA BREA BLACK VULTURES (*CORAGYPS OCCIDENTALIS*) OVER THE LAST GLACIAL-INTERGLACIAL CYCLE

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B82 **Biewer, J., Sankey, J. T., Garber, D., Wagner, H., Wilson, W., Castle, L., Beaman, M.** LOST AND FOUND: THE TURLOCK LAKE PALEOFAUNA AND FLORA

B83 **Hulbert, R. C., Bourque, J. R., Bloch, J. I., Macfadden, B. J., Steadman, D. W.** GEOLOGY, PALEOECOLOGY, AND TAPHONOMY OF A NEW LATE MIOCENE (HEMPHILLIAN) LOCALITY FROM NORTH-CENTRAL FLORIDA

B84 **Santos, G., Parham, J. F., Barboza, M., Kussman, B. N., Velez-Juarbe, J.** NEW RECORDS OF TERRESTRIAL AND MARINE MAMMALS FROM THE OSO SAND MEMBER, CAPISTRANO FORMATION, ORANGE COUNTY, CALIFORNIA

B85 **Mackenzie, K., Sertich, J.** BIOSTRATIGRAPHY OF THE HIGH-ELEVATION DRY UNION FORMATION (MIOCENE–PLIOCENE) OF SOUTH CENTRAL COLORADO

B86 **Blois, J. L., Brown, S. K., Hadly, E. A.** ASSESSING CROSS-CONTAMINATION IN ANCIENT DNA FROM TEMPERATE CAVE DEPOSITS

B87 **Beck, C., Husley, D. B., Baghai-Riding, N. L., Blackwell, E.** PALEOCOMMUNITY OF LATE PLEISTOCENE MEGAFAUNA FOUND ALONG THE LOWER MISSISSIPPI DELTA GRAVEL BARS

B88 **Semprebon, G. M., Rivals, F., Prignano, L., Lozano, S.** A NEW APPROACH FOR ESTIMATING THE RELATIVE DURATION OF MORTALITY EVENTS OF LARGE HUNTED GAME AT ARCHAEOLOGICAL SITES USING ENAMEL MICROWEAR

B89 **Feranec, R. S., Garcia, N., Arsuaga, J., Baquedano, E.** PALEOECOLOGY AND PALEOENVIRONMENT AT TWO LATE PLEISTOCENE NEANDERTHAL-BEARING SITES IN PINILLA DEL VALLE, SPAIN: STABLE ISOTOPE VALUES REVEAL NICHE CONSERVATISM

B90 **Pérez-Crespo, V., Prado, J. L., Alberdi Alonso, M. T., Arroyo-Cabrales, J.** STABLE ISOTOPIC DIETS OF PLEISTOCENE HORSES FROM SOUTHERN NORTH AMERICA AND SOUTH AMERICA: SIMILARITIES AND DIFFERENCES

B91 **Green, J. L., Desantis, L. G., Smith, G. J.** VARIATION IN THE BROWSING DIET OF PLEISTOCENE *MAMMUT AMERICANUM* (MAMMALIA, PROBOSCIDEA) AS RECORDED BY DENTAL MICROWEAR TEXTURE ANALYSIS

B92 **Smith, G. J., Desantis, L.** PROBOSCIDEAN DIETARY VARIABILITY IN NORTH AMERICA AND THE COMPETITIVE EXCLUSION PRINCIPLE

B93 **Dooley, A. C., Scott, E., Mcdonald, H.** MASTODONS OF UNUSUAL SIZE: HOW DISTINCTIVE ARE WESTERN SPECIMENS OF *MAMMUT AMERICANUM*?

B94 **Leger, A. M., Agenbroad (Posthumous), L. D.** UTILIZING PROBOSCIDEAN CRANIAL METRICS FOR ANALYSIS OF REGIONAL VARIATION IN THE COLUMBIAN MAMMOTH *(MAMMUTHUS COLUMBI)*

B95 **Lambert, W. D.** THE PHYLOGENETIC AFFINITIES OF THE SHOVEL-TUSKED GOMPHOTHERE *KONOBELODON* (MAMMALIA, PROBOSCIDEA): IS ITS SISTER GROUP *AMEBELODON* OR *PLATYBELODON*?

B96 **Carranza-Castañeda, O.** THE GENUS *RHYNCHOTHERIUM* (MAMMALIA, PROBOSCIDEA) IN THE HEMPHILLIAN–BLANCAN (NALMA) OF CENTRAL MEXICO

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B97 **Jass, C. N., Barron-Ortiz, C. R.** A SYNOPSIS OF THE QUATERNARY PROBOSCIDEAN RECORD FROM ALBERTA, CANADA

B98 **El Adli, J. J., Fisher, D. C., Vartanyan, S., Tikhonov, A.** LIFE HISTORY ANALYSES OF WOOLLY MAMMOTHS FROM WRANGEL ISLAND AND CHUKOTKA

B99 **Maschenko, E. N., Potapova, O., Protopopov, A. V., Heinzman, P. D., Kapp, J. D., Cahill, J. A., Shapiro, B., Van Der Plicht, J., Pavlov, I., Kolesov, S.** A DISCOVERY OF A NEW SKELETON OF THE MAMMOTH (*MAMMUTHUS* SP.) FROM THE SARTANIAN DEPOSITS IN EASTERN SIBERIA, RUSSIA

B100 **Potapova, O., Maschenko, E. N., Protopopov, A., Kienast, F., Rudaya, N., Kuzmina, S., Parkhaev, P. Y., Van Der Plicht, J., Galanin, A., Pavlov, I.** THE SARTANIAN BIODIVERSITY OF CENTRAL YAKUTIA, RUSSIA: THE ANALYSES OF THE NEW LATE PLEISTOCENE MEGIN SITE

B101 **Protopopov, A. V., Potapova, O., Kharlamova, A., Boeskorov, G. G., Maschenko, E. N., Shapiro, B., Soares, A., Pavlov, I., Plotnikov, V., Klimovskii, A.** THE FROZEN CAVE LION (*PANTHERA SPELAEA*) NEWBORN CUBS FROM EASTERN SIBERIA, RUSSIA: THE FIRST DATA ON EARLY ONTOGENY OF THE EXTINCT SPECIES

B102 **Kantelis, T. M., Schubert, B. W.** MORPHOMETRIC ANALYSIS OF *URSUS ARCTOS* AND *U. AMERICANUS* MOLARS AS A DIAGNOSTIC TOOL

B103 **Lynch, L. M.** *MARTES AMERICANA* IS SELECTIVE IN FOLLOWING THE RULES: A TEST OF BERGMANN'S AND ALLEN'S RULES

B104 **Flora, G. W., Mackenzie, K.** GEOMETRIC MORPHOMETRIC ANALYSIS OF *MUSTELA* (MAMMALIA, CARNIVORA) FROM THE PLEISTOCENE (IRVINGTONIAN) OF PORCUPINE CAVE, COLORADO

B105 **Jones, L. S., Moretti, J. A., Johnson E.** USING THREE DIMENSIONAL GEOMETRIC MORPHOMETRICS FOR THE IDENTIFICATION OF A *CANIS* SPP. AT A HISTORIC SITE IN WESTERN TEXAS

B106 **Prassack, K. A.** A THIRD CANID FROM THE HAGERMAN FOSSIL BEDS (HAGERMAN FOSSIL BEDS NATIONAL MONUMENT), IDAHO, USA

B107 **Therrien, F., Quinney, A., Tanaka, K., Zelenitsky, D.** DOES COMPUTED TOMOGRAPHY IMPROVE THE ACCURACY OF THE MANDIBULAR FORCE PROFILE METHOD FOR BITE FORCE ESTIMATION AND FEEDING BEHAVIOR RECONSTRUCTION IN EXTANT AND EXTINCT CARNIVORANS?

B108 **Reuter, D. M., Hopkins, S. S.** QUANTIFYING INTRASPECIFIC VARIATION ACROSS THE TOOTH ROW IN CARNIVORANS (MAMMALIA, CARNIVORA)

B109 **Werdelin, L.** PHYLOGENY OF SABERTOOTH FELIDS (CARNIVORA, FELIDAE, MACHAIRODONTINAE)

B110 **Naples, V. L., Rothschild, B. M.** SEX IDENTIFICATION IN *SMILODON* AS EXTRAPOLATED FROM RECOGNIZED MARKERS IN CONTEMPORARY FELIDAE AND PRIMATES

B111 **Reynolds, A. R., Evans, D. C.** A MULTI-ELEMENT HISTOLOGICAL ANALYSIS OF THE SABRE-TOOTHED CAT *SMILODON FATALIS* (FELIDAE, CARNIVORA)

B112 **Gillette, D. D., Carranza, O. C.** INCREMENTAL GROWTH LINES IN TEETH OF THE NORTH AMERICAN GLYPTODONT *GLYPTOTHERIUM TEXANUM* (XENARTHRA, CINGULATA)

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B113 **Mcafee, R. K., Roth, A.** HERE AND GONE: EXPLANATIONS FOR THE VARIABLE ABSENCE OF THE ENTEPICONDYLAR FORAMEN IN SLOTHS (MAMMALIA, PILOSA)

B114 **Beery, S. M., Mcafee, R. K.** EXPLORATION OF POST-CRANIAL SEXUAL DIMORPHISM IN LATE PLEISTOCENE FOSSIL SLOTHS (MAMMALIA, PILOSA) FROM THE GREATER ANTILLES

B115 **Carrillo-Briceño, J. D., Amson, E., Zurita, A., Sánchez-Villagra, M. R.** A TAXONOMIC AND GEOGRAPHIC STUDY OF HERMANN KARSTEN'S XIX CENTURY PALEOVERTEBRATE COLLECTION FROM THE NORTHERN NEOTROPICS

B116 **Kramer, M. A., Schubert, B. W.** NEW UNDERGROUND FINDINGS OF PLEISTOCENE AND HOLOCENE MAMMALS IN EXTREME NORTHEASTERN BRAZIL: FROM EXTENSIVE CAVE DEPOSITS TO POTENTIAL PALEO-BURROWS

B117 **Aziz, A. A., Alava, K. A., Shockey, B. J.** NOTOUNGULATE MIDDLE EAR ANATOMY: PARADIGMS AND ANALOGUES

B118 **Forasiepi, A. M., Macphee, R. D., Hernandez Del Pino, S., Schmidt, G., Amson, E., Grohe, C.** PALEOBIOLOGY OF *HUAYQUERIANA*, A LATE MIOCENE LITOPTERN FROM WESTERN ARGENTINA: INTERPRETING CONFLICTING SIGNALS FROM MORPHOLOGICAL ATTRIBUTES

B119 **Carroll, B. R., Anaya, F., Croft, D. A.** FIRST DESCRIPTION OF AN ARTICULATED MANUS OF A HEGETOTHERIINE NOTOUNGULATE, BASED ON A SPECIMEN FROM THE MIDDLE MIOCENE OF QUEBRADA HONDA, BOLIVIA

B120 **Alava, K. A., Aziz, A. A., Shockey, B. J.** RE-ASSOCIATION OF ISOLATED FEMORA OF SALLA, BOLIVIA (LATE OLIGOCENE): ADDITIONS TO KNOWLEDGE AND FUNCTIONAL HYPOTHESES

B121 **Bethune, E., Kaiser, T. M., Winkler, D. E.** A MULTIPROXY APPROACH TO RECONSTRUCT THE PALEOECOLOGY OF PLEISTOCENE HIPPOPOTAMIDAE FROM THE MEDITERRANEAN ISLANDS (CETARTIODACTYLA, MAMMALIA)

B122 **Lazagabaster, I. A., Rowan, J., Garello, D., Campisano, C., Arrowsmith, R., Reed, K. E.** FOSSIL ARTIODACTYLA (MAMMALIA) FROM MARKAYTOLI, A NEW MIDDLE PLEISTOCENE SITE IN THE LOWER AWASH VALLEY, ETHIOPIA

B123 **Chainey, A. R., Davis, E. B., Mclaughlin, W. N., Hopkins, S. S.** BRIDGING THE GAP BETWEEN ASIAN AND EUROPEAN FAUNA WITH THE GAZELLES OF THE CHU FORMATION IN THE KOCHKOR BASIN, KYRGYZSTAN

B124 **Thompson, M. E., Ferguson, A., Bell, K. C.** USE OF MORPHOMETRIC ANALYSIS ON ASTRAGALI TO DIFFERENTIATE BISON SPECIES

B125 **O'Donnell, K., Emery, M., Davis, E. B.** PAEDOMORPHISM IN MODERN CAMELIDS

B126 **Woodruff, A. L., Schubert, B. W.** DESCRIPTION, TAPHONOMY, AND PALEOECOLOGY OF THE LATE PLEISTOCENE PECCARIES (ARTIODACTYLA, TAYASSUIDAE) FROM BAT CAVE, PULASKI COUNTY, MISSOURI

B127 **Doughty, E. M., Wallace, S. C., Schubert, B. W.** THREE TAYASSUIDS FROM THE LATEST MIOCENE TO EARLIEST PLIOCENE (HEMPHILLIAN) GRAY FOSSIL SITE, TN

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B128 **Li, L., Dodson, P.** THE VARIATION OF THE VERTEBRAL CENTRA LENGTH AND EI IN SAUROPOD DINOSAUR—HOW TO BUILD A SAUROPOD

B129 **Kosch, J. C., Sattler, F., Schwarz, D., Zanno, L. E.** A TRIGONOMETRY BASED METRIC TO DESCRIBE SAUROPOD DENTITIONS

B130 **Saegusa, H., Ikeda, T.** SOME PECULIAR FEATURES OF *TAMBATITANIS AMICITIAE* (SAUROPODA, TITANOSAURIFORMS) REVEALED BY VIRTUAL SKELETAL RECONSTRUCTION.

B131 **Royo-Torres, R., Upchurch, P., Kirkland, J. I., Deblieux, D., Foster, J., Cobos, A., Rey, G., Alcalá, L.** SYSTEMATICS OF A NEW SAUROPOD FROM THE BASAL YELLOW CAT MEMBER (EARLY CRETACEOUS) FROM DOELLING'S BOWL (EASTERN, UTAH, USA)

B132 **Holmes, A. D., Britt, B. B., Chure, D. J., Wilson, J. A., Scheetz, R. D.** SEDIMENTOLOGY AND TAPHONOMY OF THE *ABYDOSAURUS MCINTOSHI* QUARRY, (CEDAR MOUNTAIN FORMATION, MUSSENTUCHIT MEMBER; EARLY CRETACEOUS, LATEST ALBIAN), DINOSAUR NATIONAL MONUMENT, UTAH.

B133 **Carballido, J. L., Diego, P., Otero, A., Cerda, I., Salgado, L., Garrido, A., Ramezzani, J., Cúneo, N. R., Krause, M.** A NEW GIANT TITANOSAUR FROM THE LATE EARLY CRETACEOUS OF PATAGONIA YIELDS LIGHT INTO TITANOSAUR BODY SIZE EVOLUTION

B134 **Ortega, F., Mocho, P., Páramo, A., Díez Díaz, V., Marcos-Fernández, F.** MORPHOLOGICAL AND LAMINAE PATTERN VARIATION IN THE DORSAL SERIES OF A NEW TITANOSAURIAN SPECIMEN FROM LO HUECO (CUENCA, SPAIN).

B135 **González Riga, B. J., Lamanna, M. C., Ortiz David, L. D., Curry Rogers, K.** NEWLY DISCOVERED PEDES OF TITANOSAURIAN SAUROPOD DINOSAURS FROM ARGENTINA YIELD NOVEL DATA FOR PHYLOGENETIC ANALYSIS

B136 **Shimizu, I., Chanthasit, P., Suteethorn, S., Sashida, K., Agematsu, S.** NEW SAUROPOD MATERIAL FROM THE EARLY CRETACEOUS OF THAILAND

B137 **Voegele, K., Ullmann, P., Lamanna, M. C., Lacovara, K. J.** MYOLOGICAL RECONSTRUCTIONS FROM WELL-DEFINED APPENDICULAR MUSCLE SCARS IN *DREADNOUGHTUS SCHRANI*, A GIGANTIC TITANOSAURIAN SAUROPOD FROM PATAGONIA, ARGENTINA

B138 **Kulik, Z., Curry Rogers, K.** OSTEOHISTOLOGY OF *RAPETOSAURUS KRAUSEI* (SAUROPODA, TITANOSAURIA) FROM THE LATE CRETACEOUS OF MADAGASCAR

B139 **Ortiz David, L. D., González Riga, B. J., Mannion, P., Poropat, S. F., Coria, J. P.** NEW INFORMATION ON THE LATE CRETACEOUS ARGENTINEAN SAUROPOD DINOSAUR *MENDOZASAURUS* AND ITS IMPLICATIONS FOR BASAL TITANOSAUR RELATIONSHIPS

B140 **De Blieux, D. D., Kirkland, J. I., Madsen, S. K., Hunt, G. J.** THE TAPHONOMY OF A MIRED SAUROPOD DINOSAUR AT DOELLING'S BOWL BONEBED IN THE EARLY CRETACEOUS CEDAR MOUNTAIN FORMATION, EASTERN UTAH

B141 **Haiar, B., Porter, K.** OVERALL BODY SIZE AS AN INDICATOR OF ONTOGENETIC STAGE IN SAUROPOD DINOSAURS

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B142 **Díez Díaz, V., Mallison, H., Schwarz, D.** HOW DID *GIRAFFATITAN* SHAKE ITS TAIL? STUDYING SAUROPOD BIOMECHANICS VIA 3D MODELING TECHNIQUES

B143 **Chapelle, K. E., Choiniere, J. N.** THREE DIMENSIONAL MORPHOMETRIC ANALYSIS OF THE CRANIAL ONTOGENY OF *MASSOSPONDYLUS CARINATUS* BASED ON CT RECONSTRUCTIONS

B144 **Wiersma, K., Canoville, A., Siber, H., Tschopp, E., Sander, M. P.** TESTING HYPOTHESES OF SKELETAL UNITY IN SAUROPOD REMAINS FROM THE HOWE-STEPHENS QUARRY (MORRISON FORMATION, WYOMING, USA) USING LONG BONE HISTOLOGY

B145 **Mocho, P., Royo-Torres, R., Ortega, F.** EVOLUTIONARY HISTORY OF LATE JURASSIC SAUROPODS OF THE LUSITANIAN BASIN (PORTUGAL) AND PRESENTATION OF A NEW BASAL MACRONARIAN FORM

B146 **Mchugh, J. B.** TOOTH REPLACEMENT IN A DIPLODOCOID SAUROPOD FROM THE UPPER JURASSIC MYGATT-MOORE QUARRY (MORRISON FORMATION) IN RABBIT VALLEY, COLORADO

B147 **Dinter, C. M., Benson, R., McPhee, B. W., Choiniere, J. N.** NEW ASSOCIATED BASAL SAUROPODOMORPH MATERIAL FROM THE LATE TRIASSIC LOWER ELLIOT FORMATION, KAROO BASIN, EASTERN CAPE

B148 **Holwerda, F. M., Rauhut, O. W., Furrer, H.** SAUROPODOMORPH DIVERSITY IN THE EUROPEAN TRIASSIC: A NEW SAUROPODIFORM FROM THE NORIAN–RHAETIAN OF SWITZERLAND

B149 **Clayton, K. E., McPhee, B. W., Jinnah, Z., Choiniere, J. N.** PALEOENVIRONMENTS AND DEPOSITIONAL HISTORY OF THE SAUROPODOMORPH FAUNA FROM THE TRIASSIC-JURASSIC LEBOMBO–TSHIPISE BASIN OF SOUTH AFRICA

B150 **Staunton, C. K., Choiniere, J. N.** THE EVOLUTION OF FORELIMB ARCHITECTURE IN EARLY SAUROPODOMORPHS

B151 **Retallack, G. J.** TESTING THE WOODLAND HYPOTHESIS OF TETRAPOD ORIGINS IN POLAND AND GERMANY

B152 **Fedak, T. J.** SIXTY YEARS OF CITIZEN SCIENCE: SIGNIFICANT DINOSAUR TRACKWAYS, CARBONIFEROUS FISH, INSECTS, AND AMPHIBIAN FOOTPRINTS FROM NOVA SCOTIA'S BAY OF FUNDY REGION.

B153 **Mann, A., Maddin, H. C.** A RE-DESCRIPTION OF *AMPHIBAMUS GRANDICEPS* (TEMNOSPONDYLI, DISSOROPHOIDEA) FROM THE FRANCIS CREEK SHALE, MAZON CREEK, ILLINOIS

B154 **Gren, J. A., Lindgren, J.** AN EXCEPTIONALLY PRESERVED AMPHIBIAN FROM THE PERMIAN SAAR-NAHE BASIN OF SOUTHWESTERN GERMANY: SOFT TISSUE PRESERVATION AND SKELETAL 3D IMAGING

B155 **Herhold, H. W., Pettersson, C. B., Temple, D. P., Bakker, R. T., Castillo, J. C., Sparks, G., Steinhardt, S., Smalley, S. S., Flis, C. J., Bell, T. H.** MORPHOMETRIC ANALYSIS OF A MASS ASSEMBLAGE OF *TRIMERORHACHIS* (AMPHIBIA, TEMNOSPONDYLI) FROM THE ARROYO FORMATION, LOWER CLEAR FORK

B156 **Sengupta, D. P.** NICHE SHARING AMONG EARLY TRIASSIC TEMNOSPONDYL AMPHIBIANS OF EASTERN INDIA

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B157 **Chakravorti, S., Sengupta, D. P.** A TALE OF TWO TEMNOSPONDYL-DOMINATED FAUNAL ASSEMBLAGES FROM THE MIDDLE TRIASSIC OF CENTRAL INDIA

B158 **Gee, B., Soler, J., Parker, W.** DESCRIPTION OF MATERIAL FROM A POTENTIAL NEW SPECIES OF METOPOSAUR FROM THE PETRIFIED FOREST NATIONAL PARK, AZ, USA

B159 **Hirayama, R., Nakajima, Y.** IS *EUNOTOSAURUS AFRICANUS* REALLY ANCESTRAL TO TURTLES?

B160 **Liu, J., Bever, G. S., Li, L.** THE TETRAPOD FAUNA OF THE UPPER PERMIAN NAOBAOGOU FORMATION OF DAQINGSHANG, INNER MONGOLIA, CHINA

B161 **Suarez, C. A., Knobbe, T., Milner, A. R., Kirkland, J. I., Crowley, J.** IDENTIFYING THE END TRIASSIC EXTINCTION IN THE MOENAVE FORMATION, UTAH USING C-ISOTOPE CHEMOSTRATIGRAPHY, DETRITAL ZIRCON GEOCHRONOLOGY, AND BIOSTRATIGRAPHY.

B162 **Shumway, J., Britt, B. B., Chure, D. J., Engelmann, G. F., Scheetz, R. D., Hood, S., Chambers, M.** FACIES ANALYSIS AND DEPOSITIONAL ENVIRONMENTS OF THE SAINTS & SINNERS QUARRY (SSQ) IN THE LOWER NUGGET SANDSTONE (LATE TRIASSIC) OF NORTHEASTERN UTAH SHOW THAT THE DIVERSE VERTEBRATE ASSEMBLAGE WAS PRESERVED IN A LACUSTRINE INTERDUNAL ENVIRONMENT

B163 **Engelmann, G. F., Chure, D. J., Easterday, M.** DOCUMENTING AN EXTENSIVE TRACKSITE IN THE LATE TRIASSIC–EARLY JURASSIC NUGGET SANDSTONE AT DINOSAUR NATIONAL MONUMENT USING GIGAPAN LARGE PANORAMAS AND PHOTOGRAMMETRY

B164 **Carrasco, D., Falkingham, P. L., Gatesy, S. M.** FOOT MORPHOLOGY OR EXIT FEATURE: A CT PERSPECTIVE ON HITCHCOCK'S DINOSAUR TRACKS

B165 **Tucker, R. T., Rademan, Z., Klausen, M. B.** POMPEII–LIKE FLORAL FOSSILS IN THE KRUGER NATIONAL PARK: PALAEOENVIRONMENTAL AND STRATIGRAPHIC CONTEXT FOR NEWLY DISCOVERED ASSEMBLAGES ALONG THE LETABA RIVER, SOUTH AFRICA

B166 **Parraga, J., Bernard, E., Brewer, P., Ward, D. J., Wills, S.** A DIVERSE NEW LATE BATHONIAN MICROVERTEBRATE ASSEMBLAGE FROM WOODEATON QUARRY, OXFORDSHIRE, UK

B167 **Cobos, A., Royo-Torres, R., Alcalá, L., Loewen, M., Kirkland, J. I.** DINOSAURS AS BIOCHRONOLOGICAL MARKERS IN THE EUROPEAN TITHONIAN–BERRIASIAN TRANSITION

B168 **Wolfe, D. G., Wolfe, H. D.** TRACKWAY EVIDENCE FOR A THEROPOD GROUP ATTACK UPON A POSSIBLE CERATOPSIAN DINOSAUR FROM THE MORENO HILL FORMATION (TURONIAN) NEW MEXICO

B169 **Avrahami, H. M., Humphrey, J. S., Heckert, A. B., Gates, T., Makovicky, P. J., Zanno, L. E.** THE EARLY LATE CRETACEOUS PALEOFAUNAL VERTEBRATE ASSEMBLAGE OF THE CLIFFS OF INSANITY MICROSITE IN THE MUSSENTUCHIT MEMBER OF THE CEDAR MOUNTAIN FORMATION, UTAH

B170 **Bamforth, E. L., Tokaryk, T.** EXPLORING THE CENOMANIAN AND TURONIAN (92–98 MA) SEAS OF SASKATCHEWAN, CANADA

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B171 **Pérez-García, A., Bardet, N., Barroso-Barcenilla, F., Cambra-Moo, O., Mocho, P., Narváez, I., Ortega, F., Segura, M., Torices, A.** THE FAUNA OF REPTILES FROM THE CENOMANIAN OF ALGORA (GUADALAJARA, SPAIN): SYSTEMATIC AND PALEOBIOGEOGRAPHIC IMPLICATIONS

B172 **Carvalho, N., Evans, D. C.** THE VERTEBRATE ASSEMBLAGE OF THE MADSEN BONE BED, LOWER JUDITH RIVER FORMATION (MCCLELLAND FERRY MEMBER, CAMPANIAN), NORTH-CENTRAL MONTANA

B173 **Crane, C. D.** THE CAMPANIAN OF BLADEN COUNTY, NORTH CAROLINA: REASSESSMENT OF THE VERTEBRATE FAUNA OF PHOEBUS LANDING AND COMPARISON WITH THAT OF ELIZABETHTOWN

B174 **El Dawoudi, I. A., O'Connor, P. M., Kora, M. A., Sallam, H. M., Sertich, J.** NEW DINOSAUR REMAINS FROM THE CAMPANIAN QUSEIR FORMATION, WESTERN DESERT, EGYPT

B175 **Cullen, T. M., Longstaffe, F. J., Evans, D. C.** AN INTENSIVE MULTI-TAXIC STABLE CARBON AND OXYGEN ISOTOPIC ANALYSIS OF VERTEBRATES FROM A MICROSITE IN THE OLDMAN FORMATION (LATE CRETACEOUS) OF ALBERTA

B176 **Yamamura, D., Suarez, C. A.** INVESTIGATING VERTEBRATE PALEOECOLOGY OF THE KAIPAROWITS FORMATION VIA STABLE ISOTOPIC COMPOSITION OF SKELETAL REMAINS

B177 **King, L. R.** MICROVERTEBRATES OF THE LANCE CREEK FORMATION IN EASTERN WYOMING: A COMPREHENSIVE HISTORY OF THE LAST 70 YEARS

B178 **Katsura, Y., Demar, D. G., Wilson, G. P.** THE YOUNGEST NORTH AMERICAN OCCURRENCE OF A BASAL CHORISTODERE (REPTILIA, CHORISTODERA) FROM THE UPPER CRETACEOUS (MAASTRICHTIAN) HELL CREEK FORMATION, NORTHEASTERN MONTANA, USA

B179 **Sullivan, R. M., Lucas, S., Lichtig, A., Dalman, S., Jasinski, S. E.** A CRITIQUE OF LATE CRETACEOUS DINOSAUR BIOGEOGRAPHY AND ENDEMISM IN THE WESTERN INTERIOR BASIN, NORTH AMERICA

B180 **Fowler, D. W., Horner, J. R.** THE EVOLUTIONARY PROCESS OF REINFORCEMENT RECONCILES CONFLICTING FUNCTIONAL HYPOTHESES FOR BIZARRE STRUCTURES IN NORTH AMERICAN LATE CRETACEOUS DINOSAURS, EXPLAINS APPARENT ENDEMISM AS AN ARTIFACT OF VICARIANCE AND ANAGENESIS, AND SUGGESTS PRE K–PG DIVERSITY PATTERNS MAY BE PECULIAR TO NORTH AMERICA

B181 **Lloyd, G. T., Bapst, D., Friedman, M., Davis, K. E.** A PHYLOGENETIC ALTERNATIVE TO RICHNESS AS A BIODIVERSITY METRIC SUGGESTS A MID-CRETACEOUS PEAK FOR MESOZOIC DINOSAURS

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THURSDAY MORNING, OCTOBER 27, 2016

ROMER PRIZE SESSION

GRAND AMERICA HOTEL, IMPERIAL BALLROOM AB

MODERATOR: Mark Uhen

8:00 **Chen, D.** THE ORIGIN OF TOOTH REPLACEMENT: 3D SYNCHROTRON HISTOLOGY VISUALIZES THE DENTAL ONTOGENY OF THE SILURIAN STEM OSTEICHTHYANS

8:15 **Tennant, J. P.** A HIDDEN EXTINCTION IN TETRAPODS AT THE JURASSIC–CRETACEOUS BOUNDARY

8:30 **Lemberg, J. B.** EVOLUTION OF A TERRESTRIAL-STYLE FEEDING SYSTEM IN WATER: *TIKTAALIK ROSEAE* AND *ATRACTOSTEUS SPATULA*

8:45 **Chen, J.** EAST ASIA IN THE EVOLUTION OF AMPHIBIANS IN THE MESOZOIC AND CENOZOIC: INFERRED FROM FOSSILS, MORPHOLOGY, AND MOLECULES

9:00 **Watanabe, A.** MODULAR DEVELOPMENT AND EVOLUTION OF THE THEROPOD BRAIN

9:15 **Salas-Gismondi, R.** THE EVOLUTION OF ORBITAL SHAPE IN GAVIALOID CROCODYLIANS IS ASSOCIATED WITH HABITATS AND VISUAL-FORAGING STRATEGIES

9:30 **Morhardt, A. C.** PALEONEUROLOGY OF ARCHOSAURS IN THE 21ST CENTURY: NEW ANATOMICAL AND STATISTICAL APPROACHES SHED LIGHT ON THE COMPLEX EVOLUTIONARY HISTORY OF NON-AVIAN DINOSAUR BRAINS

9:45 **Field, D.** MACROEVOLUTIONARY PATTERNS IN TOTAL-CLADE AVIALAE: THE COMPLEX EVOLUTION OF AVIAN BIOGEOGRAPHY, AND THE ORIGIN OF AVIAN FLIGHT

10:00 **BREAK**

10:15 **Carney, R. M.** EVOLUTION OF THE ARCHOSAURIAN SHOULDER JOINT AND THE FLIGHT STROKE OF *ARCHAEOPTERYX*

10:30 **Couzens, A.** THICK MOLAR ENAMEL AND INCREASED CROWN HEIGHT AS AN ADAPTIVE SIGNATURE OF NEOGENE ARIDIFICATION AMONGST KANGAROOS

10:45 **O'Brien, H. D.** THE ROLE OF CRANIAL VASCULATURE IN ARTIODACTYL MACROEVOLUTION: SELECTIVE BRAIN COOLING AS A VITAL PREREQUISITE FOR FOREGUT FERMENTATION

11:00 **Barron-Ortiz, C. R.** THE END-PLEISTOCENE EXTINCTION IN NORTH AMERICA: AN INVESTIGATION OF HORSE AND BISON FOSSIL MATERIAL AND ITS IMPLICATION FOR NUTRITIONALLY-BASED EXTINCTION MODELS

11:15 **Smiley, T. M.** MOUNTAINS AND MAMMALS: LINKING LANDSCAPE AND CLIMATE CHANGE TO DIVERSIFICATION IN NEOGENE RODENTS

11:30 **Bertrand, O.** VIRTUAL ENDOCASTS FOR ISCHYROMYIDAE AND SCIURIDAE: BRAIN EVOLUTION IN RODENTIA AND A DEEPER UNDERSTANDING OF THE ANCESTRAL CONDITION FOR THE BRAIN OF EUARCHONTOGLIRES

11:45 **Davis, M.** WHAT NORTH AMERICA'S SKELETON CREW OF MEGAFAUNA TELLS US ABOUT COMMUNITY DISASSEMBLY

12:00 **Chritz, K. L.** PALEOECOLOGICAL RESPONSE TO CLIMATE IN EAST AFRICA IS LOCALLY SPECIFIC

THURSDAY MORNING, OCTOBER 27, 2016

PREPARATOR'S SESSION

GRAND AMERICA HOTEL, IMPERIAL BALLROOM CD

MODERATORS: Steve Jabo and Matt Smith

8:00 **Bugbee, M., Wilkins, W. J., Mead, J. I.** REMOVAL OF A COLUMBIAN MAMMOTH SKULL FROM AN IN-SITU BONEBED

8:15 **Sawchuk, M. R., Barron-Ortiz, C. R., Li, C., Jass, C. N.** A COMPARISON OF FOUR DRYING TECHNIQUES FOR THE CONSERVATION OF WATER-SATURATED BONE REMAINS FROM COLD LAKE, ALBERTA, CANADA

8:30 **Kline, P., Kline, M., Osen, A.** PALEONTOLOGY LABORATORY EQUIPMENT, MATERIAL, AND METHODS FOR UTILIZING ULTRAVIOLET LIGHT IN FOSSIL PREPARATION

8:45 **Balcarcel, A.** REPAIRING THE TITANS: CHALLENGES AND CONSIDERATIONS FOR DEALING WITH SAUROPOD BONES

9:00 **Heck, C. T., Volkmann, G.** POLYESTER OR EPOXY: ASSESSING PRODUCT EFFICACY IN PALEOHISTOLOGICAL METHODS

9:15 **Smith, M. E., Lash, C. E.** CUTTING BONE—A CREATIVE USE OF CYCLODODECANE (CDD) IN HISTOLOGIC SECTIONING OF FOSSIL SPECIMENS

9:30 **Browne, I. D.** PRECISION, ACCURACY, AND REPRODUCIBILITY OF RESEARCH-QUALITY PHOTOGRAMMETRIC MODELS OF VERTEBRATE MICROFOSSILS IN THE 0.5–2 MM SIZE RANGE

9:45 **Santella, M., Milner, A. R.** PHOTOGRAMMETRY OF MICROFOSSIL VERTEBRATE TEETH FROM THE LOWER JURASSIC KAYENTA FORMATION OF SOUTHWESTERN UTAH

10:00 **BREAK**

10:15 **Mallison, H., Belvedere, M., Schurian, B., Schwarz, D.** "LIBERATION FROM THE BONE CELLAR"—LOW TECH, HIGH QUALITY—HOW TO CHEAPLY 3D DIGITIZE A COLLECTION OF VERTEBRATE MACROFOSSILS

10:30 **Pruitt, J. B., Clement, N., Druckenmiller, P. S., Serratos, D., Havens, J.** DIGITAL RECONSTRUCTION OF A HEAVILY TAPHONOMICALLY ALTERED PLESIOSAURIAN SKULL UTILIZING LASER SCAN DATA AND NOVEL 3D MODELLING TECHNIQUES

10:45 **Shelburne, E. C., Thompson, A. C.** WHEN THE SMOKE CLEARS: A DISCUSSION ON FOSSIL WHITENING AND AN EVALUATION OF CLEANING METHODS FOR SPECIMENS SMOKED WITH AMMONIUM CHLORIDE

11:00 **Bernard, E. L., Brewer, P., Stevens, L., Chapman, S., Steel, L.** EMESOZOIC: BRITISH FOSSILS IN THE DIGITAL AGE

11:15 **Miles, K., Porter, M.** PROJECT AIRLESS: A LARGE-SCALE CROSS-DISCIPLINE PROJECT TO PROTECT FOSSILS FROM PYRITE DECAY THROUGH THE USE OF ANOXIC MICROENVIRONMENTS

11:30 **Brown, M., Parker, W.** PREPARATION AS INTERPRETATION IN THE STUDY OF FOSSIL VERTEBRATES

11:45 **Barnett, J. R.** FOSSIL PREPARATION IN A SMALL LAB: A CASE STUDY OF PREPARATOR TRAINING AT THE STERNBERG MUSEUM OF NATURAL HISTORY IN HAYS, KANSAS

THURSDAY MORNING, OCTOBER 27, 2016
PREPARATOR'S SESSION (CONTINUED)

12:00 **Getty, M. A., Loewen, M. A.** PALEONTOLOGICAL EXHIBITS AT THE NATURAL HISTORY MUSEUM OF UTAH: AN OUTSTANDING EXAMPLE OF COLLABORATION WITH MUSEUM STAFF, VOLUNTEERS, GRADUATE STUDENTS, AND EXTERNAL INSTITUTIONS

THURSDAY MORNING, OCTOBER 27, 2016
TECHNICAL SESSION VI
GRAND AMERICA HOTEL, GRAND BALLROOM A
MODERATORS: Julie Meachen and Morgan Turner

8:00 **Randau, M., Goswami, A.** PATTERNS OF FELID PRESACRAL VERTEBRAL ORGANISATION SHOW MORPHOLOGICAL INTEGRATION AND DEVELOPMENTAL MODULARITY

8:15 **Balisi, M., Van Valkenburgh, B.** HYPERCARNIVORY AND EXTINCTION RISK IN NORTH AMERICAN FOSSIL CANIDS

8:30 **Prybyla, A. N., Tseng, Z., Flynn, J. J.** CRANIAL BIOMECHANICS OF *LEPTARCTUS PRIMUS* (LEPTARCTINAE, CARNIVORA) AND FUNCTIONAL MORPHOLOGICAL ANALYSIS OF *L. PRIMUS* AND *HYPSOPARIA BOZEMANENSIS* USING FINITE ELEMENT SIMULATIONS

8:45 **Boessenecker, R. W., Deméré, T. A., Churchill, M.** THE LAST OF THE DESMATOPHOCID SEALS: A NEW SPECIES OF *ALLODESMUS* FROM THE LATE MIOCENE OF WASHINGTON AND CALIFORNIA

9:00 **Wang, X., Grohé, C., White, S., Ji, X., Kelley, J., Jablonski, N. G., Su, D. F., Deng, T., You, Y., Yang, X.** A NEW BADGER-LIKE GIANT OTTER (LUTRINAE, MUSTELIDAE) FROM THE LATEST MIOCENE SITE OF SHUITANGBA IN YUNNAN PROVINCE, SOUTHWESTERN CHINA AND A TOTAL EVIDENCE PHYLOGENY SUGGESTING A PREVIOUSLY UNRECOGNIZED CLADE OF OTTERS IN EASTERN ASIA

9:15 **O'Keefe, F., Meachen, J.** QUANTITATIVE ASSESEMENT OF CURRENT PIT CHRONOLOGY AT RANCHO LA BREA AND PROSPECTS FOR ITS IMPROVMENT

9:30 **Meachen, J., Brannick, A.** A 30-YEAR CASE OF MISTAKEN IDENTITY: THE WOLVES FROM NATURAL TRAP CAVE, WYOMING

9:45 **Montanari, S., Secord, R., Brusatte, S., Williamson, T. E.** STABLE ISOTOPE VARIABILITY IN EXTANT AND EXTINCT FAUNIVORES: IMPLICATIONS FOR UNDERSTANDING NON-HERBIVOROUS MAMMALIAN ECOLOGY ACROSS TIME SCALES

10:00 **BREAK**

10:15 **Wills, S., Barrett, P. M., Choiniere, J. N.** PREDICTION OF POTENTIAL FOSSIL-BEARING LOCALITIES IN THE ELLIOT FORMATION (UPPER TRIASSIC–LOWER JURASSIC), SOUTH AFRICA

10:30 **Moore, J. R., Weissmann, G.** VERTEBRATE PALEONTOLOGY AND TAPHONOMY IN A DISTRIBUTIVE FLUVIAL SYSTEM FRAMEWORK: A NEW MODEL FOR STUDYING TERRESTRIAL FOSSIL SEQUENCES

10:45 **Carpenter, K.** AFTER THE BONE MOVES: ACTUALISTIC EXPERIMENTS AND COMPUTATIONAL FLUID DYNAMICS ON STATIONARY BONE IN A WATER FLUME

11:00 **Bader, K. S., Lundelius, E. L.** MODERN DERMESTID BEETLE TRACES IN BONE AND THEIR COMPARISON TO TRACES ON LATE PLEISTOCENE BONE FROM LAUBACH CAVE, WILLIAMSON COUNTY, TEXAS, USA

11:15 **Saitta, E. T., Rogers, C., Vinther, J.** THE TAPHONOMY OF KERATIN IN ARCHOSAURS

THURSDAY MORNING, OCTOBER 27, 2016
TECHNICAL SESSION VI (CONTINUED)

11:30 **Roy, A., Rogers, C. S., Vinther, J.** BACTERIA OR MELANOSOMES?

11:45 **Turner, M. L., Falkingham, P. L., Gatesy, S. M.** THE MORPHOLOGY OF MOTION IN SUB-SURFACE FOOT TRAJECTORIES AND FOSSIL DINOSAUR TRACKS

12:00 **Lallensack, J. N.** AN OBJECTIVE METHOD FOR THE GENERATION OF FOOTPRINT OUTLINES

THURSDAY AFTERNOON, OCTOBER 27, 2016
TECHNICAL SESSION VII
GRAND AMERICA HOTEL, IMPERIAL BALLROOM AB
MODERATORS: Victoria Arbour and Mateusz Wosik

1:45 **Brown, C. M.** QUANTIFYING INTRASPECIFIC MORPHOMETRIC VARIATION IN PUTATIVE DISPLAY STRUCTURES IN ORNITHISCHIAN DINOSAURS

2:00 **Evans, D. C., Williamson, T. E., Goodwin, M. B., Loewen, M.** NEW *STEGOCERAS*-GRADE PACHYCEPHALOSAURS (ORNITHISCHIA) REVEAL A LATE CAMPANIAN OF RADIATION OF DOME-HEADED DINOSAURS IN SOUTHERN LARAMIDIA

2:15 **Goodwin, M. B., Nirody, J. A., Huynh, T., Horner, J. R., Parkinson, D. Y., Schott, R. C., Evans, D. C.** MAPPING AND VISUALIZING THE COMPLEX INTERNAL ANATOMY OF PACHYCEPHALOSAUR DOMES

2:30 **Hobe, S. J.** ANAGENESIS AND CRANIOFACIAL ONTOGENY OF *CORYTHOSAURUS*

2:45 **Freedman Fowler, E. A., Horner, J. R.** ONE DINOSAUR IS NOT ENOUGH: *GRYPOSAURUS* (HADROSAURIDAE) BONEBED ILLUSTRATES MULTIPLE NON-PHYLOGENETIC SOURCES OF MORPHOLOGICAL DIFFERENCES

3:00 **Wosik, M., Goodwin, M. B., Evans, D. C.** A NESTLING-SIZED SKELETON OF *EDMONTOSAURUS* (ORNITHISCHIA, HADROSAURIDAE) WITH AN ANALYSIS OF ONTOGENETIC LIMB ALLOMETRY IN RELATION TO MAJOR GAIT SHIFTS

3:15 **Norman, D., Brasier, M., Liu, A., Garwood, R., Antcliffe, J., Wacey, D.** REMARKABLE PRESERVATION OF BRAIN TISSUES IN AN EARLY CRETACEOUS IGUANODONTIAN DINOSAUR

3:30 **Erickson, G. M., Kuhn-Hendricks, S. M., Sidebottom, M. A., Curry, J. F., Zeng, G., Norell, M. A., Krick, B. A.** WAVY ENAMEL IN HADROSAURID DINOSAURS WITH GRINDING DENTITIONS FUNCTIONED TO LIMIT FRACTURE DAMAGE THROUGH ENERGY-ROBBING CRACK DEFLECTION AND CHANNELING

3:45 **Wiersma, J. P.** THE BIOGEOGRAPHY OF LATE CRETACEOUS ANKYLOSAURID DINOSAURS: IMPLICATIONS FOR ANKYLOSAURID DIVERSITY IN WESTERN NORTH AMERICA

4:00 **Arbour, V., Zanno, L. E.** CORRELATIONS AND CONGRUENCE IN THE STEPWISE EVOLUTION OF AMNIOTE TAIL WEAPONRY

THURSDAY AFTERNOON, OCTOBER 27, 2016

TECHNICAL SESSION VIII

GRAND AMERICA HOTEL, IMPERIAL BALLROOM CD

MODERATORS: Sergi Lopez Torres and Paul Morse

1:45 **Wilson, G. P., Widdowson, M., Anantharaman, S., Das Sarma, D. C., Wilson, J. A., Renne, P. R.** NEW MAMMALIAN FOSSILS FROM THE INTERTRAPPEAN BEDS OF THE SOUTHERN PART OF THE DECCAN VOLCANIC PROVINCE AND THE CRETACEOUS–PALEOGENE TRANSITION IN INDIA

2:00 **López-Torres, S., Prufrock, K. A., Selig, K. R., Silcox, M. T.** DENTAL TOPOGRAPHIC ANALYSIS OF PAROMOMYID (PLESIADAPIFORMES, PRIMATES) CHEEK TEETH: MORE THAN 15 MILLION YEARS OF CHANGING SURFACES AND SHIFTING ECOLOGIES

2:15 **Morse, P. E., Chester, S. G., Boyer, D. M., Bloch, J. I.** MORPHOLOGICAL VARIATION IN THE OLDEST NORTH AMERICAN EUPRIMATE, *TEILHARDINA BRANDTI*, AND ITS IMPLICATIONS FOR EARLY PRIMATE EVOLUTION

2:30 **Rankin, B. D., Holroyd, P. A.** DIVERSIFICATION OF A NEWLY IDENTIFIED CLADE OF EARLY EOCENE OMOMYIDS FROM THE GREATER GREEN RIVER BASIN

2:45 **Hoffman, E., Upham, N., Fabbri, M., Field, D., Hanson, M., Mongiardino Koch, N., Leiss, A., Miyamae, J. A., Whalen, C. D., Bhullar, B. S.** RECONSTRUCTING THE BEHAVIOR AND ECOLOGY OF THE ANCESTRAL PRIMATE AND FOSSIL TAXA USING COMPARATIVE PHYLOGENETIC TECHNIQUES

3:00 **Garrett, E. C., Gonzales, L. A., Kirk, E. C., Seiffert, E. R.** THE VOMERONASAL GROOVE IN FOSSIL PRIMATES

3:15 **Fox, D. L., Cicak, T. S., Badgley, C.** ECOLOGICAL BIOGEOGRAPHY OF MODERN NORTH AMERICAN RODENTS IN RELATION TO CLIMATE AND PHYSIOGRAPHY

3:30 **Burroughs, R. W.** USE OF AUTOMATED THREE-DIMENSIONAL MORPHOMETRICS TO DETECT TAPHONOMIC BIAS: FOSSIL ARVICOLINE RODENT TEETH AS A CASE STUDY

3:45 **Casanovas-Vilar, I., Fortuny, J., Llácer, S., Prieto, J., Garcia-Porta, J., Robles, J. M., Alba, D. M.** FIRST COMPLETE SKULL OF A FOSSIL FLYING SQUIRREL FROM THE MIOCENE OF CATALONIA

4:00 **Marcy, A. E., Sherratt, E., Hadly, E. A., Weisbecker, V. E.** GETTING A HEAD IN HARD SOIL: CONVERGENT AND DIVERGENT CRANIAL ALLOMETRIC TRAJECTORIES REFLECT MOSAIC EVOLUTION IN THE HIGHLY MORPHOLOGICALLY DIVERSE RODENT GENUS *THOMOMYS*

THURSDAY AFTERNOON, OCTOBER 27, 2016

TECHNICAL SESSION IX

GRAND AMERICA HOTEL, GRAND BALLROOM A

MODERATORS: Per Ahlberg and Richard Blob

1:45 **Ahlberg, P. E., Zhu, Y., Zhu, M.** NEW LIGHT ON THE EXTRAORDINARY EYES OF MAXILLATE PLACODERMS

2:00 **Zhu, M.** SILURIAN PLACODERMS FROM THE XIAOXIANG FAUNA REVEAL HIGH MORPHOLOGICAL DISPARITY CLOSE TO CROWN GNATHOSTOMES

2:15 **Pan, Z., Zhu, M.** EUANTIARCH PLACODERMS FROM THE EMSIAN (LOWER DEVONIAN) OF WUDING, YUNNAN, CHINA

2:30 **Zhu, Y., Ahlberg, P. E., Snitting, D., Blom, H., Hu, Y.** REANALYSIS OF SERIAL GRINDING DATA SHEDS LIGHT ON THE EVOLUTION OF THE NEUROCRANIUM IN PRIMITIVE JAWED VERTEBRATES

THURSDAY AFTERNOON, OCTOBER 27, 2016
TECHNICAL SESSION IX (CONTINUED)

2:45 **Scott, B.** THE LIMITATIONS OF GAPE-BASED SUCTION MECHANICS IN ARTHRODIRA (PLACODERMI)

3:00 **Lu, J., Giles, S., Friedman, M., Zhu, M.** THE FIRST STEM-SARCOPTERYGIAN FROM THE PRAGIAN OF SOUTH CHINA HIGHLIGHTS THE EARLY EVOLUTION OF SARCOPTERYGIANS

3:15 **Cloutier, R., Long, J. A., King, B., Béchard, I., Clement, A.** RATES OF PHENOTYPIC EVOLUTION DURING THE FISH TO TETRAPOD TRANSITION: THE ELPISTOSTEGALIAN FAST-LANE

3:30 **Wilhelm, B.** EXAMINATION OF CHANGES TO THE PECTORAL MUSCULATURE ACROSS THE FIN-LIMB TRANSITION USING EXTANT FISHES

3:45 **Blob, R. W., Mcinroe, B., Astley, H. C., Gong, C., Kawano, S. M., Schiebel, P. E., Rieser, J., Choset, H., Goldman, D. I.** MODELING THE VERTEBRATE INVASION OF LAND: TAIL USE IMPROVES TERRESTRIAL LOCOMOTOR PERFORMANCE ON SOFT SUBSTRATES

4:00 **Maciver, M. A., Schmitz, L.** A DOUBLING OF EYE SIZE AND MASSIVE INCREASE IN VISUAL RANGE ENABLED COMPLEX VISUALLY-GUIDED BEHAVIORS IN EARLY DIGITED TETRAPODS

THURSDAY, OCTOBER 27, 2016
POSTER SESSION II
GRAND AMERICA HOTEL, IMPERIAL BALLROOM FOYER
Authors must be present from 4:15 – 6:15 p.m.
Posters must be removed by 6:30 p.m.

Posters Associated with the Preparator's session

IB1 **Minnebo, A., Rountrey, A., Sanders, W. J.** THINKING INSIDE THE BOX: CONSTRUCTION OF INEXPENSIVE, LIGHTWEIGHT STORAGE CONTAINERS FOR MEDIUM-SIZED FOSSIL SPECIMENS

IB2 **Sato, T.** PILING, SLOTTING, AND SURROUNDING: SHIPPING FOSSILS FROM CHINA TO ITALY

IB3 **Behlke, A.** THE USE OF RECYCLED MATERIALS IN THE MOLDING AND CASTING PROCESS

IB4 **Schulp, A. S., Van Liere, R., Batenburg, K. J.** TRANSPARENT MATRIX: BRINGING X-RAY GOGGLES TO THE PREP LAB

IB5 **Ridgwell, N. M., Chure, D. J.** LONG-TERM PRESERVATION CHALLENGES IN THE CARNEGIE QUARRY, DINOSAUR NATIONAL MONUMENT, UTAH, USA

IB6 **Carrio, V.** TETRAPOD WORLD: EARLY EVOLUTION AND DIVERSIFICATION (TW:EED) PROJECT FIELDWORK: CONSOLIDATION OF DAMP SPECIMENS FOR TRANSPORTATION USING PRIMAL WS 24 AND FABRIC BANDAGES AS FIELD JACKETS

IB7 **Knauss, G., Johnson, S. L.** A FALL DINOSAUR EXCAVATION: INSIGHTS ON COLD WEATHER JACKETING

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EXHIBIT HALL GRAND BALLROOM

Regular Session Posters

B76 **Afanassieva, O. B.** MODELS OF THE DEVELOPMENT OF THE EXOSKELETON IN EARLY VERTEBRATES (OSTEOSTRACI, AGNATHA)

B77 **Elliott, D. K.** A NEW AGNATHAN SUBFAMILY (HETEROSTRACI, CYATHASPIDIDAE) FROM THE LATE SILURIAN AND EARLY DEVONIAN OF THE WESTERN UNITED STATES AND THE CANADIAN ARCTIC

B78 **Gai, Z., Yu, X., Zhu, M.** THE DEEP HOMOLOGY OF THE ZYGOMA

B79 **Boyle, J. T., Ryan, M. J., Snively, E., Hlavin, W. J.** JAW ONTOGENY OF THE LATE DEVONIAN "*T. REX*", WITH IMPLICATIONS FOR FEEDING STRATEGIES AND LIFE HISTORY OF THE ARTHRODIRE *DUNKLEOSTEUS TERRELLI*

B80 **Hall, L. E., Ryan, M. J., Scott, E.** POSSIBLE EVIDENCE FOR CANNIBALISM IN THE GIANT ARTHRODIRE *DUNKLEOSTEUS*, THE APEX PREDATOR OF THE CLEVELAND SHALE MEMBER (FAMMENIAN) OF THE OHIO SHALE

B81 **Richter, M., Smith, R. M., Cisneros, J. C., Angielczyc, K. D., Fröbisch, J., Marsicano, C. A., Kammerer, C. F.** NEW LOWER PERMIAN (CISURALIAN) ACTINOPTERYGIANS (OSTEICHTHYES) FROM THE PEDRA DO FOGO FORMATION, NORTHEAST BRAZIL

B82 **Choo, B., Long, J. A., Lu, J., Giles, S.** A NEW ACTINOPTERYGIAN FISH FROM THE UPPER DEVONIAN GOGO FORMATION OF WESTERN AUSTRALIA.

B83 **Gibson, S. Z.** THREE-DIMENSIONAL FISH FOSSILS FROM A TRIASSIC TEXAS POND: NOVEL ANATOMICAL INSIGHTS AND SYSTEMATIC PLACEMENT OF A NEW SPECIES OF REDFIELDIID FISH (OSTEICHTHYES, ACTINOPTERYGII)

B84 **Hunt-Foster, R. K., Foster, J., Kirkland, J. I.** FIRST REPORT OF THE GIANT ICHTHYODECTID *XIPHACTINUS AUDAX* FROM THE MANCOS SHALE (CAMPANIAN) OF WESTERN COLORADO

B85 **Brinkman, D. B., Murray, A. M., Newbrey, M., Neuman, A. G.** ARTICULATED TELEOST FISH FROM THE PISCES POINT LOCALITY, LATE CRETACEOUS, SCOLLARD FORMATION, ALBERTA, CANADA, AND THE IDENTIFICATION OF ISOLATED ELEMENTS FROM VERTEBRATE MICROFOSSIL LOCALITIES

B86 **Murray, A. M., Grieve, K., Zaim, Y., Rizal, Y., Aswan, A., Gunnell, G. F., Ciochon, R.** FOSSIL CYPRINIDS (OSTARIOPHYSI, CYPRINIFORMES) FROM SUMATRA, INDONESIA

B87 **Koevoets, M. J., Hurum, J. H., Friedman, M.** THE REDISCOVERY OF *LEPTOLEPIS NATHORSTI*: A JURASSIC TELEOST FROM THE AGARDHFJELLET FM, SPITSBERGEN, SVALBARD

B88 **Van Vranken, N., Fielitz, C.** BRIDGING THE GAP: THE BIOSTRATIGRAPHIC RECORD OF THE GENUS *BELONOSTOMUS* WITH NOTES ON NEW OCCURENCES IN TEXAS AND MEXICO

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B89 **Carpenter, N. E., Smith, G. R.** THE YELLOWSTONE HOT SPOT AND WESTERN FRESHWATER FISH EVOLUTION

B90 **Sankey, J. T., Biewer, J., Basuga, J., Palacios, F.** DID THE GIANT, TUSK-TOOTHED SALMON (*ONCORHYNCHUS RASTROSUS*) MORPH BEFORE MIGRATION UPRIVER LIKE MODERN SALMON DO TODAY?

B91 **Rufolo, S. J., Stewart, K. M.** PALAEOECOLOGICAL INFERENCES FROM FOSSIL FISH AT THE KANAPOI SITE, KENYA

B92 **Challands, T. J., Smithson, T. R., Clack, J., Marshall, J. E., Bennett, C. E., Fraser, N. C., Walsh, S., Finney, S.** EARLIEST CARBONIFEROUS DIPNOI: POST-HANGENBERG RECOVERY AND THE DAWN OF A NEW ERA OF LUNGFISH

B93 **Ehret, D. J., Harrell, L., Phillips, G. E.** LUNGFISH (DIPNOI, CERATODONTIFORMES) TOOTH PLATES FROM THE LATE CRETACEOUS (LATE SANTONIAN) TOMBIGBEE SAND MEMBER, EUTAW FORMATION OF ALABAMA AND MISSISSIPPI, USA

B94 **Harrison, G. W., Kirkland, J. I., Fischer, J., San Miguel, G., Santucci, V. L.** TWO CHIMAERID (CHONDRICHTHYES, HOLOCEPHALI) EGG CASES FROM THE UPPER CRETACEOUS CLIFF HOUSE SANDSTONE OF THE MESAVERDE GROUP AT MESA VERDE NATIONAL PARK (MEVE): WITH COMMENTS ON THE CLASSIFICATION OF EGGS

B95 **Johnson-Ransom, E. D., Popov, E. V., Demere, T. A., Shimada, K.** THE LATE CRETACEOUS CHIMAEROID FISH, *ISCHYODUS BIFURCATUS*, FROM SOUTHERN CALIFORNIA, USA, AND ITS PALEOBIOGEOGRAPHICAL SIGNIFICANCE

B96 **Bazzi, M., Campione, N., Kear, B., Blom, H., Ahlberg, P. E.** MORPHOLOGICAL RELEASE FOLLOWING SELECTIVE EXTINCTION AMONGST SHARKS AT THE END OF THE MESOZOIC

B97 **Veach, A., Gottfried, M.** MORPHOLOGICAL OBSERVATIONS AND BODY SIZE ESTIMATES BASED ON LAMNOID SHARK VERTEBRAL CENTRA FROM THE LATE CRETACEOUS OF SEYMOUR ISLAND, ANTARCTICA

B98 **Shimada, K., Ward, D. J.** THE OLDEST FOSSIL RECORD OF THE MEGAMOUTH SHARK (LAMNIFORMES, MEGACHASMIDAE) FROM THE LATE EOCENE OF DENMARK

B99 **Maisch Iv, H. M., Becker, M. A., Chamberlain Jr, J. A.** BATHYMETRIC CONTROLS ON TAPHONOMIC REWORKING AND BIOEROSION OF CHONDRICHTHYAN TEETH: A COMPARATIVE STUDY FROM THE PUNGO RIVER AND YORKTOWN FORMATIONS, ONSLOW BAY, NORTH CAROLINA

B100 **Romano, M., Fröbisch, J.** EVOLUTION OF LONG BONES IN CASEID SYNAPSIDS: A COMBINED CLADISTIC AND MORPHOMETRIC APPROACH

B101 **Nicosia, U., Romano, M., Maganuco, S., Ronchi, A., Fröbisch, J.** NEW MATERIAL OF THE ITALIAN CASEID *ALIERASAURUS RONCHII* (SYNAPSIDA, CASEIDAE) AND ITS PHYLOGENETIC POSITION WITHIN CASEASAURIA

B102 **Brocklehurst, N., Romano, M., Fröbisch, J.** REVISITING CASEID PHYLOGENY: AN ALTERNATIVE TREATMENT FOR MORPHOMETRIC CHARACTERS

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B103 **Rowland, S. M., Rickerson, C., Matz, S., Vosburgh, S., Cluff, T., Burkett, M.** FIRST REPORT OF A LARGE TETRAPOD TRACKWAY IN THE LOWER PERMIAN (WOLFCAMPIAN) QUEANTOWEAP SANDSTONE OF SOUTHERN NEVADA

B104 **Whitney, M. R., Mose, L., Sidor, C. A.** HISTOPATHOLOGY OF A POTENTIALLY CANCEROUS MASS IN A LATE PERMIAN GORGONOPSID CANINE

B105 **Tsuji, L. A., Mann, A., Paterson, R. S.** CRANIAL OSTEOLOGY OF A NEW SPECIMEN OF *LYCAENOPS* (THERAPSIDA: GORGONOPSIA)

B106 **Fröbisch, J., Jansen, M., Aschenbach, T., Rothschild, B. M., Witzmann, F.** SPINA BIFIDA IN THE EARLY TRIASSIC DICYNODONT THERAPSID *MYOSAURUS GRACILIS*

B107 **Hendrickx, C., Abdala, F., Choiniere, J. N.** POSTCANINE MICROSTRUCTURE IN *CRICODON METABOLUS*, A MIDDLE TRIASSIC GOMPHODONT CYNODONT FROM SOUTHEASTERN AFRICA

B108 **Panciroli, E., Walsh, S., Brusatte, S., Fraser, N.** RE-EXAMINATION OF *STEREOGNATHUS HEBRIDICUS* (SYNAPSIDA, TRITYLODONTIDAE) FROM THE MIDDLE JURASSIC OF SKYE, SCOTLAND

B109 **Pittman, M., Kaye, T. G., Schwarz, D., Pei, R., Xu, X.** 150 YEAR OLD *ARCHAEOPTERYX* MYSTERY SOLVED

B110 **McIntosh, A. P.** GEOMETRIC MORPHOMETRIC ANALYSIS OF THE PEDAL CLAW OF *CONFUCIUSORNIS SANCTUS* (AVES, CONFUCIUSORNITHIDAE) AND ITS IMPLICATIONS FOR MORPHOLOGICAL VARIATION BETWEEN BEHAVIORAL GROUPS

B111 **Wang, R., Hu, D., Zhang, M., Xu, X.** A NEW CONFUCIUSORNITHID SPECIMEN FROM THE LOWER CRETACEOUS OF WESTERN LIAONING, CHINA

B112 **O'Connor, J., Zheng, X., Wang, X., Pan, Y., Zhou, Z.** THE BIOLOGY OF *EOCONFUCIUSORNIS*

B113 **Hu, H., O'Connor, J. K., Zheng, X., Wang, X., Wang, Y., Zhou, Z.** A RECONSTRUCTION OF THE SKULL OF *SAPEORNIS* AND CRANIAL EVOLUTION IN EARLY BIRDS

B114 **Imai, T., Azuma, Y., Shibata, M., Miyata, K.** REPORT ON A FOSSIL BIRD FROM THE LOWER CRETACEOUS KITADANI FORMATION, TETORI GROUP, FUKUI, JAPAN

B115 **Navalón, G., Chiappe, L. M., Marugán-Lobón, J., Meng, Q.** A PRIMITIVE CONFUCIUSORNITHID BIRD FROM THE HUAJIYING FORMATION (HEBEI, NORTHEASTERN CHINA) SHEDS NEW LIGHT ON THE DIVERSITY AND EVOLUTION OF CONFUCIUSORNITHIDAE

B116 **Tykoski, R. S., Fiorillo, A. R.** NEW BIRD FOSSILS FROM THE WOODBINE FORMATION (LOWER MIDDLE CENOMANIAN) OF TEXAS

B117 **O'Connor, P. M., Turner, A. H., Groenke, J. R.** NEW AVIALANS FROM THE LATE CRETACEOUS MAEVARANO FORMATION, MAHAJANAGA BASIN, NORTHWESTERN MADAGASCAR

B118 **Mohr, S. R., Currie, P. J., Acorn, J.** AN ORNITHURINE CORACOID FROM THE LATE CRETACEOUS OF ALBERTA, CANADA

B119 **Wilson, L. E.** A BIRD'S EYE VIEW OF THE WESTERN INTERIOR SEAWAY: THE ROLE OF SEABIRDS IN UNDERSTANDING LATE CRETACEOUS MARINE ECOSYSTEMS

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B120 **Kirchner-Smith, M. E.** HOW GOOD IS THE TARSOMETATARSUS FOR AVIAN SPECIES IDENTIFICATION? 3D GEOMETRIC MORPHOMETRICS IN THE HESPERORNITHIFORMES (AVES, ORNITHURAE)

B121 **Tütken, T., Held, P., Hellmund, M., Galer, S. J.** CALCIUM ISOTOPE ANALYSIS OF FOSSIL BONES: THE PALEOGENE GIANT FLIGHTLESS BIRD *GASTORNIS* WAS A HERBIVORE

B122 **Stidham, T. A., Rose, K. D.** A NEW SANDCOLEID (AVES, COLIIFORMES) FROM THE EARLY EOCENE OF WYOMING AND ITS IMPLICATIONS FOR PALEOBIOLOGY, INTRASPECIFIC VARIATION, AND EVOLUTION IN EARLY MOUSEBIRDS

B123 **Yury, R. E.** A SMALL FOSSIL PENGUIN (AVES, SPHENISCIFORMES) FROM THE LATE MIOCENE BAHÍA INGLESA FORMATION, ATACAMA DESERT, NORTHERN CHILE

B124 **Rozin, R. E., Cost, I. N., Holliday, C. M.** FEEDING BIOMECHANICS IN GALLIFORM BIRDS AND ITS SIGNIFICANCE FOR AVIAN CRANIAL EVOLUTION

B125 **Torres, C. R., Viola, P., Eliason, C. M., Clarke, J. A.** NEUROANATOMICAL EVOLUTION OF PALAEOGNATHS: INSIGHT FROM NEW CRANIAL ENDOCASTS OF ELEPHANT BIRDS (AEPYORNITHIFORMES)

B126 **Lubeek, J. K., Jansen, M. N., Kluiving, S. J., De Louw, P. G., Meijer, H. J., Hume, J. P., De Vos, J., Janoo, A., Claessens, L., Rijsdijk, K.** RECONSTRUCTING INTERNAL ANATOMY OF THE BONE LAYER IN THE MARE AUX SONGES DODO-LAGERSTÄTTE (MAURITIUS): 3D-BONE MAPPING USING GEOGRAPHIC INFORMATION SYSTEMS (GIS)

B127 **Ferguson, A. L., Varricchio, D. J.** MODERN TAPHONOMY OF FOUR SPECIES OF COLONIAL GROUND NESTING BIRDS: IMPLICATIONS FOR IDENTIFYING DEVELOPMENTAL STRATEGIES

B128 **Caggiano, E. G., Witmer, L. M.** THE ANATOMY OF THE NASAL SALT GLAND OF EXTANT BIRDS AND ITS RELEVANCE FOR INFERRING THE BEHAVIOR AND HABITAT PREFERENCES OF EXTINCT BIRDS AND OTHER ARCHOSAURS

B129 **Early, C. M., Witmer, L. M.** PREDICTING VISUAL ABILITIES AND BEHAVIORS IN EXTINCT BIRDS BASED ON BRAIN ENDOCASTS

B130 **Macaluso, L., Tschopp, E.** KEY INNOVATIONS AND EVOLUTIONARY CONSTRAINTS DURING THE EVOLUTION OF AVIAN FLIGHT

B131 **Button, K., Zanno, L. E.** LINEAR MORPHOMETRIC ANALYSIS OF BEAK ECOMORPHOLOGY IN AVIAN AND NON-AVIAN DINOSAURS

B132 **Proffitt, J. V.** INVESTIGATING THE EVOLUTION OF LIMB MORPHOSPACE AND LOCOMOTOR BEHAVIOR DIVERSITY IN AVES

B133 **Jung, J., Sumida, S. S.** NEW INFORMATION ON THE CAPTORHINID REPTILE *CAPTORHINIKOS CHOZAENSIS* FROM THE LOWER PERMIAN OF TEXAS

B134 **Macdougall, M. J., Reisz, R. R.** THE EARLY PERMIAN (CISURALIAN) RICHARDS SPUR LOCALITY, OKLAHOMA, USA, AND THE EARLY EVOLUTION AND DIVERSITY OF PARAREPTILIA

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B135 **Lu, H., Jiang, D., Sun, Z., Li, Z., Zhou, M.** A NEW SPECIMEN OF TRIASSIC PISTOSAUROID *YUNGUISAURUS* FROM LADINIAN (LATE MIDDLE TRIASSIC) XINGYI FAUNA OF GUIZHOU, SOUTHWESTERN CHINA

B136 **Jenkins, K. M., Lewis, P. J.** PHYLOGENETIC POSITION OF *PALACRODON:* AN ENIGMATIC EARLY TRIASSIC LEPIDOSAUR FROM SOUTHERN GONDWANA

B137 **Gay, R. J., Jenkins, X., St. Aude, I., Azouggagh, D.** A NEW, DIVERSE MICROVERTEBRATE LOCALITY FROM THE LOWER CHINLE FORMATION OF SOUTHEASTERN UTAH (USA)

B138 **Hartman, S., Lovelace, D. M., Linzmeier, B. J.** MECHANISTIC PHYSIOLOGICAL MODELLING PREDICTS GEOGRAPHIC DISTRIBUTION OF LATE TRIASSIC TETRAPODS

B139 **Mueller, B. D., Martz, J. W., Hungerbuhler, A., Nesbitt, S. J.** A DIVERSE LATE TRIASSIC (NORIAN) TETRAPOD FAUNA AND TAPHONOMY OF MOTT VPL 3869 FROM THE TECOVAS FORMATION (DOCKUM GROUP) IN GARZA COUNTY, TEXAS, USA

B140 **Peecook, B. R., Sidor, C. A., Angielczyk, K. D., Nesbitt, S. J., Smith, R., Tabor, N. J., Steyer, J., Tolan, S.** THE OLDEST CROWN-GROUP SAURIAN? A LARGE-BODIED ARCHOSAUROMORPH FROM THE MIDDLE PERMIAN OF ZAMBIA

B141 **Foth, C., Ezcurra, M., Sookias, R., Brusatte, S., Butler, R. J.** UNAPPRECIATED HIGH CRANIAL DISPARITY IN STEM ARCHOSAURS PREDATED THE DOMINANCE OF THE ARCHOSAUR CROWN

B142 **Weinbaum, J. C., Martz, J. W., Knell, M. J., Hungerbuehler, A., M'Sadoques, J. G.** A NEW HIGHLY PRODUCTIVE BONEBED OF THE LATE TRIASSIC AETOSAUR *TYPOTHORAX*

B143 **Stefanic, C. M., Nesbitt, S. J.** THE EVOLUTION OF ARCHOSAURIAN BODY SIZE: AN ANALYSIS OF THE INTERVERTEBRAL ARTICULATIONS OF STEM CROCODYLIANS FROM THE TRIASSIC

B144 **Hoffman, D. K., Heckert, A. B., Schneider, V. P., Fraser, N. C., Zanno, L. E.** X-RAY COMPUTED TOMOGRAPHIC RECONSTRUCTION OF THE AETOSAUR *COAHOMASUCHUS* (ARCHOSAURIA, STAGONLEPIDIDAE) AND RE-ANALYSIS OF ITS PHYLOGENETIC RELATIONSHIPS

B145 **Holloway, W. L.** PHYTOSAURIAN CRANIAL EVOLUTION: INSIGHTS FROM GEOMETRIC MORPHOMETRICS

B146 **Stocker, M. R., Nesbitt, S. J., Zhao, L., Wu, X., Li, C.** MOSAIC EVOLUTION IN PHYTOSAURIA: THE ORIGIN OF LONG-SNOUTED MORPHOLOGIES BASED ON A COMPLETE SKELETON OF A PHYTOSAUR FROM THE MIDDLE TRIASSIC OF CHINA

B147 **Heckert, A. B., Nesbitt, S. J., Schneider, V. P., Stocker, M. R., Hoffman, D.** A NEW, SHORT-FACED ARCHOSAURIFORM (CROCODYLOMORPHA) FROM THE UPPER TRIASSIC *PLACERIAS*/DOWNS' QUARRY COMPLEX, EAST-CENTRAL ARIZONA

B148 **Martz, J. W., Small, B. J.** A NEW SILESAURID (DINOSAURIFORMES) ALLIED TO *DIODORUS* FROM THE CHINLE FORMATION OF NORTHERN COLORADO, AND ITS SIGNIFICANCE TO LATE TRIASSIC DINOSAUROMORPH PALEOBIOGEOGRAPHY

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B149 **Nesbitt, S. J., Butler, R. J., Barrett, P. M., Stocker, M. R., Sidor, C. A., Angielczyk, K. D., Ezcurra, M. D., Smith, R. M.** THE EARLY EVOLUTION OF BIRD-LINE ARCHOSAURS: A POSSIBLE NEW CLADE OF GLOBALLY DISTRIBUTED AVEMETATARSALIANS JUST OUTSIDE THE DINOSAUR-PTEROSAUR SPLIT

B150 **Frigot, R. A.** RETROVERSION OF THE PUBIS IN PTEROSAURIA AND ITS SIGNIFICANCE IN RECONSTRUCTING GAIT

B151 **Rodrigues, T., Sobral, G., Mueller, J., Rauhut, O. W.** INSIGHTS ON THE NEUROANATOMY OF THE PTEROSAUR *PTERODACTYLUS* (PTERODACTYLOIDEA)

B152 **Martin-Silverstone, E., Naish, D.** POSTCRANIAL PALEONEUROLOGY OF PTEROSAURS

B153 **Anderson, E. C., O'Keefe, F.** ANALYZING PTEROSAUR ONTOGENY AND SEXUAL DIMORPHISM WITH MULTIVARIATE ALLOMETRY

B154 **Mccormack, L., Sertich, J.** A POSSIBLE LATE CAMPANIAN RECORD OF PTERANODONTIA FROM THE KAIPAROWITS FORMATION OF GRAND STAIRCASE-ESCALANTE NATIONAL MONUMENT, SOUTHERN UTAH

B155 **Lichtig, A. J., Lucas, S. G.** *CHINLECHELYS:* A REEXAMINATION OF NORTH AMERICA'S OLDEST (TRIASSIC, REVULTIAN, NORIAN) TURTLE AND ITS IMPACT ON THEORIES OF TURTLE ORIGINS

B156 **Obraztsova, E. M., Danilov, I. G.** AN UPDATE ON THE MIDDLE JURASSIC TURTLE ASSEMBLAGE OF THE BEREZOVSK QUARRY (WEST SIBERIA, RUSSIA)

B157 **Chapman, S., Rabi, M., Kear, B. P., Evers, S. W.** THE ANATOMY OF *NOTOCHELONE* LYDEKKER, 1889 AN EARLY CRETACEOUS PROTOSTEGID (TESTUDINES) FROM AUSTRALIA AND ITS BEARING ON THE ORIGIN AND EARLY EVOLUTION OF SEA TURTLES

B158 **Hutchinson, H. R., Vlamis, T. W., White, L. J., Wilson, L. E.** PRELIMINARY ANALYSIS OF *PROTOSTEGA GIGAS* OSTEOHISTOLOGY

B159 **Nakajima, Y., Danilov, I. G., Hirayama, R., Sonoda, T., Scheyer, T.** MORPHOLOGICALLY AND HISTOLOGICALLY DIAGNOSTIC SOFTSHELL TURTLES FROM THE LOWER CRETACEOUS OF JAPAN

B160 **Edgar, S. C., Evans, D. C.** A NEW PLASTOMENINE (TESTUDINES, TRIONYCHIDAE) FROM THE MILK RIVER FORMATION OF ALBERTA (LATE CRETACEOUS: SANTONIAN)

B161 **Manlove, H., Yamamura, D., Suarez, C. A.** INVESTIGATING THE DIAGENESIS OF TURTLE SHELL FRAGMENTS USING STABLE ISOTOPE, KAIPAROWITS FORMATION, SOUTHERN UTAH

B162 **Hu, Y., Huang, J., Obraztsova, E. M., Syromyatnikova, E. V., Danilov, I. G.** A NEW NANHSIUNGCHELYID TURTLE FROM THE LATE CRETACEOUS OF JIANGXI, CHINA

B163 **Danilov, I. G., Vitek, N., Nakajima, Y., Hirayama, R.** PHYLOGENETIC POSITION OF SOME FOSSIL SOFT-SHELLED TURTLES FROM THE CRETACEOUS AND PALEOGENE OF ASIA

B164 **Ricker, A. C.** DESCRIPTION OF PENNY CREEK CHELONIAN FAUNA (MIOCENE: EARLY CLARENDONIAN), WEBSTER COUNTY, NEBRASKA AND DIVERSITY COMPARISON TO NORDEN BRIDGE CHELONIAN FAUNA (MIOCENE: MEDIAL BARSTOVIAN), BROWN COUNTY, NEBRASKA

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THURSDAY, OCTOBER 27, 2016
POSTER SESSION II (CONTINUED)

B165 **Alicea, J., Jud, N., Vitek, N.** REANALYSIS OF A COMPLETE TRIONYCHID SKULL FROM FLORIDA ASSIGNED TO *A. FEROX*

B166 **Lucas, S. G., Lichtig, A. J.** DISCORDANCE BETWEEN MOLECULAR AND MORPHOLOGICAL PHYLOGENIES REQUIRES A REEXAMINATION OF CLADISTIC METHODOLOGY: TURTLES AS AN EXAMPLE

FRIDAY MORNING, OCTOBER 28, 2016
PODIUM SYMPOSIUM II: PALEO EVO-DEVO: THE NEW SCIENCE OF THE VERY OLD
GRAND AMERICA HOTEL, IMPERIAL BALLROOM AB
MODERATORS: Alistair R. Evans and Bhart-Anjan S. Bhullar

8:00 **Goswami, A., Randau, M., Bennett, C., Tilley, H., Polly, P., Weisbecker, V., Hautier, L., Sánchez-Villagra, M.** DEVELOPMENTAL CONSTRAINTS ON THE EVOLUTION OF THE MARSUPIAL CRANIUM

8:15 **Weisbecker, V., Hinds, L., Selwood, L., Whish, S., Carlisle, A.** EVO-DEVO OF MAMMALIAN BRAIN PROPORTIONS: TESTING PARADIGMS OF CONSERVED GROWTH AND EVOLUTIONARY SCALING IN THE GROWING MARSUPIAL BRAIN

8:30 **Urban, D. J., Anthwal, N., Maier, J. A., Tucker, A. S., Sears, K. E.** AN EARFUL OF JAW, THEN AND NOW: USING MARSUPIAL EVO-DEVO TO SHED LIGHT ON A MAJOR EVOLUTIONARY TRANSITION IN THE PALEONTOLOGICAL RECORD

8:45 **Luo, Z., Schultz, J. A.** PHYLOGENETIC HOMOPLASY AND DEVELOPMENTAL MORPHOGENESIS OF MAMMALIAFORM INNER EAR COCHLEA

9:00 **Jernvall, J., Savriama, Y., Valtonen, M.** CONSERVATION OF THE FINE-TUNING OF MAMMALIAN TOOTH SHAPE

9:15 **Evans, A., Catlett, K., Daly, E., King, S., Samonds, K., Godfrey, L., Schwartz, G.** INTEGRATION OF THE MAMMALIAN DENTITION BY THE INHIBITORY CASCADE

9:30 **Boisvert, C. A., Johanson, Z., Maksimenko, A., Currie, P. D., Trinajstic, K.** SHARKS IN TECHNICOLOR: DEVELOPMENT OF THE SYNARCUAL IN ELEPHANT SHARKS (HOLOCEPHALI, CHONDRICHTHYES) AND PLACODERMS

9:45 **Sears, K., Maier, J., Rivas-Astroza, M., Bormet, A., Rapti, Z., Zhao, K., Sinha, S., Ma, J., Behringer, R., Cretekos, C., Marcot, J. D.** THE DEVELOPMENTAL BASIS OF MAMMALIAN LIMB DIVERSIFICATION

10:00 **BREAK**

10:15 **Bhullar, B. S., Sefton, E. M.** THE VERTEBRATE NECK IS OLD AND SOME OF IT IS MADE OF HEAD

10:30 **Coates, M., Stewart, T. A.** ALL CHANGE? PAIRED FINS AND THE NEW PHYLOGENIES OF EARLY GNATHOSTOMES

10:45 **Hirasawa, T., Fujimoto, S., Kuratani, S.** EVOLUTIONARY ORIGIN OF THE DIAPHRAGM

11:00 **Bell, M. A.** FOSSILS, GENES, AND EVERYTHING IN BETWEEN: PELVIC REDUCTION IN THREESPINE STICKLEBACK FISH

11:15 **Head, J. J., Royle, S. R.** ROCKS BEAT *HOX*: FOSSIL AND EXTANT ANATOMICAL TESTS OF CONSERVATION IN REGULATORY GENE FUNCTION IN THE EVOLUTION OF NEW VERTEBRATE BODY FORMS

FRIDAY MORNING, OCTOBER 28, 2016

PODIUM SYMPOSIUM II: PALEO EVO-DEVO: THE NEW SCIENCE OF THE VERY OLD (CONTINUED)

11:30 **Kavanagh, K., Young, N.** SHARED DEVELOPMENTAL RULES PREDICT PATTERNS OF SIZE EVOLUTION IN VERTEBRATE SEGMENTED STRUCTURES

11:45 **Felice, R. N., Cuff, A., Witmer, L. M., O'Connor, P. M., Rayfield, E. J., Goswami, A.** QUANTIFYING MODULARITY AND RATES OF MORPHOLOGICAL EVOLUTION ACROSS ARCHOSAURIA USING PHENOMIC DATA

12:00 **Larsson, H. C., Caldwell, J. R., Du, T. Y., Fowler, D. A., Tahara, R.** DEVELOPMENTAL EVOLUTION OF DISCRETE TO CONTINUOUS TO COMPLEX MORPHOLOGIES: EXAMPLES FROM THE DINOSAUR–BIRD TRANSITION

FRIDAY MORNING, OCTOBER 28, 2016

TECHNICAL SESSSION X

GRAND AMERICA HOTEL, IMPERIAL BALLROOM CD

MODERATORS: Alex Hastings and Jess Miller-Camp

8:00 **Ford, D. P., Pierce, S. E., Benson, R. B.** NEW INSIGHTS ON THE ANATOMY OF *PALEOTHYRIS ARCADIANA* USING MICRO-CT SCANNING

8:15 **Elsler, A., Benton, M. J., Ruta, M., Dunhill, A. M.** MACROEVOLUTION OF PARAREPTILIA

8:30 **Andrus, A. S.** PROBABLE SEMI-FOSSORIAL BEHAVIOR IN A NEW DREPANOSAUR: RESULTS OF A COMPREHENSIVE APPROACH TO BEHAVIORAL TYPING

8:45 **Pritchard, A. C., Sues, H.** MOSAIC EVOLUTION OF THE EARLY SAURIAN POSTCRANIUM REVEALED BY THE POSTCRANIAL SKELETON OF *TERATERPETON HRYNEWICHORUM* (ARCHOSAUROMORPHA; LATE TRIASSIC)

9:00 **Parker, W. G., Marsh, A., Nesbitt, S. J., Stocker, M. R., Smith, M.** THE DECLINE OF EARLY ARCHOSAUROMORPHS IN THE NORIAN (UPPER TRIASSIC) IN THE LOW LATITUDES: NEW INSIGHTS FROM THE UPPER TRIASSIC CHINLE FORMATION OF ARIZONA

9:15 **Lessner, E. J., Sues, H., Stocker, M. R.** CONSERVED SEMIAQUATIC MORPHOLOGIES BETWEEN EXTANT CROCODYLIANS AND PHYTOSAURIA

9:30 **Melstrom, K., Irmis, R.** MULTIPLE ORIGINS OF HERBIVORY IN MESOZOIC CROCODYLIFORMS SUGGEST NOVEL ECOLOGICAL DYNAMICS DURING THE MESOZOIC

9:45 **Hastings, A. K., Callahan, W. R., Pellegrini, R., Parris, D. C.** CLADISTIC AND BIOGEOGRAPHIC ANALYSES OF A NEARLY COMPLETE SKELETON OF *HYPOSAURUS ROGERSII* (CROCODYLIFORMES, DYROSAURIDAE) INDICATE MULTIPLE CROCODYLIFORM DISPERSALS ACROSS THE EARLY ATLANTIC OCEAN

10:00 **BREAK**

10:15 **Clark, J. M., Turner, A. H., Reynoso, V. H.** A NEW NEOSUCHIAN CROCODYLIFORM FROM THE EARLY CRETACEOUS OF MEXICO PRESERVING A STERNUM, AND THE RELATIONSHIPS OF *ISISFORDIA* AND *SUSISUCHUS*

10:30 **Turner, A. H., Brochu, C. A., Miller-Camp, J., Clark, J. M., Narváez, I., Puértolas, E.** PHYLOGENETIC SYSTEMATICS OF NEOSUCHIA BASED ON EXPANDED TAXONOMIC AND CHARACTER SAMPLING: IMPLICATIONS FOR CROCODYLIFORM HISTORICAL BIOGEOGRAPHY, BASAL NEOSUCHIAN DIVERSITY, AND THE ORIGIN OF CROCODYLIA

FRIDAY MORNING, OCTOBER 28, 2016
TECHNICAL SESSSION X (CONTINUED)

10:45 **Miller-Camp, J., Brochu, C. A., Turner, A. H.** EMPIRICAL EVIDENCE OF A PROCESS THROUGH WHICH COPE'S "LAW OF THE UNSPECIALIZED" CAN BE BROKEN

11:00 **Boles, Z. M., Schweitzer, M. H., Lacovara, K. J.** PRESERVATION OF SOFT-TISSUE-LIKE STRUCTURES IN FOSSILS OF CRETACEOUS MARINE REPTILES AND SHARKS

11:15 **Myers, T. S., Mateus, O., Polcyn, M. J., Vineyard, D., Jacobs, L. L.** A NEW CHELONIOID TURTLE FROM THE PALEOCENE OF CABINDA, ANGOLA

11:30 **Evers, S. W., Choiniere, J. N., Benson, R. B.** LABYRINTH MORPHOLOGY OF THE EARLY JURASSIC STEM-TURTLE *AUSTRALOCHELYS* REVEALS NEUROANATOMICAL CHANGES ASSOCIATED WITH THE ORIGINS OF CROWN-GROUP TURTLES

11:45 **Rabi, M., Kear, B. P.** TRANSITIONAL FOSSILS SHED LIGHT ON THE BASAL DIVERGENCE OF ADVANCED MARINE TURTLES

12:00 **Vermillion, W. A.** THE EFFECTS OF POST GLACIAL CLIMATE CHANGE ON THE EVOLUTION OF MEMBERS OF THE *CHRYSEMYS* COMPLEX

FRIDAY MORNING, OCTOBER 28, 2016
TECHNICAL SESSION XI
GRAND AMERICA HOTEL, GRAND BALLROOM A
MODERATORS: Nicholas Campione and Kerin Claeson

8:00 **Snyder, D., Burrow, C., Pardo, J., Anderson, J. S., Turner, S.** MULTIPLE TECHNIQUES YIELD COMPLEMENTARY DATA ON GYRACANTH ANATOMY

8:15 **Johanson, Z., Underwood, C., Fraser, G., Welten, M., Kriwet, J., Pfaff, C., Meredith Smith, M.** DIVERSITY OF SKIN DENTICLES IN FOSSIL AND EXTANT RAYS AND THE ORIGINS OF VERTEBRATE DENTITIONS

8:30 **Bronson, A. W., Pradel, A., Denton, J. S., Maisey, J.** AN OPERCULATE CHONDRICHTHYAN FROM THE FAYETTEVILLE SHALE (UPPER MISSISSIPPIAN, ARKANSAS, USA)

8:45 **Stilson, K. T., Coates, M., Tietjen, K.** NEW CHONDROCRANIUM FROM *TANAODUS WEISI* ADDS TO PETALODONT DIVERSITY

9:00 **Argyriou, T., Friedman, M., Romano, C., Kogan, I., Sánchez-Villagra, M. R.** ENDOCRANIAL ANATOMY AND INTERRELATIONSHIPS OF THE PERMO–TRIASSIC EARLY ACTINOPTERYGIAN *SAURICHTHYS* WITH HIGH-RESOLUTION COMPUTER-ASSISTED MICROTOMOGRAPHY (MCT)

9:15 **Latimer, A. E.** NEUROCRANIAL MORPHOLOGY OF A NEW LARGE LATE TRIASSIC NEOPTERYGIAN FISH AND DEEP-BODIED FISHES ON THE TELEOST STEM

9:30 **Maltese, A., Liston, J.** FIN END OF THE WEDGE: CONSERVATISM OF THREE DIMENSIONAL STRUCTURE WITH DIVERSITY IN TWO DIMENSIONAL FORM REVEALED IN THE PACHYCORMID APPENDICULAR SKELETON

9:45 **Itano, W. M.** INFERENCES ON FUNCTIONAL MORPHOLOGY OF *EDESTUS HEINRICHI* FROM TOOTH MACROWEAR

10:00 **BREAK**

10:15 **Campione, N., Bazzi, M., Gates, T., Kear, B., Blom, H., Ahlberg, P. E.** DIETARY SELECTION IN LAMNIFORM SHARKS ACROSS THE CRETACEOUS–PALEOGENE BOUNDARY

FRIDAY MORNING, OCTOBER 28, 2016

TECHNICAL SESSION XI (CONTINUED)

10:30 **Liu, J., Wilson, M. V.** EOCENE FOSSIL RECORD OF CATOSTOMIDS (TELEOSTEI, CYPRINIFORMES) FROM NORTH AMERICA AND DISCOVERY OF THE FIRST LOACH-LIKE CATOSTOMID

10:45 **Gottfried, M. D., Eberle, J. J.** NEW RECORDS EXPAND THE DIVERSITY OF EOCENE FISHES FROM CANADA'S WESTERN ARCTIC GREENHOUSE

11:00 **Withdrawn**

11:15 **Abdelgawad, M. K., Argyriou, T., Carrillo Briceño, J. D., Hamdan, M., El-Barkooky, A., Miller, E., Gunnell, G. F.** A DIVERSE FOSSIL FISH ASSEMBLAGE FROM THE LOWER MIOCENE MOGHRA FORMATION, EGYPT

11:30 **Claeson, K. M., Davis, E. B., Sidlauskas, B., Prescott, Z., Andrews, J.** THE SABERTOOTH SALMON, *ONCORHYNCHUS RASTROSUS*, GETS A FACELIFT

11:45 **Carrillo Briceño, J. D.** SWIMMING IN TWO OCEANS: TROPICAL AMERICAN CHONDRICHTHYAN PALEODIVERSITY AND FAUNAL TURNOVER BEFORE AND AFTER THE RISE OF THE PANAMA ISTHMUS

12:00 **Denton, J. S.** APPLICATION OF TAXON INFLUENCE INDICES TO PALEONTOLOGICAL DATASETS: ROLES FOR BOTH NOVELTY AND IMPORTANCE

FRIDAY AFTERNOON, OCTOBER 28, 2016

TECHNICAL SESSION XII

GRAND AMERICA HOTEL, IMPERIAL BALLROOM AB

MODERATORS: Gabriela Sobral and Aaron Leblanc

1:45 **Sobral, G., Butler, R. J., Müller, J.** THE EVOLUTION OF THE ARCHOSAUR EAR: NEW INSIGHTS FROM THE INNER EAR ANATOMY OF RHYNCHOSAURS (DIAPSIDA, ARCHOSAUROMORPHA)

2:00 **Tsai, H. P., Middleton, K. M., Holliday, C. M.** THE CARTILAGE CONE OF ARCHOSAUROMORPHS: IMPLICATIONS OF CHONDRO-OSSEOUS JUNCTION ON HIP JOINT LOADING AND FEMORAL OSSIFICATION

2:15 **Manafzadeh, A. R., Padian, K.** COULD PTEROSAURS ADOPT A BATLIKE WING POSE? IMPLICATIONS OF A FUNCTIONAL ANALYSIS OF THE AVIAN HIP LIGAMENTS FOR THE EVOLUTION OF ORNITHODIRAN STANCE AND GAIT

2:30 **Sullivan, C., Stidham, T. A., Wang, Y., Claessens, L. P.** STRUCTURE, FUNCTION, AND EVOLUTIONARY HISTORY OF UNCINATE PROCESSES IN EXTANT CROCODILIANS AND OTHER ARCHOSAURS

2:45 **Holliday, C. M., Porter, W., Owerkowicz, T., Vliet, K., Witmer, L. M.** THE SOFT TISSUES OF THE DORSOTEMPORAL FENESTRA OF ARCHOSAURS AND ITS SIGNIFICANCE FOR DINOSAUR BIOLOGY

3:00 **Leblanc, A. R., Reisz, R. R.** SEPARATING TOOTH IMPLANTATION FROM TOOTH ATTACHMENT: A CASE STUDY USING DINOSAURS

3:15 **Reisz, R. R., Larson, D. W.** DID THEROPOD DINOSAURS HAVE LIPS?

3:30 **Cost, I. N., Sellers, K. C., Davis, J. L., Middleton, K. M., Witmer, L. M., Holliday, C. M.** POSTURAL CHANGES AND KINETIC COMPETENCY IN THE PALATES OF BIRDS AND OTHER DIAPSIDS

FRIDAY AFTERNOON, OCTOBER 28, 2016
TECHNICAL SESSION XII (CONTINUED)

3:45 **Kaye, T. G., Pittman, M., Wang, X., Zheng, X., Xu, X., Hartman, S., Falk, A.** NOTHING BUT SKIN AND BONES: *ANCHIORNIS* BODY OUTLINE REVEALED BY LASER FLUORESCENCE

4:00 **Organ, C. L.** ADVANCING BEYOND THE PHYLOGENETIC BRACKET

FRIDAY AFTERNOON, OCTOBER 28, 2016
TECHNICAL SESSION XIII
GRAND AMERICA HOTEL, IMPERIAL BALLROOM CD
MODERATORS: Natasha Vitek and Ross Secord

1:45 **Hovatter, B. T., Wilson, G. P.** THE EARLY PALEOGENE RISE OF PLACENTALS AND DECLINE OF MULTITUBERCULATES: INSIGHTS FROM ANALYSIS OF DENTAL DISPARITY, MORPHOSPACE OCCUPATION, AND BODY SIZE OF EARLIEST TORREJONIAN (TO1) MAMMALS FROM NORTHEASTERN MONTANA, USA

2:00 **Smith, S. M., Aranoff, G., Wilson, G. P.** QUANTITATIVE DENTAL ECOMORPHOLOGY REVEALS A WIDE RANGE OF MAMMALIAN DIETARY ECOLOGIES IN THE FIRST 1.2 MILLION YEARS FOLLOWING THE CRETACEOUS–PALEOGENE MASS EXTINCTION

2:15 **Secord, R., Williamson, T. E., Leslie, C., Peppe, D., Brusatte, S.** FIRST RECOGNITION OF CLIMATE HYPERTHERMALS IN THE LOWER PALEOCENE RECORD OF THE SAN JUAN BASIN, NEW MEXICO, USA

2:30 **Shelley, S. L., Williamson, T. E., Brusatte, S.** THE ANATOMY OF *PERIPTYCHUS CARINIDENS* WITH COMMENTS ON FUNCTIONAL MORPHOLOGY AND THE PHYLOGENY OF 'ARCHAIC' PALEOCENE MAMMALS

2:45 **Solé, F., De Bast, E., Yang, J., Li, C., Smith, T.** A NEW HAPALODECTID (MESONYCHIA, MAMMALIA) FROM THE LATE PALEOCENE OF THE QIANSHAN BASIN (ANHUI PROVINCE, CHINA): NEW DATA ON THE RADIATION OF THE HAPALODECTIDS

3:00 **Vitek, N. S., Morse, P. E., Strait, S. G., Boyer, D. M., Bloch, J. I.** MULTIVARIATE CHANGE IN THE DENTAL MORPHOLOGY OF THE SMALL-BODIED INSECTIVOROUS MAMMAL *MACROCRANION* (EULIPOTYPHLA, ERINACEOMORPHA) ACROSS THE PALEOCENE–EOCENE THERMAL MAXIMUM

3:15 **Fraser, D. L., Lyons, S.** STASIS IN LOCALITY-SCALE MAMMAL COMMUNITY STRUCTURE ACROSS THE PALEOCENE–EOCENE THERMAL MAXIMUM

3:30 **Smith, T., Quesnel, F., Baron, V., De Ploëg, G., De Bast, E., Folie, A., Smith, R., Solé, F.** NEW EARLIEST EOCENE MAMMAL FAUNA FROM CLAIROIX, FRANCE: FIRST DEFINITIVE DORMAAL (REFERENCE LEVEL MP7) EQUIVALENT OUTSIDE OF BELGIUM

3:45 **Beard, K., Metais, G., Coster, P., Ocakoglu, F., Licht, A., Taylor, M.** TETHYAN ISLAND BIOGEOGRAPHY DURING THE EOCENE: A VIEW FROM NORTHERN ANATOLIA

4:00 **Poust, A. W.** HISTOLOGY OF THE EARLY PALEOGENE MAMMAL *CORYPHODON* (EUTHERIA, PANTODONTA): A DISTINCT APPROACH TO LARGE BODY SIZE?

FRIDAY AFTERNOON, OCTOBER 28, 2016

TECHNICAL SESSION XIV

GRAND AMERICA HOTEL, GRAND BALLROOM A

MODERATORS: Kirsten Brink and Christian Kammerer

1:45 **Brink, K.** EVOLUTIONARY CHANGES IN THE FEEDING APPARATUS OF THE EARLY PERMIAN SPHENACODONTID SYNAPSID *DIMETRODON* IN THE CONTEXT OF THE ESTABLISHMENT OF MODERN TERRESTRIAL ECOSYSTEMS

2:00 **Lungmus, J. K., Angielczyk, K. D.** MORPHOMETRIC ANALYSIS OF PELYCOSAUR-GRADE SYNAPSID PECTORAL ELEMENTS REVEALS DECREASED DISPARITY APPROACHING THERAPSIDS

2:15 **Sidor, C. A., Hopson, J. A., Angielczyk, K. D., Nesbitt, S. J., Peecook, B. R., Smith, R., Steyer, J., Tabor, N. J., Tolan, S.** A NEW SPECIES OF TRAVERSODONT CYNODONT WITH TRITYLODONT-LIKE FEATURES AND POSSIBLE ARBOREAL ADAPTATIONS FROM THE UPPER NTAWERE FORMATION, NORTHEASTERN ZAMBIA

2:30 **Kammerer, C. F., Fröbisch, J.** A NEW JURASSIC TRITHELEDONTID CYNODONT AND ITS IMPLICATIONS FOR SYNAPSID SURVIVORSHIP ACROSS THE TRIASSIC–JURASSIC BOUNDARY

2:45 **Bendel, E., Kammerer, C. F., Kardjilov, N., Fernandez, V., Fröbisch, J.** CRANIAL ANATOMY AND SYSTEMATIC POSITION OF *AELUROSAURUS* (SYNAPSIDA, GORGONOPSIA) BASED ON A CT-RECONSTRUCTION

3:00 **Viglietti, P. A.** THE LOPINGIAN *DAPTOCEPHALUS* ASSEMBLAGE ZONE (KAROO BASIN, SOUTH AFRICA): A REVISED BIOSTRATIGRAPHY SUPPORTS A PHASED PERMO–TRIASSIC MASS EXTINCTION EVENT

3:15 **Smith, R. M., Sidor, C. A., Angielczyk, K. D., Nesbitt, S. J., Tabor, N. J.** TAPHONOMY AND SEDIMENTARY ENVIRONMENTS OF MID-TRIASSIC VERTEBRATE ACCUMULATIONS, LIFUA MEMBER (MANDA BEDS), RUHUHU BASIN, TANZANIA

3:30 **Angielczyk, K. D., Nabavizadeh, A., Hancox, J., Sidor, C. A., Nesbitt, S. J., Smith, R. M., Tsuji, L. A.** MORPHOLOGY, PHYLOGENETIC RELATIONSHIPS, AND FEEDING SYSTEM FUNCTION OF THE ENIGMATIC TRIASSIC DICYNODONT *SANGUSAURUS* (THERAPSIDA, ANOMODONTIA)

3:45 **Nabavizadeh, A., Angielczyk, K. D.** THE EVOLUTION OF JAW MECHANICS AND CRANIAL MUSCULATURE IN DICYNODONTS (THERAPSIDA, ANOMODONTIA)

4:00 **Araujo, R. M., Fernandez, V., Polcyn, M. J., Fröbisch, J., Martins, R. M.** THE NEURAL CREST–MESODERM BOUNDARY IN THE BASICRANIUM OF MAMMAL PREDECESSORS: INSIGHTS FROM THERAPSID SKULLS

FRIDAY, OCTOBER 28 THROUGH SATURDAY, OCTOBER 29, 2016

POSTER SYMPOSIUM II: AN ECOSYSTEM WE THOUGHT WE KNEW: THE EMERGING COMPLEXITIES OF THE MORRISON FORMATION

GRAND AMERICA HOTEL, EXHIBIT HALL GRAND BALLROOM

Authors must be present from 4:15 – 6:15 p.m., Friday, October 28

Posters must be removed by 6:30 p.m., Saturday, October 29

B51 **Breithaupt, B. H., Matthews, N. A., Southwell, E. H., Brinkman, P.** OLD SITES–NEW TECHNOLOGIES: REEVALUATION OF THE MORRISON FORMATION: FROM HISTORIC EXPEDITIONS TO NEW SCIENTIFIC DISCOVERIES

B52 **Hotton, C. L., Baghai-Riding, N. L.** PALYNOLOGY OF THE LATE JURASSIC MORRISON FORMATION: NEW INSIGHTS INTO FLORISTICS, PALEOCLIMATE, PHYTOGEOGRAPHY, AND TETRAPOD HERBIVORY

B53 **Gee, C. T.** EMERGING DATA ON THE MORRISON FLORA: OPULENT CONIFER FORESTS OR A HINTERLAND XERISCAPE FOR THE SAUROPODS?

B54 **Nydam, R. L., Caldwell, M. W., Apesteguía, S., Palci, A.** LIZARDS AND SNAKES OF THE MORRISON FORMATION (UPPER JURASSIC, USA) AND THE EARLY GLOBAL DISTRIBUTION AND DIVERSITY OF SQUAMATES

B55 **Jones, M. E., Watson, A. P., Sertich, J., Foster, J., Garbe, U., Salvemini, F.** NEUTRON COMPUTED TOMOGRAPHY SUCCEEDS WHERE X-RAY COMPUTED TOMOGRAPHY FAILS: ENAMEL THICKNESS IN THE HERBIVOROUS RHYNCHOCEPHALIAN *EILENODON* FROM THE LATE JURASSIC MORRISON FORMATION OF USA

B56 **Davis, B. M., Rougier, G. W.** THE ICONIC MESOZOIC MAMMALS: THE LONG SHADOW OF MORRISON MAMMALS ON OUR UNDERSTANDING OF EARLY MAMMALIAN EVOLUTION

B57 **Peterson, J. E., Warnock, J. P., Clawson, S. R.** NEW DATA TOWARDS A TAPHONOMIC FRAMEWORK FOR THE CLEVELAND-LLOYD DINOSAUR QUARRY

B58 **Woodruff, C., Fowler, D. W.** WHAT FACTORS INFLUENCE OUR RECONSTRUCTIONS OF MORRISON FORMATION SAUROPOD DIVERSITY?

B59 **Foster, J. R., Irmis, R. B., Trujillo, K. C., Mcmullen, S. K., Gillette, D. D.** *DYSTROPHAEUS VIAEMALAE* COPE FROM THE BASAL MORRISON FORMATION OF UTAH: IMPLICATIONS FOR THE ORIGIN OF EUSAUROPODS IN NORTH AMERICA

B60 **Tschopp, E., Giovanardi, S., Maidment, S. C.** TEMPORAL DISTRIBUTION OF DIPLODOCID SAUROPODS ACROSS THE UPPER JURASSIC MORRISON FORMATION (USA)

B61 **Galton, P. M., Carpenter, K.** BIPEDAL ORNITHISCHIAN DINOSAURS (HETERODONTOSAURIDAE AND ORNITHOPODA) FROM THE MORRISON FORMATION (UPPER JURASSIC) OF THE WESTERN UNITED STATES OF AMERICA

B62 **Kirkland, J. I., Carpenter, K., Morgan, K.** THE MORRISON FORMATION'S ANKYLOSAURS

B63 **Fricke, H. C., Hoerner, M., Foster, J.** SAUROPOD AND THEROPOD MOVEMENT AND HABITAT PREFERENCES OVER DIFFERENT PARTS OF THE MORRISON BASIN: INSIGHTS FROM CARBON, OXYGEN AND STRONTIUM ISOTOPE RATIOS OF TOOTH ENAMEL

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B64 **Whitlock, J. A., Hanik, G. M., Trujillo, K. C.** USING BIPARTITE NETWORKS TO EXAMINE MORRISON FORMATION DINOSAUR COMMUNITY STRUCTURE

B65 **Trujillo, K. C.** TYING IT ALL TOGETHER: USING RADIOMETRIC AGES TO CORRELATE FOSSIL LOCALITIES ACROSS THE UPPER JURASSIC MORRISON FORMATION, WESTERN INTERIOR, USA

B66 **Maidment, S. C., Muxworthy, A.** A CHRONOSTRATIGRAPHIC FRAMEWORK FOR THE MORRISON FORMATION, AND THE LATITUDINAL BIODIVERSITY GRADIENT IN MORRISON DINOSAURS

B67 **Mcmullen, S. K.** CONTROLS ON THE STRATIGRAPHIC DISTRIBUTION OF NON-MARINE FOSSILS: A CASE STUDY IN THE JURASSIC MORRISON FORMATION, WESTERN USA

B68 **Mateus, O.** LATE JURASSIC OF MORRISON FORMATION AND PORTUGAL TETRAPODS COMPARED: A MODEL TO EXPLAIN FAUNAL EXCHANGE AND SIMILARITY

B69 **Rauhut, O. W.** LATE JURASSIC DINOSAURS FROM GONDWANA: MATERIALS FOR COMPARISON WITH THE MORRISON FORMATION

FRIDAY, OCTOBER 28, 2016
POSTER SESSION III
GRAND AMERICA HOTEL, EXHIBIT HALL GRAND BALLROOM
Authors must be present from 4:15 – 6:15 p.m.
Posters must be removed by 6:30 p.m.

B70 **Esplin, R., Britt, B. B., Chure, D. J.** AN EMBARRASSMENT OF PALEONTOLOGICAL RICHES: 3D IMAGERY AND ASSOCIATED DATA FOR THE FOSSILS OF THE CARNEGIE QUARRY, DINOSAUR NATIONAL MONUMENT

B71 **Martínez, R. N., Sojo Aguero, C. N., Garcia, G. N., Apaldetti, C. N.** A LATE NORIAN COELOPHYSID NEOTHEROPOD (DINOSAURIA, SAURISCHIA) FROM NORTHWESTERN ARGENTINA

B72 **Stiegler, J. B., Wang, S., Xu, X., Clark, J. M.** *LIMUSAURUS* AND THE EVOLUTION AND BIOGEOGRAPHY OF CERATOSAURS

B73 **Demic, M., Curry Rogers, K., O'Connor, P. M.** BONE HISTOLOGY REVEALS UNUSUAL LIFE HISTORY IN THE THEROPOD DINOSAUR *MAJUNGASAURUS CRENATISSIMUS* FROM THE LATEST CRETACEOUS OF MADAGASCAR

B74 **Malafaia, E., Ortega, F., Mocho, P., Escaso, F.** NEW SPECIMEN OF ALLOSAUROIDEA (DINOSAURIA, TETANURAE) FROM THE UPPER JURASSIC OF PORTUGAL

B75 **Cuesta, E., Ortega, F., Sanz, J.** PHYLOGENETIC REASSESSMENT OF *CONCAVENATOR CORCOVATUS* (LOWER CRETACEOUS, SPAIN) AND ITS IMPLICATIONS FOR CARCHARODONTOSAURIDAE RELATIONSHIPS

B76 **Bourke, J., Witmer, L. M., Ridgely, R. C., Porter, W., Zanno, L. E.** AIRFLOW SIMULATIONS IN THE ANTORBITAL SINUS OF *ACROCANTHOSAURUS*. TESTING THE POTENTIAL FOR THEROPOD PARANASAL SINUSES TO FUNCTION AS ACCESSORY COOLING STRUCTURES

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B77 **White, M. A.** PEDAL SOFT TISSUE AND BIOLOGICAL RESTORATION OF *AUSTRALOVENATOR WINTONENSIS* (THEROPODA, MEGARAPTORIDAE) TO DETERMINE THE EFFECTS SOFT TISSUE HAS ON RANGE OF MOTION

B78 **Samathi, A., Chanthasit, P., Sander, M. P.** NEW MATERIAL OF A NEW METRIACANTHOSAURID (DINOSAURIA, THEROPODA) FROM THE PHU NOI LOCALITY (LATE JURASSIC–EARLY CRETACEOUS) OF THAILAND

B79 **Carr, T. D.** TOWARD UNDERSTANDING PHYLOGENETIC AND ONTOGENETIC TOOTH LOSS IN ARCHOSAURIA: DOCUMENTING PATTERNS OF TOOTH REPLACEMENT IN *TYRANNOSAURUS REX*

B80 **Brusatte, S., Muir, A., Averianov, A., Balanoff, A., Bever, G., Carr, T. D., Kundrat, M., Sues, H., Williamson, T. E., Xu, X.** BRAINS BEFORE BRAWN: NEUROSENSORY EVOLUTION IN TYRANNOSAUROID DINOSAURS

B81 **Prieto-Marquez, A., Stubbs, T. L., Benton, M. J., Brusatte, S.** REGIONAL MORPHOLOGICAL DISPARITY AND RATES OF EVOLUTION IN COELUROSAURIAN THEROPOD DINOSAURS

B82 **Kaskes, P., Schulp, A. S., Larson, P. L., Smit, J., Kuiper, K. F., Abels, H. A.** PLACING NATURALIS' *TYRANNOSAURUS REX* SPECIMEN IN A TAPHONOMIC, PALEOENVIRONMENTAL AND INTEGRATED STRATIGRAPHIC FRAMEWORK: HELL CREEK FORMATION, EASTERN MONTANA

B83 **Qin, Z., Zhao, Q., Xu, X.** BONE HISTOLOGY IN *XIXIANYKUS ZHANGI* (THEROPODA, ALVAREZSAUROIDEA): IMPLICATIONS FOR THE MINIATURIZATION OF ALVAREZSAUROIDEA

B84 **Tsuihiji, T., Watabe, M., Witmer, L. M., Tsogtbaatar, K., Barsbold, R.** A NEW SPECIMEN OF *MONONYKUS OLECRANUS* (DINOSAURIA: THEROPODA) FROM BUGIN TSAV, WESTERN GOBI DESERT, MONGOLIA, WITH NEW INFORMATION ON THE VERTEBRAL AND SKULL MORPHOLOGY

B85 **Benner, E. K., Cullen, T. M., Evans, D. C.** A NEW LARGE-BODIED CAENAGNATHID SPECIMEN (THEROPODA, OVIRAPTOROSAURIA) FROM THE HELL CREEK FORMATION (LATE CRETACEOUS) OF MONTANA, WITH IMPLICATIONS FOR OSTEOHISTOLOGICAL VARIABILITY IN CAENAGNATHIDS

B86 **Funston, G. F., Currie, P. J., Eberth, D., Ryan, M. J., Tsogtbaatar, C., Longrich, N.** THE FIRST OVIRAPTOROSAUR (DINOSAURIA, THEROPODA) BONEBED: INSIGHTS INTO SOCIAL BEHAVIOUR IN A MANIRAPTORAN THEROPOD

B87 **Blake, S.** THE LATEST KNOWN ORNITHOMIMID FROM THE UPPER HELL CREEK FORMATION, MONTANA: FURTHER CLOSING THE THREE-METER GAP

B88 **Boitsova, E., Skutschas, P., Averianov, A., Sues, H.** ONTOGENETIC CHANGES IN LONG-BONE HISTOLOGY OF AN ORNITHOMIMID THEROPOD DINOSAUR FROM THE BISSEKTY FORMATION (UPPER CRETACEOUS, TURONIAN) OF UZBEKISTAN

B89 **Lautenschlager, S.** FUNCTIONAL NICHE PARTITIONING AND DIETARY SPECIALISATION IN THERIZINOSAUR DINOSAURS

B90 **Chen, A., Holtz, T. R.** EVOLUTION AND ECOLOGICAL ASSOCIATIONS IN HERBIVOROUS THEROPODS

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B91 **Pei, R., Pittman, M., Norell, M., Xu, X.** A REVIEW OF PARAVIAN PHYLOGENY WITH NEW DATA

B92 **Xu, X.** A NEW PROTOCOL FOR MORPHOLOGY-BASED SYSTEMATICS: A CASE STUDY OF MICRORAPTORINE THEROPOD PHYLOGENY

B93 **Thomson, T. J., Kirkland, J. I., Bybee, P. J.** A PRELIMINARY INVESTIGATION OF ALLOMETRY IN THE TIBIA AND PEDAL DIGIT II UNGUAL OF THE LARGE DROMAEOSAURID *UTAHRAPTOR* (DINOSAURIA, THEROPODA)

B94 **Kurosu, M.** NEW DROMAEOSAURID DINOSAUR FROM THE EARLY CRETACEOUS OF JIUQUAN AREA, GANSU PROVINCE, CHINA

B95 **Ely, R. C., Case, J. A.** A BASAL DEINONYCHOSAUR FROM THE EARLY MAASTRICHTIAN, ANTARCTIC PENINSULA AND THE BIOSTRATIGRAPHY OF THE LATEST CRETACEOUS DINOSAUR FAUNA OF ANTARCTICA.

B96 **Brewer, T. J.** NEW SPECIMENS OF *TROODON FORMOSUS* HIND LIMBS FROM THE FOX HILLS FORMATION OF SOUTH DAKOTA

B97 **Powers, M., Torices, A., Currie, P. J.** AN EXAMINATION OF TROODONTID TOOTH ANATOMY AND THE IMPLICATIONS OF FUNCTIONAL MORPHOLOGY ON DIET

B98 **Yu, C., Allen, V., Hutchinson, J. R., Xu, X.** ESTIMATION OF BODY MASS AND CENTER OF MASS OF THE TROODONTID *SINOVENATOR CHANGII*

B99 **Noto, C. R.** NEW THEROPODS FROM THE WOODBINE FORMATION OF TEXAS: INSIGHTS INTO CENOMANIAN APPALACHIAN ECOSYSTEMS

B100 **Jasinski, S. E., Sullivan, R. M., Snively, E., Morschhauser, E. M., Dalman, S., Dodson, P.** THEROPODS (DINOSAURIA: THEROPODA) FROM THE SAN JUAN BASIN, NEW MEXICO, AND IMPLICATIONS FOR LATE CRETACEOUS THEROPOD FAUNAS OF LARAMIDIA

B101 **Zelenitsky, D. K., Therrien, F., Tanaka, K., Debuhr, C. L., Currie, P. J.** FOSSIL EGGSHELLS REVEAL PREVIOUSLY UNKNOWN DINOSAUR DIVERSITY OF THE END CRETACEOUS WILLOW CREEK FORMATION IN SOUTHWESTERN ALBERTA

B102 **Brum, A. S., Machado, E. B., Campos, D. D., Kellner, A. A.** INTERNAL PNEUMATIC STRUCTURES IN CERVICAL VERTEBRAE OF THEROPOD DINOSAURS

B103 **Burch, S. H., Gage, S.** OSTEOLOGICAL INDICATORS OF PREY SIZE PREFERENCE IN THE FORELIMBS OF FELIDS AND NONAVIAN THEROPOD DINOSAURS

B104 **Anduza, D., Fowler, D. W.** A NOTCH ABOVE: THE SUBROSTRAL INDENT OF CARNIVOROUS BIPEDS AS A CLUE TO FEEDING BEHAVIOR

B105 **Bailleul, A. M., Witmer, L. M., Horner, J. R., Holliday, C. M.** NEW HISTOLOGICAL DATA ON THE CRANIAL JOINTS OF ARCHOSAURS: SIGNIFICANCE FOR THE EVOLUTION AND FUNCTIONAL INFERENCES OF DINOSAUR CRANIAL KINESIS

B106 **Hattori, S.** HOMOLOGIES OF PEDAL MUSCLES BETWEEN AVIAN AND NON-AVIAN REPTILES AS A BASIS FOR THEIR RECONSTRUCTION IN FOSSIL ARCHOSAURS

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B107 **Milner, A. R., Santucci, V. L., Lockley, M., Wood, J. R., Doyle, S., Kirkland, J. I.** THE "POWELL FOSSIL TRACK BLOCK": THEROPOD TRACKS WITH ORNITHOPOD-LIKE MORPHOLOGY FROM THE LOWER JURASSIC NAVAJO SANDSTONE FORMATION, GLEN CANYON NATIONAL RECREATION AREA, UTAH

B108 **Kim, K., Lim, J., Lockley, M., Xing, L., Kim, D., Piñuela, L., Romillio, A., Yoo, J., Kim, J.** THE SMALLEST KNOWN DIDACTYL DINOSAUR FOOTPRINTS FROM THE EARLY CRETACEOUS JINJU FORMATION, JINJU, KOREA

B109 **Smith, J. A., Zanno, L. E., Lockley, M.** LARGE TETRADACTYL FOOTPRINTS IN THE UPPER CRETACEOUS HUNTER CANYON FORMATION OF WESTERN COLORADO: ICHNOLOGICAL EVIDENCE FOR THERIZINOSAURIDS IN THE CAMPANIAN OF NORTH AMERICA?

B110 **Gatesy, S. M., Falkingham, P. L.** FOOTPRINTS ARE NEITHER BONES NOR FEET: PROBLEMS WITH TRACK "PRESERVATION" AND THE MOLD-BASED PARADIGM

B111 **Snively, E.** FOOT STRESS SCALING CONSTRAINS ESTIMATES OF MASS FOR ISOLATED, LARGE SAURISCHIAN DINOSAUR SPECIMENS

B112 **Yoshida, J., Carpenter, K.** BURROWS OF SMALL ANIMALS FROM THE MID-CRETACEOUS CEDAR MOUNTAIN FORMATION, UTAH, USA

B113 **Jimenez Huidobro, P., Caldwell, M. W.** PHYLOGENETIC RELATIONSHIPS OF TYLOSAURINE MOSASAURS (SQUAMATA, MOSASAUROIDEA) AND THEIR BIOGEOGRAPHIC PATTERNS OF DISTRIBUTION

B114 **Green, C. C., Wilson, L. E.** HISTOLOGICAL DESCRIPTION OF AN INFECTIOUS PATHOLOGY IN THE VERTEBRAE OF *TYLOSAURUS* SP. (MOSASAURIDAE)

B115 **Pagnac, D., Abrams, K.** FINDING NEMO: TRAUMATIC PATHOLOGY IN THE LEFT FORELIMB OF A *PLATECARPUS PLANIFRONS* FROM THE NIOBRARA FORMATION (UPPER CRETACEOUS) OF SOUTH DAKOTA, USA

B116 **Chavarría Arellano, M. L., Montellano, M.** A NEW LOOK AT THE LATE CRETACEOUS LIZARD *DICOTHODON BAJAENSIS* FROM THE EL GALLO FORMATION, BAJA CALIFORNIA, MÉXICO

B117 **Cleary, T. J.** GLOBAL DIVERSITY PATTERNS OF LEPIDOSAURIA FROM THE TRIASSIC-OLIGOCENE: WHAT CAN THEY TELL US ABOUT THE LONG-TERM EVOLUTIONARY HISTORY OF THE CLADE?

B118 **Bouchard, S. N., Mccartney, J. A., O'Connor, P. M., Stevens, N. J.** A COLUBROID-DOMINATED FAUNA FROM THE LATE OLIGOCENE NSUNGWE FORMATION OF TANZANIA PROVIDES EARLIEST EVIDENCE OF THE LAMPROPHIID RADIATION (LAMPROPHIIDAE, LAMPROPHIINAE)

B119 **Jacisin, J. J.** THE FIRST EARLY CLARENDONIAN (MIOCENE) SNAKE ASSEMBLAGE FROM THE PENNY CREEK LOCAL FAUNA, WEBSTER COUNTY, NEBRASKA

B120 **Scarpetta, S. G., Ledesma, D.** CRANIAL OSTEOLOGY OF EXTINCT AND EXTANT GERRHONOTINE LIZARDS

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B121 **Cieri, R., Brainerd, E., Moritz, S.** ANALYSIS OF VENTILATORY RIB KINEMATICS VIA XROMM IN THE SAVANNAH MONITOR, *VARANUS EXANTHEMATICUS*: IMPLICATIONS FOR COSTOVERTEBRAL JOINT EVOLUTION IN SQUAMATES

B122 **Pearson, L. K., Clites, E., Santucci, V. L., Boessenecker, R. W.** VERTEBRATE PALEONTOLOGICAL RESOURCE SITE MONITORING AT POINT REYES NATIONAL SEASHORE

B123 **Boessenecker, S. J., Boessenecker, R. W., Manning, P. L.** NEW COLLECTION CONTRIBUTES INSIGHT TO THE NEOGENE MARINE VERTEBRATE PALEONTOLOGY OF THE LEE CREEK MINE, NORTH CAROLINA

B124 **Scherzer, B.** AN ARCHAIC BALEEN WHALE (CETACEA, MYSTICETI) FROM THE VAQUEROS FORMATION AND OTHER FOSSIL MATERIAL FROM THE SKYRIDGE PROJECT, ORANGE COUNTY, CALIFORNIA

B125 **Samonds, K. E., Fordyce, R. E.** LATE MIOCENE CETACEAN FROM NORTHWESTERN MADAGASCAR

B126 **Tanaka, Y., Ichishima, H.** A NEW SKULL OF *NUMATAPHOCOENA YAMASHITAI*, A FOSSIL PORPOISE FROM THE LOWER PLIOCENE, THE UPPER PART OF THE HOROKAOSHIRARIKA FORMATION, NUMATA, HOKKAIDO, JAPAN, AND PHYLOGENY OF THE PHOCOENIDAE

B127 **Voss, M., Hampe, O.** SEA COWS IN THE STREET—HOW FOSSIL REMAINS IN THE PEDESTRIAN ZONE OF GIRONA (SPAIN) EXTEND OUR KNOWLEDGE ON EOCENE SIRENIANS (MAMMALIA, TETHYTHERIA)

B128 **Shinmura, T., Ando, T., Aoyagi, C., Ando, T., Sawamura, H., Sawada, K.** PALEODIETARY RECONSTRUCTION USING STEROIDS IN PALEOGENE FOSSIL BONES OF MARINE MAMMALS FROM HOKKAIDO, JAPAN

B129 **Uno, H., Kimura, M.** MORPHOLOGICAL VARIATIONS IN MOLARS OF PALEOPARADOXIID FROM THE MIDDLE MIOCENE TONOKITA FORMATION IN AKAN, HOKKAIDO, JAPAN

B130 **Osimanti, C. E., Boardman, G. S., Kantelis, T. M., Dewar, E. W.** WHITE RIVER CHRONOFAUNA MAMMALS SHOWED MARGINAL NICHE RESPONSES TO SUBSTANTIAL CLIMATIC CHANGE

B131 **Grass, A.** UNGULATE CRANIAL SHAPE AND THE TRANSITION FROM BROWSING COMMUNITIES TO GRAZING

B132 **Ferrusquia-Villafranca, I., Perez-Crespo, V., Ruiz-Gonzalez, J., Martinez-Hernandez, E., Morales-Puente, P., Cienfuegos-Alvarado, E.** ON THE DIET OF *LEPTOMERYX* SP., LATE EOCENE OF NORTHWESTERN OAXACA, SOUTHEASTERN MEXICO

B133 **Sileem, A. H., Sallam, H. M., Miller, E. R., Gunnell, G. F.** THE OLDEST CRANIODENTAL REMAINS OF ANTHRACOTHERIIDAE (MAMMALIA, ARTIODACTYLA) FROM THE PALEOGENE OF AFRICA

B134 **Tsubamoto, T., Kunimatsu, Y., Sakai, T., Saneyoshi, M., Shimizu, D., Morimoto, N., Nakaya, H., Nakatsukasa, M.** TWO RARE ARTIODACTYL MAMMALS FROM THE UPPER MIOCENE NAKALI FORMATION OF KENYA, EAST AFRICA

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FRIDAY, OCTOBER 28, 2016
POSTER SESSION III (CONTINUED)

B135 **Hanson, D. A., Scannella, J.** SKULL VARIABILITY WITHIN A POPULATION OF THE LARGE OREODONT *MEGOREODON GRANDIS* FROM A SINGLE LOCALITY IN WEST CENTRAL MONTANA—A PRELIMINARY ASSESSMENT

B136 **Bevers, J. E., Weideman, C., Curtis, D.** THE MILK CREEK MAMMAL FAUNA OF CENTRAL ARIZONA (LATE MIOCENE) WITH NEW TAXA AND AN ESTIMATE OF BODY MASS OF CAMELIDS AND ANTILOCAPRIDS USING ASTRAGALI AREAS

B137 **Prothero, D. R.** A NEW GENUS OF HESPERHYINE PECCARY (ARTIODACTYLA, TAYASSUIDAE) FROM THE EARLY MIOCENE JOHN DAY BEDS OF OREGON: IMPLICATIONS FOR FOSSIL DATABASES

B138 **Tuttle, K., Taylor, M. A., Naples, V.** ASCENDANCY OF THE ECOLOGICAL NICHE: COMPARATIVE FORELIMB MORPHOLOGY AND FUNCTION IN BODY FORM ECOMORPHS, THE HIPPOPOTAMIDS, PECCARIES, AND SUIDS

B139 **Bales, G. S.** MORPHOSPACE AT AN INTERFACE: OCCIPUT SHAPE IN RHINOCEROTOIDS

B140 **Bogner, E. L., Simpson, E. L., Otto, R.** HERDING STRUCTURE OF THE EXTINCT NORTH AMERICAN RHINOCEROS *TELEOCERAS MAJOR*

B141 **Schellhorn, R.** REMARKABLE CARPAL BONES IN *PROSANTORHINUS GERMANICUS* (MAMMALIA, RHINOCEROTIDAE)

B142 **Zack, S. P., Tomiya, S.** NEW POSTCRANIA CLARIFY THE AFFINITIES OF THE UNUSUAL EOCENE MAMMAL *SIMIDECTES*

B143 **Ahrens, H. E.** EVOLUTIONARY TRENDS IN THE POSTCRANIAL SKELETON AND LOCOMOTOR BEHAVIOR OF OXYAENIDAE AND HYAENODONTIDAE (MAMMALIA, LAURASIATHERIA)

B144 **Borths, M. R., Roberts, E. M., Stevens, N. J.** THE FIRST HYAENODONT FROM THE LATE OLIGOCENE NSUNGWE FORMATION, RUKWA RIFT BASIN, TANZANIA: ECOLOGICAL DIVERSITY OF AFRO–ARABIAN MAMMALIAN CARNIVORES NEAR THE PALEOGENE–NEOGENE BOUNDARY

B145 **Fowler, L. R., Rankin, B. D., Holroyd, P. A.** CARNIVORANS AND CREODONTANS FROM THE EARLY EOCENE WASATCH FORMATION OF SOUTHWESTERN WYOMING

B146 **Janis, C. M., Panciroli, E., Stockdale, M.** CORRELATION BETWEEN CALCANEAL MORPHOLOGY AND LOCOMOTION IN CARNIVOROUS MAMMALS: INFERENCE OF LOCOMOTOR DIVERSITY WITHIN NIMRAVIDAE

B147 **Orcutt, J. D., Hopkins, S. S., Calede, J. J.** TESTING THE DIAGNOSTIC POTENTIAL OF FELID POSTCRANIA USING GEOMETRIC MORPHOMETRICS

B148 **Lyon, L. M., Wallace, S. C., Salesa, M. J., Siliceo, G., Anton, M.** ANATOMICAL COMPARISON OF THE POSTCRANIAL SKELETON OF THE EXTANT RED PANDA, *AILURUS FULGENS*, TO THE EXTINCT LATE MIOCENE AILURIDS *SIMOCYON BATALLERI* AND *PRISTINAILURUS BRISTOLI* (CARNIVORA, AILURIDAE)

B149 **Robson, S. V., Mclaughlin, W. N., Hopkins, S. S.** NEW SPECIES OF *HYAENICTITHERIUM* RECOVERED FROM THE LATE MIOCENE OF KYRGYZSTAN

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FRIDAY, OCTOBER 28, 2016
POSTER SESSION III (CONTINUED)

B150 **Bredehoeft, K., Schubert, B. W.** A LATE RECORD OF *URSAVUS* (URSIDAE) FROM THE RATTLESNAKE FORMATION (EARLY HEMPHILLIAN, LATE MIOCENE) OF OREGON

B151 **Schubert, B. W., Chatters, J. C., Arroyo-Cabrales, J., Soibelzon, L. H., Awe, J. J., Griffith, C. S., De Anda, G., Luna Erreguerena, P.** THE 'SOUTH AMERICAN' SHORT-FACED BEAR *ARCTOTHERIUM* FROM THE YUCATÁN PENINSULA OF BELIZE AND MEXICO: IMPLICATIONS FOR THEIR BIOGEOGRAPHY, PALEOBIOLOGY, EVOLUTION, AND EXTINCTION

B152 **Paterson, R. S., Rybczynski, N., Kohno, N., Maddin, H. C.** A COMPLETE DESCRIPTION AND PHYLOGENETIC ANALYSIS OF *PUIJILA DARWINI*, A TRANSITIONAL PINNIPED FROM THE CANADIAN HIGH ARCTIC

B153 **Garibay, A., Parham, J. F., Velez-Juarbe, J.** NEW SPECIES OF THE STEM SEAL *ALLODESMUS* FROM THE MIDDLE MIOCENE TOPANGA FORMATION OF ORANGE COUNTY

B154 **Tonomori, W., Sawamura, H., Sato, T., Kohno, N.** NEW SKELETAL MATERIAL OF THE EXTINCT MIOCENE PINNIPED *ALLODESMUS* FROM JAPAN INDICATES THEIR NEW SYSTEMATICS AND LOCOMOTORY ADAPTATION

B155 **Nagatsuka, M., Kohno, N.** FIRST RECORD OF *PROTEROZETES ULYSSES* (CARNIVORA, OTARIIDAE) FROM THE WESTERN NORTH PACIFIC, AND ITS IMPLICATIONS FOR PALEOBIOGEOGRAPHY OF THE PLEISTOCENE OTARIID PINNIPEDS IN THE NORTH PACIFIC

B156 **Shabazi, S., Magallanes, I., Parham, J. F., Boessenecker, R. W.** FOSSIL WALRUS SKULLS FROM THE EMPIRE FORMATION OF OREGON REPRESENT A NEW LINEAGE FROM THE LATE MIOCENE AND SUPPORT A SIGNIFICANT LATE MIOCENE RADIATION OF ODOBENIDS

B157 **Govender, R., Avery, G.** CARNIVORE DAMAGE ON SEAL FOSSILS FROM LANGEBAANWEG, WEST COAST OF SOUTH AFRICA

B158 **Damron, B. M., Kallamata, E., Hartnett, M. M., Dewar, E. W.** ORBITAL MORPHOLOGY AND OPTIC CANAL SIZE DISTINGUISHES DIEL ACTIVITY PATTERN IN CARNIVORANS

B159 **Brewer, P., Archer, M., Hand, S.** NEW WOMBATS FROM RIVERSLEIGH, NORTHWESTERN QUEENSLAND, INCLUDE POUCH YOUNG

B160 **Spradley, J. P., Kay, R. F.** HOMOLOGY-FREE DENTAL TOPOGRAPHY MEASURES CAN DISTINGUISH DIETARY CATEGORIES IN MARSUPIALS

B161 **Rubinstein, J., Desantis, L.** DIETARY ECOLOGY OF DIPROTODONTIDS FROM SAHUL

B162 **Boyd, C. A., Person, J. J.** NEW ADDITIONS TO THE LANCIAN MAMMALIAN FAUNA FROM SOUTHWEST NORTH DAKOTA

B163 **Miyata, K., Azuma, Y., Luo, Z.** FIRST ARTICULATED MULTITUBERCULATE SKELETON FROM THE LOWER CRETACEOUS KITADANI FORMATION (TETORI GROUP), FUKUI, JAPAN

B164 **Harper, T., Hu, H., Passey, B.** CARBON ISOTOPE COMPOSITIONS OF *KRYPTOBAATAR* ENAMEL AND ECOLOGICALLY WIDESPREAD ^{13}C ENRICHMENT IN UPPER CRETACEOUS MONGOLIA

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FRIDAY, OCTOBER 28, 2016
POSTER SESSION III (CONTINUED)

B165 **Krause, D. W., Hu, Y., Hoffmann, S., Groenke, J. R., Schultz, J. A., Von Koenigswald, W.** THE BIZARRE DENTAL MORPHOLOGY OF A NEW GONDWANATHERIAN MAMMAL FROM THE LATE CRETACEOUS OF MADAGASCAR

B166 **Plogschties, T., Martin, T.** A FIRST APPROACH TO EVALUATE SYMMETRODONT MASTICATION

B167 **Wings, O., Martin, T., Schwermann, A.** THE TERRESTRIAL VERTEBRATE ASSEMBLAGE OF LANGENBERG QUARRY (LOWER SAXONY, NORTHERN GERMANY): A GLIMPSE OF A LATE JURASSIC ISLAND ECOSYSTEM

SATURDAY MORNING, OCTOBER 29, 2016
PODIUM SYMPOSIUM III: RECENT ADVANCES IN UNDERSTANDING THE ORIGINS AND EVOLUTION OF TETRAPOD ENDOTHERMY
GRAND AMERICA HOTEL, IMPERIAL BALLROOM AB
MODERATORS: Adam K. Huttenlocker and Colleen G. Farmer

8:00 **Bakker, R. T., Zoehfeld, K. W., Temple, D., Flis, C.** ENDOTHERMY ACQUIRED: TRACKS AND PRODUCTIVITY EFFICIENCY SHOW ELEVATED ENERGY CONSUMPTION DURING ORIGIN OF DINOSAURS AND ADVANCED THERAPSIDS

8:15 **Knaus, P. L., Sander, P., Van Heteren, A. H., Lungmus, J. K.** BLOOD FLOW INDEX OF BASAL EUPELYCOSAURIA SUGGESTS ELEVATED METABOLIC RATES SINCE THE CARBONIFEROUS

8:30 **Shelton, C. D., Chinsamy-Turan, A.** POSTCRANIAL BONE HISTOLOGY OF DINOCEPHALIANS (THERAPSIDA) REVEALS PERIODIC RAPID RATES OF BONE DEPOSITION AND EVIDENCE OF A PATHOLOGY IN A TITANOSUCHID

8:45 **Seymour, R. S.** THE HOLES IN THE FOSSIL RECORD: FEMORAL NUTRIENT FORAMINA REVEAL THE ANTIQUITY OF ENDOTHERMY IN ARCHOSAURS, AND THE CONSEQUENCES OF REVERSION TO ECTOTHERMY WITHIN THE CROCODYLIAN LINEAGE

9:00 **Crompton, A. W., Owerkowicz, T., Bhullar, B. S., Musinsky, C.** ORIGIN OF THE DUAL FUNCTION OF RESPIRATORY TURBINATES IN MAMMALS

9:15 **Sander, P., Hayashi, S., Houssaye, A., Nakajima, Y., Sato, T., Wintrich, T.** THE INDEPENDENT EVOLUTION OF ENDOTHERMY IN PLESIOSAURIA: EVIDENCE FROM THEIR UNIQUE LONG BONE HISTOLOGY

9:30 **Legendre, L. J., Guénard, G., Botha-Brink, J., Cubo, J.** ENDOTHERMIC ARCHOSAURS? THE USE OF BONE HISTOLOGY IN PHYLOGENETIC RETRODICTIONS

9:45 **Tattersall, G. J.** FACULTATIVE THERMOGENESIS IN TEGU LIZARDS PROVIDES METABOLIC SUPPORT FOR THE PARENTAL CARE MODEL OF ENDOTHERMY

10:00 **BREAK**

SATURDAY MORNING, OCTOBER 29, 2016
TECHNICAL SESSION XV
GRAND AMERICA HOTEL, IMPERIAL BALLROOM AB
MODERATORS: Matt Lamanna and Christopher Griffin

10:15 **McPhee, B. W., Bordy, E. M., Sciscio, L., Choiniere, J. N.** A REVISED SAUROPODOMORPH-BASED BIOSTRATIGRAPHY OF THE ELLIOT FORMATION, LATE TRIASSIC–EARLY JURASSIC, SOUTH AFRICA

SATURDAY MORNING, OCTOBER 29, 2016
TECHNICAL SESSION XV (CONTINUED)

10:30 **Lamanna, M. C., Martínez, R. D., Novas, F. E., Ridgely, R. C., Casal, G. A., Witmer, L. M.** ANATOMY, PHYLOGENY, AND PALEOBIOLOGY OF *SARMIENTOSAURUS MUSACCHIOI*, A TITANOSAURIAN SAUROPOD DINOSAUR FROM THE UPPER CRETACEOUS OF CENTRAL PATAGONIA, ARGENTINA

10:45 **Fronimos, J. A., Wilson, J. A.** COMPLEX, INTERDIGITATED SUTURES WITHIN SAUROPOD VERTEBRAE PROVIDED STABILITY IN SUPPORT OF LONG, HEAVY NECKS

11:00 **Gorscak, E.** CHARACTERIZING AFRICAN CRETACEOUS CONTINENTAL FAUNAS: PALEOBIOGEOGRAPHICAL PATTERNS AND NEW INSIGHTS FROM SUB-SAHARAN AFRICAN TITANOSAURIAN SAUROPOD DINOSAURS

11:15 **Upchurch, P., Mannion, P., Poropat, S. F.** MAXIMUM LIKELIHOOD ESTIMATION OF TITANOSAURIFORM SAUROPOD BIOGEOGRAPHIC HISTORY IN THE LATE CRETACEOUS

11:30 **Barrett, P. M., Lautenschlager, S., Brassey, C., Button, D. J.** COMPARATIVE BIOMECHANICS OF 'UNSPECIALISED' DINOSAUR HERBIVORES: CONVERGENT MORPHOLOGY DOES NOT PREDICT CRANIAL FUNCTION

11:45 **Yang, T., Van Heteren, A., Wiemann, J., Chen, C., Spiering, B.** COMMUNAL NESTING BEHAVIOR OF DINOSAURS REVEALED BY STATISTICAL ANALYSES OF PHOSPHORUS DISTRIBUTION IN, AND EXTERNAL MORPHOLOGY OF, EGGSHELLS

12:00 **Griffin, C., Nesbitt, S. J.** ANOMOLOUSLY HIGH VARIATION IN ONTOGENY IS THE ANCESTRAL DINOSAURIAN GROWTH CONDITION

SATURDAY MORNING, OCTOBER 29, 2016
TECHNICAL SESSION XVI
GRAND AMERICA HOTEL, IMPERIAL BALLROOM CD
MODERATORS: Catherine Badgley and Anna Behrensmeyer

8:00 **Hopkins, S. S., Davis, E. B., Theodor, J. M., Famoso, N. A., Mclaughlin, W. N., Reuter, D., Perdue, G., Oberg, D., Biedron, E., Walters, K.** APPLICATION OF QUANTITATIVE BIOSTRATIGRAPHIC METHODS TO THE RECORD OF TERRESTRIAL VERTEBRATES: CAN WE GAIN NEW INSIGHTS?

8:15 **Badgley, C., Smiley, T. M., Holt, W. E., Rasbury, E. T.** GREAT BASIN MAMMAL DIVERSITY AND TECTONIC HISTORY

8:30 **Calede, J. J.** QUANTITATIVE BIOSTRATIGRAPHY AND FAUNAL TURNOVER OF THE ARIKAREEAN-AGED CABBAGE PATCH BEDS OF WESTERN MONTANA (RENOVA FORMATION)

8:45 **Famoso, N. A., Samuels, J. X., Hopkins, S. S., Davis, E. B., Emery, M.** UPDATED BIOSTRATIGRAPHY OF THE TURTLE COVE MEMBER (JOHN DAY FORMATION) IN THE JOHN DAY BASIN, OREGON

9:00 **Manthi, F. K., Plavcan, J., Ward, C. V.** THE PALEOECOLOGY OF THE PLIOCENE SITE OF KANAPOI, NORTHWESTERN KENYA

9:15 **Villaseñor, A., Behrensmeyer, A. K., Bobe, R.** SPATIAL VARIATION IN PLIOCENE PALEOHABITATS IN THE TURKANA BASIN, KENYA: IMPLICATIONS FOR LARGE-MAMMAL PALEOCOMMUNITY ASSEMBLY

9:30 **Du, A., Behrensmeyer, A. K., Bobe, R.** APPLYING THE ECOLOGICAL CORE–TRANSIENT SPECIES PARADIGM TO PLIO–PLEISTOCENE FOSSIL MAMMALS IN THE OMO–TURKANA BASIN, EAST AFRICA

SATURDAY MORNING, OCTOBER 29, 2016
TECHNICAL SESSION XVI (CONTINUED)

9:45 **Dumouchel, L.** PALEOECOLOGICAL ANALYSES OF FOSSIL BOVIDAE FROM PLIOCENE HOMININ SITES FROM THE OMO-TURKANA BASIN, EASTERN AFRICA

10:00 **BREAK**

10:15 **Behrensmeyer, A. K., Du, A., Villasenor, A., Patterson, D., Hatala, K., Roach, N. T., Richmond, B. G., Bobe, R.** BODY FOSSILS, TRACKWAYS AND STABLE ISOTOPES: SYNTHESIZING PLEISTOCENE PALEOECOLOGY IN THE OKOTE MEMBER, KOOBI FORA FORMATION, KENYA

10:30 **Robinson, J. R.** THINKING LOCALLY: SPATIAL AND TEMPORAL VARIATION IN LATE QUATERNARY PALEOENVIRONMENTS OF SUB-SAHARAN AFRICA INFERRED FROM UNGULATE ISOTOPIC ECOLOGY

10:45 **Jukar, A. M.** TURNOVER OF LARGE HERBIVOROUS MAMMALS IN THE INDIAN SUBCONTINENT DURING THE PLIO-PLEISTOCENE

11:00 **Deng, T., Wang, X., Li, Q., Tseng, Z., Hou, S.** QUATERNARY FAUNAL REPLACEMENT IN NORTHERN CHINA BY PLIOCENE MAMMALS FROM THE TIBETAN PLATEAU

11:15 **Mclaughlin, W. N., Hopkins, S. S., Davis, E. B.** TAPHONOMY OF NEWLY DISCOVERED NEOGENE MASS DEATH ASSEMBLAGES IN KOCHKOR BASIN, KYRGYZSTAN

11:30 **Zazula, G. D., Macphee, R. D., Hall, E., Southon, J.** NORTHWARD DISPERSAL OF LARGE MAMMALS INTO THE ARCTIC AND SUBARCTIC DURING THE LAST INTERGLACIATION (SANGAMONIAN)

11:45 **Stegner, M.** FLUCTUATION IN SMALL MAMMAL COMMUNITY STRUCTURE DURING THE LATE HOLOCENE IN SOUTHEASTERN UTAH

12:00 **Pineda-Munoz, S., Jukar, A. M., Ete Working Group, Lyons, S. K.** HUMAN IMPACT ON NORTH AMERICAN MAMMAL FAUNAS

SATURDAY MORNING, OCTOBER 29, 2016
TECHNICAL SESSION XVII
GRAND AMERICA HOTEL, GRAND BALLROOM A
MODERATORS: Patrick Druckenmiller and Judy Massare

8:00 **Metz, E. T., Druckenmiller, P. S., Carr, G.** CRANIAL ANATOMY OF A NEW SPECIES OF THALATTOSAUR BASED ON THREE DIMENSIONAL MATERIAL FROM THE CARNIAN VESPER FORMATION OF CENTRAL OREGON

8:15 **Druckenmiller, P. S., Kelley, N., Baichtal, J., May, K., Metz, E.** AN EXCEPTIONAL NEW THALATTOSAUR (REPTILIA) FROM THE UPPER TRIASSIC (NORIAN) HOUND ISLAND VOLCANICS OF SOUTHEASTERN ALASKA

8:30 **Jiang, D., Motani, R., Tintori, A., Rieppel, O. C., Fraser, N. C.** A LARGE EARLY TRIASSIC ICHTHYOSAURIFORM FROM CHAOHU OF SOUTH CHINA AND FAST RADIATION OF MARINE REPTILES IN THE WAKE OF THE END-PERMIAN EXTINCTION

8:45 **Zhou, M., Jiang, D., Motani, R., Sun, Z., Ji, C.** A THREE-DIMENSIONAL SKULL OF *CHAOHUSAURUS* (REPTILIA, ICHTHYOPTERYGIA) FROM THE LOWER TRIASSIC OF ANHUI, CHINA

9:00 **Wolniewicz, A. S., Motani, R., Morrison, I., Benson, R. B.** A LARGE MACROPREDATORY ICHTHYOSAUR FROM THE LATE TRIASSIC OF WILLISTON LAKE (BRITISH COLUMBIA, CANADA) INDICATES HIGH ECOLOGICAL DIVERSITY OF BASAL PARVIPELVIA

SATURDAY MORNING, OCTOBER 29, 2016

TECHNICAL SESSION XVII (CONTINUED)

9:15 **Kelley, N. P., Irmis, R., Rasmussen, C., Depolo, P. E., Pyenson, N.** BEYOND THE *SHONISAURUS* DEATH CULT: NEW INSIGHTS INTO THE ECOLOGY AND LIFE HISTORY OF THE EARLIEST GIGANTIC MARINE TETRAPOD

9:30 **Lawrence Wujek, J.** WHAT MAKES AN *ICHTHYOSAURUS*? A MORPHOMETRIC AND PHYLOGENETIC ANALYSIS OF THE CLASSIC LOWER JURASSIC GENUS

9:45 **Massare, J. A., Lomax, D. R., Mistry, R. T.** THE RETURN OF *PROTOICHTHYOSAURUS*: A VALID SISTER TAXON OF *ICHTHYOSAURUS* (REPTILIA, ICHTHYOSAURIA)

10:00 **BREAK**

10:15 **Stubbs, T. L., Benton, M. J.** MORPHOLOGICAL DIVERSIFICATION DRIVES ADAPTIVE RADIATION IN SAUROPTERYGIAN MARINE REPTILES

10:30 **Wang, W., Li, C., Wu, X.** AN ADULT SPECIMEN OF *SINOCYAMODUS XINPUENSIS* (SAUROPTERYGIA: PLACODONTIA), WITH NEW INFORMATION ON CYAMODONTOID ONTOGENY

10:45 **Motani, R., Jiang, D., Rieppel, O. C., Xue, Y., Tintori, A.** TESTING SEXUAL SELECTION OF FOSSIL VERTEBRATES WITH SEXUAL SIZE DIMORPHISM AND ADULT SEX RATIO, WITH AN EXAMPLE OF *KEICHOUSAURUS HUI* (REPTILIA, SAUROPTERYGIA)

11:00 **Roberts, A. J., Druckenmiller, P. S., Delsett, L. L., Cordonnier, B., Hurum, J. H.** THE CRANIAL ANATOMY OF A NEW CRYPTOCLIDIDS PLESIOSAUR FROM THE JURASSIC–CRETACEOUS BOUNDARY OF CENTRAL SPITSBERGEN, SVALBARD, NORWAY

11:15 **Muscutt, L. E., Dyke, G., Ganapathisubramani, B., Weymouth, G. D., Palmer, C.** WHY DID PLESIOSAURS HAVE FOUR FLIPPERS? AN EXPERIMENTAL APPROACH

11:30 **Wintrich, T., Sander, P. M.** THE FUNCTION OF THE PLESIOSAUR NECK—A SMART INVENTION FOR THE AQUATIC ENVIRONMENT

11:45 **Neenan, J. M., Benson, R. B.** THE EVOLUTION OF INNER EAR MORPHOLOGY IN SAUROPTERYGIA

12:00 **Driscoll, D. A., Dunhill, A. M., Stubbs, T. L., Benton, M. J.** FOSSIL COMPLETENESS IN UPPER CRETACEOUS MARINE REPTILES

SATURDAY AFTERNOON, OCTOBER 29, 2016

TECHNICAL SESSION XVIII

GRAND AMERICA HOTEL, IMPERIAL BALLROOM AB

MODERATORS: Derek Larson and Alexander Dececchi

1:45 **Fabbri, M., Pritchard, A., Hanson, M., Mongiardino, N. K., Hoffman, E., Balanoff, A., Bever, G., Norell, M. A., Abzhanov, A., Bhullar, B. S.** SKULL ROOF AND BRAIN INTERRELATIONSHIP: MACROEVOLUTIONARY AND DEVELOPMENTAL PROSPECTIVES

2:00 **Marsh, A. D., Parker, W. G., Langer, M. C., Nesbitt, S. J.** AN ANATOMICAL AND PHYLOGENETIC REVISION OF *CHINDESAURUS BRYANSMALLI* FROM PETRIFIED FOREST NATIONAL PARK AND ITS IMPLICATION FOR THE LATE TRIASSIC DINOSAURIAN RECORD OF NORTH AMERICA

2:15 **Carrano, M. T., Rauhut, O. W.** THE THEROPOD DINOSAUR *ELAPHROSAURUS BAMBERGI* JANENSCH, 1920, FROM THE LATE JURASSIC OF TENDAGURU, TANZANIA

2:30 **Wang, S., Stiegler, J., Amiot, R., Clark, J. M., Balanoff, A. M., Xu, X.** CRANIAL ONTOGENETIC VARIATION IN THE LATE JURASSIC CHINESE CERATOSAUR *LIMUSAURUS INEXTRICABILIS*

SATURDAY AFTERNOON, OCTOBER 29, 2016
TECHNICAL SESSION XVIII (CONTINUED)

2:45 **Smith, D. K., Sanders, R., Wedel, M. J., Wolfe, D. G.** BASICRANIAL AND VERTEBRAL PNEUMATICITY IN THERIZINOSAURS: IMPLICATIONS FOR DEVELOPMENT AND FUNCTION

3:00 **Choiniere, J. N., Tan, Q., Benson, R. B., Clark, J. M., Sullivan, C., Tan, L., Xu, X.** TWO NEW EARLY CRETACEOUS ALVAREZSAURIANS AND CONSERVED PATTERNS OF FORELIMB REDUCTION IN THEROPODS

3:15 **Holtz, T. R.** EVOLUTION OF POTENTIAL CURSORIAL ADAPTATIONS IN MESOZOIC THEROPODA: PHYLOGENETIC, GEOCHRONOLOGIC, AND BIOGEOGRAPHIC DISTRIBUTIONS

3:30 **Dececchi, A., Holtz, T. R., Larsson, H. C., Habib, M.** NOT SO FAST: A RE-EVALUATION OF CURSORIALITY IN THEROPODS

3:45 **Bykowski, R. J., Polly, P.** ECOLOGICAL ONTOGENY AND FUNCTIONAL CHANGES IN THE GROWTH OF TYRANNOSAUROIDS

4:00 **Larson, D. W., Brown, C. M., Therrien, F., Evans, D. C.** SUB-MILLION YEAR EVOLUTIONARY PATTERNS IN SMALL THEROPOD DINOSAUR LINEAGES CORRESPOND TO PERIODS OF CLIMATIC CHANGE IN THE LATE CRETACEOUS

SATURDAY AFTERNOON, OCTOBER 29, 2016
TECHNICAL SESSION XIX
GRAND AMERICA HOTEL, IMPERIAL BALLROOM CD
MODERATORS: Michelle Spaulding and David Grossnickle

1:45 **Schultz, J. A., Zeller, U., Luo, Z.** THE ANATOMY OF THE MEMBRANOUS LABYRINTH OF MONOTREMES AND IMPLICATIONS FOR THE EVOLUTION OF THE MAMMALIAN INNER EAR

2:00 **Brannick, A. L., Wilson, G. P., Varricchio, D. J., Ekdale, E. G.** NESTLED AMONG DINOSAUR EGGS: NEW *ALPHADON* SPECIMENS FROM EGG MOUNTAIN AND THEIR IMPLICATIONS FOR METATHERIAN EVOLUTION

2:15 **Grossnickle, D. M.** INCREASED TRANSVERSE JAW MOVEMENT DURING MASTICATION WAS A CRITICAL EVOLUTIONARY CHANGE IN EARLY MAMMALS

2:30 **Jäger, K. R., Gill, P., Corfe, I. J., Martin, T.** 3D ANALYSIS OF THE CHEWING CYCLE AND DENTAL OCCLUSION OF *MORGANUCODON WATSONI*

2:45 **Mao, F., Wang, Y., Bi, S., Meng, J.** TOOTH ENAMEL MICROSTRUCTURES OF THREE JURASSIC EUHARAMIYIDANS AND IMPLICATIONS FOR PRISM EVOLUTION IN ALLOTHERIAN MAMMALS

3:00 **Huttenlocker, A. K., Grossnickle, D. M., Schultz, J. A., Kirkland, J. I., Luo, Z.** A LATE-SURVIVING STEM MAMMAL FROM THE CRETACEOUS OF UTAH

3:15 **Cohen, J., Cifelli, R.** EMERGENCE OF THERIAN MAMMAL GROUPS IN THE LATE CRETACEOUS OF NORTH AMERICA: NEW EVIDENCE FROM THE TURONIAN OF UTAH

3:30 **Spaulding, M., Shine, H.** EXAMINING THE ORIGIN OF PLACENTAL MAMMALS VIA 'PSEUDO-FOSSILIZATION'

3:45 **Bonnan, M. F., Shulman, J., Horner, A., Brainerd, E.** WHAT CAN RAT FORELIMB MOVEMENTS TEACH US ABOUT EARLY EUTHERIAN MAMMAL LOCOMOTOR HABITS?

4:00 **Webb, N. M.** TAKING IT A STEP FURTHER: THE ASSESSMENT OF STRIDING BIPEDALISM IN EXTINCT KANGAROOS

SATURDAY AFTERNOON, OCTOBER 29, 2016

TECHNICAL SESSION XX

GRAND AMERICA HOTEL, GRAND BALLROOM A

MODERATORS: Hillary Maddin and Jason Pardo

1:45 **Maddin, H. C., Scott, D., Skilliter, D., Grey, M., Adams, K., Reisz, R. R.** AN EXQUISITELY PRESERVED, NEW EUCACOPINE DISSOROPHID (TEMNOSPONDYLI) FROM THE CARBONIFEROUS OF NOVA SCOTIA, CANADA

2:00 **Rasmussen, C., Huttenlocker, A. K., Irmis, R.** A NEW SPECIES OF *ERYOPS* FROM THE LOWER PERMIAN CEDAR MESA SANDSTONE (CUTLER GROUP) OF SOUTHEASTERN UTAH AND ITS IMPLICATIONS FOR THE PHYLOGENY AND BIOGEOGRAPHY OF ERYOPIDS

2:15 **Atkins, J., Reisz, R. R., Fröbisch, N. B., Maddin, H. C.** EARLY PERMIAN AMPHIBAMID *PASAWIOOPS* (DISSOROPHOIDEA, AMPHIBAMIDAE): AN ONTOGENETIC SERIES

2:30 **Carter, A. M., Sallan, L., Hsieh, T., Dodson, P.** JUST HOW DIFFERENT? QUANTIFYING VERTEBRAL DIVERSITY IN TEMNOSPONDYLS

2:45 **Pardo, J. D., Small, B. J., Huttenlocker, A. K.** A CAECILIAN-LIKE TEMNOSPONDYL FROM THE TRIASSIC CHINLE FORMATION OF COLORADO AND ITS BEARING ON THE ORIGINS OF LISSAMPHIBIA

3:00 **Marjanović, D.** TEMNOSPONDYLS, LISSAMPHIBIANS, AND MIDDLE EARS

3:15 **Tarailo, D. A.** TEMNOSPONDYL ECOMORPHOLOGICAL DIVERSITY ACROSS THE PERMIAN–TRIASSIC BOUNDARY IN THE KAROO BASIN, SOUTH AFRICA

3:30 **Beightol, C. V., Sidor, C. A., Steyer, J., Smith, R., Peecook, B., Huttenlocker, A. K.** WERE GONDWANAN TEMNOSPONDYLS MORE ENDEMIC THAN CONTEMPORANEOUS AMNIOTES DURING THE PERMIAN AND TRIASSIC?

3:45 **Mercier, G. K., Demar, D. G., Wilson, G. P.** ANURANS, CAUDATES, AND ALBANERPETONTIDS (LISSAMPHIBIA) REVEAL DIFFERENTIAL PATTERNS OF TURNOVER AND EXTINCTIONS DURING THE END-CRETACEOUS MASS EXTINCTION, NORTHEASTERN MONTANA, USA

4:00 **Henrici, A. C., Druschke, P., Bonde, J., Hilton, R. P., Snell, K.** *EORUBETA NEVADENSIS* REVEALED: NEW SPECIMENS OF THIS ENIGMATIC ANURAN FROM THE LATE CRETACEOUS–MIDDLE EOCENE SHEEP PASS FORMATION OF EASTERN NEVADA SHED LIGHT ON ITS PHYLOGENETIC POSITION

SATURDAY, OCTOBER 29, 2016

POSTER SESSION IV

GRAND AMERICA HOTEL, IMPERIAL BALLROOM FOYER

Authors must be present from 4:15 – 6:15 p.m.

Posters must be removed by 6:30 p.m.

Posters Associated with Symposium III: Recent Advances in Understanding the Origins and Evolution of Tetrapod Endothermy

IB1 **Grady, J. M.** ASSESSING THE ECOLOGICAL AND EVOLUTIONARY DRIVERS OF ENDOTHERMY

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IB2 **Owerkowicz, T., Felbinger, K. L., Eme, J., Blank, J. M., Hicks, J. W.** NUTRIENT FORAMEN SIZE DOES NOT PREDICT EXERCISE OR GROWTH PHYSIOLOGY IN AN EXPERIMENTAL ARCHOSAUR MODEL WITH IN-PARALLEL AND IN-SERIES CIRCULATION

EXHIBIT HALL GRAND BALLROOM

Regular Session Posters

B70 **Spencer, M. R.** ESTIMATING THE ANCESTRAL MORPHOLOGY OF MAJOR ORNITHISCHIAN CLADES IN A SPATIOTEMPORAL CONTEXT

B71 **Morgan, K., Kirkland, J. I., Suarez, C. A., Pittman, J.** FIRST OCCURRENCE OF AN ARKANSAS ANKYLOSAUR

B72 **Buskuskie, T. R., Wilson, L. E.** OSTEOHISTOLOGY OF *NIOBRARASAURUS COLEII* (DINOSAURIA, NODOSAURIDAE)

B73 **Burns, M. E., Ebersole, J. A.** JUVENILE APPALACHIAN NODOSAUR MATERIAL (NODOSAURIDAE, ANKYLOSAURIA) FROM THE LOWER CAMPANIAN LOWER MOOREVILLE CHALK OF ALABAMA

B74 **Penkalski, P.** DOUBLE OR NOTHING: AN ANKYLOSAURID RIOT IN NORTHERN LARAMIDIA, WITH NEW DATA ON CERVICAL ARMOUR MORPHOLOGY AND DISPLAYS

B75 **Hill, R. V., Demic, M., Bever, G., Norell, M. A.** ONTOGENETIC ENDPOINTS AND TAXONOMIC IDENTITIES OF ANKYLOSAURID DINOSAURS FROM THE DJADOKHTA FORMATION OF SOUTHERN MONGOLIA

B76 **Tumanova, T., Penkalski, P.** THE LAST ANKYLOSAURID FROM ASIA: *TARCHIA* OR *SAICHANIA*?

B77 **Zanno, L. E., Makovicky, P. J.** A NEW SPECIES OF EARLY DIVERGING ORNITHOPOD INCREASES THE PALEOBIODIVERSITY OF HERBIVOROUS DINOSAURS IN LATE CRETACEOUS ECOSYSTEMS IN NORTH AMERICA

B78 **Poole, K.** A SPECIMEN-LEVEL PHYLOGENY OF WEALDEN IGUANODONTIANS: IMPLICATIONS FOR TAXONOMY

B79 **Knoll, F., Lautenschlager, S., Rayfield, E. J., Espílez, E., Mampel, L., Alcalá, L.** PALEONEUROLOGY OF THE SPANISH IGUANODONT *PROA VALDEARINNOENSIS*

B80 **Shibata, M., Kawabe, S., Chokchaloemwong, D., Jintasakul, P., Miyata, K., Azuma, Y.** ENDOCRANIAL ANATOMY OF *SIRINDHORNA KHORATENSIS* (ORNITHOPODA, HADROSAUROIDEA) AND ITS IMPLICATION

B81 **Fiorillo, A. R., Tykoski, R. S.** MANUS AND PES JUVENILE HADROSAUR TRACKS (LOWER CANTWELL FORMATION, UPPER CRETACEOUS, DENALI NATIONAL PARK, ALASKA): IMPLICATIONS FOR BODY ORIENTATION IN JUVENILE HADROSAURS

B82 **Bramble, K. K., Currie, P. J.** A RARE ABNORMALITY IN A HADROSAUR DENTAL BATTERY FROM THE DINOSAUR PARK FORMATION (UPPER CAMPANIAN) OF ALBERTA, CANADA

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B83 **Lowi-Merri, T. M., Evans, D. C.** MORPHOMETRIC AND BIOSTRATIGRAPHIC ANALYSIS OF CRANIAL VARIATION IN *GRYPOSAURUS* (ORNITHISCHIA, HADROSAURIDAE) FROM THE DINOSAUR PARK FORMATION (CAMPANIAN)

B84 **Stein, K., Bolotski, Y., Bolotski, I., Snoeck, C., Dewinter, N., Tsogtbaatar, K., Barsbold, R., Hayashi, S., Godefroit, P., Claeys, P.** PRELIMINARY RESULTS ON THE BONE HISTOLOGY OF HADROSAURS FROM THE LATEST CRETACEOUS OF FAR EASTERN RUSSIA

B85 **Takasaki, R., Chiba, K., Kobayashi, Y., Currie, P. J.** OSTEOHISTOLOGICAL ONTOGENETIC ASSESSMENT AND PHYLOGENETIC ANALYSIS OF *NIPPONOSAURUS SACHALINENSIS* (DINOSAURIA, HADROSAURIDAE)

B86 **Siviero, B., Brand, L., Chadwick, A.** BONE MODIFICATIONS INDICATING PATHOLOGY WITHIN A MONOSPECIFIC HADROSAUR BONEBED FROM THE LANCE FORMATION (MAASTRICHTIAN), WYOMING

B87 **Zorigt, B., Horner, J. R.** INTRASKELETAL HISTOVARIABILITY IN THE HIND LIMB OF *PSITTACOSAURUS MONGOLIENSIS*

B88 **Varriale, F. J.** QUANTITATIVE DENTAL MICROWEAR SUPPORTS CLINOLINEAL MASTICATION IN *PSITTACOSAURUS* (ORNITHISCHIA, CERATOPSIA)

B89 **Morschhauser, E. M.** A NEW PHYLOGENETIC AND BIOGEOGRAPHIC ANALYSIS OF BASAL NEOCERATOPSIA (ORNITHISCHIA, DINOSAURIA) RECOVERS UNCERTAIN GEOGRAPHIC ORIGIN OF CERATOPSOIDEA

B90 **Malinowski, B. L., Rooney, L. A., Schein, J. P., Poole, J. C.** A NEW PARTIAL SKELETON OF *LEPTOCERATOPS GRACILIS* FROM THE LANCE FORMATION OF WYOMING, USA

B91 **Ryan, M. J., Chiba, K., Evans, D. C., Mallon, J., Fiorillo, A. R., Tykoski, R. S.** EVOLUTION OF PACHYROSTRAN CENTROSAURINES IN THE LATE CRETACEOUS OF NORTHERN LARAMIDIA

B92 **Chiba, K., Ryan, M. J., Loewen, M., Evans, D. C.** NEW MATERIAL OF THE CENTROSAURINE *MEDUSACERATOPS LOKII* (DINOSAURIA, ORNITHISCHIA) WITH IMPLICATIONS FOR POSTORBITAL HORNCORE SIZE EVOLUTION IN BASAL CERATOPSIDS

B93 **Wilson, J. P., Scannella, J. B.** COMPARATIVE CRANIAL OSTEOLOGY OF SUBADULT CENTROSAURINE DINOSAURS FROM THE TWO MEDICINE FORMATION, MONTANA

B94 **Scannella, J.** NEW INSIGHTS INTO THE EVOLUTION OF THE PREMAXILLA IN THE TRICERATOPSINI (CERATOPSIDAE, CHASMOSAURINAE) AS REVEALED BY A SPECIMEN FROM THE BASAL SANDSTONE OF THE HELL CREEK FORMATION, MONTANA

B95 **Bastiaans, D., Trapman, T., Guliker, M., Kaskes, P., Schulp, A. S.** MULTIGENERATIONAL ASSEMBLAGE OF *TRICERATOPS* FROM THE NEWCASTLE AREA, WYOMING, USA—AN IN-DEPTH ANALYSIS OF CRANIAL AND POST-CRANIAL ONTOGENESIS

B96 **Mears, E. M., Brusatte, S. L., Fraser, N. C.** CROCODILIAN CONTROVERSY: A RE-DESCRIPTION OF THE DEBATED TAXON *TERRESTRISUCHUS GRACILIS* AND ITS POSITION WITHIN BASAL CROCODYLOMORPHA

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SATURDAY, OCTOBER 29, 2016
POSTER SESSION IV (CONTINUED)

B97 **Trapman, T.** REDESCRIPTION OF A TELEOSAURID SKULL (CROCODYLOMORPHA, THALATTOSUCHIA) FROM THE LIASSIC OF HOLZMADEN, GERMANY

B98 **Yi, H., Young, M., Tennant, J. P., Hudson, J., Brusatte, S.** AN ENIGMATIC CROCODYLIFORM FROM THE MIDDLE JURASSIC OF SCOTLAND, UK, AND ITS IMPLICATIONS FOR THE EVOLUTIONARY TRANSITION FROM SMALL-BODIED NEOSUCHIANS TO EUSUCHIA

B99 **Hester, D. A., Brochu, C. A., Turner, A. H.** A RE-EVALUATION OF THE CROCODYLIFORM *BATRACHOMIMUS PASTOSBONENSIS* FROM THE LATE JURASSIC OF BRAZIL: IMPLICATIONS FOR NEOSUCHIAN PHYLOGENY, BIOGEOGRAPHY, AND DIVERGENCE TIMING

B100 **Salih, K. O., Evans, D., Bussert, R., Klein, N., Nafi, M., Eisawi, A., Mueller, J.** A NEW LONG-SNOUTED DYROSAURID (MESOEUCROCODYLIA) FROM THE LATE CRETACEOUS OF NORTH CENTRAL SUDAN

B101 **Kuzmin, I., Skutschas, P.** A REVIEW OF THE LARGE NEOSUCHIAN *KANSAJSUCHUS* (CROCODYLIFORMES, NEOSUCHIA) FROM THE LATE CRETACEOUS OF ASIA

B102 **Geroto, C. F.** TESTING THE PALEOBIOGEOGRAPHICAL HISTORY OF MESOEUCROCODYLIA (CROCODYLOMORPHA, CROCODYLIFORMES) USING RASP (RECONSTRUCT ANCESTRAL STATE IN PHYLOGENIES) SOFTWARE

B103 **Saber, S., Sertich, J., Sallam, H., Ouda, K., O'Connor, P. M.** ENIGMATIC CROCODYLIFORM REMAINS FROM THE UPPER CRETACEOUS QUSEIR FORMATION OF DAKHLA OASIS, WESTERN DESERT, EGYPT

B104 **Crawford, D. S., Evans, D. C., Brochu, C. A.** A NEW RECORD OF A LARGE GAVIALOID (CROCODYLIA) FROM THE HELL CREEK FORMATION (UPPER CRETACEOUS) OF SOUTH DAKOTA, USA

B105 **Adams, A. J., Brochu, C. A.** A REASSESSMENT OF THE LATE EOCENE–EARLY OLIGOCENE CROCODYLIDS *"CROCODYLUS" MEGARHINUS* AND *"CROCODYLUS" ARTICEPS* FROM THE FAYUM PROVINCE, EGYPT

B106 **Cossette, A. P., Brochu, C. A.** A NEW ALLIGATOROID FROM THE EARLY PALEOGENE BLACK PEAKS FORMATION OF TEXAS

B107 **Brochu, C. A.** PHYLOGENETIC RESPONSE TO ENVIRONMENTAL CHANGE IN NEOGENE AND QUATERNARY CROCODYLIANS FROM THE VICTORIA AND TURKANA BASINS OF KENYA

B108 **Scheyer, T. M., Delfino, M.** LATE MIOCENE CAIMANINES (CROCODYLIA, ALLIGATOROIDEA) FROM THE URUMACO FORMATION, VENEZUELA

B109 **Farrugia, P., Polly, P., Njau, J.** AN ANALYSIS OF SHAPE DIFFERENCES IN CROCODYLIAN DENTITION USING GEOMETRIC MORPHOMETRICS

B110 **English, L. T.** WHY GROW ARMOR AFTER THE PREDATORS ARE GONE? LATE ONTOGENETIC DEVELOPMENT OF CROCODILIAN OSTEODERMS WITH BEHAVIORAL IMPLICATIONS

B111 **Wilberg, E., Brochu, C. A.** EXPLORING THE EVOLUTIONARY STRUCTURE AND TIMING OF MAJOR HABITAT SHIFTS IN CROCODYLOMORPHA

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B112 **Fisher, C., Sweetman, M., Snively, E.** THE CROCODYLIAN SECONDARY PALATE DIRECTLY FACILITATES DUROPHAGY IN CONCERT WITH TENSED LIGAMENTS

B113 **Stockdale, M., Bronzati, M., Andrade, M., Benton, M. J.** MACROEVOLUTION OF THE CROCODYLOMORPHA

B114 **Figueiredo, R. G., Pinheiro, A. E., Rodrigues, T., Leite, Y. L., Campos, D. A., Kellner, A. W.** NOTES ON THE BASICRANIUM, OCCIPUT, AND BRAINCASE ANATOMY OF *SAHITISUCHUS FLUMINENSIS* (CROCODYLIFORMES, NOTOSUCHIA) AND ITS PHYLOGENETIC IMPLICATIONS

B115 **Farlow, J. O., Robinson, N. J., Kumagai, C. J., Paladino, F. V., Falkingham, P. L., Martin, A. J., Elsey, R. M.** TRACKWAYS OF THE AMERICAN CROCODILE (*CROCODYLUS ACUTUS*), NORTHWEST COSTA RICA: IMPLICATIONS FOR ARCHOSAURIAN ICHNOLOGY

B116 **Drumheller, S. K., Vliet, K. A., Darlington, J.** THE CROCODYLIAN DEATH ROLL: THE UTILITY OF MULTIPLE MODERN ANALOGUES IN PALEONTOLOGICAL RESEARCH OF BEHAVIOR

B117 **Beardmore, S. R.** AN INVESTIGATION OF THE IMPACT OF BODY SIZE ON SKELETAL PRESERVATION USING THE ICHTHYOSAUR *STENOPTERYGIUS*

B118 **Zhang, Q., Wang, J., Lin, W.** A 3D PRELIMINARY RECONSTRUCTION OF THE SKULL OF *LARIOSAURUS HONGGUOENSIS* (REPTILIA, SAUROPTERYGIA) BASED ON MICRO-COMPUTED TOMOGRAPHIC DATA

B119 **He, S., Lin, W.** MATURATION AND GROWTH PATTERN OF *KEICHOUSAURUS HUI* (REPTILIA, SAUROPTERYGIA) REVEALED BY LONG BONE HISTOLOGY AND GROWTH CURVE

B120 **Wang, J., He, S., Lin, W.** NEW INFORMATION ON SOCIAL BEHAVIOR IN *KEICHOUSAURUS HUI*, A PACHYPLEUROSAUR FROM THE MIDDLE TRIASSIC OF GUIZHOU, SOUTH CHINA

B121 **Wildman, M., Graham, M. R., Harrington, C., Nicklin, C., Tranter, S. J., Moore-Fay, S., Wills, S., Middleton, H., Benson, R. B., Ketchum, H. F.** AN IMPORTANT PLESIOSAUR DISCOVERY FROM THE OXFORD CLAY: HOW COOPERATION BETWEEN SCIENCE AND INDUSTRY IS BENEFITTING PALAEONTOLOGY

B122 **Krahl, A., Witzel, U., Sander, M. P.** PLESIOSAUR HUMERUS MUSCLE RECONSTRUCTIONS AND FINITE ELEMENT ANALYSES IN COMPARISON TO SEA TURTLES REVEALS OPTIMIZED BIOLOGICAL LIGHT-WEIGHT STRUCTURES

B123 **Morgan, D. J., O'Keefe, F.** REVISION OF POLYCOTYLID PLESIOSAUR SYSTEMATICS (SAUROPTERYGIA, PLESIOSAURIA) AND DESCRIPTION OF THE AXIAL OSTEOLOGY OF THE WALLACE RANCH POLYCOTYLIDS

B124 **Boudreau, D. M., O'Keefe, F.** ONTOGENETIC HISTOLOGY OF POLYCOTYLID LONG BONES AND IMPLICATIONS FOR PHYSIOLOGY

B125 **Smith, E. A., Kinyon Boodhoo, T. A., Chure, D. J.** UNUSUAL EXHIBIT PROPOSALS FOR THE CARNEGIE QUARRY AT DINOSAUR NATIONAL MONUMENT

B126 **Wilhite, R., Britt, B. B., Curtice, B., Scheetz, R. D., Chure, L., Chure, D. J.** THE MCINTOSH PALEONTOLOGICAL ARCHIVE: MAKING A LIFETIME OF RESEARCH AVAILABLE TO THE WORLD ONLINE

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B127 **Chure, D. J., Ridgwell, N.** IN SITU FOSSIL VERTEBRATE EXHIBITS (ISFVE): A GLOBAL SURVEY OF THEIR DIVERSITY AND APPROACHES TO THEIR PROTECTION AND PRESERVATION

B128 **Mizuno, F., Fujiwara, S.** COMPARISON BETWEEN TERRESTRIAL MAMMAL ANKLE JOINT AND FOOT BONE MORPHOLOGY

B129 **Figueirido, B., Palmqvist, P., Pérez-Claros, J., Janis, C. M.** AN ECOMORPHOLOGICAL CHARACTERIZATION OF NORTH AMERICAN CENOZOIC MAMMALIAN EVOLUTIONARY FAUNAS

B130 **Tornow, M. A., Arbor, T. C.** NEW APATEMYIDS FROM THE CHADRONIAN OF SIOUX COUNTY, NEBRASKA WITH REASSESSMENT OF SPECIMENS FROM RABEN RANCH

B131 **Birlenbach, D. M., Fox, D. L.** TAXONOMIC COMPOSITION AND DIVERSITY OF MULTITUBERCULATA, PLESIADAPIFORMES, AND RODENTIA ACROSS CONTINENTS DURING THE EARLY PALEOGENE

B132 **De Bast, E., Smith, T.** RADIATION OF PLESIADAPID MAMMALS AT THE END OF THE PALEOCENE EVIDENCED BY NEW DISCOVERIES FROM THE LATEST PALEOCENE OF FRANCE: ONE MORE EXAMPLE OF BUSH-LIKE EVOLUTION

B133 **Toussaint, S. L., Godinot, M., Youlatos, D.** FUNCTIONAL ANALYSIS OF HAND AND FOOT METAPODIALS AND PHALANGES OF *PLESIADAPIS TRICUSPIDENS* (PLESIADAPIFORMES, PLESIADAPOIDEA; PALEOCENE, FRANCE)

B134 **White, C. L., Bloch, J. I., Silcox, M. T.** VIRTUAL ENDOCAST OF LATE PALEOCENE *NIPTOMOMYS* (MICROSYOPIDAE, PRIMATES) AND EARLY PRIMATE BRAIN EVOLUTION

B135 **Allen, K. L., Clarke, T. A.** NEW VIRTUAL ENDOCASTS OF EXTINCT LARGE-BODIED LEMURS FROM NORTHERN MADAGASCAR

B136 **Femenias-Gual, J., Minwer-Barakat, R., Marigó, J., Moyà-Solà, S.** THE MOST COMPLETE EARLY EOCENE PRIMATE SPECIMEN FROM THE IBERIAN PENINSULA

B137 **Grider-Potter, N., Mcgrosky, A., Nalley, T.** THE EVOLUTION OF THE NEUROCRANIUM AND ITS EFFECTS ON BALANCE OF THE HEAD IN HOMINOIDS

B138 **Begun, D., Kelley, J.** HOMINID LOCALITIES FROM THE PANNONIAN BASIN (HUNGARY) AND YUNNAN PROVINCE (CHINA) AND RELATIONS AMONG EURASIAN MIOCENE APES

B139 **Fleagle, J., Tejedor, M., Novo, N., Gonzalez Ruiz, L., Brandoni, D., Martin, G.** RECENT RESEARCH IN THE MIOCENE PINTURAS FORMATION, SANTA CRUZ, ARGENTINA

B140 **Flynn, L. J., Kelley, J., Jablonski, N. G., Su, D. F., Ji, X.** A WETLAND SMALL MAMMAL FAUNA FROM THE LATE MIOCENE OF YUNNAN, SOUTH CHINA

B141 **Nishioka, Y., Nakaya, H., Suzuki, K., Ratanasthien, B., Jintasakul, P., Hanta, R., Kunimatsu, Y.** LARGE FOSSIL RODENTS FROM THAILAND

B142 **Kimura, Y., Lindsay, E., Jacobs, L. L., Flynn, L. J.** ISOTOPIC DIETARY RESPONSE TO INTERSPECIFIC COMPETITION BETWEEN MURINE AND CRICETID RODENTS IN THE EARLY MIOCENE OF PAKISTAN

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B143 **Stevens, N. J., Roberts, E. M., O'Connor, P. M.** A DIVERSE NEW FOSSIL LOCALITY IN THE LATE OLIGOCENE NSUNGWE FORMATION, SOUTHWESTERN TANZANIA

B144 **López-Antoñanzas, R., Prieto-Marquez, A., Stubbs, T. L., Knoll, F.** TEMPO AND MODE IN THE EVOLUTION OF CTENODACTYLINE RODENTS

B145 **Levy, J., Burroughs, R. W., Pierce, Z., Vallejo-Pareja, M. C., Lewis, P. J.** A RIGID PALM TREE OR A MIGHTY BRANCHING OAK? USING MUSKRATS TO STUDY EVOLUTIONARY MODE

B146 **Pierce, Z., Levy, J., Vallejo-Pareja, M., Lewis, P.** TO LUMP OR NOT TO LUMP? ANALYZING FOSSIL MUSKRAT TAXONOMY USING MOLAR MORPHOLOGY

B147 **Penkrot, T. A., Zack, S. P.** TARSAL DIVERSITY OF MIDDLE EOCENE (UINTAN) RODENTS FROM SAN DIEGO COUNTY, CALIFORNIA

B148 **Prufrock, K. A., Ruff, C. B., Rose, K. D.** A LITTLE SQUIRRELY: RECONSTRUCTING LOCOMOTOR BEHAVIOR AND BODY MASS OF EARLY ISCHYROMYIDAE (RODENTIA) USING EXTANT SCIURIDAE

B149 **Biedron, E., Hopkins, S. S.** SURPRISING DIVERSITY IN A MID-MIOCENE SQUIRREL ASSEMBLAGE: THE SCIURIDAE (MAMMALIA:RODENTIA) OF CAVE BASIN, OREGON

B150 **Perdue, G. V., Hopkins, S. S., Davis, E. B.** ESTIMATING BODY MASS IN FOSSIL RODENTS: CAN LOG BIAS BE REMOVED BY NONLINEAR REGRESSION?

B151 **Rinaldi, C. E., Kuhn-Hendricks, S. M., Erickson, G. M.** A NOVEL APPROACH TO MODELING TOOTH GROWTH AND FORM IN EXTANT AND FOSSIL RODENTS

B152 **Moretti, J. A., Johnson, E.** PRINCIPAL COMPONENT ANALYSIS OF VARIABLES OF THE LOWER 3RD PREMOLAR OF *AZTLANOLAGUS AGILIS* (MAMMALIA, LAGOMORPHA)

B153 **Flora, H. M., Mclaughlin, W. N., Davis, E. B., Hopkins, S. S.** A TRUE LEPORID FROM THE TIEN SHAN MOUNTAINS OF KYRGYZSTAN

B154 **Jones, M. F., Beard, K., Coster, P., Metais, G., Ocakoglu, F., Licht, A., Taylor, M.** A PRIMITIVE FOSSIL BAT FROM THE LATE MIDDLE EOCENE OF NORTHERN ANATOLIA

B155 **Napoli, J., Williamson, T. E., Shelley, S. L., Brusatte, S.** A DIGITAL ENDOCRANIAL CAST OF THE EARLY PALEOCENE (PUERCAN) *ONYCHODECTES TISONENSIS* (EUTHERIA, TAENIODONTA)

B156 **Gaudin, T. J., Wible, J. R., Rose, K. D., Emry, R. J., Spaulding, M.** ANALYSIS OF THE SKELETAL ANATOMY OF THE BASICRANIUM AND AUDITORY REGION IN THE METACHEIROMYID PALAEANODONT *METACHEIROMYS* (MAMMALIA, PHOLIDOTAMORPHA) BASED ON HIGH-RESOLUTION CT-SCANS

B157 **Holbrook, L. T.** A SKULL OF *ARCTOCYON FEROX* (MAMMALIA, ARCTOCYONIDAE) FROM THE PALEOCENE OF WYOMING

B158 **Williamson, T. E., Secord, R., Brusatte, S., Shelley, S. L., Leslie, C. E., Peppe, D. J.** A HIGH-RESOLUTION RECORD OF EARLY PALEOCENE FAUNAL DYNAMICS IN THE SAN JUAN BASIN, NEW MEXICO

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B159 **Bown, T. M., Chew, A. E., Nichols, K. A., Rose, K. D., Weaver, L. N., Rodwell, B. W.** USING FOSSIL VERTEBRATES TO DATE EARLY EOCENE TECTONOSEDIMENTARY ACTIVITY IN THE GREYBULL/BASIN AREA OF NORTHWEST WYOMING

B160 **Franzen, J. L., Godinot, M., Erfurt, J., De Lapparent De Broin, F.** A NEW EOCENE VERTEBRATE LOCALITY, ROUZILHAC (MP 10–11, AUDE, FRANCE)

B161 **Mccomas, K. M., Eberle, J. J., Gauthier, J. A.** ADDITIONS TO THE MAMMALIAN FAUNA AND THE FIRST DOCUMENTED NON-AVIAN REPTILE FROM THE LATEST EOCENE FLORISSANT FORMATION, FLORISSANT FOSSIL BEDS NATIONAL MONUMENT, COLORADO

B162 **Samuels, J. X., Mihlbachler, M. C., Korth, W. W., Holbrook, L. T., Bredehoeft, K. E., Fremd, T. J.** THE FIRST LATE EOCENE AND EARLIEST OLIGOCENE FAUNAS FROM THE JOHN DAY BASIN OF OREGON: FILLING GAPS IN THE MOST COMPLETE RECORD OF MAMMAL EVOLUTION IN NORTH AMERICA

B163 **Korth, W. W., Cavin, J. L.** NEW MATERIAL OF THE DIDELPHID MARSUPIAL (MAMMALIA) *HERPETOTHERIUM MERRIAMI* FROM THE JOHN DAY FORMATION (LATE OLIGOCENE: ARIKAREEAN: CHATTIAN), OREGON, USA

B164 **Albright Iii, B., Phillips, G., Starnes, J., Stringer, G. L., Weller, A.** THE JONES BRANCH LOCAL FAUNA: AN EARLY ARIKAREEAN MAMMALIAN ASSEMBLAGE FROM THE UPPER OLIGOCENE CATAHOULA CLAY, WAYNE COUNTY, MISSISSIPPI

EXHIBIT HALL GRAND BALLROOM

Education & Outreach Poster Session

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*Numbers beginning with “B” represent the poster board number in Exhibit Hall Grand Ballroom.

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Technical Session XI (Friday, October 28, 2016, 11:15 AM)

A DIVERSE FOSSIL FISH ASSEMBLAGE FROM THE LOWER MIOCENE MOGHRA FORMATION, EGYPT

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The modern character of African ichthyofaunas emerged in the early Miocene, around the time that the first land connection between Eurasia and Afro-Arabia was established. However, the state of African ichthyofaunas during this time remains poorly known due to the scarcity of early Miocene fish-bearing deposits. Moghra is an early Miocene site situated in the Qattara Depression, Egypt. The locality comprises a series of shale-sandstone interbedded units. Vertebrate remains are concentrated within coarse lag deposits in four stratigraphic horizons. Fourteen genera of cartilaginous and bony fishes have been previously reported, including *Carcharias* sp., *Carcharocles chubutensis*, *Isurus* (*Cosmopolitodus*) sp., *Hemipristis* sp., *Carcharhinus* spp., *Galeocerdo* sp., *Sphyrna* sp., *Pristis* sp., *Myliobatis* sp., *Aetomylaeus* (*Pteromylaeus*) sp., *Aetobatus* sp., *Synodontis* sp., *Lates* sp., and *Semlikiichthys* sp. New fish material led to the recognition of a minimum of five new taxa (*Rhinoptera* sp., *Protopterus* sp., *Clarotes/Chrysichthys* sp., *Auchenoglanis* sp., and Sparidae indet.), the addition of which allows a more accurate paleoenvironmental reconstruction for the area. The dominant elasmobranch component of this assemblage indicates the presence of shallow, inshore tropical–subtropical marine waters, while the bony fishes have freshwater affinities. *Lates* and *Semlikiichthys* indicate the presence of a large freshwater body in the area, while *Protopterus* and *Auchenoglanis* likely occupied neighboring vegetated swamps. This reconstruction is congruent with sedimentological and tetrapod signatures, suggestive of a tide dominated estuary with seasonal salinity variations (where the allochthonous freshwater taxa mixed with the autochthonous marine and brackish taxa), in a shallow, marine environment, surrounded by tropical forests. Furthermore, the absence of Eurasian migrants in the Moghra sample may indicate that deposition of the Moghra Formation predates their dispersal in the African mainland. Additional fossil material from all fossiliferous horizons in Moghra is expected to add significantly to our understanding of the evolution of the modern African ichthyofauna.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

A REASSESSMENT OF THE LATE EOCENE–EARLY OLIGOCENE CROCODYLIDS *"CROCODYLUS" MEGARHINUS* AND *"CROCODYLUS" ARTICEPS* FROM THE FAYUM PROVINCE, EGYPT

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The Fayúm Province of Egypt covers an almost continuous time span from the middle Eocene through the early Oligocene and has produced a number of vertebrate fossils important to evolutionary history. This area includes early crocodylids inaccurately assigned to crown-group *Crocodylus*, which has been shown through molecular and morphological phylogenetic analyses to have diverged during the Miocene. We reviewed two taxa from the early Oligocene Gebel Qatrani Formation, *Crocodylus megarhinus* and *Crocodylus articeps*, which had previously been synonymized, with *C. articeps* thought to be based on a juvenile specimen of *C. megarhinus*. *Crocodylus megarhinus* outwardly resembles most living species of *Crocodylus*, however it is a basal crocodylid lacking diagnostic features for the crown genus. The holotype of *C. articeps* is now lost, but based on a cast and published images of the original material, it was a slender-snouted form that can be distinguished from smaller specimens of *C. megarhinus*. Although not synonymous with *C. megarhinus*, *C. articeps* cannot be diagnosed or scored for existing character matrices sufficiently to allow precise phylogenetic placement. Previous analyses of *C. megarhinus* included information from *C. articeps*; recoding *C. megarhinus* based only on material referable to that species does not change its phylogenetic position, but it forces a reconsideration of the polarity of character states in clades leading to the origin of crown-genus *Crocodylus* which, in turn, may inform efforts to resolve the relationships among living crocodylid lineages. Based on its confirmed phylogenetic position as a basal crocodylid, *C. megarhinus* provides insight into the ancestral conditions of all crocodylids and supports an African origin for Crocodylidae.

Poster Symposium I (Wednesday–Thursday, October 26–27, 2016, 4:15–6:15 PM)

NEW REPORTS AND DISTRIBUTION OF RARE TURTLES IN THE UINTA FORMATION, INCLUDING SPECIMENS FROM CARETTOCHELYIDAE, PLANETOCHELYIDAE, TESTUDINIDAE, GEOEMYDIDAE, AND BAENIDAE

ADRIAN, Brent, Midwestern University, Glendale, AZ, United States of America; HUTCHISON, J. Howard, Escalante, UT, United States of America; TOWNSEND, K.E. Beth, Midwestern University, Glendale, AZ, United States of America

Fossil turtles are plentiful in the Uinta Formation and provide a strong indicator of ecosystem evolution during the middle Eocene. Though the collection of mammals has been a greater historic priority, turtle genera such as *Echmatemys* are abundant (N=350). The less common taxa discussed here (*Anosteira pulchra*, *Planetochelys sp.,* cf. *Hesperotestudo sp.*, *Bridgeremys sp.*, and *Chisternon undatum*) provide unique insight into the scantly reported distribution, taxonomy, and ecological diversity of Uintan turtles. Of these, *Planetochelys*, cf. *Hesperotestudo*, and *Bridgeremys* have not been previously described from the Uinta Basin. Our study examines the distribution of specimens collected from more than 265 stratigraphically constrained fossil localities by researchers from Washington University and Midwestern University, 66 of which have yielded turtle fossils. Though the total number of turtles identified to at least the family level is 705, these rare taxa have been identified in less than 5% of collected specimens: *Anosteira* (4.3%; N=30), *Planetochelys* (0.6%; N=4), cf. *Hesperotestudo* (1.8%; N=13), *Bridgeremys* (2.7%; N=19), and *Chisternon* (0.7%; N=5). Our results also show that the mean meter level of *Anosteira* and *Bridgeremys* are predominantly located higher in the section (Ui3 biochron) than other collected taxa, while *Chisternon*, cf. *Hesperotestudo*, and *Planetochelys* have been collected primarily from the historically fossiliferous upper portion of Uinta B (Ui2 biochron). These differences could provide clues to understanding the biogeography of the most temperature sensitive turtles and the role of paleoclimate in middle Eocene vertebrate evolution. Additionally, continued collection of rare turtle taxa will likely expand the range of these species and broaden our understanding of the paleobiogeography of Uintan faunas.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

MODELS OF THE DEVELOPMENT OF THE EXOSKELETON IN EARLY VERTEBRATES (OSTEOSTRACI, AGNATHA)

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The external skeleton (the sculpture and the histological structure) of the osteostracans (Osteostraci) of different species was studied. The material come from the lower Silurian–early Devonian deposites of the Severnaya Zemlya Archipelago, North Timan, Russia, and Saaremaa, Estonia. The sculpture of the exoskeleton of the osteostracans under investigation is extremely diverse. There are separate and fused tubercles and ridges varying in shape and size (*Thyestes*, *Septaspis*, *Timanaspis*), three-dimensional network (*Reticulaspis*) on the surface of the head shields, sometimes consolidated shields (or the parts of the shield) are smooth (*Trematraspis*, *Dartmuthia*). The microstructural study of exoskeletal fragments revealed the presence of several generations of dentine (tubercles, ridges, and three-dimensional network) in the exoskeleton of *Reticulaspis*.

The formation of dentine tissue in vertebrates is connected with the epidermis–dermis (corium) boundary. Dentine structures are being developed centripetally in the upper corium from epidermis towards the forming bone tissues. In the osteostracan ontogenesis, a *synchronous initiation* of a certain number of the same points (the future tubercles) results in the formation of the sculpture consisting of uniformsized dentine tubercles; an initiation of a certain number of lines (respectively, ridges), leads to the formation of ridges; and an initiation of a plane (a smooth surface), to the formation of a smooth dentin surface. In addition, along with simple cases considered, points and lines can occur with a varying density on a plane: uniformly or in groups, orderly or randomly. Along with the main types of initiation of dentine structures, transitional states were identified in the osteostracans: the segment initiation type (the "point–line = segment" transitional state) may eventually lead to the formation of elongated tubercles or dentine ridges varying in size; the network (the "line–plane = network" transitional state), to the formation of a porous surface of a dentine layer of the external skeleton or a three-dimensional dentinal network on the shield surface; the plate ("point–plane = plane fragment or plate"), to the formation of more or less wide smooth surface of dentine tubercles, or a smooth surface of tesserae and scales covered with dentine. Successive initiation of the dentine structures leads to a horizontal growth (an increase in the absolute size of the animal) and a vertical growth (the thickening of the shield and scales) of the external skeleton during ontogenesis.

Grant Information

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Technical Session IX (Thursday, October 27, 2016, 1:45 PM)

NEW LIGHT ON THE EXTRAORDINARY EYES OF MAXILLATE PLACODERMS

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The maxillate placoderm *Entelognathus* from the late Silurian (Kuanti Formation, Ludlow) of Yunnan, China, has become famous as the first known fossil gnathostome to combine "osteichthyan" marginal jaw bones with an otherwise placoderm-like dermal skeleton. In addition to this combination of osteichthyan-like and placoderm-like characters, *Entelognathus* displays one very puzzling autapomorphy: an eye morphology unlike any other known vertebrate. The sclerotic ring, which normally in early vertebrates wraps tightly round the external half of an essentially spherical eyeball, and has no sutural or overlap contacts with the circumorbital bones, is in *Entelognathus* developed into a flat, anteroposteriorly elongated plate that overlaps the bones of the cheek and was evidently immobile. Unfortunately, the endoskeletal ossifications are not well preserved in the holotype of *Entelognathus* and show up only faintly in µCT scans, with the result that the internal morphology of this extraordinary eye remains unknown.

Here we present a new *Entelognathus*-like gnathostome with similar eyes, from a different Kuanti Formation locality that yields better endoskeletal preservation. µCT scans of the face reveal the complete morphology of the eye capsule. The cavity that housed the actual eye is small, appropriate in size to the small opening in the sclerotic plate. Conversely, the perichondrally ossified cartilaginous internal wall of the eye is enormously thickened compared to a normal placoderm eye such as that of *Murrindalaspis*. It is also asymmetrical: anterior to the eye cavity (i.e., towards the nasal capsule) the cartilage forms a large cushion-like structure, pierced by a complex branching vasculature and enclosed externally by a robust, convex, strongly ornamented dermal sclerotic ossification; posterior to the eye cavity the cartilage is much thinner, and the dermal bone is thinner, flatter and less strongly ornamented. The cartilage stops well short of the posterior edge of the dermal sclerotic plate, which forms a free overlap margin for the cheek bones. The perichondrally ossified rear surface of the eye capsule, normally hemispherical in shape, has a complex concavo-convex curvature, making the complete eye capsule comma-shaped in dorsal view. This curious and unique morphology suggests a very distinctive adaptation, possibly protection against mechanical trauma. Eyes of this type are not universal among maxillate placoderms but seem to define a distinct group comprising *Entelognathus*, the new taxon, and possibly "*Wangolepis*".

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

EVOLUTIONARY TRENDS IN THE POSTCRANIAL SKELETON AND LOCOMOTOR BEHAVIOR OF OXYAENIDAE AND HYAENODONTIDAE (MAMMALIA, LAURASIATHERIA)

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Oxyaenidae and Hyaenodontidae, usually included in the group Creodonta, were important and diverse members of the emerging eutherian fauna of the North American Paleogene. Species exhibited a range of dental and postcranial morphologies leading to the hypothesis that they filled numerous ecological roles, from small-bodied predators capable of climbing to large, high-speed pursuit predators. In addition to hypotheses regarding their functional morphology and ecology, researchers have observed that changes in their postcranial skeleton and eventual extinction may have been correlated with environmental and climatic shifts of the Paleogene. Specifically, more recent hyaenodontids are hypothesized to have possessed relatively cursorial behaviors compared to earlier species of both Oxyaenidae and Hyaenodontidae. Here, I test the hypothesis that a trend towards more specialized terrestrial behaviors, including cursoriality, existed in Oxyaenidae and Hyaenodontidae by applying two different models of trait evolution, directional selection and pure Brownian motion. I performed a principal coordinates analysis (PCO) to visualize locomotor variation, as well as a phylogenetic generalized least squares analysis of variance to test for a correlation between PCO score and locomotor behavior in a comparative sample of extant Carnivora. I then applied directional selection (DS) and Brownian motion (BM) models to the continuous trait data for North American creodonts and used the weighted Akaike Information Criterion (AICw) to determine the relative fit of each model. Though there is phylogenetic signal in the data, differences among PCO scores were significant between locomotor categories (p-value < 0.01). The directional selection model indicated a slight shift towards specialized terrestrial behaviors through time. The directional selection model also provided a slightly better fit for the data (AICw = 0.531) than did Brownian motion (AICw = 0.469). Trait evolution among individual functional metrics was also examined. These results lend support to hypotheses of environmental impact on the locomotor behavior of creodonts. However, examination of trait values indicate that much of this shift is concentrated among the highly derived *Hyaenodon*, and the weak support for directional selection indicates that overwhelming specialization towards cursoriality may not have driven morphological evolution in creodonts.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

RE-ASSOCIATION OF ISOLATED FEMORA OF SALLA, BOLIVIA (LATE OLIGOCENE): ADDITIONS TO KNOWLEDGE AND FUNCTIONAL HYPOTHESES

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We recognize distal femora of several taxa from Salla, Bolivia (late Oligocene) that had not been previously reported or described. We note the functional significance of specialized morphologies and of our failure to re-associate the common small typotherians to their dental taxa. The re-association of these elements to the five-to-six typotherian notoungulates of Salla was confounded by the lack of size gaps among these typotherians, extreme size variation within these species, and the conservative nature of their distal femora.

Some of the distal femora were so distinctive that they could be confidently assigned to species. Such included that of *Pyrotherium macfaddeni* (femur graviportal and 'rectigrade'); the dasypodid, *Kuntinaru* (broad shaft and stable trochlear-patellar articulation); the peltephilid (rounded femoral shaft and shallow patellar groove); and a sloth, cf. *Paroctodontotherium* (broad femoral shaft, relatively flat trochlea).

Of particular interest was our finding of the distal femur of a small unnamed proterotheriid. This element has a deep 'patellar pit' similar to those of macraucheniids. Based upon mechanical models and the observation that the articular facets of the patella conform to the walls of the pit, the knees of these macraucheniids have been interpreted as being 'patellar pit' knee locks, structurally distinct from the medial hook knee locks of horses, rhinos, and *Toxodon*. We interpret the knee of the new Salla proterotheriid as also serving as a patellar pit knee lock. Though the patella of the Salla proterotheriid is unknown, that of the Neogene proterotheriid *Eoauchenia* has near perfect patella/patellar-pit conformation. The homology of the proterotheriid-macraucheniid knee lock is questioned as we note great differences in their patellae. Those of proterotheriids are short and wide, whereas patellae of macraucheniids are long and so narrow that we suspect that the medial and lateral connections of the quadriceps to the tibia were tendonous rather than ligamentous, as occurs in horses and rhinos and presumptively in proterotheriids. We note the ubiquity of knee locks in post-Eocene litopterns and their apparent absence in pre-Oligocene faunas and suggest that standing for long periods of time was important for litopterns in post-Eocene habitats. Such is congruent with other features of ungulate evolution over the Eocene–Oligocene boundary where herbivore faunas changed from being brachydont dominated to hypsodont dominated and from plantigade dominated to digitigrade dominated.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

THE JONES BRANCH LOCAL FAUNA: AN EARLY ARIKAREEAN MAMMALIAN ASSEMBLAGE FROM THE UPPER OLIGOCENE CATAHOULA CLAY, WAYNE COUNTY, MISSISSIPPI

ALBRIGHT III, Barry, University of North Florida, Jacksonville, FL, United States of America; PHILLIPS, George, Mississippi Museum of Natural Science, Jackson, MS, United States of America; STARNES, James, Jackson, MS, United States of America; STRINGER, Gary L., University of Louisiana Monroe, Monroe, LA, United States of America; WELLER, Andy, Waynesboro, MS, United States of America

A preliminary report on a diverse assemblage of mammals from near Waynesboro, southeastern Mississippi, was presented at the annual meeting of the Southeastern Association of Vertebrate Paleontology in 2014 and at the 2016 South Central meeting of the Geological Society of America. Continued work at the site, and further study of new and previously recovered fossils, prompts this update. The fossils are derived from a distributary channel lag at the base of the Catahoula Formation that rests unconformably on interbedded marl-clay beds of the subjacent marine Paynes Hammock Formation. To date, the mammalian component of the fauna includes a leporid, rodents, carnivores, artiodactyls, perissodactyls, and a small dugong. The early Arikareean age of the fauna is based on the presence of a eutypomyine castorid, the tapir *Protapirus*, the rhinoceros *Subhyracodon*, the anthracothere *Elomeryx*, and a leptochoerid tentatively assigned to *Nanochoerus*. Except for *Subhyracodon*, all of these occurrences are firsts for the Gulf Coastal Plain. Additional taxa include the horse *Miohippus*, the giant entelodont *Dinohyus*, a tiny species of *Hypertragulus*, and a small protoceratid similar to *Prosynthetoceras orthrionanus* from the later Arikareean Toledo Bend Local Fauna of eastern-most Texas. Two of three carnivores appear representative of small borophagine canids, and the third is a mustelid-like species superficially resembling "*Plesictis*." A very small sirenian appears referable to *Crenatosiren*. Like the Toledo Bend Local Fauna, the Jones Branch Local Fauna lacks camels and oreodonts. Supporting the early Arikareean age (= lower Chattian Stage) are numerous teleostean otoliths, which are dominated by sciaenids (drums), including three taxa that are known only from the Oligocene (*Aplodinotus gemma*, *Aplodinotus distortus*, and "*Sciaenida*" *radians*). The predominance of sciaenid otoliths, the preferred habitats of sciaenids based on Recent analogs, and the size of these otoliths (i.e., age of the fish) are strong indicators of a tidally influenced estuarine paleoenvironmental setting. The Jones Branch Local Fauna is the only assemblage of early Arikareean age yet known from the Gulf Coastal Plain.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

REANALYSIS OF A COMPLETE TRIONYCHID SKULL FROM FLORIDA ASSIGNED TO *A. FEROX*

ALICEA, Justy, Florida Museum of Natural History/Makerbot, New York, NY, United States of America; JUD, Nathan, Florida Museum of Natural History, Gainesville, FL, United States of America; VITEK, Natasha, University of Florida, Gainesville, FL, United States of America

The soft shell turtle genus *Apalone* (Trionychidae) includes only three extant species, and they are the only in North America. Fossil shell fragments attributed to trionychids date back to the Cretaceous;however, the history of species diversity within the genus is poorly known. I describe a nearly complete fossil skull collected from the Leisey shell pits (Irvingtonian; ~2 million years old) in Florida, USA, that was assigned to the species *A. ferox*. *A. ferox* is common in lakes and ponds of the southeastern United States. However, this specimen, although not the largest, is larger than most modern samples and bears a broad maxilla, wide triturating surface and very pronounced rugosities across the anterior surface of the skull, seen to such degrees in only a small subset of *A. ferox* specimens. A phylogenetic analysis of morphological characters did not confirm the assignment of the fossil to the extant species, instead resolving the fossil as a polytomy at the base of the subfamily Trionychinae. Until fossil species of *Apalone* can be recognized by apomorphies or unique combinations of characters, particularly of the skull, species attributions should be treated with caution, perhaps being best restricted to the genus level. It is just as possible for the skull described here and other fragments from the Leisey shell pits to represent an extinct relative of *A. ferox*.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

NEW VIRTUAL ENDOCASTS OF EXTINCT LARGE-BODIED LEMURS FROM NORTHERN MADAGASCAR

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Subfossil primate remains discovered in Madagascar demonstrate that the modern representatives of the Malagasy primates widely underestimate the amount of historical diversity in body size, brain size, and dietary niche among crown Lemuroidea, as many now-extinct large-bodied and dietarily diverse lemurs roamed the island as recently as ~500 yr BP. This study provides descriptions of new virtual endocasts of several extinct large-bodied lemur species and re-evaluates the relationship between diet and brain size in Malagasy strepsirrhines in light of these new data.

Virtual endocasts were derived from microCT scans of subfossil lemur crania housed at the Duke University Division of Fossil Primates. Subfossil species include: *Archaeolemur edwardsi* (DPC 7850, DPC 9104, DPC 9889), *Babakotia radofilai* (DPC 10994, 92-M-224), *Megaladapis madagascarensis* (DPC 24801), and *Mesopropithecus dolichobrachion* (DPC 11755). These were analyzed in the context of a comparative sample of 54 extant primate species. The first principal component (PC1) of 14 standard craniodental linear dimensions was used as a proxy for body mass (logBodyMass = 3.44 + 0.199 * PC1, RSquare = 0.97). The relative size of the endocranium was calculated as a residual from a phylogenetically informed regression of log endocranial volume (ECV) on PC1 from the craniodental measurements

As with other previously described representatives of Archaeolemuridae (i.e., *Hadropithecus*), the frugivorous/hard-object feeder *Archaeolemur* has a relatively large brain for a lemuroid (mean ECV = 106.2 cc). In contrast, the highly folivorous *Megaladapis* has a particularly small brain (ECV = 86.4 cc)—roughly 1/8th the endocranial volume of a similarly sized modern *Gorilla* skull, while *Babakotia* (mean ECV = 43.2 cc) and *Mesopropithecus* (ECV = 39.5 cc), both mixed feeders, are well within the CI derived from the modern lemuroid regression. Despite their large brains, the 'monkey lemurs' Archaeolemuridae are distinctly strepsirrhine-like in endocast shape, indicating a somewhat conserved pattern of brain proportions across strepsirrhines, regardless of encephalization.

These data provide some support for the notion that high-quality diets may act as a selective force and/or a release of metabolic constraints for encephalization in strepsirrhines; however, the extant and extinct sample taken as a whole fail to conform to a strict correlation between diet and brain size, demonstrating the expected pattern only at the polar extremes of brain size.

Grant Information

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Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

ANALYZING PTEROSAUR ONTOGENY AND SEXUAL DIMORPHISM WITH MULTIVARIATE ALLOMETRY

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The relationships of pterosaurs have been previously inferred from observed traits, depositional environments, and phylogenetic associations. A great deal of research has begun to analyze pterosaur ontogeny, mass estimates, wing dynamics, and sexual dimorphism in the last two decades. The latter has received the least attention because of the large data set required for statistical analyses. Analyzing pterosaurs using osteological measurements will reveal different aspects of size and shape variation in Pterosauria (in place of character states) and sexual dimorphism when present. Some of these variations, not easily recognized visually, will be observed using multivariate allometry methods including Principle Component Analysis (PCA) and bivariate regression analysis. Using PCA to variance analysis has better visualized ontogeny and sexual dimorphism among *Pterodactylus antiquus,* and *Aurorazhdarcho micronyx*. Each of the 24 (*P. antiquus*) and 15 (*A. micronyx*) specimens had 14 length measurements used to assess isometric and allometric growth. Results for *P. antiquus* analyses show modular isometric growth in the 4th metacarpal, phalanges I–II, and the femur. Bivariate plots of the ln-geometric mean vs ln-lengths correlate with the PCA showing graphically the relationship between *P. antiquus* and *A. micronyx* which are argued here to be sexually dimorphic and conspecific. Wing schematic reconstructions of all 39 specimens were done to calculate individual surface areas and scaled to show relative intraspecific wing shape and size. Finally, *Pteranodon*, previously identified having with sexually dimorphic groups, was compared with ln-4th metacarpal vs ln-femur data, bivariately, revealing similarities between the two groups (*P. antiquus* and *A. micronyx* = group 1; *Pteranodon* = group 2) in terms of a sexual dimorphic presence within the data sets.

Technical Sesssion X (Friday, October 28, 2016, 8:30 AM)

PROBABLE SEMI-FOSSORIAL BEHAVIOR IN A NEW DREPANOSAUR: RESULTS OF A COMPREHENSIVE APPROACH TO BEHAVIORAL TYPING

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Although the bizarre skeletal specializations of the drepanosauridae were at first ascribed to various behavioral habits, more recent models suggest that the clade was entirely arboreal. Abundant material from a new Utah drepanosaur, however, calls this single-habitat theory into question. Comparative and statistical analysis permitted by well-preserved forelimb elements, considered alongside the find's eolian setting, suggest that the new species is much more likely to have been a scratch-digger.

Arboreal explanations of drepanosaur behavior are often based on comparison with chameleons or anteaters, but whereas these climbers possess many adaptations for mobility, the rigid forelimb of the new drepanosaur is better suited to force production. A notarium and keeled sternum with fused clavicles form a stable base for muscle attachment. Moreover the shoulder girdle is narrow and rostrally displaced—an adaptation seen in moles to minimize cross-sectional area and maximize forward reach. Large ulnar muscle insertions, reduced carpal count, and enlarged claws are also features inhibitory to arboreal motion, but common among digging animals.

Suspected digging behavior can be quantitatively confirmed. In extant animals, robustness of the humerus and ulna is used to predict fossoriality, while claw curvature is associated with arboreal behavior. When compared with a sample of 121 modern diggers and climbers, the drepanosaur's humerus and ulna proportions placed it squarely within the fossorial group. Claw curvature was assessed in a second sample of 113 lizard species, which correlated arboreality with tall, highly-curved claws. In contrast, the majority of the drepanosaur's unguals are thin and straight.

The depositional setting of the drepanosaur material—an interdunal lake amidst the eolian Nugget Sandstone—casts further doubt on climbing behavior. The arid environment, with evidence only of algae and cycad flora near the quarry, makes exclusively arboreal fauna unlikely. The Nugget Sandstone has, however, yielded many invertebrate burrows, indicating an acceptable digging substrate.

In summary, anatomical, statistical, and paleoecological analysis of the new drepanosaur render an arboreal lifestyle improbable at best. A scratch-digging, arenicolous model is better equipped to explain the morphology of this unique creature. This conclusion calls into question the behavioral homogeneity of the drepanosaurs. In light of these findings, it may be appropriate to reassess the behavior of other species in this enigmatic group.

Grant Information

This research was funded in part by an ORCA student mentoring grant from Brigham Young University.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

A NOTCH ABOVE: THE SUBROSTRAL INDENT OF CARNIVOROUS BIPEDS AS A CLUE TO FEEDING BEHAVIOR

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The subrostral indent (sometimes called the subrostral notch) is a widely known but poorly studied feature in the cranial anatomy of many extinct tetrapod taxa. Made up of a curved 'step' between the premaxilla and maxilla, the trait appears to have evolved independently in several disparate groups, including pelycosaur synapsids, ornithosuchians, primitive theropods such as *Dilophosaurus*, and most notably, in spinosaurids. The authors examined this feature in extinct organisms and searched for analogues in living tetrapods. e found that modern piscivorous bipeds such as the shoebill (*Balaeniceps rex*) and other fish-eating birds possess a morphologically analogous indent at the tip of the rostrum. By observing feeding behavior in these taxa, we conclude that this structure is an adaptation for restraining fishes, securely grasping them transversely so they may be repositioned and swallowed. The authors hereby propose that the subrostral indent was a convergent adaptation for the same purpose in extinct tetrapods.

An upright bipedal stance may hold the key to understanding the presence or absence of the subrostral indent in piscivores. An elevated torso, provided by vertically-held limbs in many of the tetrapods examined here, allows a wider range of vertical motion than does a sprawling gait. Thus, we correlate a significant subrostral indent with movement of the head in the sagittal plane. We therefore explain the absence of a significant subrostral indent in modern specialized piscivores such as gharials (genus *Gavialis*) as an artifact of their laterally-focused feeding style.

Previous authors have proposed fish-eating behavior for *Dimetrodon*, theropod dinosaurs such as *Dilophosaurus*, and spinosaurids. The presence of a prominent subrostral indent in these taxa is consistent with these proposals, and furnishes further support for piscivorous habits in each. We surmise that a more thorough understanding of this convergent feature will provide direction for crafting and testing future hypotheses about feeding behavior in these extinct tetrapods.

Technical Session XIV (Friday, October 28, 2016, 3:30 PM)

MORPHOLOGY, PHYLOGENETIC RELATIONSHIPS, AND FEEDING SYSTEM FUNCTION OF THE ENIGMATIC TRIASSIC DICYNODONT *SANGUSAURUS* (THERAPSIDA, ANOMODONTIA)

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The Triassic dicynodont *Sangusaurus edentatus* was named from skull fragments collected in the upper horizon of the Ntawere Formation in Zambia. Two more complete skulls from the Lifua Member (Manda beds) of Tanzania were described as a second species, *S. parringtonii*. Both descriptions were extremely brief, leaving the cranial morphology of *Sangusaurus* largely unknown. Despite this fact, it has played an important role in Triassic biostratigraphy by serving as a link between the Ntawere Formation and the Lifua Member. We undertook a reassessment of *Sangusaurus* based in part on a new, nearly complete skull from Tanzania. The skull of *Sangusaurus* is highly autapomorphic. The snout is distinctly telescoped, with only a thin strip of the frontals separating the nasals from the parietals, and highly ornamented. The external surfaces of the premaxilla, maxillae, nasals, and prefrontals are extremely rugose, and a sharp median crest extends from the premaxilla to the frontals, where it terminates in a thickened boss. The occiput is broader than the skull is long, and the adductor fossa on the squamosal is nearly vertical. The new specimen confirms that a rounded boss is present posterior to the pineal foramen in both species. Unlike most dicynodonts, the feeding system of *Sangusaurus* emphasizes an orthal motion of the jaw. The articular surfaces of the articular and the articular recess form a single posteroventrally-sloping surface; translation across the quadrate results in a primarily orthal movement of the jaw symphysis. The internal and external jaw adductors insert at high angles on the mandible, providing a strong dorsally-directed component to the power stroke. Adductor mechanical advantage is similar to *Stahleckeria*, but *Sangusaurus* likely had a more powerful bite because of enlarged adductor and pterygoideus musculature. A transverse component of jaw movement is suggested by the broad occiput and potential for kinesis between the dentary and postdentary bones. Our phylogenetic analysis shows that *Sangusaurus* is not a kannemeyeriid, contra the original descriptions of the two species, but instead is found within Stahleckeriidae. Although stahleckeriids display less morphological disparity than most major clades of Permian dicynodonts, they occupy a region of morphospace separate from the Permian taxa. This indicates that dicynodonts were capable of generating morphological novelties late in their history, but the degree to which new morphotypes could be modified as sub-clades diversified was apparently more limited.

Grant Information

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Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

AN ATTRITIONAL ASSEMBLAGE TAPHONOMIC MODEL FOR THE FAIRMEAD LANDFILL FOSSIL LOCALITY (PLEISTOCENE, IRVINGTONIAN), MADERA COUNTY, CALIFORNIA

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The mid-Irvingtonian Fairmead Landfill fossil locality preserves a diverse assemblage of vertebrates, invertebrates, and plants from the upper unit of the Turlock Lake Formation. Remains were deposited in distal alluvial fan channels, distal alluvial fan overbank sediments, and marsh/lacustrine sediments. These varied facies preserved fossils mostly from late Pleistocene megafauna that were grazers and mixed feeders on lush grasslands.

Of the 72 taxa recovered from Fairmead Landfill, 29 are mammals. The fossils preserve a predominance of large herbivorous mammals including *Equus*, *Camelops*, and *Mammuthus* and less commonly xenarthrans, *Hemiauchenia*, and antilocaprids. Remains of carnivores are diverse but quite rare. Rodents are surprisingly underrepresented. Also uncommon, but noteworthy, are several small aquatic and semi-aquatic taxa including turtles, amphibians, fish, and ducks.

Lacustrine and alluvial fan channel water sources were likely attractants to animals in this habitat, resulting in the concentration of remains that are not consistent with accumulation via transport. Isolated bones mostly exhibit random long axis orientations rather than alignment with stream channel current directions.

The site preserves thousands of isolated remains, as well as very rare examples of articulated limbs and vertebral segments, and five multi-species bone beds of comingled elements. Evidence of scavenging, trampling, and weathering of bones as well as burrows

and mud cracks suggest varied exposure times consistent with burial by occasional, and likely seasonal, high discharges and overbank flooding.

The site exhibits multiple taphonomic pathways. The majority of fossils represent an attritional assemblage, with exposure prolonged enough to permit breakage of many elements via scavenging and trampling. Other remains were preserved with minimal weathering, or very rarely in articulation, and thus, suggest rapid burial. Dense elements, most commonly tooth fragments, likely experienced some transport in stream channel bed loads, yet often lack long axes for comparison to current direction indicators. The bone beds are the most likely candidates for accumulation due to fluvial transport based on the rounding of elements and the diversity of taxa represented.

Symposium I (Wednesday, October 26, 2016, 10:30 AM)

IMAGING THE CHEMISTRY OF LIFE: INTERPRETING EXTINCT VERTEBRATE PHYSIOLOGY USING SYNCHROTRON X-RAY ANALYSES

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Many of the complex processes of bone physiology are regulated by biomolecules with trace elements integral to their structure and function. The presence of these elements in bone are well known to correlate with specific biochemical pathways and processes, making it possible to use trace metals in the identification of bone physiological processes in the fossil record.

Here we focus on mapping and quantifying trace elements that are crucial for the maintenance and repair of bone using a combination of multi-scale (micro-decimeter) synchrotron X-ray fluorescence elemental mapping and X-ray Absorption Spectroscopy (XAS). This method uniquely allows us to simultaneously: (1) rapidly and non-destructively map the elements in large specimens under ambient conditions; (2) detect elements present at biological levels (ppm); and (3) determine the atomic configuration of these elements, which reveals whether an element is organic or inorganic in nature.

Results have revealed that zinc (a key element in bone physiology) is associated with actively remodeling or ossifying bone in: (1) the fracture callus of a large theropod (*Allosaurus fragilis*: ~146 Ma); (2) the secondary osteons of an extinct dugong (*Metaxytherium* sp.: ~17 Ma); and (3) the plexiform tissue of an extinct hyena (*Crocuta crocuta spelaea*: ~40 Ka). The distribution, concentration, and chemical coordination of zinc in each case is consistent with those found in modern tissues from comparable species.

Synchrotron X-ray analyses is a unique experimental setup that allows for the correlation of chemical physiological processes in vivo of fossil and extant bone tissues. This method is optimized for mapping 2D surface chemistry of specimens over relatively large surface areas, which limits specimens to those with low topographic relief (< ~10 mm) such as bedding plane fossils or cut surfaces. In isolation, imaging would not be sufficient to draw conclusions about the origin of the elemental inventory observed in fossils. It is the combination of elemental mapping, quantification, spectroscopy, and comparison to extant material that make it possible to distinguish diagenetic versus endogenous chemistry.

Technical Session XIV (Friday, October 28, 2016, 4:00 PM)

THE NEURAL CREST–MESODERM BOUNDARY IN THE BASICRANIUM OF MAMMAL PREDECESSORS: INSIGHTS FROM THERAPSID SKULLS

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Important insights into key developmental transformations in major clades can be gained indirectly from fossils. The detailed study of a gorgonopsian braincase and occiput (*Aloposaurus gracilis*), a therocephalian (*Silphoictidoides ruhuhensis*), and a cynodont (*Thrinaxodon liorhinus*), using propagation phase-contrast X-ray synchrotron microtomography, reveals profound modifications with developmental implications in the parabasisphenoid, prootic and basioccipital when compared to their reptilian outgroups.

In non-mammalian synapsids, the prootics, which are otic capsule derivatives, meet in the skull midline overlaying the ossifications of the trabeculae cranii and parachordal regions, where the parabasiphenoid and basioccipital ossify later in ontogeny. This otic capsule invasion onto the trabeculae and parachordal regions had previously only been recorded in non-mammalian synapsids, with anomodonts being a clear exception and cynodonts possessing the mammalian condition. These arrangements have led to confusion in the nomenclature of certain elements. For instance, the element in the gorgonopsian basicranium that has been called the "basisphenoid" is in fact an intermediate ossification between what has been previously referred as the "parasphenoid" and basioccipital. An examination of the dorsal aspect of the parasphenoid-basisphenoid complex in *Aloposaurus* reveals that the sella turcica lies on the "parasphenoid", at odds with the highly conservative location of the pituitary gland on the basisphenoid in vertebrates. Instead, the "parasphenoid" appears to be the result of the fusion of the parasphenoid with the basi-presphenoid, and the intermediate ossification previously called "basisphenoid" is the basi-postsphenoid.

Taking into consideration the known vertebrate germ layer fate maps, this configuration likely marks the neural crest–mesoderm boundary in the basicranium, and shows the plesiomorphic condition for the shift of this boundary in mammals. The prootic (otic capsule derivative) invasion onto the basi-postsphenoid (mesoderm-derived trabeculae) may have influenced this ossification center, as it is not seen in therocephalians and cynodonts including mammals. The basicranium, thought to be a conservative region of the skull in vertebrates, now with the advent of non-destructive imaging techniques, is unveiling a plethora of profound anatomical modifications with uncircumventable developmental roots.

Grant Information

FCT/MEC through the EXPL/BIA-EVF/0665/2013 project and the SFRH/BPD/96205/2013 scholarship, by ESRF (proposal HG-23), PalNiassa Project.

Technical Session VII (Thursday, October 27, 2016, 4:00 PM)

CORRELATIONS AND CONGRUENCE IN THE STEPWISE EVOLUTION OF AMNIOTE TAIL WEAPONRY

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Weaponry is a pervasive trait among amniotes. The vast majority of amniote weapons are located on either the head or the limbs, despite the trade-offs that must occur given the critical functions these parts of the body must perform. In contrast, tail weaponry is an extremely rare occurrence, with specialized bony tail weaponry present in only three highly disparate clades: mammals, turtles, and dinosaurs. Ankylosaurid dinosaurs had sledgehammer-like tails with tightly interlocking distal caudal vertebrae and mediolaterally expanded terminal osteoderms. Glyptodonts and meiolaniid turtles enveloped the distal tail in an immobile tube of osteoderms, sometimes bearing spikes. Stegosaurs and some basal sauropods retained a flexible tail, but elaborated the terminus either by co-ossifying and inflating the terminal vertebrae or elongating the terminal osteoderms into conical spikes.

We examined the evolution of tail weaponry by investigating character correlations and the order of appearance of key traits. We compiled a dataset of over 280 amniote taxa and over 40 characters including detailed anatomical features of the tail, functional characters potentially associated with tail weaponry, and ecological parameters such as diet, habitat, and body mass. We tested potential character correlations using pairwise comparisons and Pagel's correlation method, using multiple grafted trees in order to account for uncertainty in the placement of certain clades. Characters broadly correlated with use of the tail as a weapon in extant amniotes are limited to quadrupedality and the presence of spikes anywhere on the body. These features are also present in all of the extinct taxa with putative tail weapons, except for sauropods. In extinct taxa, mediolateral expansion of the distal tail is significantly correlated with coossification of at least three vertebrae in the tail terminus. No other significant correlations with tail weaponry have yet been identified in our dataset, indicating that the evolution of tail weaponry is both rare, and arises within unique ecological and environmental contexts in each clade in which it occurs.

We also tested for congruence in the order of appearance of key traits in ankylosaurids and glyptodonts. Results demonstrate that glyptodont tail clubs evolved in a stepwise manner similar to ankylosaurids, despite the differences in morphological construction of the club in these taxa. In both clades, stiffening of the tail precedes mediolateral expansion of the tail tip or the appearance of terminal spikes.

Grant Information

This research was supported by a grant from the Jurassic Foundation.

Technical Session XI (Friday, October 28, 2016, 9:00 AM)

ENDOCRANIAL ANATOMY AND INTERRELATIONSHIPS OF THE PERMO–TRIASSIC EARLY ACTINOPTERYGIAN *SAURICHTHYS* WITH HIGH-RESOLUTION COMPUTER-ASSISTED MICROTOMOGRAPHY (MCT)

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Saurichthys (latest Permian–Late Triassic) is often considered one of the best known fossil actinopterygians, represented by a rich record of over 40 species from all continents except South America and Antarctica. Early anatomical interpretations and subsequent cladistic studies, dealing with early actinopterygians, have placed *Saurichthys* on the stem of the Chondrostei, living members of which include sturgeons and paddlefishes. However, chondrostean affinity is weakly supported and not universally agreed upon. Until now, our knowledge about the phylogenetically informative endocranial anatomy of *Saurichthys* rested, chiefly, on Stensiö's serial grinding-aided study from the 1920s, with a few minor additions by later authors. Our µCT-aided investigation of an undistorted *Saurichthys* skull from the Early Triassic of East Greenland, as well as observations on disarticulated fossils from the Middle Triassic of Switzerland, reveal new data on the endocranial anatomy of this taxon. We identify the presence of a lateral cranial canal, which extends through the loop of the posterior semicircular canal and exits into the fossa bridgei as in *Polyodon, Pteronisculus*,and *Boreosomus*. A dermohyal, a primitive actinopterygian feature absent in extant chondrosteans, is present on the lateral side of the hyomandibula. A posterior projection of the dermohyal was previously erroneously identified as an opercular process, which is in fact absent in *Saurichthys*. The dorsalmost bone of the opercular series articulates with the ventral tip of the hyomandibula, rather than with the dorsal half of the bone. We therefore interpret this bone as an expanded suboperculum, matching the arrangement seen in chondrosteans. Our virtual 3D reconstruction permits the first detailed description of the hyoid and branchial arches in *Saurichthys,* including ceratohyals with a notch for the afferent hyoidean artery, a feature not seen in modern chondrosteans. Our observations provide additional evidence supporting the placement of *Saurichthys* as the oldest known, albeit highly derived, member of the chondrostean lineage. More generally, our results highlight the need for a systematic reinvestigation of the endocranial morphology of critical and supposedly well-known early actinopterygian taxa using µCT. Such studies provide an important check on historical accounts, and have potential to yield important new data bearing on the longstanding problem of early actinopterygian phylogeny.

Technical Session XX (Saturday, October 29, 2016, 2:15 PM)

EARLY PERMIAN AMPHIBAMID *PASAWIOOPS* (DISSOROPHOIDEA, AMPHIBAMIDAE): AN ONTOGENETIC SERIES

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Amphibamids (Temnospondyli, Dissorophoidea) were small, amphibian taxa that lived mostly during the Early Permian (~270 to 300 Ma). These taxa are generally considered to be close relatives of modern amphibians (Lissamphibia). Thus, detailed analysis of their morphology and phylogenetic relationships sheds light on the evolution of lissamphibians and the origin of several of their unique traits. Amphibamids are additionally interesting because in some taxa larval, juvenile, and adult specimens have been found, allowing researchers to discern the ontogenetic progression of morphological traits. However, because many adult amphibamids have a more juvenile appearance than other amphibians (e.g., comparatively large orbits and small body size), distinguishing between ontogeny dependent traits and taxonomically diagnostic traits has been challenging. The goal of the present research is to first document the detailed morphology of the skull of the recently described amphibamid *Pasawioops* (OMNH 73019; 32.6 mm skull length) using new CT data, and to second, explore the nature of potential ontogeny dependent traits in this taxon through comparison with a recently referred specimen of *Pasawioops* (MCZ 1415; 64 mm skull length). We found the smaller, holotype specimen OMNH 73019 specimen differs from MCZ 1415 in the following ways: the skull bones are not as tightly sutured, the anterior skull margin has a more rounded appearance, the orbits occupy a greater proportion of the skull roof, and the jaw articulations do not extend as far posteriorly beyond the occiput. These features are consistent with those hypothesized to be ontogeny dependent in other amphibamid species, and suggest OMNH 73019 likely represents a juvenile specimen of *Pasawioops*. These data further reveal the conservation of ontogeny dependent traits across Amphibamidae, and as they are among the best preserved amphibamid specimens currently known, they contribute to a better understanding of amphibamid development, diversity and evolution.

Grant Information
OGS to JBA and NSERC Discovery Grants to HCM and RRR.

Poster Symposium I (Wednesday–Thursday, October 26–27, 2016, 4:15–6:15 PM)

NEW UINTAN OMOMYOIDS (PRIMATES, HAPLORHINI) FROM SOUTHERN CALIFORNIA AND THE IMPLICATIONS FOR NORTH AMERICAN PRIMATE RICHNESS DURING THE MIDDLE EOCENE

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The Friars, Santiago, and Mission Valley Formations in San Diego County are composed of fluvial sediments and are Uintan in age. The omomyoid primates currently recognized from the Uintan formations of San Diego County include *Dyseolemur*, *Chumashius*, *Omomys*, *Hemiacodon*, *Washakius*, *Macrotarsius, Uintanius*, and *Ourayia*. New primate fossils from the Friars Formation (Ui1) are described. Fifteen specimens represent a new omomyoid genus, tentatively referred to as 'genus A.' Dental measurements reveal that genus A is significantly smaller than *Omomys carteri* but larger than *Dyseolemur*. The upper molars of genus A lack a pericone, have well-defined conules, and lack a continuous lingual cingulum. Seventeen specimens represent a second new omomyoid genus, tentatively referred to as 'genus B.' Genus B is significantly larger than *Omomys carteri* but smaller than *Macrotarsius*. Genus B has a distinctive upper fourth premolar with a mesiobuccally oriented protocone. Genus B also exhibits upper molars with moderate exodaenodonty, a continuous lingual cingulum, and well-developed conules. The dental characters of the new genera suggest a close relationship to *Omomys*. The preceding Bridgerian land mammal age was marked by the presence of numerous small anaptomorphine species in North America. However, by the beginning of the Uintan, only one anaptomorphine (*Trogolemur*) remained. By contrast, omomyines diversified from the Early Bridgerian to the Uintan. Accordingly, anaptomorphines and omomyines appear to exhibit opposite trends of species richness over time during the middle Eocene. The discovery of two new genera from the Friars Formation augments the known diversity of omomyines during the late middle Eocene and provides further evidence for this observed shift in Eocene primate richness. The new taxa described here also further highlight the endemism characterizing primate faunas from different regions of North America (e.g., the Uinta Basin of Utah, southern California, and the Tornillo Basin of Texas) during the Uintan.

Grant Information
Atwater is a National Science Foundation Graduate Research Fellow.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

THE EARLY LATE CRETACEOUS PALEOFAUNAL VERTEBRATE ASSEMBLAGE OF THE CLIFFS OF INSANITY MICROSITE IN THE MUSSENTUCHIT MEMBER OF THE CEDAR MOUNTAIN FORMATION, UTAH

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The Upper Cretaceous Mussentuchit Member of the Cedar Mountain Formation (~99 million years old) of central Utah documents a period of faunal exchange between Asia and North America together with dramatic changes to North America's landscape such as transgression of the Western Interior Seaway. Microvertebrate sampling within the Mussentuchit offers the opportunity to explore faunal changes and gain insight into the influence of sea level rise on biotic turnover during this interval. We report on a new productive microvertebrate locality in the Mussentuchit Member—the Cliffs of Insanity (COI) microsite—which has yielded ~500 identifiable specimens of a highly diverse assemblage dominated by reptiles, yet also includes fish, amphibians, and mammals. Strata at the COI microsite exhibit a coarsening upwards sequence, from siltstone below the fossil-bearing layer to a bentonitic, fine-grained sandstone within it and then a transition back to siltstone above the fossil-bearing layer, possibly representing an oxbow lake with an adjacent river migrating towards the lake. Approximately 150 kg of sediment was collected from the site and washed with fabric paint sieves in conjunction with an automated screenwashing system and then subsequently sorted with nested sieves. The only trace fossils recovered were ~15 minute egg shell fragments. Osteichthyan teeth representing Lepisosteiformes, Pycnodontiformes, and Amiiformes are identified as well as a number of indeterminate scales. A single pleurodont jaw fragment represents a lissamphibian. We also recovered turtle shell fragments referable to a new species closely related to *Naomichelys*. The most numerous fossils are hundreds of teeth referable to several carnivorous and durophagous crocodylomorph morphotypes. Saurischian teeth include four complete and several fragmentary dromaeosaur teeth from an as-yet indeterminate species. We tentatively identify two teeth as Avialae indet., possibly representing a hesperornithiform. Other dinosaurian remains include ornithischian teeth from basal ornithopods, ankylosaurids, and hadrosauromorphs. This includes two larger (6-8 mm length) heavily worn crowns of hadrosauromorphs. Two worn mammalian postcanine teeth appear to represent a multituberculate or symmetrodont. In spite of the relatively small volume of material collected and washed, this site is exceptionally rich and diverse, and yields ~20 of the ~50 described taxa recorded previously from multiple localities in the Mussentuchit Member.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

NOTOUNGULATE MIDDLE EAR ANATOMY: PARADIGMS AND ANALOGUES

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We use the quasi-independent paradigm and analogue methods to generate functional hypotheses regarding the epitympanic sinus (ETS) and the tympanohyal recess of notoungulates. The Electrical Analogue Model of Middle Ear Function served as our paradigm for the ETS, and several extant rodents with inflated middle ear cavities were explored as extant analogues. The paradigm predicts that cavity compliance is proportional to total volume of middle ear cavities, thus the enlarged ETS would increase cavity compliance, which in turn facilitates tympanic membrane sensitivity. However, resistance at the foramen between the tympanic cavity and ETS is inversely proportional to the cross-sectional area of the foramen and proportional to frequency. Thus, the narrow inter-cavity foramen in notoungulates would increase resistance to a degree too great at high frequencies for the sinus to facilitate hearing. Thus, the ETS would aid hearing only at low frequencies, with resonance occurring between cavities at intermediate frequencies. *Pedetes* (African spring hare) was our preferred extant analogue; however, most available information regarding auditory abilities of rodents with large middle ears came from species of *Meriones* (gerbils). These modern analogues are indeed sensitive to low frequencies.

The articulation of an ossified tympanohyoid along and within the ectotympanic adjacent to the tympanic membrane suggests a functional paradigm where vibrations of the hyoid (e.g., vocalizations) would generate action potentials in the cochlea via the membrane and middle ear ossicles. Thus, the brain would receive outgoing signals of vocalizations independent of any incoming airwave-carried manifestations of such vocalizations. Laryngeal echolocating bats are modern analogues that also have extensive hyoidal-tympanic contact. Reliable discrimination of outgoing and incoming signals is thought to facilitate bat echolocation.

The paradigms and analogues suggest that notoungulates were both sensitive to low frequency sounds and good at discriminating outgoing and incoming vocal signals. The biological significance of low frequency detection includes predator detection and/or intraspecific communication. Good discrimination between outgoing and incoming vocalizations could facilitate echolocation. We consider the possibility that these two features worked as a functional complex; that is, vocalizations at intermediate frequencies would cause resonance between the middle ear chambers, making the incoming signals yet more distinct.

Technical Session VI (Thursday, October 27, 2016, 11:00 AM)

MODERN DERMESTID BEETLE TRACES IN BONE AND THEIR COMPARISON TO TRACES ON LATE PLEISTOCENE BONE FROM LAUBACH CAVE, WILLIAMSON COUNTY, TEXAS, USA

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Dermestid beetles feed on subaerially-exposed dried carcasses and occasionally bore into hard surfaces, including bone, to construct pupation chambers. Damage to bone is primarily confined to the epiphyses of limb bones in juvenile animals and removal of thin laminae in skulls. A stillborn *Camelus dromedarius* was dissected and dried before being skeletonized using *Dermestes maculatus*. The dermestid larvae bored underneath the epiphyses of the limb bones and vertebral centra to consume the epiphyseal plate, often leaving shallow feeding trails. The periosteum near the epiphyses was also chewed, exposing the spongy cancellous bone underneath. Mature larvae constructed pupation chambers by chewing cylindrical holes and troughs into the soft metaphysial bone. The pupation chambers are roughly test-tube-shaped and range from 2.44–4.7 mm in diameter and up to 19.5 mm in length; slightly larger than the size of a mature larva. Individual mandible marks within the pupation chambers are not discernible from the spongy texture of the surrounding bone. Dermestid beetle traces often overlap, resulting in the appearance of an anastomosing network of trails and pits. Given sufficient time, dermestid larvae will completely destroy metaphysial bone in juvenile mammals.Initially discovered in 1963, Laubach Cave was dissolved out of the Cretaceous Edwards Formation in the Balcones Fault Zone of Central Texas. Late Pleistocene vertebrate fossils were recovered from debris cones which lie underneath collapsed sink holes within the cave. Examination of 640 *Playgonus* bones and additional bones from *Equus*,

Tetrameryx, *Camelops*, *Odocoilius*, *Panthera onca*, *Tremarctos*, Ground Sloth, and a Proboscidean revealed a variety of trace fossils, including rodent gnaw marks, possible carnivore bite marks, root etching, cylindrical pits and grooves, and focal destruction of long bone epiphyses and vertebral centra. Some bone surfaces and their trace fossils are coated in thin layers of travertine. Three isolated and two overlapping test-tube-shaped holes were found on *Platygonus* bones. A single vertebral centrum and one distal femur fragment have large patches of overlapping pits covering their epiphyses. The morphology of the holes and overlapping pits on the Laubach bones are consistent with dermestid beetle pupation chambers found on the stillborn camel. The presence of pupation chambers suggests that dermestid beetles fed on the remaining dried tissue on carcasses in Laubach cave before the bones were buried in debris and travertine.

Technical Session XVI (Saturday, October 29, 2016, 8:15 AM)

GREAT BASIN MAMMAL DIVERSITY AND TECTONIC HISTORY

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The topography of the Great Basin developed over the last 30 million years through extension, volcanism, and emplacement of metamorphic complexes. The fossil record of mammals spans much of this interval, and we evaluated how tectonic development influenced the diversity and biogeography of Great Basin mammals. Although the mammalian fossil record is sparse and uneven from the Oligocene through the early Miocene, from the middle Miocene onward, the record is continuous at a temporal resolution of 1-myr intervals. We compiled mammal occurrences from the NeoMap Database of North American mammals and analyzed changes in diversity, per-capita diversification rates, and taxonomic composition across the entire hydrographic Great Basin and for specific subregions. We compared the timing of faunal changes with geological estimates of the timing and magnitude of extensional deformation in order to test the hypothesis that regional mammal diversity is proportional to topographic complexity.

For the Great Basin as a whole, the largest peak in mammal diversity occurred between 16 and 14 Ma, when interactions between the Farallon and North American plates changed from compressional to extensional regimes and crustal strain rates were at their highest for the Neogene. Geodynamic models indicate that areal extension rates in the Great Basin were at their greatest in the middle Miocene, as was topographic relief. Much of the gain in area occurred in the Mojave region; among all fossiliferous subregions of the Great Basin during the middle Miocene, the Mojave record shows the greatest increase in mammal diversity. Diversification rates and species distributions indicate that both geographic-range shifts and speciation contributed to the middle Miocene peak in diversity. A subsequent decline in extension rates was accompanied by lower regional diversity. These parallel trajectories offer strong support for the hypothesis that changes in topographic complexity directly influence mammal diversity. Potential confounding factors include changes in the regional distribution of fossiliferous sediments and the scarcity of high-elevation habitats in the continental fossil record.

Technical Session I (Wednesday, October 26, 2016, 10:15 AM)

ORIGIN AND CRANIODENTAL EVOLUTION OF DEPERETELLIDAE (MAMMALIA, PERISSODACTYLA)

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Deperetellidae, consisting of four genera (*Teleolophus*, *Deperetella*, *Diplolophodon*, and *Bahinolophus*), is an endemic and common tapiromorph group in the Eocene of Asia. Species of Deperetellidae are mainly known from dentitions, maxillae and lower jaws, and cranial material is rare. Among tapiroids, deperetellids were characterized by an inverted, U-shaped ridge on the upper molars formed by the protoloph, paracone, and metaloph; an enamel microstructure with compound HSBs; and a postcranial skeleton adapted for cursoriality. The origin and phylogenetic relationships of Deperetellidae remain obscure, although the Lophialetidae, helaletid genus *Colodon*, and "*Irdinolophus*" have all been considered as the closest relatives of deperetellids. Based on our recent field work in the Erlian Basin, Inner Mongolia, we report a cranial specimen of the earliest known deperetellid from the base of the Arshanto Formation, as well as several skulls of *Teleolophus* from the 'Basal White' bed of Erden Obo outcrop, which was roughly correlative to the Irdin Manha Formation. From the earliest deperetellid to *Teleolophus*, an interval of about 4 Ma, transformations of the cranium include the retraction of the nasal incision from the level of the canine to the P3/4, the loss of contact between the premaxilla and the nasals, the retraction of the anterior end of the nasals from the level of the incisors to the postcanine diastema, the relative shortening of the maxilla, and the retraction of the anterior border of the orbit from the M2 to the M3. These cranial modifications suggest the presence of a prehensile proboscis in *Teleolophus*. By contrast, the dental morphologies of these taxa are relatively conservative and less modified. The main evolutionary transformations include a reduction in the metacone of the upper molar and a shift to a more typically U-shaped configuration, and a mesiodistal elongation of the lower premolars. Based on the preliminary analyses of craniodental characters of the basal deperetellids and *Teleolophus*, a close relationship with "*Irdinolophus*" and Lophialetidae was excluded. However, whether deperetellids are closely related to *Colodon* and what their phylogenetic position is within the tapiromorphs needs further investigation.

Grant Information
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Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

NEW HISTOLOGICAL DATA ON THE CRANIAL JOINTS OF ARCHOSAURS: SIGNIFICANCE FOR THE EVOLUTION AND FUNCTIONAL INFERENCES OF DINOSAUR CRANIAL KINESIS

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Archosaurs, like all vertebrates, have different types of joints that allow or restrict cranial kinesis, such as sutures and synovial joints. In general, synovial joints are more kinetic than sutures, because the former possess a fluid-filled cavity and articular cartilage that facilitate movements. Even though there is a considerable lack of data on the microstructure and the structure-function relationships in the joints of extant archosaurs, many paleontological inferences of cranial kinesis in dinosaurs have hinged on the assumption that condylar joints are synovial and kinetic.

In this study, cranial joint microstructure was investigated in ontogenetic series of two extant archosaurs, *Anas platyrhynchos* (n = 5) and *Alligator mississippiensis* (n = 3), as well as an outgroup sample of lizards. Selected sutures and condylar joints were studied by means of paraffin histology paired with microCT data to better visualize 3D morphology.

Results show that all the condylar joints (jaw, otic, palatobasal joints, and parts of the craniofacial hinge) in *A. platyrhynchos* were synovial and occasionally mediated by avian secondary cartilage. However, among the three condylar joints studied in *A. mississippiensis*, the jaw joint was synovial as expected, but the otic and laterosphenoid-postorbital joints lacked a synovial cavity, and these joints are immobile. Therefore, condylar morphology does not always imply the presence of a synovial articulation, nor mobility. Moreover, we found that the articulations between two membrane bones in alligators are always sutures, whereas they may form sutures or synovial joints in ducks and other birds. We hypothesize that this ability to build new, condylar synovial joints-between membrane bones, played a fundamental role in the evolution of modern avian cranial kinesis. These findings will be used to investigate the origin of this skeletal tissue adaptation among theropods and other non-avian dinosaurs, and its role in the evolution of vertebrate cranial kinesis. This study will also have implications for functional inferences of cranial kinesis in extinct dinosaurs.

Grant Information
NSF IOS 1457319

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

TEACHING AND LEARNING CLADOGRAMS: HOW COGNITIVE SCIENCE PREDICTS "BETTER" AND "WORSE" DIAGRAM STYLES AND LEARNING PROGRESSIONS

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Biological education research has identified expert-like skills and student learning difficulties associated with interpreting and constructing cladograms. Cognitive science informs diagram design that reduces or avoids misconceptions, and many common misconceptions and difficulties learning "tree-thinking" skills relate to the design of evolutionary tree diagrams. However, recent research has largely not been incorporated into teaching and communicating evolutionary trees in geology and paleontology contexts. The purposes of this study are to: (1) summarize recent research applicable to teaching and learning evolutionary tree diagrams; (2) test whether modifying a "tree-thinking" assessment explicitly to avoid cognitive interference improves scores; and (3) test whether research-based teaching materials and strategies promote improvement in tree-thinking skills and avoidance of misconceptions.

Materials and strategies for teaching evolution and "tree-thinking" in undergraduate geology and paleontology courses were designed to avoid cognitive interference through diagram design, emphasize the hierarchical structure of cladograms, reduce common misconceptions about evolution and evolutionary trees. Modifying an assessment to reduce cognitive interference produced comparable results between post-test scores of students in an upper level majors' paleontology course using partially reformed instruction and pre-test scores of students in introductory courses. A pilot study of reformed teaching materials and strategies shows improved tree-thinking skills and reduction in misconceptions in both an upper level majors' paleontology course and introductory courses.

Specific recommendations from recent research are: (1) use "tree-style" cladograms to support understanding of evolutionary concepts; (2) initial work should not use real organisms in trees to avoid cognitive interference; (3) explicitly teach multiple representations and diagram reading strategies to promote hierarchical thinking; and (4) teach using synapomorphies to support understanding of cladistic analysis and evolutionary relationships.

Symposium III (Saturday, October 29, 2016, 8:00 AM)

ENDOTHERMY ACQUIRED: TRACKS AND PRODUCTIVITY EFFICIENCY SHOW ELEVATED ENERGY CONSUMPTION DURING ORIGIN OF DINOSAURS AND ADVANCED THERAPSIDS

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Over a ten year interval, the Houston Museum of Natural Science and the Whiteside Museum of Natural History have censused: (1) the foraging speed recorded in fossil tetrapod trackways; and (2) the productivity of apex carnivores and their probable prey. Foraging speed for extant ectotherms, e.g., turtles and lizards, averages one fifth that of endothermic mammals of the same body mass, because endotherms must harvest ten to thirty times as much energy and water per unit body mass per unit time. Our slowest fossil track sample: *Dimetrodon*-like carnivores, 0.8 km/h. Fastest fossil sample: Cretaceous dinosaurian apex carnivores, 4.4 km/h, even higher than that for extant and

extinct mammals of comparable body mass. Unfortunately, there are only small track samples for Mid Permian through Triassic therapsids.

To analyze trophic efficiency, we use "taphonomy purified samples": flood basin samples containing carnivore and prey carcasses with tooth damage matching carnivore tooth shape and mingled with carnivore coprolites, plus shed carnivore teeth (for non mammals). Such samples exclude mass burials with little evidence of carnivore action. Compared to endotherms, ectotherms fix a much greater fraction of the food consumed into growth and reproduction (= secondary productivity [sp]). For both ectotherms and endotherms, at a given body temperature, body mass and climate, carnivore and herbivore produce flesh at a rate sp = (standing crop)k(mean body mass)$^{0.68}$. The same k applies to ectotherm and endotherm. Yearly flesh consumption (c) by carnivores is c = (standing crop) K(body mass)$^{0.68}$. For endotherms, the K is 10 to 30 times greater than for ectotherms. Carnivore sp /prey sp is the trophic efficiency. Highest efficiency in our purified samples: 0.30 to 0.44 in *Dimetrodon*. Bone histology confirms slow "reptile-grade" growth. Intermediate efficiency: 0.11 in early therapsid sample from the middle Permian *Tapinocephalus* Zone and late Permian Orange River. Histology suggests some elevated growth rates. Lowest efficiency: 0.01 to 0.05, Jurassic–Cretaceous dinosaurs and mid-late Cenozoic mammals with strong histological evidence of high growth rates. Thus efficiency values agree with foraging speed and histology in identifying endothermic trends in the origin of dinosaurs and advanced therapsids.

Grant Information
Field Work and Fossil Preparation Supported by the Wilbert and Nellie Bakker Foundation

Preparator's Session (Thursday, October 27, 2016, 8:45 AM)

REPAIRING THE TITANS: CHALLENGES AND CONSIDERATIONS FOR DEALING WITH SAUROPOD BONES

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A new exhibit featuring the largest known titanosaur was unveiled at the American Museum of Natural History in January of 2016. Along with a complete mounted skeletal cast, five original fossil elements of an as-yet unnamed Argentine titanosaur are showcased. Stresses on two elements (a scapula and a 500 kg femur) during the extended air and ground transport from Argentina resulted in significant damage. Transverse fissures along the femur yielded broken elements, each piece weighing between 100–250 kg. A team consisting of Preparation, Exhibit, and Conservation staff arranged logistics for repair during a two-week time frame. Due to the outstanding dimensions and masses of these specimens, critical decisions were made in the choice of treatment, specifically in the selection of adhesive, and in the mechanical handling of broken elements (particularly for the femur). Paraloid B-72 (in acetone 1:1 w/v) and Devcon 2-ton epoxy (an irreversible structural adhesive) were each considered. Working qualities and setting times of these materials were assessed within the context of the very limited time frame. Most importantly, physical qualities including shear, tensile, and compression strengths were compared with the aid of limited but impactful conservation literature on this subject. Despite its irreversibility (and sometimes controversial use) in fossil conservation, epoxy adhesive was employed for the repairs. Shear and compression load calculations on the two femoral breaks as estimated by basic mechanical stress formulae, were pivotal in making this choice. Unlike the majority of fossil repairs wherein the strength of Paraloid B-72 suffices or exceeds the demand, specimen repairs of titanosaurian size leave room to question this adhesive's suitability. I will describe the practical and physical quality comparisons of both adhesive options which resulted in the final treatment plan, and handling logistics for the femoral repair. Details on the utility of stress load calculations for large specimen repairs will be coupled with a summary of important published data on tensile/shear strengths of some of the most widely-used adhesives in fossil preparation and conservation.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

MORPHOSPACE AT AN INTERFACE: OCCIPUT SHAPE IN RHINOCEROTOIDS

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Occiputs are little studied, but may be expected to have morphologies correlated to interface requirements between neck and skull (proximately) and to behavioral-ecological head and neck functions (ultimately). Morphological features of rhinocerotoids are generally influenced by several contrasting spectra: primitive vs. derived, small vs. large, grazer vs. browser, graviportal vs. cursorial, and horned vs. unhorned. Here, a small set of simple occipital measures were analysed for patterns of shape within a 2-D shape ratio space. Basic rhinocerotoid occiput shape was characterized by three transverse measures: upper width (UW) at the nuchal crest, lower width (LW) at the occipital condyles, and middle width (MW) midway between UW and LW. Using arbitrary widths of 1,2, and 3, an idealized morphospace was determined comprising five shape groups: rectangular (R: UW = MW = LW), bottom heavy (BH: UW $\leq$ MW $\leq$ BW), top heavy (TH: UW $\geq$ MW $\geq$ LW), middle heavy (MH: UW < MW > LW), and waisted (W: UW > MW < LW). A derived 2-D shape space was determined by using the ratios of UW to LW (UR; x-axis) and MW to LW (LR; y-axis). The minimal polygonal areas defined by the idealized shapes in the ratio space do not overlap. Rectangular shapes plot as a singularity (UR = LR = 1). All of the rhinocerotoid mean ratios plot within, or adjacent to, the bottom heavy minimal polygon without overlapping other shape areas. Taxa plotting within the BH polygon include *Hyrachyus*, *Amynodon*, *Hyracodon*, *Procadurcodon*, *Menoceras*, *Aceratherium*, *Aphelops, Peraceras, Dicerorhinus,* and *Rhinoceros*. These are on the side of the BH polygon converging toward rectangularity. *Triplopus* is the furthest outlier from the other rhinos, but is bottom heavy by virtue of a significantly narrowed UW. *Paraceratherium*, *Indricotherium*, and *Forstercooperia*, all hyracodontids, lie to the right of the BH region in the direction of the waisted group. *Trigonias* and *Subhyracodon* plot in the zone triangulated between bottom heavy, waisted, and top heavy. *Teleoceras* and *Diceros* are slightly bottom heavy but plot closest to rectangularity. *Ceratotherium* has a shape closest to the middle and top heavy groups. The bottom heavyness of rhinocertoid occiputs in general suggests that condylar influence is predominant ventrally, and that adaptive differences among taxa have most to do with occipital responses to demands of nuchal and masticatory muscles dorsally. There do not appear to be any clear shape trajectories correlated to phylogeny.

Technical Session VI (Thursday, October 27, 2016, 8:15 AM)

HYPERCARNIVORY AND EXTINCTION RISK IN NORTH AMERICAN FOSSIL CANIDS

BALISI, Mairin, University of California, Los Angeles, Los Angeles, CA, United States of America; VAN VALKENBURGH, Blaire, University of California Los Angeles, Los Angeles, CA, United States of America

Hypercarnivory and bone-crushing are metabolically costly specializations, and their appearance in a lineage is invariably irreversible: an example of an evolutionary 'ratchet.' While modern ecosystems are relatively depauperate of hypercarnivores and bone-crushers, these specializations have repeatedly arisen in the fossil record, permitting exploration of a) how hypercarnivory may affect extinction rate and b) how quickly an empty hypercarnivore niche is filled. North American fossil dogs (Mammalia: Carnivora: Canidae) comprise over 100 species spanning a wide range of ecomorphologies, including iterative occurrences of hypercarnivory. Here, we reconstruct the initial rise of hypercarnivory in canids, examining a set of 12 ecomorphological indices over nine time slices from the origin of Canidae (40 million years ago) to the height of canid species richness (25 species at peak richness; 15 million years ago). Hotspots of elevated extinction rate correspond to areas of the canid morphospace occupied by large—but not small—hypercarnivores, matching the prediction of hypercarnivory representing an evolutionary 'dead end.' However, hypercarnivory is slow to arise in canids. With non-canids occupying the carnivore and large-hypercarnivore space, canids first saturate the omnivore and small-carnivore space. Even as large hypercarnivorous non-canids become extinct, canids remain in the omnivore and small-carnivore space, becoming large hypercarnivores only after several million years. This significant lag in the movement of canids into the large-hypercarnivore space suggests that the turnover resulted from passive replacement and ecological release rather than active displacement. Strikingly, little ecomorphological overlap occurs among canids and non-canids, confounding hypotheses that canids declined taxonomically from competition with non-canid clades.

Grant Information
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Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

EXPLORING THE CENOMANIAN AND TURONIAN (92–98 MA) SEAS OF SASKATCHEWAN, CANADA

BAMFORTH, Emily L., Royal Saskatchewan Museum, Eastend, SK, Canada; TOKARYK, Tim, Royal Saskatchewan Museum, Eastend, SK, Canada

The Pasquia Palaeontological Site (PPS) is a Provincial Heritage Property on the Carrot River, in the Pasquia Hills region of the Manitoba Escarpment, located in east-central Saskatchewan, Canada. The PPS represents one of the best known records of Cenomanian and Turonian-aged (92–98 Ma) marine life in Canada, with faunas comprised of a wide diversity of sharks, cartilaginous and bony fish, crocodylians, marine reptiles, dinosaurs, invertebrates, and aquatic birds. In the early 1990s, the PPS produced a near complete specimen of *Terminonaris robusta* (a large marine pholidosaurid crocodile) and a well-preserved skeleton of *Xiphactinus* from the Turonian Favel Formation, as well as two species of basal hesperornithiformes birds belonging to a new genus, *Pasquiaornis*, from the underlying Cenomanian Ashville Formation. The paleontological significance of this locality, which provides insights into the little known time period in Saskatchewan's geological history, is such that is was designated as a Provincial Heritage Property in 1995. During the summer and fall of 2015, the Royal Saskatchewan Museum returned to the PPS to do the first extensive survey in almost 20 years. During two weeks of collection, hundreds of new fossils were recovered. Bivalves, namely oysters, comprised a large proportion of the invertebrate fossils found. Trace fossils also indicated the presence of worms, crabs and other burrowing animals. Teeth from at least five different species of shark were discovered and collected. Large (6–7 cm), ovaoid fish scales, likely from ichthyodectid fish and/or *Xiphactinus*, were ubiquitous in all of the deposits explored. Bony fish material, including vertebra and skull fragments, was also collected. One of the most remarkable finds was an articulated specimen of *Pachyrhizodus*; this 15 cm-long fish was so well-preserved that the scales were all still in place along the body. Probable bird and plesiosaur material was also recovered, and is currently under study at the Royal Saskatchewan Museum *T. rex* Discovery Centre in Eastend, SK. Future work on the PPS assemblages will include a paleobiodiversity study, comparing the fauna found in PPS's Favel Formation with that described from the nearby Ashville Formation at Bainbridge River, SK. These studies will lead to critical insights about the paleoecology and paleobiodiversity dynamics occurring in the northern regions of the Western Interior Sea during the late Cenomanian and early Turonian periods.

Colbert Prize (Wednesday–Saturday, October 26–29, 2016, 4:15–6:15 PM)

PHYLOGENY, ECOLOGY, AND TIME: 2D OUTLINE ANALYSIS OF ANURAN SKULLS FROM THE EARLY CRETACEOUS TO RECENT

BARDUA, Carla, University College London, London, United Kingdom; EVANS, Susan E., University College London, London, United Kingdom; GOSWAMI, Anjali, University College London, London, United Kingdom

Anura have a long fossil record spanning from the Early Jurassic to Recent. However, even the best-preserved specimens are often severely flattened, limiting their inclusion in quantitative analyses of anuran morphological evolution. Here we perform a 2D morphometric analysis of anuran skull outlines obtained from the published literature, incorporating 42 Early Cretaceous to Miocene species, as well as 93 extant species in 32 families.

Outlines were traced in tpsDig2 and analysed with elliptical Fourier analysis (EFA) in the R package 'Momocs'. EFA permits increased sampling from areas of high curvature so that the anuran skull outline can be well represented by the resulting ellipses. Fourier coefficients were used as high dimensional variables in MANOVAs and disparity

analyses across multiple ecological and life history groupings, such as region, habitat, and developmental strategy. As skull outlines showed significant phylogenetic signal (k = 0.53, p = 0.006), phylogenetic MANOVAs, using composite phylogenetic trees generated from recent published analyses, were also conducted.

In extant taxa, the Neotropical realm showed higher disparity than the Australian, Palearctic, and Oriental realms (p = 0.007, 0.013, and 0.038, respectively), suggesting concordance of disparity and diversity. Developmental strategy had a weak effect on skull shape (Rsq = 0.02, p = 0.039), and disparity was similar in metamorphosing and direct developing frogs. Ecological niche was a significant discriminator of skull shape (F = 1.44, p = 0.004), but not after phylogenetic correction. The effect of body size on shape was assessed in living and extinct taxa and was strongly associated with differences in skull shape in fossil frogs (Rsq = 0.44, p = 0.017), and to a lesser extent, in extant taxa (Rsq = 0.10, p = 0.049). This effect was only partly due to allometry, which was a weak but significant influence on skull shape in both fossil (Rsq = 0.11, p = 0.002) and extant frogs (Rsq = 0.09, p = 0.001).

Finally, morphospace occupation of anuran skull outlines, analysed by binning skulls in five million year bins based on first occurrence date, appears to have changed over time (F = 2.42, p = 2.2 E^{-16}). However, as with ecological signal, this shift appears to be largely driven by phylogeny and was not significant after phylogenetic correction (Rsq = 0.258, p = 0.221).

This study thus suggests that phylogeny is a greater influence than ecology on frog skull shape, as measured by 2D outlines, which may reflect the observation that in many anuran families, genera share a similar ecology.

Grant Information
European Research Council grant 167769

Preparator's Session (Thursday, October 27, 2016, 11:45 AM)

FOSSIL PREPARATION IN A SMALL LAB: A CASE STUDY OF PREPARATOR TRAINING AT THE STERNBERG MUSEUM OF NATURAL HISTORY IN HAYS, KANSAS

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The process of fossil preservation is exhaustive and meticulous, and demands knowledgeable specialists. In small museums, the preparation staff can often be limited by the need for tools, funds, and experience. Although online resources are available, it can be difficult for novice preparators to find current information in a single location and evaluate the resource's legitimacy. This case study highlights the development and field-testing of preparatory resources to train novice students at the Sternberg Museum of Natural History. The Sternberg Museum has a backlog of fossils requiring preparation and a need for volunteers trained in fossil preparation, making it an ideal location.

At the start of training, student volunteers were provided with a workbook containing guidelines, common mistakes, and tips on preparatory techniques. A teaching manual was also compiled, detailing lesson plans to guide the trainer through a series of workshops and pedagogical techniques for training different types of volunteers. Over the course of four two-hour sessions, students learned techniques for assessing fossils and their matrix, determining the appropriate tools to use for any given sample, proper use of materials and tools (including hand and pneumatic), and molding and casting. The students were also given a list of resources if they had questions and the lab manager was not available. Qualitative skill assessments were based on final prepared specimens, knowledge of methods, and a self-assessment at the end of the fourth session.

Upon completion of all sessions, students were able to satisfactorily prepare a variety of specimens. The course material successfully trained the beginnings of a preparation corps of volunteers for the Sternberg Museum and allowed for greater engagement with the public by more consistently populating the preparation laboratory. The simple and methodical nature of the materials produced educated students that were permitted ample time for practice, assessment, and improvement. Upon refinement, the versatility and scope of the materials will provide an easily downloadable and free resource for museums of any size to train and educate new preparators in proper fossil preparation techniques.

Technical Session XV (Saturday, October 29, 2016, 11:30 AM)

COMPARATIVE BIOMECHANICS OF 'UNSPECIALISED' DINOSAUR HERBIVORES: CONVERGENT MORPHOLOGY DOES NOT PREDICT CRANIAL FUNCTION

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Morphological convergence is common and often equated with functional equivalence. However, qualitative assessments based on simple form/function comparisons might be misleading and recent work on extant taxa has highlighted the need to test function experimentally, rather than rely on extrapolations from form alone. Here, we test the biomechanical function of three morphologically similar, but distantly related, dinosaur herbivores to determine if their convergent cranial characters also convey biomechanical similarity. The therizinosaurian theropod *Erlikosaurus*, the basal sauropodomorph *Plateosaurus*, and the thyreophoran ornithischian *Stegosaurus* were selected for analysis. All share a suite of craniodental features, including a long, narrow snout, small adductor chambers, simple tooth morphology, and orthal jaw actions. CT scans of each skull were rendered into 3D models, combined with reconstructions of the jaw musculature, and subjected to both Finite Element and Multibody Dynamic analyses. Skull function was assessed during anterior, midpoint, and posterior bite scenarios, and sensitivity analyses were carried out with respect to the presence/absence of various cranial characters (e.g., beak, antorbital fenestra). Inspection of the Von Mises stress distributions and comparisons of calculated bite forces indicates that despite a high degree of morphological similarity, biomechanical function differed substantially in each case. Surprisingly, bite forces in *Stegosaurus* were substantially higher than in the other two taxa; and, contrary to their phylogenetic relationships, bite performance in *Stegosaurus* and *Plateosaurus* was more similar to each other than either was to *Erlikosaurus*. It seems likely that *Stegosaurus* had access to a wider range of potential food plants than the other taxa, with high bite forces and moderate stress distributions; *Erlikosaurus* was highly susceptible to high stresses and seems to have specialised in anterior bites. This work demonstrates that biomechanical validation of functional hypotheses is necessary to avoid falling into a form/function pitfall and highlights the decoupling of form and function in at least some extinct taxa.

Romer Prize Session (Thursday, October 27, 2016, 11:00 AM)

THE END-PLEISTOCENE EXTINCTION IN NORTH AMERICA: AN INVESTIGATION OF HORSE AND BISON FOSSIL MATERIAL AND ITS IMPLICATION FOR NUTRITIONALLY-BASED EXTINCTION MODELS

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Approximately 50,000–11,000 years ago many species around the world became extinct or were extirpated at a continental scale in what is known as the end-Pleistocene extinction. Several extinction models have been proposed, but a firm connection between particular variables and particular species remains elusive. In this study, I tested two nutritionally-based extinction models (coevolutionary disequilibrium and mosaic-nutrient) by analyzing changes in diet and systemic stress in *Equus* and *Bison* samples from the Western Interior of North America. To accomplish this task, I first determined the number of equid species that inhabited this region during the late Pleistocene. More than 40 species of North American Pleistocene equids have been named and, despite several attempts at revising the taxonomy of this group, there is still considerable disagreement on the number of species that inhabited the continent. Based on morphological and molecular data analyzed in this study, three species of equids (two non-caballine and one caballine) occurred in the Western Interior in the late Pleistocene. Notably, the separation into caballine and non-caballine species was observed in the phylogenetic analysis of mitochondrial ancient DNA as well as in the geometric morphometric analyses of the upper and lower cheek teeth.

Subsequently, I tested predictions formulated for each extinction model by reconstructing the diet of *Equus* and *Bison* samples through the analysis of dental wear patterns (microwear and mesowear). I also determined whether the incidence of systemic stress, inferred from the study of enamel hypoplasia, increased during the terminal Pleistocene as predicted by both extinction models. Investigation of the dental wear of the equid and bison samples yielded results that are consistent with predictions established for the coevolutionary disequilibrium model, but not for the mosaic-nutrient model. Species of *Equus* and *Bison* show statistically different dental wear patterns (suggesting dietary resource partitioning) prior to and during the Last Glacial Maximum (LGM), but not during the post-LGM. In addition to changes in diet, these ungulates, particularly the equid species, show increased levels of enamel hypoplasia during the post-LGM indicating higher levels of systemic stress. The extent to which the increase in systemic stress was detrimental to equid populations requires further investigation, but it is suggestive that environmental changes might have played an important role in the extinction of these ungulate mammals.

Grant Information
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Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

THE MANUS OF EARLY THEROPOD DINOSAURS: DIGITAL RECONSTRUCTIONS OF ARTICULATED SPECIMENS REVEAL A COMPLEX EVOLUTIONARY PATTERN OF DIGIT REDUCTION

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Basal theropod dinosaurs are central to our understanding of the identities and evolution of avian wrist bones and manual digits because they serve as essential outgroups for research on the well-studied transition from four- to three-fingered taxa, and exemplify an earlier, less well-studied, evolutionary transition from five- to four-fingered taxa. Though several articulated specimens are known, the study of broader evolutionary patterns in digit reduction along the grade of early-diverging theropods is often constrained by (1) incomplete fossil preparation, (2) lack of knowledge of intraspecific variation, and (3) the limited taxonomic scope of previous analyses. In an attempt to rectify these issues, computed tomography scans of two species, *Coelophysis bauri* and *Coelophysis* (=*Megapnosaurus*, = "*Syntarsus"*) *rhodesiensis* were reconstructed, described, and compared to one another and other basal theropods for which near-complete manus are also known. These comparisons reveal intraspecific differences within *C. bauri*, including the first evidence of a centrale in one specimen, and an intermedium in another. Interspecific differences between *C. bauri* and *C. rhodesiensis* include the presence of an ossified remnant of the fifth metacarpal and a centrale in *C. bauri*, but not in *C. rhodesiensis*. *Coelophysis rhodesiensis* appears to possess a pisiform, in contrast to *C. bauri*, which lacks this element. The number of phalanges on digit four also varies between one and two among early theropods. This research imparts a more complex picture of digit reduction along the five- to four-fingered transition, including up to three independent losses (depending on the tree topology) of an ossified fifth metacarpal within Theropoda (in *Tawa hallae, Coelophysis rhodesiensis*, and Averostra). The phylogenetic position of *Dilophosaurus wetherilli*, which possesses a remnant fifth metacarpal similar to that of *C. bauri*, greatly influences the reconstructed pattern of digit reduction. This complexity, including polymorphism within species, may be evidence of an earlier "zone of developmental variability" in theropod digit reduction.

Grant Information
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Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

MULTIGENERATIONAL ASSEMBLAGE OF *TRICERATOPS* FROM THE NEWCASTLE AREA, WYOMING, USA—AN IN-DEPTH ANALYSIS OF CRANIAL AND POST-CRANIAL ONTOGENESIS

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Here we report on a multigenerational assemblage of *Triceratops* from the Upper Maastrichtian Lance Formation near Newcastle, eastern Wyoming, USA. In excess of five hundred elements were uncovered belonging to a minimal number of five individuals. Detailed geological fieldwork at the excavation site shows that the *Triceratops* skeletons are entombed within an organic-rich siltstone unit characterized by abundant micro- and macro-floral and -vertebrate remains. The *Triceratops* bones are associated, but also show clear disarticulation. The fifth skeleton is located at the same site, but circa 4 meters above the main bonebed.

The site is remarkable since it yields both cranial and post-cranial remains of individuals of different sizes, representing several ontogenetic stages. This assemblage is one of only a handful known sites of the genus *Triceratops* that contain abundant post-cranial material. Ontogeny and especially the validity of taxa in *Triceratops*, and other Chasmosaurinae (e.g. *Torosaurus*), have been heavily debated subjects. However, studies have mostly been restricted to descriptions of cranial material due to the scarcity of post-cranial remains. Therefore, this assemblage helps to fill in a hiatus in our knowledge regarding the post-cranial development of these highly derived ceratopsids.

The *Triceratops* site in Wyoming offers a higher resolution in the ontogenetic development in particularly the late juvenile or early sub-adult to adult stages of *Triceratops*. By combining histology, allometric measurements, and analysis of morphological characters, the timing of attaining skeletal maturity along with the expression of morphological characters, like suture closure and cranial ornamentation, can be specified. It is evident that individuals in the sub-adult stage reach near-adult size before the closure of most cranial sutures. Additionally, it is recognized that certain post-cranial elements, especially in the pelvic region, experience major remodelling during ontogeny.

Future studies with emphasis on intense histological sampling and the use of (μ-) CT scans, will aid in determining the specific timing of these ontogenetic changes.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

MORPHOLOGICAL RELEASE FOLLOWING SELECTIVE EXTINCTION AMONGST SHARKS AT THE END OF THE MESOZOIC

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The Cretaceous–Paleogene mass extinction event (K–Pg) is considered a critical phase in the evolutionary history of neoselachians with a documented decline in the taxonomic richness of cartilaginous fishes. However, the ecological significance of this event remains poorly understood with patterns of extinction selectivity being especially controversial. Some authors have proposed a selective decline amongst large-bodied, pelagic apex predators (particularly lamniform sharks), a pattern well established among actinopterygian fishes, but recently contested in neoselachians and alternatively posited as random with respect to environment and ecology. Furthermore, under a non-random selective extinction model, pelagic top-predatory lamniform sharks may have been replaced by other lamniforms as well as ecologically comparable carcharhiniform species following the extinction event. Current analyses, however, are based on assessments of taxonomic richness, and lack the necessary morphological framework with which to adequately test ecological dynamics in sharks across the K–Pg.

Based on a dataset of 806 carcharhiniform and lamniform teeth spanning the Maastrichtian–Paleocene we employed a 2D geometric morphometric analysis to test for: (1) non-random morphological selectivity in these clades across the K–Pg; and (2) ecological dynamics in the diversity of lamniforms vs. carcharhiniforms: the hypothesis that carcharhiniforms filled vacated regions of eco(morpho)space following the extinction event. Our results reveal stasis in lamniform disparity across the K–Pg, whereas carcharhiniformes underwent a notable decline. Both patterns contrast previous understandings of how these clades were affected across the K–Pg interval and hint at more complex extinction dynamics. Notwithstanding their overall disparity stasis, observations along the first principal component (63.19% of the total variance) reveal notable decreases in regions of lamniform morphospace associated with cutting rather than grasping dentitions and support the hypothesis of non-random selectivity against macropredatory forms such as anacoracids (e.g., *Squalicorax*). In contrast, post-extinction carcharhiniforms are more abundant in cutting-type dentitions indicating that they filled regions of morphospace vacated by lamniforms. We therefore propose that the post-Cretaceous radiation of carcharhiniforms was not general, but rather focused on particular ecological opportunities created by the extinction of lamniform sharks.

Technical Session XIII (Friday, October 28, 2016, 3:45 PM)

TETHYAN ISLAND BIOGEOGRAPHY DURING THE EOCENE: A VIEW FROM NORTHERN ANATOLIA

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New paleontological and geochronological data from the Eocene Uzunçarsidere Formation (UCF) in northern Anatolia underscore the highly endemic nature of its mammalian fauna. Fossil mammals currently recorded from the UCF include palaeoamasid embrithopods, multiple species of the pleuraspidotheriid "condylarth" genus *Hilalia*, at least two marsupial taxa, a bat, an omomyid primate, and other mammals whose affinities remain to be deciphered. The most commonly encountered fossils in the UCF are embrithopods and pleuraspidotheriids, and these mammals appear to have been the dominant terrestrial herbivores in the UCF ecosystem. Perissodactyls and artiodactyls are conspicuously absent from the UCF fauna. Elsewhere in Eurasia, a dramatic shift in the composition of the herbivorous mammal guild occurred across the Paleocene–Eocene boundary, when perissodactyls and artiodactyls replaced archaic "condylarth" taxa such as pleuraspidotheriids. If northern Anatolia maintained a direct land connection to either western Europe or Asia during earlier intervals of the Eocene, perissodactyls and artiodactyls would be expected to have replaced pleuraspidotheriids and embrithopods as the dominant terrestrial herbivores. However, new U-Pb detrital zircon age estimates for the UCF mammal fauna suggest that it is no older than 43 Ma. Taken together, the new geochronological and paleontological data from the UCF are consistent with a long interval of isolation for its mammalian fauna, with isolation from western European faunas having been continuous since the late Paleocene (an interval spanning almost 15 million years). The retention of surprisingly primitive features in the UCF bat and primate is consistent with such a long interval of isolation, although both of the latter taxa must have dispersed over water to the Tethyan island on which the sediments comprising the UCF accumulated.

Grant Information
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Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

AN INVESTIGATION OF THE IMPACT OF BODY SIZE ON SKELETAL PRESERVATION USING THE ICHTHYOSAUR *STENOPTERYGIUS*

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Specimens of *Stenopterygius* (Reptilia; Ichthyosauria) from the Posidonia Shale Formation were used to test the fundamental assumption of better preservation with larger body size. The investigation, using a semi-quantitative analysis scoring nine distinct anatomical units for articulation and completeness, suggests size does influence final appearance. But while high values of articulation and completeness are noted in large (ca. 3 metre) specimens, similar high values were also returned for smaller specimens, ca. 1 metre. However, in the smaller specimens the range of articulation and completeness values is considerably wider, which is interpreted as the greater susceptibility of smaller skeletons and the elements comprising them to the effects of biostratinomic processes, notably bottom currents in the depositional setting. Further investigation of articulation and completeness separately against body length revealed that while size has a limited influence on articulation, completeness of an ichthyopterygian skeleton apparently improves with increasing size in the absence of all but the most intense biostratinomic processes. That is, elements from larger carcasses were more difficult to move and remove after arrival at the sediment. Crucially, the body size categories relate to ontogenetic stages, the extent of disarticulation and loss of completeness being greater in juveniles (0-1.5 metres ±) compared to adults (over 1.5 metres). An additional group of 'embryonic' skeletons was also designated (>0.6 metres long), which showed articulation and completeness values between the other two groups. These specimens were observed either in the abdominal region of, or outside but in close proximity to, an adult skeleton, suggesting that such an association provided the embryo with shelter, unavailable to the isolated juvenile specimens, that limited disarticulation and loss of completeness to some degree. The findings of the study have important implications for the preservation of ichthyopterygians and marine reptiles as well as the preservation of different body size ranges in vertebrates generally.

Technical Session IV (Wednesday, October 26, 2016, 1:45 PM)

ASSESSMENT OF LUMBAR MOBILITY IN ARCHAEOCETES (MAMMALIA, CETACEA): INSIGHTS INTO THE EVOLUTION OF AQUATIC LOCOMOTION IN THE EARLIEST WHALES

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Evaluating functional changes in the vertebral column of early cetaceans is vital to address hypotheses of locomotor evolution. The transition from foot-powered to tail-powered swimming in archaeocete cetaceans required significant reconfiguration of the post-thoracic spine. The evolution of the lumbar region is especially intriguing, given that models of locomotor evolution propose that early cetaceans passed through an undulatory stage of locomotion that would have required substantially greater lumbar flexibility than that presumably possessed by their artiodactyl ancestors. In order to assess relative lumbar mobility across early archaeocetes, data were collected from the lumbar vertebrae of modern dorsostable and dorsomobile mammals. Fourteen linear and three angular measurements were collected from each lumbar vertebra, and principal components analyses (PCAs) were carried out for each vertebral position. The PCAs successfully differentiate mammals with more stable lumbar regions from those with more mobile lumbar regions. Dorsostable mammals tend to have lumbar vertebrae with anteroposteriorly short centra, anteroposteriorly long neural spines, and transverse processes with little cranial or ventral inclination. In contrast, dorsomobile mammals tend to have lumbar vertebrae with anteroposteriorly long centra, anteroposteriorly short neural spines, and transverse processes that are angled cranially and ventrally. When lumbar vertebrae from archaeocetes are included, a general trend of increasing mobility is apparent. More primitive archaeocetes, such as pakicetids and remingtonocetids, tend to plot among the dorsostable mammals, while early protocetids plot closer to dorsomobile mammals. More derived protocetids and basilosaurids plot among the more extreme dorsomobile mammals. This supports the hypothesis that the lumbar region of archaeocetes exhibited a trend of increasing mobility as they became more adapted to an aquatic lifestyle. Notably, a pair of modern cetaceans included in this study plot among the more dorsostable mammals. This is consistent with the observation that most modern cetaceans limit vertebral movement to the middle and posterior caudal vertebrae just anterior to the fluke. In sum, these results suggest that the lumbar region of cetaceans was marked by an increase in mobility during the transition from foot-powered swimming to dorsoventral undulation, followed by a subsequent decrease in lumbar mobility during the development of an oscillatory swimming mode.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

PALEOCOMMUNITY OF LATE PLEISTOCENE MEGAFAUNA FOUND ALONG THE LOWER MISSISSIPPI DELTA GRAVEL BARS

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The Rancholabrean age of the late Pleistocene is characterized by large vertebrate animals including *Mammut americanum* (American mastodon), *Bison* spp. (bison), *Megalonyx jeffersonii* (Jefferson's ground sloth), *Canus dirus* (dire wolf), *Arctodus simus* (short-faced bear), and others living within the pine-hardwood forests and grasslands during that time. Disarticulated cranial and post-cranial elements are frequently found on the floodplain and gravel bars throughout the Mississippi River Delta, especially after the floodwaters retreated in the late spring. One collection known as the Looper Collection, catalogued in early to mid-1990s, consists of 550 cranial and post-cranial elements. The fossils in this unpublished collection were recovered from Mississippi River gravel bars that spanned 142 river miles (499.7 – 641) and 19 counties within three states (Arkansas, Mississippi, and Louisiana) from Coahoma County Mississippi in the north to East Carroll Parish, Louisiana in the south. Mammals assigned to the Artiodactyla, Carnivora, Edentata, Lagomorpha, Proboscidea, Perissodactyla, Rodentia, and Sirenia are represented as well as bone fragments of Aves, dorsal fin spines of *Pylodictis olivaris* (flathead catfish), and plastron and shell fragments of various Testudines. This collection is significant since it contains specimens of several species that have not been previously reported from the Mississippi Delta: *Canis dirus*, *Mammuthus columbi* (Columbian mammoth), *Tapirus veroensis* (Florida tapir), and *Paleolama mirifica* (stout-legged llama). Other species contained in this collection appear to represent first time occurrences within the southeastern United States: *Trichechus manatus* (manatee), *Ictiobus bubalus* (small mouth buffalo), *Castor canadensis* (modern beaver), *Tapirus haysii* (giant tapir), and *Euarctos americanus* (American black bear). Herbivores represent 98% of the total megafauna. The most common elements catalogued include herbivores of *Bison*, *Odocoileus virginianus* (white tailed deer), *Equus* spp. (fossil horse) and *Megalonyx jeffersonii*. In contrast, carnivores represent less than 2% of the total assemblage.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

EXPLORATION OF POST-CRANIAL SEXUAL DIMORPHISM IN LATE PLEISTOCENE FOSSIL SLOTHS (MAMMALIA, PILOSA) FROM THE GREATER ANTILLES

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Evidence for sexual dimorphism in fossil sloths has increased in recent years but findings have primarily been restricted to investigations examining only the crania. Even for the living tree sloths, there is little non-pelage related evidence for sexual dimorphism—one study noted that female sloths had a slightly larger body mass than males. Fossil sloths from the Greater Antilles (Cuba, Puerto Rico, Hispaniola) of the Caribbean represent a good starting point for investigations into post-cranial sexual dimorphism given the plethora of specimens in various collections and the past records of taxa (e.g., *Megalocnus*) possessing large and short morphs. As such, evidence for sexual dimorphism in the post-crania of these sloths has implications for taxonomic assignments of genera and species, especially for sloths from Hispaniola (Haiti + Dominican Republic). Forelimb elements (humerus, radius, ulna) of Caribbean sloths from major collections in the United States, as well as new specimens from the Dominican Republic at the Museo del Hombre Dominicano, were studied for both qualitative and quantitative characters. Specimens were primarily assessed at the generic level, which often corresponded to a singular species for that genus per island, with the main genera being *Acratocnus*, *Megalocnus*, *Neocnus*, and *Parocnus*. The exception for species level assessment is *Neocnus* from Haiti, which currently recognizes three species: *N. comes*, *N. dousman*, and *N. toupiti*. Each genus per island typically displayed two size morphs for the forelimb elements: a longer, robust morph and a short, slender morph. Quantitative assessment of two morphs together produced coefficients of variance (CV) of about 5–6 for total length of the bone in all the genera and on each island, except for *Neocnus* specimens from Haiti. All species combined results in CVs of 10–11, which is considered too high a variance for a singular species. *Neocnus comes* alone exhibits the two morphs and has average CVs in the 5–6 range, while *N. dousman* and *N. toupiti* alone show no evidence of any size morphs. However, *N. dousman* is larger in size than *N. toupiti* and a combined CV for their elements falls just under 5. The existence of two size morphs for all the other Caribbean sloths, and for *N. comes* specifically, suggests the taxonomic placement of *N. dousman* and *N. toupiti* as separate species may be erroneous. Additional investigations of the post-cranial elements are underway to assess the size morph trend, as well as reassessment of the original characters used to establish these two species.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

HOMINID LOCALITIES FROM THE PANNONIAN BASIN (HUNGARY) AND YUNNAN PROVINCE (CHINA) AND RELATIONS AMONG EURASIAN MIOCENE APES

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The sites of Kaiyuan, Yuanmou, Shihuiba (Lufeng) and Shuitangba in Yunnan, and those of Rudabánya and Alsótelekes in Hungary, preserve rich records of late Miocene hominid evolution. While fossil apes at these sites have long been considered to represent separate hominid clades, the pongines in Asia and the hominines in Europe, new evidence suggests a more complex story. Rudabánya and Alsótelekes are about 10 Ma while the Yunnan localities range in age from about 11 to 6 Ma. While Shihuiba is younger (6–7 Ma) than Rudabánya, both are among the rare Miocene localities with both a hominid and a crouzeline pliopithecoid. Both also consist of lignites and lake clay-mudstones, and their faunas are more similar to one another—and to the fluvio-lacustrine deposits at the hominine-bearing sites of the Vallès Penedès in Spain—than they are to the *Sivapithecus*-bearing faunas from the Siwaliks. Rudabánya, Can Llobateres, Yuanmou and Shihuiba share ursids, tapirs, and cervids, all of which are absent from the Miocene Siwalik faunas. They have very diverse small carnivore faunas (mustelids, small felids). Rudabánya and the Yunnan sites, unlike the Siwaliks, lack anthracotheres and giraffids and have low diversity among tragulids and especially bovids. Newly described crania of *Lufengpithecus* from Shuitangba and Yuanmou share many attributes with European hominines (*Rudapithecus* and *Hispanopithecus*) and crown hominines. Though some of these attributes have been interpreted as primitive for the hominids, a number, such as the African ape-like subnasal complex and ethmoidal/frontal sinus continuity are most parsimoniously interpreted as hominine synapomorphies. *Lufengpithecus*, *Hispanopithecus* and *Rudapithecus*, as well as *Ouranopithecus* from Greece, are distinguished from most other Miocene apes in having tall, slender and buccolingually compressed canines, especially in males, and mesiodistally compressed incisors with high-relief lingual pillars. While more evidence is needed to confidently demonstrate that the Yunnan hominids are hominines, there is faunal, ecological and morphological evidence of a connection with Europe beginning in the late middle Miocene. This was a time of substantial faunal exchanges between Europe, Asia and Africa that established the basic structure of the modern mammalian communities in all three continents. Hominines were certainly part of these dispersals, but the details of the timing and precise patterns of hominine dispersals remain to be worked out.

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Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

THE USE OF RECYCLED MATERIALS IN THE MOLDING AND CASTING PROCESS

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As part of the molding and casting process, excess materials are removed from around the specimen and typically discarded. The two main materials that are trimmed away are the molding material: tin-cured RTV silicone rubber #GI-1000 from Silicone INC, and the casting material: Isophthalic Polyester #90 from Fibre Glast. These materials were tested for feasibility of the incorporation of cured material into a fresh batch, and suitability of the heterogeneous mixture in molds and casts.

In the test of feasibility, a batch of each material was mixed, divided into two containers, and cured material mixed into one container. Results were evaluated qualitatively against the control container.

In the test for suitability, a batch of each material was mixed, cured material added, then applied. The silicone rubber was vacuumed to remove excess air bubbles and poured over a specimen to form a block mold. The polyester resin was poured into a two-part mold and clamped together.

The new silicone rubber combined well with cured silicone rubber. This result was expected, and it passed the test of feasibility. When applied, the silicone rubber forms an exact mold of the original. The small chunks of cured silicone are suspended in the body of the mold and do not appear to alter the fidelity of the mold. The silicone rubber passed the test of suitability.

The new polyester combined well with cured polyester. It passed the test of feasibility. When applied to a mold, the cast contained a number of large air pockets on the up surface, but there was no evidence of chunks affecting the fidelity of the cast. I think the heterogeneity of the polyester trapped air that settled out as the cast rested on the bench. Subsequent tests showed that the polyester mixture worked well in layup molds. The polyester conditionally passed the test of suitability as it is appropriate in some casting procedures.

The incorporation of cured materials is both feasible and suitable for the molding and casting process. Not all specimens will respond the same and exercise care to determine cases where this will work.

Technical Session XVI (Saturday, October 29, 2016, 10:15 AM)

BODY FOSSILS, TRACKWAYS AND STABLE ISOTOPES: SYNTHESIZING PLEISTOCENE PALEOECOLOGY IN THE OKOTE MEMBER, KOOBI FORA FORMATION, KENYA

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Systematic surface surveys, stable isotopes, trace fossils and lithofacies analysis allow unusually detailed paleoecological reconstruction of the Ileret Tuff Complex (ITC), an 8–9 m unit within the Okote Member dated at 1.53–1.51 Ma. The ITC preserves contemporaneous vertebrate fossils and numerous trackway surfaces from a time interval spanning ~20 kyr with two hominin taxa represented by body fossils and at least one species (probably *Homo erectus*) recorded in multiple footprint assemblages. The fluvial and deltaic ITC deposits are an unusually rich source of fossil primates, bovids, suids, hippos, and other ungulates. Taphonomic surveys indicate spatial differences in faunal composition across distances of ~5 km within the ITC, with more reduncin and alcelaphin bovids near the hypothesized paleo-lake margin and more aepycerotins and tragelaphins farther inland. Stable isotopes in ITC paleosol carbonates indicate mainly C_4 (grass) with some C_3 (bush, trees) vegetation. $\delta^{13}C$ analyses of herbivore tooth enamel show a range of diets dominated by C_4 vegetation, but C_3 taxa also are a persistent component of the fauna. The combined faunal and stable isotope evidence from the ITC indicates predominantly open grassland habitats with smaller, stable regions of woodland and bushland supporting a core community of grazing and browsing taxa. The preserved trackways record numerous mammal species as well as crocodiles and water birds indicating proximity to a large body of water, possibly paleo-Lake Lorenyang. Twenty randomly placed excavations were sampled within the ITC track-bearing lithofacies over

a 2.5 km^2 area to measure the frequency of hominin tracks relative to other ichnotaxa (bovids, elephants, etc.). Based on these data, hominin footprints are disproportionately abundant in the ichnofauna relative to frequencies of their skeletal fossils in the ITC. Comparisons of the faunal and isotopic results for the ITC with similar evidence from contemporaneous deposits in two other areas of East Turkana (Karari, Koobi Fora) reveal larger scale differences in faunal composition over distances of 30–50 km, supporting paleoecological heterogeneity at multiple spatial scales.

Grant Information
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Technical Session XX (Saturday, October 29, 2016, 3:30 PM)

WERE GONDWANAN TEMNOSPONDYLS MORE ENDEMIC THAN CONTEMPORANEOUS AMNIOTES DURING THE PERMIAN AND TRIASSIC?

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Like extant anamniote tetrapods, temnospondyls are thought to have been constrained to water throughout their lifecycle, since water is necessary for copulation, physical support for developing eggs, and providing moist conditions to reduce desiccation. It has also been suggested that many large temnospondyls had internal gills further restricting them to water. These physiological constraints in many ways likely dictated the biogeography of temnospondyls. Furthermore, climate may have geographically isolated non-marine temnospondyl populations throughout southern Pangea as the cool, humid conditions of the late Permian gave way to increasingly warm, arid conditions of the Early and Middle Triassic, perhaps leading to allopatric speciation within temnospondyls. Corroborating this, most Gondwanan temnospondyls during the late Permian through Middle Triassic were endemic to their individual basins, with the exception of six genera (*Lydekkerina*, *Metoposaurus*, *Parotosuchus*, *Rhinesuchus*, *Stanocephalosaurus*, *Trematosaurus*). However, end-Paleozoic faunas from southern Pangea were generally homogenous, adding uncertainty to how temnospondyl endemism compares to contemporaneous amniotes that were less physiologically constrained.

Here we assess the degree to which temnospondyls were endemic relative to contemporaneous amniotes during late Permian through Middle Triassic times. We compiled and bootstrapped presence-absence matrices of every species within the basins of the late Permian, Early Triassic and Middle Triassic of Gondwana (Basins: Beacon, Chiweta, Damodar, Karoo, Luangwa, Ruhuhu, and several from South America and Australia). Each replicate calculates a percentage of endemics by comparing the number of endemic species to the total number of species within either Temnospondyli or Amniota. Significance between the endemic percentages of temnospondyls and contemporaneous amniotes were tested with a Welch's two-sided t-test. We show that temnospondyls had a spike in endemic percentage during the Early Triassic whereas amniotes gradually increase in endemic percentage throughout this interval. Surprisingly, temnospondyls were only more endemic than amniotes during the Early Triassic. Also, temnospondyls had a drastic increase in species diversity during the Early Triassic, perhaps due to allopatric speciation. Finally, both amniotes and temnospondyls were highly endemic (≥70%) during the Middle Triassic.

Grant Information
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Symposium II (Friday, October 28, 2016, 11:00 AM)

FOSSILS, GENES, AND EVERYTHING IN BETWEEN: PELVIC REDUCTION IN THREESPINE STICKLEBACK FISH

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Natural selection acts on heritable traits and results in evolution of the causal genetic variation. Thus, morphological evolution depends on genetic, developmental, ecological, and population genetic mechanisms. Interactions among these mechanisms may influence macroevolution, but it is generally impossible to infer them for fossil species. These mechanisms have been inferred for reduction of the pelvic skeleton in extant Threespine Stickleback fish (*Gasterosteus aculeatus* species complex) and studied in an excellent microstratigraphic sequence. The stickleback pelvis is primitively large and complex and functions for defense against gape-limited predators. Several extant populations have independently evolved reduction of the pelvic skeleton. It is usually caused by a recessive null allele of the *Pitx1* gene and occurs in lakes that lack predatory fishes and have abundant aquatic insects and water with low ionic concentration. Fossil Threespine Stickleback (*G. doryssus*) occur in a 10 Ma lake deposit with annual laminations. The fossil stickleback are well preserved, abundant, and almost continuously distributed for about 110,000 years. Within a 10,000 year interval, a lineage with a large and complex pelvic skeleton switched from eating benthic prey to eating plankton, and pelvic reduction and several other traits evolved dramatically. Pelvic reduction initially involved a slight reduction in size without reduced complexity, but extreme reduction and loss occurred after a delay of about 2500 years. Directional asymmetry of the vestiges implicates *Pitx1* in the delayed extreme pelvic reduction, and this delay was probably due to recessiveness of reduced *Pitx1* alleles. The initial minor size reduction and persistent variation of pelvic vestiges implicate additional genes with small effects, as in extant populations. Microstratigraphic variation of pelvic structure, including directional asymmetry of vestiges, would be uninterpretable without information on the developmental genetics of pelvic reduction in extant populations. The paleoecology of *G. doryssus* is also consistent with conditions under which pelvic reduction occurs in extant *G. aculeatus* populations. Microstratigraphic variation of pelvic phenotypes in the fossil stickleback could not be interpreted without information on the developmental genetics and ecology of closely related extant populations.

Grant Information
Supported by grants from the National Science Foundation EAR-9870337, DEB-0322818, DEB-0919184; National Geographic Society 2869-84; and Earthwatch (1981-1983).

Technical Session XIV (Friday, October 28, 2016, 2:45 PM)

CRANIAL ANATOMY AND SYSTEMATIC POSITION OF *AELUROSAURUS* (SYNAPSIDA, GORGONOPSIA) BASED ON A CT-RECONSTRUCTION

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Gorgonopsia is one of the major clades of non-mammalian synapsids, and included the dominant predators in tetrapod faunas of the Late Permian. Gorgonopsian taxonomy is highly problematic, due to a lack of precise diagnoses and thorough descriptions of individual species and their respective type specimens. Although significant progress has recently been made in revising the taxonomy of the largest gorgonopsian species (rubidgeines), small-bodied gorgonopsians remain poorly understood. Here we present new data on small gorgonopsian anatomy and relationships, based on restudy of the cranial anatomy of MB.R.999, a gorgonopsian skull from the Late Permian of South Africa housed in the collection of the Museum für Naturkunde, Berlin. The anatomical analysis of MB.R.999 has been undertaken with the help of high-resolution computer tomography and neutron imaging technologies, and the subsequent 3D reconstruction yields insights into otherwise inaccessible features of the skull. We have identified this specimen as *Aelurosaurus felinus*, permitting a detailed redescription of this historic taxon. *Aelurosaurus felinus* can be recognized by its extensive dentition on the palatine and the pterygoid, delta-shaped palatine bosses, high maxillary tooth count (five postcanines), and sharply curved transverse processes of the pterygoid. A parsimony-based phylogenetic analysis of Gorgonopsia revealed a basal position for *Aelurosaurus* within gorgonopsians, close to *Eriphostoma* and *Gorgonops*. CT scanning also revealed new insights on tooth replacement in *Aelurosaurus*. In MB.R.999, tooth replacement occurs most rapidly in the canines. A functional and erupting replacement canine are present in the upper canine alveoli, with an additional replacement canine forming below the functional one. Given that the canines have been interpreted as crucial for killing prey in gorgonopsians, rapid canine replacement would have been an important adaptation for maintaining individual fitness.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

A NEW LARGE-BODIED CAENAGNATHID SPECIMEN (THEROPODA, OVIRAPTOROSAURIA) FROM THE HELL CREEK FORMATION (LATE CRETACEOUS) OF MONTANA, WITH IMPLICATIONS FOR OSTEOHISTOLOGICAL VARIABILITY IN CAENAGNATHIDS

BENNER, Elizabeth K., University of Toronto, Toronto, ON, Canada; CULLEN, Thomas M., University of Toronto, Toronto, ON, Canada; EVANS, David C., Royal Ontario Museum, Toronto, ON, Canada

ROM 65884, a partial caenagnathid skeleton from the Hell Creek Formation (Montana) is described and identified as belonging to a large-bodied taxon similar in size to the recently described, coeval taxon *Anzu wyliei*. The new specimen includes three caudal vertebrae, a dorsal rib, gastralia fragments, fragments of the pubis, an almost complete fibula, partial metatarsals (MT II-V), and a pedal phalanx. Although the fragmentary nature and lack of overlapping elements do not allow definitive assignment to *Anzu*, ROM 65884 differs from *Caenagnathus collinsi*, another large-bodied caenagnathid, in the presence of a distinct ridge on the posteromedial shaft of the second metatarsal. Material from ROM 65884 was used to perform the first assessment of osteohistological variability in caenagnathids, with thin sections indicating it was actively growing due to the predominance of primary fibrolamellar bone in the outer cortex, spacing of lines of arrested growth (LAGs), and the absence of an External Fundamental System (EFS) within the tibia. LAG counts were found to vary between the tibia, rib, and pedal phalanx. In addition, osteocyte lacunar density (OLD) varied greatly between sampled skeletal elements: tibia, 51913 osteocyte lacunae (OL)/µm^3 (standard deviation [SD] of 1429 OL/µm^3); pedal phalanx, 41046 OL/µm^3 (SD of 4973 OL/µm^3). Osteocyte lacunar density also varied within an individual bone, depending on the sampled location within the cortex. For example, vascular patterns within the pedal phalanx differed considerably, with the ventral side more secondarily remodelled and having relatively higher OLD count (average of 45078 OL/µm^3 +/- 1255 OL/µm^3) than the lateral side, which grew more slowly and had a lower OLD count (average of 37013 OL/µm^3 +/- 1736 OL/µm^3). These histological results are consistent with the variation observed in other theropods, such as ornithomimids

Grant Information
Natural Sciences and Engineering Research Council of Canada (NSERC)

Preparator's Session (Thursday, October 27, 2016, 11:00 AM)

EMESOZOIC: BRITISH FOSSILS IN THE DIGITAL AGE

BERNARD, Emma L., Natural History Museum, London, United Kingdom; BREWER, Philippa, Natural History Museum, London, United Kingdom; STEVENS, Liadan, Natural History Museum, London, United Kingdom; CHAPMAN, Sandra, The Natural History Museum of London, London, United Kingdom; STEEL, Lorna, Natural History Museum, London, United Kingdom

Museums are under pressure to digitise and share collection information. Consequently, many institutions are investing in large-scale digitisation programmes. The Natural History Museum, London (NHM) has embraced this and is investigating how best to digitise its large, diverse, and internationally significant collections; thereby making our collections openly available.

eMesozoic was an NHM pilot digitisation project focusing on British Mesozoic vertebrate collections. These collections were selected as they are subject to intense

research activity and have wide public appeal. They also present many challenges to digitisation such as the wide variation in specimen size from microscopic teeth and scales to large articulated specimens.

Consultation with collection users established the need for clean, high quality data as essential for effective use of the collections, particularly for research along with an image of the specimen. To achieve this, we trialed the use of Master records covering sites, stratigraphy, and taxonomy to aid with transcription. Using this methodology, only clean, verified metadata is available to append to specimen records, significantly reducing the need for post-digitisation validation. An outcome of this is a wealth of clean metadata which could be exchanged with other institutions to assist with digitisation projects, therefore reducing the burden on individual projects to clean and verify data and ensure that collection data from multiple sources could be more easily integrated into large-scale datasets.

Issues arising when dealing with a historic collection have included many legacy issues, the critical importance of pre-digitisation collection preparation, multiple work flows encompassing the wide range of specimen sizes and the relatively slow speed of digitising diverse palaeontological collections.

The project has been successful and we have digitised 20,000 specimens and gathered valuable data on estimating the time, effort and resources required to digitise large historical palaeontological collections. The specimen data available via our data portal is proving fruitful, with researchers from across the globe approaching the NHM to discuss new research projects based on the eMesozoic specimens and data. This data will be beneficial to other institutions considering embarking on similar projects, particularly ensuring its utility to researchers, exhibitions, outreach facilities, and curation.

Romer Prize Session (Thursday, October 27, 2016, 11:30 AM)

VIRTUAL ENDOCASTS FOR ISCHYROMYIDAE AND SCIURIDAE: BRAIN EVOLUTION IN RODENTIA AND A DEEPER UNDERSTANDING OF THE ANCESTRAL CONDITION FOR THE BRAIN OF EUARCHONTOGLIRES

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The brain of rodents has rarely been studied from the perspective of the fossil record, and little is known of the process of brain evolution in this group. What's more, rodents are members of Euarchontoglires and could help form a better understanding of the ancestral condition for this group, augmenting what has been learned from primates. A total of 14 fossil Ischyromyidae and one fossil Sciuridae as well as 20 extant virtual endocasts for Sciuridae were obtained for this study. Virtual endocasts from the primitive members of Ischyromyidae include specimens belonging to the following genera: *Ischyromys*, *Rapamys, Paramys*, *Pseudotomus*, *Notoparamys*, and *Reithroparamys*. The study of those virtual endocasts show that exposure of the midbrain is likely to be primitive for Rodentia, as observed for Primates. Decrease in the proportion of the olfactory bulbs and increase in neocortical surface area may have occurred through time in rodent evolution similar to Primates, but with less intensity in Rodentia. Ischyromyid rodents exhibit variation in their encephalization quotient (EQ) through time, with some Eocene taxa displaying a higher EQ (e.g., 0.84, *P. copei*) compared to Oligocene species (e.g., 0.51–0.77, *I. typus*; calculated using a rodent-specific EQ equation), demonstrating that the group did not show a simple increase in EQ through time, although an increase in EQ may have occurred in sciurid evolution specifically. Indeed, the Oligocene sciurid *C. wilsoni* has an EQ in the lower part of the range for modern squirrels. The study of the virtual endocast of the early squirrel *Cedromus wilsoni* and extant members of Sciuridae reveal that fundamental changes in the organization of the brain occurred in the transition from more primitive ischyromyids to early squirrels, with an increase in neocortex size, the appearance of a sylvian fossa, and a more complex cerebellar structure including an increase in the relative size of the paraflocculi. These neurological modifications could potentially be related to the process of becoming arboreal in rodents, forming a contrast with Primates in which key changes postdated the origin of arboreality. Ultimately, this study provides a better understanding of the process of brain evolution for Euarchontoglires by studying another order in this group aside from Primates.

Grant Information
NSERC Discovery Grant to M. Silcox, School of Graduate Studies Travel Grant and Research Expenses Grant (University of Toronto)

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

A MULTIPROXY APPROACH TO RECONSTRUCT THE PALEOECOLOGY OF PLEISTOCENE HIPPOPOTAMIDAE FROM THE MEDITERRANEAN ISLANDS (CETARTIODACTYLA, MAMMALIA)

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Geographically isolated insular species constantly have to cope with energetic restrictions and often evolve adaptations that are distinct from their mainland ancestors. During the Pleistocene, several Mediterranean islands were inhabited by now extinct Hippopotamidae: *Hippopotamus pentlandi* from Sicily, *Hippopotamus melitensis* from Malta, *Hippopotamus creutzburgi* from Crete and *Phanourios minor* from Cyprus. They underwent diverse changes in locomotion, dentition and body size, indicating differences in their ecological niches. In this study, the paleoecology of the dwarfed hippopotami is reconstructed by using two dental dietary proxies. Firstly, Dental Topography Analysis using Geographic Information Systems was applied to measure the slope of the occlusal surface, which provides large scale information on adaptive dietary traits. Secondly, 3D surface texture analysis (3DST) using 30 parameters according to ISO 25178-2 was employed for measuring the roughness of the enamel surface, which correlates with dietary abrasiveness. Mean slope values gradually increase from the larger hippopotami, *H. pentlandi* and *H. melitensis*, over the medium sized, *H. creutzburgi*, to the smallest, *P. minor*. Low mean slopes in the larger species reveal lower occlusal reliefs, representing rather horizontal jaw kinematics and complex enamel patterns as indicative of grazing species in ruminants. The highest mean slope values found in the smallest and lophodont *P. minor* are characteristic for a larger occlusal relief featuring compression-basins for extracting cell content. The relatively low and homogenous enamel surface textures in *H. creutzburgi* and *H. pentlandi* indicate dietary specialisation similar to the extant *Hippopotamus amphibius*, which feeds on fresh grasses near the shores, free of accumulated dust. In contrast, the rougher and more variable enamel surface textures in *H. melitensis* and *P. minor* suggest more generalistic dietary traits and/or dietary shifts linked to a climate change, resulting in an alteration of environmental and vegetal conditions from the Pleistocene to the Holocene.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

THE MILK CREEK MAMMAL FAUNA OF CENTRAL ARIZONA (LATE MIOCENE) WITH NEW TAXA AND AN ESTIMATE OF BODY MASS OF CAMELIDS AND ANTILOCAPRIDS USING ASTRAGALI AREAS

BEVERS, Jeb E., Yavapai College, Prescott, AZ, United States of America; WEIDEMAN, Carley, Yavapai College, Prescott, AZ, United States of America; CURTIS, Dirilee, Yavapai College, Prescott, AZ, United States of America

The Milk Creek fossil site (late Miocene) of Yavapai County, Arizona was initially surveyed in 1949 and first described in 1950. A more recent review of the Milk Creek collections and faunal diversity were conducted in 2015. This examination of the collections was to obtain a larger and more complete inventory of the mammalian fauna from this site. The largest of these holdings is in the Frick Collections of fossil mammals held at the American Museum of Natural History. Other collections that were examined are from regional museums across Arizona. A description of fauna from this examination of collections is listed with the majority of the taxa being from two types of Camelidae: *Michenia yavapaiensis* and *Protolabis coartatus*. In addition to these two listed genera of camelids, post-cranial remains were located, both in the field and from the University of Arizona Laboratory of Paleontology Milk Creek collections, of a third camel type for this locality. In addition to a new camelid for this site, a new Canidae, the first *Leptocyon* sp. known to the Milk Creek Formation, was located in the Sharlot Hall Museum Milk Creek collections. This specimen includes the upper left M1 and M2.

The specimens for the recently located third camelid included a right astragalus. Using a linear regression model of the astragali areas, the body masses for camelid and antilocaprid specimens from the Milk Creek Formation and two other late Miocene localities, the Barstow Formation in California and the Tesuque Formation in New Mexico, were estimated.

Symposium II (Friday, October 28, 2016, 10:15 AM)

THE VERTEBRATE NECK IS OLD AND SOME OF IT IS MADE OF HEAD

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Among deuterostomes, vertebrates alone have developed an enormously complex and fully differentiated head quite distinct from the more conservative chordate trunk. Subsequent transitions of this basic vertebrate architecture are well-documented in the fossil record. In particular, whereas in primitive vertebrates the head/trunk transition zone is dominated by the gill or branchial region, fossil and extant tetrapods have a novel, highly mobile neck. Data from extant forms must be used to understand developmental processes underlying the transformation. These data indicate that the muscles that span the gap and connect head to pectoral girdle are derivatives of the embryonic cucullaris group, including the trapezius. There is a longstanding debate regarding whether the cucullaris is in reality a head or a trunk muscle and therefore to what extent the neck is a cranial, a trunk, or a composite structure.

We addressed the question of the head/trunk boundary paleontologically, anatomically, and developmentally. First we used contrast-stained CT scanning to test the hypothesis that the cucullaris group is a ubiquitous component of the head/trunk boundary by conducting a broad survey of extant vertebrates bracketing much of gnathostome fossil diversity and searching for the cucullaris in coelacanth and caecilians, where it has been reported absent. We found the muscle in both. It is clearly in series with the gill levators, and the general musculoskeletal architecture of the head/trunk boundary region in early sarcopterygians (*Eusthenopteron*), stem tetrapods, stem amniotes (*Limnoscelis*), and extant taxa is not fundamentally different between "fishes" and tetrapods. Structural innovation to form the neck resulted from repurposing and rearrangement.

For our developmental studies, we used axolotl, a tetrapod that retains a primitive gnathostome arrangement of gills. First we fate-mapped the gill levators and cucullaris to a region of unsegmented non-somitic paraxial mesoderm continuous with the more anterior region that contributes to the jaw muscles. We found that this mesoderm is cranial in terms of gene expression and competence to form other head structures. Thus a major component of the neck region is in fact composed of head (branchial) derivatives. Finally, the head/trunk boundaries in the segmented and unsegmented mesoderm of axolotl are even with each other. It is unclear whether this represents the ancestral tetrapod condition, but the cervical region of the axial skeleton does show gradual elaboration in fossil stem amniotes.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

SURPRISING DIVERSITY IN A MID-MIOCENE SQUIRREL ASSEMBLAGE: THE SCIURIDAE (MAMMALIA:RODENTIA) OF CAVE BASIN, OREGON

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Screenwashing small vertebrates can often add substantial diversity of rodents, lagomorphs, and eulipotyphlans to fossil faunas. The Mascall Formation has not previously been subjected to screenwashing, but new efforts to screen middle Miocene material from the Crooked River Basin have added species not known in the preceding 150 year collecting history of this assemblage. We wet-screened and picked microfossils from roughly three tons of sediment from Cave Basin, a new middle Miocene site in the Crooked River area of central Oregon. Cave Basin sediments are stratigraphically equivalent to the Mascall Formation of the John Day Basin, but the microfauna is concentrated in anthills, allowing screenwashing of a previously surface-collected fauna. The microfauna from Cave Basin is abundant and diverse, producing hundreds of

specimens of microfossils of carnivorans, eulipotyphlans, castorids, aplodontids, and sciurids, among other groups. The Sciuridae are represented by 292 isolated cheek teeth. We have identified members of the tribes Tamiini (*Tamias*) and Marmotini (*Protospermophilus* and *Miospermophilus*) and have tentatively identified members of the Pteromyini (probably *Cryptopterus* and *Sciurion*) for a total diversity of at least seven species. This indicates a diverse sciurid community composed of fossorial, terrestrial, arboreal and gliding ecological niches. These specimens include multiple size classes in similar reported ecologies, indicating a high degree of habitat partitioning. This fauna is exceptionally diverse, unlike any known today outside of the Southeast Asian tropics. The diversity of squirrels in Cave Basin is consistent with floral evidence suggesting a warm, moist, and well-forested habitat in the middle Miocene of Oregon, in some contrast with the drier, more open habitats known from the Great Plains at this time.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

LOST AND FOUND: THE TURLOCK LAKE PALEOFAUNA AND FLORA

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Context is one of the most important pieces of information in any paleontological find, next to the fossils themselves. The geology, stratigraphy, and location of fossil localities can tell us much about depositional setting and how it changes over time and through space on top of what the specimens themselves tell us. But what happens when this information goes missing or wasn't collected at all? This is what occurred in the case of the Turlock Lake fauna and flora, a vast collection of plant and animal fossils found by one man over 40+ years and now housed at the University of California Museum of Paleontology, Berkeley (UCMP) and the Natural History Museum of Los Angeles County (LACM). The fossils come from the upper Mehrten Formation, roughly 5 Ma (Hemphillian), which is exposed at a reservoir in the low foothills of the Sierra Nevadas, east of Modesto, California. Dennis Garber, the original collector, did not take notes on his discoveries other than marking rough locations on a map. Hugh Wagner, who researched the lake for a USGS geologic map and for his dissertation on the geology and mammals, did take notes when he visited the sites, however these are nowhere to be found. Since early 2014 we have made efforts to recreate these notes and rediscover the Turlock Lake fossil localities. Most of the sites on the lake required the use of a kayak to access them. We possessed a map showing the general areas of the sites, however it did not pin point their locations. In addition, there are many differences between the modern day topography of the lake and the old map. We took photos of each area and showed them to Dennis, who pointed out the sites in each, and then we recorded their GPS coordinates and lithological descriptions. There are three main depositional environments represented at Turlock Lake, which from oldest to youngest are: (1) a flood plain, in which fossils of the giant tortoise *Hesperotestudo orthopygia* have been found; (2) river deposits with many horse and other fossils such as the giant tusk-toothed salmon *Oncorhynchus rastrosus*; and (3) bedded lake deposits which have produced turtles, salamanders, fish, and many plants. There are also possible lahar deposits near some of the major sites. Dennis, UCMP, and LACM each used their own unique system of numbering for the sites so we correlated and collected all locality numbers together for each site. The photos, GPS coordinates, lithologies, locality number triplets, and other information gathered through interviews with Dennis were collected into a single document to act as field notes and then given to UCMP and LACM.

Grant Information

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Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

TAXONOMIC COMPOSITION AND DIVERSITY OF MULTITUBERCULATA, PLESIADAPIFORMES, AND RODENTIA ACROSS CONTINENTS DURING THE EARLY PALEOGENE

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For most of the Paleocene epoch, terrestrial faunas were largely isolated on separate continents. During the late Paleocene, species of Rodentia emigrated from Asia into North America and Europe. After the immigration event, endemic Multituberculata and Plesiadapiformes began to decline in taxonomic richness. The declines of these endemics has been attributed to the immigration and subsequent radiation of ecologically similar rodent competitors. The biogeographic events and changes in diversification of these clades contributed to distinctions between continental Paleocene and Eocene mammal faunas at a high taxonomic level (i.e., relative abundances of orders). To test for compositional differences at a lower taxonomic level, we compared species occurrences in families of rodents, multituberculates, and plesiadaforms in North America, Europe, and Asia (southern, central, and eastern) over the first 16 Myr of the Cenozoic. Occurrences for the three clades were downloaded from the Paleobiology Database, divided by continent and then binned into 16 sequential one million year intervals, from 66 to 50 Ma. Species occurrences are unevenly distributed across the three continental regions, with a much larger sample for North America (n = 1677) than for Europe (n = 51) or Asia (n = 59). Taxonomic composition in each bin was assessed as the number of species in each family, and the time series for each continent was summarized using principal component analysis. The first principal component for each analysis accounts for ca. 50% of the variation in taxonomic composition. Scores for each bin in the time series for North America and Europe show similar patterns with Paleocene intervals dominated by multituberculates and plesiadapiforms and a long term shift from the late Paleocene to the early Eocene reflecting increased taxonomic diversity of rodents. Later in the Eocene, the European record returns to scores like those of Paleocene bins, apparently driven mostly by fluctuations in the species diversity of European Plesiadapidae. The Asian record is similar to the other with an abrupt shift from multituberculate dominated Paleocene faunas to rodent dominated faunas of the Eocene. Analyzing numbers of genera in families increases samples for Europe and Asia and yields similar results. These results suggest that the emigration of rodents out of Asia had long term changes on the taxonomic composition of North American and European faunas, and that Asian faunas also continued to experience taxonomic changes long after the first appearance of rodents there.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

THE LATEST KNOWN ORNITHOMIMID FROM THE UPPER HELL CREEK FORMATION, MONTANA: FURTHER CLOSING THE THREE-METER GAP

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In 1994, the University of California Museum of Paleontology (UCMP) collected a partial ornithomimid skeleton (UCMP 154569) from the Hell Creek Formation (Maastrichtian) of Montana, approximately 2.4 meters below the K/Pg boundary. This well preserved, partial ornithomimid specimen is stratigraphically positioned within the "three-meter gap" just below the K/Pg boundary that accounts for the last 100,000 years of the Cretaceous. The three-meter stratigraphic gap is known for its paucity of fossil material and hypothesized indication of the decline of non-avian dinosaurs prior to the Chixulub impact event. UCMP 154569 is the first reported Hell Creek specimen of ornithomimid within the three-meter gap.

Ornithomimids are a clade of theropod dinosaurs from the Cretaceous sediments of North America and Asia. Two sister genera are known from Hell Creek: *Struthiomimus* and *Ornithomimus*. They are characterized by an evolutionary trend toward cursoriality, and thus have distinctively long pedes, metatarsi, and tibiae. Ornithomimid genera are often diagnosed by autapomorphies in the cranium, vertebral column, and manus, although some autapomorphies are present in the metatarsi. UCMP 154569 is three-dimensionally preserved and consists of a nearly complete right foot and leg: partial tibia, partial fibula, astragalus, calcaneum, metatarsus, phalanges, and unguals. UCMP 154569 is tentatively identified as *Struthiomimus* and is diagnosed by: a ratio of 7% maximum metatarsal III diaphysis anteroposterior width divided by length of metatarsal III, lack of a square distal cross section of metatarsal III where the ratio between anteroposterior and transverse diameters is about 0.81, and proximal overlapping contact where metatarsal II meets metatarsal IV. The specimen appears to be the highest stratigraphically known Hell Creek ornithomimid, and thus extends the temporal range of ornithomimids whether the specimen is *Struthiomimus* or *Ornithomimus*. This description of UCMP 154569 adds a new taxon to the three-meter gap and furthers our knowledge of non-avian dinosaur diversity in the upper Hell Creek Formation.

Technical Session IX (Thursday, October 27, 2016, 3:45 PM)

MODELING THE VERTEBRATE INVASION OF LAND: TAIL USE IMPROVES TERRESTRIAL LOCOMOTOR PERFORMANCE ON SOFT SUBSTRATES

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In the evolutionary transition from an aquatic to a terrestrial environment, the first vertebrates attempting to move over land faced novel locomotor challenges. Terrains emerging from nearshore habitats presented substrates comprised of complex, flowable materials (e.g., sand and mud), and likely also required animals to scale inclines. There has been limited study of how animals move over such surfaces, restricting potential insights into a crucial stage in the functional evolution of vertebrates. We integrated experiments on a modern analog of tetrapodomorphs with data from robotic and computational models to clarify whether specific control strategies could have improved locomotion over soft, inclined substrates during the invasion of land. Model choices and designs were inspired by published reconstructions of limb joint mobility that indicated some early tetrapodomorphs, such as *Ichthyostega*, likely propelled themselves over land by crutching with their pectoral appendages. Using living mudskipper fish as a functional analog for such tetrapodomorphs, our high-speed video measurements of locomotor performance by crutching mudskippers moving over sand showed that, as the slope of the substrate increased, mudskippers added tail movements into locomotor cycles with greater frequency. The tail was angled against the sand and pushed the fish forward in combination with the pectoral fins, reducing slope-related declines in performance. Using a robotic model of the mudskipper (MuddyBot) for which we could program different combinations of appendage and tail kinematics, we found that some patterns of coordination between the appendages and tail were neutral or even harmful to performance, but that patterns of coordination generally matching those used by mudskippers made performance more robust, allowing effective locomotion over a wider range of slopes and limb postures than without tail use. These results suggest that, for early invaders of land that used crutching, coordinating movements of the appendages with the tail could have provided critical advantages for terrestrial locomotion that have received little previous attention. Originally used for swimming, the prominent tails of tetrapodomorphs may have been coopted to promote reliable locomotion over challenging substrates, providing an exaptation that facilitated the invasion of land.

Grant Information

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Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

ASSESSING CROSS-CONTAMINATION IN ANCIENT DNA FROM TEMPERATE CAVE DEPOSITS

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Ancient remnants of species with preserved DNA can reveal responses to past environmental changes through genetic information in the form of ancient DNA (aDNA). Ancient DNA is enormously useful for gaining insight into ecological and evolutionary processes such as how climate has affected population dynamics through time, evolutionary and ecological dynamics immediately prior to extinction, genomic adaptation to the environment, and past environmental conditions and habitats. However, because bones within fossil deposits are intermingled with one another and exposed to exogenous DNA—both from other species as well as potentially from other individuals of the same species—ensuring that extracted DNA is retrieved from the target individual only is difficult, especially in an era of whole-genome sequencing of anonymous loci. This is particularly problematic for the species that help form the cave deposits, such as with *Neotoma* middens. Because the animals are living in close contact with the midden and other bones, shedding DNA through their cells, urine, and feces, the potential for recovering inauthentic DNA is high.

In this project, we assessed the extent of potential cross-contamination and tested the effectiveness of several methods for decontaminating bones. We focused on *Peromyscus* spp. individuals from two caves in North America: Lamar Cave in Yellowstone National Park, Wyoming, and Samwell Cave Popcorn Dome in the Shasta-Trinity National Forest, California. Using appropriate aDNA protocols, we extracted DNA from 30 specimens ranging in age from modern to ~6000 years before present, while preparing the specimens according to three treatments: 10 specimens were soaked for five minutes in water as a control, 10 specimens were soaked for 1 minute in bleach, and 10 specimens were soaked for five minutes in sodium phosphate. We then extracted DNA and sequenced the full mitochondrial genome of each individual using targeted bait capture. During sequencing, we included baits specific to *Peromyscus* (target DNA), as well as baits for *Neotoma* and other rodent species likely found in the deposits (non-target DNA). Preliminary results indicate that both the bleach and sodium phosphate treatments were relatively successful at eliminating inauthentic DNA. These results suggest high confidence in DNA recovered from cave midden deposits and support reconstruction of population-level metrics from ancient populations.

Symposium I (Wednesday, October 26, 2016, 10:15 AM)

CHARACTERIZATION OF *TYRANNOSAURUS* STRUCTURAL PROTEINS USING SYNCHROTRON X-RAY AND INFRARED MICRO-BEAM TECHNIQUES

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Multiple studies have demonstrated the survival of endogenous structural proteins in vertebrate microvascular tissues extracted from bone via demineralization, and non-enzymatic crosslinking has been hypothesized as a chemical mechanism supporting their longevity. Observations of the intimate association of distributed iron oxyhydroxides (specifically, $FeO(OH)_n$), among other transition metal species, to these structures have narrowed these hypothesized mechanisms to transition metal-mediated crosslinking reactions. We have combined multiple synchrotron X-ray and infrared (IR) characterization techniques, including micro-beam X-ray diffraction (μ-XRD) and small-angle scattering (SAXS) methods, X-ray fluorescence (μ-XRF), X-ray absorption near-edge structure spectroscopy (μ-XANES), and Fourier-transform infrared spectroscopy (FTIR) with other, more traditional methods, such as immunohistochemistry, to study the chemical inventory of ancient microvascular structures. Synchrotron techniques offer the opportunity for analytical chemical analysis at both high spatial and energy resolutions. In this work, application of this multidisciplinary approach to isolated microvascular tissues recovered from fossil vertebrate compact bone (in particular, *Tyrannosaurus*) has demonstrated several preserved structural proteins consistent with an endogenous source. Furthermore, synchrotron FTIR spectromicroscopy reveals that these proteins show a crosslink character consistent with the hypothesized non-enzymatic, transition metal-mediated mechanisms. These findings not only provide additional evidence for the survival of microvascular tissues and structural proteins across deep time, but also for critical mechanisms that could have contributed to their longevity. The application of synchrotron X-ray and IR micro-beam characterization techniques to fossil tissues is an emerging field of inquiry, but the associated body of literature on their application to modern biological tissues, biomaterials, and mineral specimens provides a wealth of data against which fossil tissues may be compared. Nonetheless, although our imaging and SAXS data suggest that the microvascular structures and associated proteins, in particular fibrillar collagens, have been preserved, these same preservational mechanisms cause an undefined degree of chemical alteration to the protein structures, as evidenced by the spectral changes observed when our *Tyrannosaurus* data are compared with those from extant chicken tissues.

Grant Information

Work at the Lawrence Berkeley National Laboratory was supported by the U.S. Dept. of Energy, Office of Science, Office of Basic Energy Sciences via contract # DE-AC02-05CH11231

Technical Session VI (Thursday, October 27, 2016, 8:45 AM)

THE LAST OF THE DESMATOPHOCID SEALS: A NEW SPECIES OF *ALLODESMUS* FROM THE LATE MIOCENE OF WASHINGTON AND CALIFORNIA

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The Desmatophocidae represent an extinct clade of pinnipeds known only from the North Pacific during the early and middle Miocene (~23–13 Ma) with scattered reports of late Miocene (9–12 Ma) occurrences. Though six to ten species have been proposed for the middle and late Miocene, desmatophocids abruptly became extinct in the early late Miocene. It is further unclear what led to the demise of this early radiation of endemic North Pacific pinnipeds. New fossils from upper Miocene strata of Washington and southern California document a new species of *Allodesmus*, which represents the last member of this clade. An articulated partial skeleton (UWBM 75640) from the lower Montesano Formation (9.1–10.5 Ma) of southwestern Washington includes a complete skull (CBL = 39 cm), dentary, cervical and thoracic vertebrae, ribs, and the manubrium. The cranium preserves typical *Allodesmus* features: anteriorly widening prenarial shelf, large orbit, dorsoventrally expanded squamosal-jugal articulation, flattened tympanic bulla, and dentary with large digastric insertion. UWBM 75640 preserves features not found in other allodesmines, including an enlarged triangular postorbital process, large nuchal crests, elongate neural spine of the axis, and a spatulate manubrium. A referred humerus collected nearby is nearly identical to *A. kernensis*. Allodesmine fossils from the upper part of the Monterey Formation (~12 Ma) in southwestern southern California may represent the same new species and include the partial skeleton of a subadult male individual (SDNHM 100999) with a complete skull and dentary with nearly complete dentition, thoracic, lumbar, and caudal vertebrae, ribs, partial right humerus, distal tibia and fibula, and major portions of the right and left pes. Additional specimens from this site include a partial skeleton of an adult female consisting of sternebrae, vertebrae, ribs, and fore- and hind limb elements, and an isolated left dentary with a nearly complete male dentition. Preliminary cladistic analysis includes UWBM 75640 in a clade with *Allodesmus kernensis*, *Allodesmus sinanoensis*, and *Allodesmus sadoensis* to the exclusion of *Allodesmus packardi, Allodesmus naorai, Atopotarus courseni,* and *Desmatophoca*. The new fossils provide an opportunity to document patterns of diversity and disparity at this critical time in pinniped faunal evolution marked by the transition from the desmatophocid-rich middle Miocene assemblages to the odobenid (walrus)-dominated assemblages of the late Miocene and Pliocene.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

NEW COLLECTION CONTRIBUTES INSIGHT TO THE NEOGENE MARINE VERTEBRATE PALEONTOLOGY OF THE LEE CREEK MINE, NORTH CAROLINA

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The Lee Creek Mine in Aurora (NC) is an open-pit phosphate mine operated by the Potash Corporation. The mine exposes two fossiliferous marine units: the Pungo River Limestone (middle Miocene; Langhian) and the Yorktown (lower Pliocene, Zanclean) Formations. The Pungo River Limestone and base of the Yorktown Formation are richly phosphatic and are commercially mined. These two units have yielded one of the most important assemblages of Neogene marine vertebrates in the world, including hundreds of species of sharks, rays, skates, chondrosteans, teleosts, birds, sea turtles, estuarine crocodiles, seals, walruses, dolphins, and baleen whales. These fossils are found in-situ as well as in reworked sediments in the spoils leftover from the mining. Unfortunately, the mine has been closed to the public since 2009.

The College of Charleston Mace Brown Museum of Natural History (CCNHM) recently acquired a large donation of vertebrate fossils from the Lee Creek mine collected by former mine tour leader Rita McDaniel; Ms. McDaniel recently passed away and desired that her spectacular collection be made available to science. This collection notably comprises over one thousand specimens that include fish, bird, seal, walrus and hundreds of cetacean rostromandibular fragments, teeth, bullae and periotics. The collection includes many new records for cetaceans from both the Pungo and Yorktown Formations.

New cetacean records in this collection include *Kogia* sp., Ziphiidae indet. (*Messapicetus*?), cf. *Hadrodelphis*, cf. *Goniodelphis*, *Parietobalaena*, *Diorocetus*, and Herpetocetinae n. g., making this one of the most significant collections from Lee Creek. This collection also includes several true seal (Phocidae) mandibles with teeth, which may permit resolution of the confused taxonomy of Pliocene seals from the western North Atlantic.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

HERDING STRUCTURE OF THE EXTINCT NORTH AMERICAN RHINOCEROS *TELEOCERAS MAJOR*

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Ashfall Fossil Beds State Historical Park protects a graveyard of hundreds of extinct mid-Miocene North American rhinoceros, *Teleoceras major*. The spectacular abundance of *Teleoceras* at Ashfall is due to the 12 Ma Bruneau-Jarbidge super volcano eruption. After the ingestion and inhalation of rhyolitic ash, *Teleoceras* developed Hypertrophic Pulmonary Osteopathy and succumbed quickly to the disease. Significant strides have been made into understanding the individual lives of *Teleoceras*; however, knowledge gaps exist concerning their social lives. Whether *Teleoceras* lived solitary lives similar to modern day white rhinoceros, *Ceratotherium simum,* or lived in small groups like modern day black rhinoceros, *Diceros bicornis,* is unknown. In order to determine if *Teleoceras*

more closely resembles the herding structure of *Ceratotherium* or *Diceros*, the ratio between males and females was recorded using a quarry map from 1977–1979. The ratio within the quarry is skewed, containing more than three times the number of females than males, which is interpreted as though *Teleoceras* more closely resembled the herding structure of *Diceros bicornis*. Understanding why the rhinos are positioned the way they are in the quarry provides potential information regarding *Teleoceras*' social life. Some anomalies within the quarry, such as mothers and calves being separate from the main clusters are more difficult to explain than old bulls being isolated from the group. The Nearest Neighbor Analysis was used to examine how many potential sub-herds were present. Seven possible herds were identified, all of which displayed clustering and, when plotted on a range of random matching graph, every group showed statistically significant clustering like modern day black rhinoceros. Understanding *Teleoceras major*'s herding structure provides paleontologists and biologist with a better understanding of the species' behavior and ecosystem of the time period.

Symposium II (Friday, October 28, 2016, 9:30 AM)

SHARKS IN TECHNICOLOR: DEVELOPMENT OF THE SYNARCUAL IN ELEPHANT SHARKS (HOLOCEPHALI, CHONDRICHTHYES) AND PLACODERMS

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The synarcual, a structure resulting from the fusion of anterior vertebrae, has been independently acquired in placoderms (Arthrodira, Ptyctodontida and Rhenanida) and some chondrichthyans (holocephalans and some batoids). The presence of a synarcual is part of a well regionalised vertebral column in placoderms and indicates that a regionalised skeleton is a primitive feature of gnathostomes. To better understand the developmental process of the synarcual, a specimen of the placoderm *Campbellodus decipiens* was synchrotron scanned and a growth series of the holocephalan *Callorhinchus milii* was immunostained for cartilage and muscle markers and imaged with confocal microscopy. In *Campbellodus*, the developmental process of the synarcual is still visible, recorded as lines of arrested growth within the perichondral ossicifation that has overgrown the individual vertebrae, the more posterior vertebrae still identifiable. The synarcual is composed of three neural spines which have been incorporated antero-posteriorly. A similar pattern is observed in the growth series of *Callorhinchus* where individual vertebrae develop separately and subsequently grow, change shape and fuse to form the synarcual. A CT-scan of an adult synarcual shows that mineralisation continues well after the end of the embryonic process and also proceeded antero-posteriorly. This commonality between the development of placoderms and elephant sharks (as well as batoids) shows that fusion involves the formation of cartilage and its subsequent ossification or mineralisation outside of the zone generally occupied by the vertebra. Studying the mechanisms underlying this process of heterotropic chondrification in both placoderms and elephant shark can help us to better understand the origins of vertebral differentiation as well as the formation of unique structure along the vertebral axis.

Grant Information
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Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

ONTOGENETIC CHANGES IN LONG-BONE HISTOLOGY OF AN ORNITHOMIMID THEROPOD DINOSAUR FROM THE BISSEKTY FORMATION (UPPER CRETACEOUS, TURONIAN) OF UZBEKISTAN

BOITSOVA, Elizaveta, Saint Petersburg State University, Saint Petersburg, Russia; SKUTSCHAS, Pavel, Saint Petersburg State University, Saint Petersburg, Russia; AVERIANOV, Alexander, Zoological Institute of the Russian Academy of Sciences, St Petersburg, Russia; SUES, Hans-Dieter, National Museum of Natural History, Washington, DC, United States of America

Ornithomimidae is a clade of Ornithomimosauria, a group of coelurosaurian theropods closely related to Maniraptora. Ornithomimids are characterized by a unique combination of characters that lends them superficial resemblance to present-day large ground-dwelling birds. Expeditions to the Dzharakuduk locality of the Upper Cretaceous (Turonian) Bissekty Formation in Uzbekistan from 1977 to1994 by L.A. Nesov and in 1997–2006 by the Uzbek-Russian-British-American-Canadian Paleontological Expeditions (URBAC) yielded some 800 isolated ornithomimid bones referable to a single taxon. Phylogenetic analysis places the ornithomimid from the Bissekty Formation (BO) near the base of the ornithomimid radiation, between *Archaeornithomimus* and *Sinornithomimus*.

For the present study, thin-sections of six femora of different size (diaphyseal diameter from 1.8 cm to 4.5 cm) of BO were examined to assess ontogenetic changes in long-bone histology. Analysis of the femoral growth series revealed early histological maturation during ontogeny. Femora of small individuals are predominantly composed of primary bone tissues surrounding a relatively restricted medullary cavity. The primary bone is highly vascularized by longitudinally oriented primary vascular canals and fibrolamellar, indicating a fast appositional rate. Even in the smallest femur, the innermost edge of the cortex is partly lined with endosteal bone and partly remodeled with secondary osteon formation. Subsequent ontogenetic changes are represented by a change in orientation of the primary vascular canals from longitudinal to circumferential in the outer layers of the cortex, with a change in primary bone matrix composition from woven-fibered to parallel-fibered bone, the progressive appearance of growth marks, and remodeling features in the primary bone tissues with formation of secondary Haversian bone. Apart from the early histological maturation and absence of lamellar and plexiform vascularization in the primary bone, the long-bone histology of BO is similar to that of other ornithomimids and most other theropods.

Highly porous, secondary bone tissue in a mid-sized femur of BO was interpreted as medullary bone, which forms before ovulation in the medullary cavities of birds as calcium is sourced for egg-shell formation.

Grant Information
This study was supported by the Russian Scientific Fund (14-14-00015).

Technical Sesssion X (Friday, October 28, 2016, 11:00 AM)

PRESERVATION OF SOFT-TISSUE-LIKE STRUCTURES IN FOSSILS OF CRETACEOUS MARINE REPTILES AND SHARKS

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Soft-tissue-like structures have been observed in vertebrate fossil material since the 1970s. However, it wasn't until more recently that the description and analyses of these structures became common. A number of papers have described osteocyte-, collagen-fibril-, and vessel-like structures from a number of organisms including dinosaurs, mosasaurs, turtles, and mammoths; however, only a few of these observations are supported by chemistry. Here, we describe soft-tissue structures recovered from various crocodilian, sea turtle, and shark material recovered from a shallow marine K/Pg bonebed. Cell-like structures were recovered from most of the sampled fossils. Intriguingly, for those fossils from which soft-tissue microstructures could not be recovered, histological sectioning also shows bone microstructure to be obliterated, and instead evidences features consistent with microbial invasion.

Most of the osteocyte-like structures exhibited a flattened-oblate or stellate morphology. These cell-like structures also demonstrated differential preservation. Some well-preserved specimens having numerous long, branching filopodia; more commonly, the cell-like structures retained only a few filopodia. The structures with poorest preservation were darkly colored and only retained stubby filopodia. SEM-EDS analysis of an osteocyte-like structure from a *Thoracosaurus* femur indicates that the elemental composition of the cells is primarily oxygen, iron, and carbon; this is consistent with previously studies that suggest a role for iron in this exceptional preservation. Vessel-like structures were rare and only the *Thoracosaurus* femur produced a few long and/or branching vessels. We also report for the first time the recovery of chondrocyte-like structures from Miocene and Cretaceous shark vertebrae, further expanding the types of tissue than can preserve soft-tissue-like structures over geologic time.

These data support the hypothesis that preservation of soft-tissue structures in the fossil record does not appear to be linked to geologic age, depositional environment, tissue type, or taxonomic affinity. They have been recovered from both terrestrial and marine taxa and from various time periods. The main control(s) of soft-tissue preservation seem to be operating, at least for this site, on a very localized scale as different parts of a skeleton or of a single bone may or may not preserve these structures.

Technical Session XIX (Saturday, October 29, 2016, 3:45 PM)

WHAT CAN RAT FORELIMB MOVEMENTS TEACH US ABOUT EARLY EUTHERIAN MAMMAL LOCOMOTOR HABITS?

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Juramaia and *Eomaia*, some of the earliest known eutherian mammals, have been inferred to have had scansorial habits based on forelimb morphology. In particular, it is often hypothesized that the earliest eutherians were small-bodied locomotor generalists. The forelimb morphology of early eutherians strongly resembles that of extant rats. Therefore, understanding the kinematics of the humerus, radius, and ulna of rats can inform and constrain hypotheses concerning typical posture and mobility in early eutherian forelimbs. We used markerless XROMM (Scientific Rotoscoping) to explore the three-dimensional long bone movements in *Rattus norvegicus* during a normal, symmetrical gait (walking). Our data agree broadly with previous studies of rats and other small mammals: a crouched forelimb posture was maintained throughout the step cycle, and the ulna is confined to flexion/extension in a parasagittal plane. However, our three-dimensional data showed that long-axis rotation (LAR) is present in both the humerus and the radius. Medial LAR of the humerus throughout stance maintains an adducted elbow with a caudally-facing olecranon process, which in turn maintains a cranially-directed manus orientation (pronation). The radius also shows significant LAR correlated with manus pronation and supination, and our data suggest that manus pronation and orientation in *R. norvegicus* rely on a divided system of labor between the ulna and radius. The radius must rotate on its long axis relative to the ulna so that during the stance phase its distal end lies medial to the ulna, ensuring that the manus remains pronated while the forelimb is supporting the body. We suggest that forelimb posture and kinematics in *Juramaia*, *Eomaia*, and other basal eutherians were grossly similar to those of rats, and that humerus and radius LAR may have always played a significant role in forelimb and manus posture in small eutherian mammals.

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Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

THE DIGITAL QUARRY PROJECT AT DINOSAUR NATIONAL MONUMENT: A LEARNING TOOL FOR STUDENTS, TEACHERS, VISITORS AND SCIENTISTS NEAR AND FAR

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The Carnegie Quarry at Dinosaur National Monument has been on display for the public since its discovery in 1909. To share the quarry with a broader audience, a public outreach effort using digital technology was implemented, the Digital Quarry Project (DQP). The Digital Quarry is an interactive, online tool that utilizes scalable vector graphics (SVG) of each fossil in the quarry, allowing website users to learn about them in the context of their relative in-situ positions. The Digital Quarry surfaces formerly-inaccessible information to both remote and in-person visitors.

The DQP also provides users with information about the history of Dinosaur National Monument, the taxa of the quarry, and the Morrison ecosystem. Paper archives, including correspondence, memos, progress reports, planning and development documents, historic quarry maps, preparation records, researcher notebooks, historic excavation photos, and a collection of digital photos of fossils were read and evaluated for relevance to project goals, and digitized using tablet computers, before being made available online. Metadata for each document was recorded to enable search engine discovery and aid human readers.

This multi-year, work-in-progress collaboration between paleontologists, university students, interns and volunteers across several organizations includes extensive mapping and photography, graphic design, writing, web design and development, database management, data digitization, and digital archiving. Official work began in 2014 and the DQP launched publicly on October 7th, 2015. It has since been incorporated by park staff into live demonstrations with quarry visitors as well as remote learning. Progress is ongoing to increase the benefits of the DQP to researchers, interpretive staff at the park, students, teachers, and the general public. We will provide a video preview and direct access to the DQP at the poster session.

Technical Session I (Wednesday, October 26, 2016, 12:00 PM)

SUBSTRATE AND LIMB EVOLUTION: A GLOBAL ECOMORPHOLOGICAL ANALYSIS OF RUMINANT UNGUALS

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The Ruminantia (Artiodactyla, Mammalia) are prolifically found in a variety of environments. However, the suborder is considered to be best adapted to open habitats, in large part because of their unguligrade morphology that consists of just two weight-bearing digits per hoof. The apparent discrepancy between the unified ecomorphology of ruminant feet and the variety of environments they inhabit calls for closer study of variation in limb morphology with respect to habitat. Previous studies have linked ungual features to environmental parameters in several dozen ruminant species. To expand upon these studies, we examine ungual plantar morphology across the Ruminantia suborder. We test whether large scale patterns are driven by ecological, phylogenetic, or body size factors. Further, we generate an analogue that will be used for ecometric comparison to fossil unguals, allowing for the reconstruction of paleoenvironments and the elucidation of ruminant response to climate change across the Cenozoic. Our study includes 720 unguals from 93 ruminant species, permitting us to examine ungual ecomorphological association with a global spectrum of habitats (prairies, deserts, tundras, forests, and swamps) and substrates (wet, ecotone, rocky, and dry). We photographed skeletal ungual plantar (i.e., in contact with the ground) surfaces. Outlines with 100 semilandmarks were then Procrustes superimposed to produce shape variables for subsequent analysis. Results show, regardless of taxonomy, that species that live on fluidly unstable substrates (e.g., snow or sand) tend to have blunter, flatter unguals, undoubtedly aiding in locomotion over the dynamic surface. Furthermore, this effect is strong in wild animals but muted in captives, suggesting that it is a plastic response to substrate. These results show that substrate is also an important factor in ruminant limb evolution—making ungual shape more than just a reflection of phylogeny.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

THE FIRST HYAENODONT FROM THE LATE OLIGOCENE NSUNGWE FORMATION, RUKWA RIFT BASIN, TANZANIA: ECOLOGICAL DIVERSITY OF AFRO–ARABIAN MAMMALIAN CARNIVORES NEAR THE PALEOGENE/NEOGENE BOUNDARY

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Throughout the Paleogene, most terrestrial meat-eating niches in Afro-Arabia were occupied by species from the extinct placental order Hyaenodonta. Near the Paleogene/Neogene boundary, tectonic events in the African Rift System facilitated faunal exchange between Afro-Arabia and Eurasia, and members of the order Carnivora began to arrive on the African continent. Paleontological evidence documents the coexistence of carnivorans and hyaenodonts in a mixed carnivore community through the Miocene, but by the Pliocene, hyaenodonts had disappeared and only carnivorans remained. This transition between meat-eating mammalian lineages in Cenozoic faunas offers insight into the dynamics of carnivorous niches through time.

Here we describe a new hyaenodont from the ~25 Ma Nsungwe Formation of Tanzania. The Nsungwe localities preserve a rare glimpse of Africa's terrestrial vertebrate communities before the Neogene faunal exchange and, ultimately, the diversification of Carnivora on the African continent. The Nsungwe hyaenodont is comparable in size to *Didelphis virginiana,* and it is represented by a right maxilla preserving P4, the alveoli of M1 and M2, and portions of the alveoli of M3. In buccal view, P4 bears a triangular paracone with a notched postparacrista that slopes to form a deep carnassial notch with the metastylar blade. A similar, distinct postparacrista notch is present on P4 in the large hyainailourine *Leakitherium* and in the small prionogalid *Namasector*, both from the early Miocene. Based on the alveoli of M1 and M2, successive molars increased in mesiodistal length and buccolingual width. The protocone of each molar appears prominent, and the metastyle extensive. The specimen preserves a wide infraorbital canal that emerges superior to the roots of P4. Based on comparisons with a robust sample of 45 Paleogene–Neogene hyaenodont and carnivore taxa, the Nsungwe hyaenodont is similar in size and shearing specialization to the earliest Afro-Arabian carnivorans. Interestingly, the late Oligocene Nsungwe taxon exhibits a combination of body size and dietary specialization that is distinct from known hyaenodonts in the mixed carnivore fauna of the African early Miocene.

Grant Information

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Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

A COLUBROID-DOMINATED FAUNA FROM THE LATE OLIGOCENE NSUNGWE FORMATION OF TANZANIA PROVIDES EARLIEST EVIDENCE OF THE LAMPROPHIID RADIATION (LAMPROPHIIDAE, LAMPROPHIINAE)

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The shift from booid-dominated to colubroid-dominated snake faunas marks an important transition in the evolutionary history of snakes worldwide. This faunal shift is well documented in mid-Miocene localities in Europe and North America and has been attributed to global cooling resulting in open environments that favored actively foraging colubroid snakes. However, finds in the Nsungwe Formation in the Rukwa Rift Basin of southwestern Tanzania have revealed a rich snake fauna from the late Oligocene of Africa that suggests the booid-colubroid transition occurred in parts of the East African Rift up to ten Ma earlier than is documented on northern continents.

New material from the Nsungwe Formation increases the known diversity in the Rukwa Rift to ten taxa. It provides evidence of additional colubroid taxa in the fauna, and allows reassignment of previously collected material to Colubroidea. To date, over 80% of Nsungwe snake specimens represent Colubroidea, supporting the notion of a diverse colubroid-dominated late Oligocene fauna in this segment of the rift. Additionally, the fossils provide new insights into regional variation in the vertebral column of previously reported taxa. Notable in the collection is the first cranial material recovered from the fauna in the form of an isolated colubroid dentary. The newly discovered specimens also include a vertebra referable to the extant East African lamprophiine genus, *Gonionotophis*. The vertebra represents the first definitive fossil of Lamprophiinae, extending the known temporal range of the clade by over 24 Ma. This provides the first fossil evidence congruent with molecular estimates for the divergence of Lamprophiinae, providing a new calibration point for Lamprophiinae within Lamprophiidae. The temporal proximity of this find with estimates of the origin of the clade suggests either an earlier radiation than previously supposed, or a rapid diversification of the African clade.

Taken together, the Nsungwe snakes document that in this region, a transition from booid-dominated to colubroid-dominated faunas occurred by no later than ~25 Ma. Of particular note is the appearance of *Gonionotophis*, an extant genus in the Rukwa Rift Basin. This adds supporting evidence to the hypothesis that the pattern of evolution in snake faunas appears temporally distinct on the African continent from better studied locales in North America and Europe, minimally suggesting that local environments in Africa experienced habitat shifts prior to the large-scale mid-Miocene global cooling.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

ONTOGENETIC HISTOLOGY OF POLYCOTYLID LONG BONES AND IMPLICATIONS FOR PHYSIOLOGY

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Polycotylids were a derived group of short-necked plesiosaurs (Sauropterygia: Reptilia) with a global distribution in the Cretaceous seas. Previous osteohistological studies of plesiosaurs show radial vascularization, fibro-lamellar tissues, and heavy remodeling, indicative of fast growth and high metabolism. However, few studies documenting osteohistology of Plesiosauria have examined a single taxon at different ontogenetic stages. Therefore, this study examines three closely related individuals from the Burning Brule Member of the Sharon Spring Formation within the Pierre Shale Group at Wallace Ranch (SD) (80.54 ± 0.55 mya). Phylogenetic analysis supports the hypothesis that the neonate and adult are of the same taxon, while the isolated fetal humerus is too immature for certain taxonomic assignment. Sections of fetal humerus, neonatal humerus, and adult femur were prepared at the Field Museum of Natural History in Chicago, IL. Samples were collected by making transverse cuts of the propodial diaphysis, the location where most primary tissue is preserved. Slices of each bone were mounted on histological slides and ground, and then viewed using polarizing light microscopy. Radial vascularization and fibro-lamellar tissues dominate the neonatal specimen, and one cyclical growth marker, or line of arrested growth (LAG), is present. This LAG is an increase in bone density, and probably reflects changes in physiological demands after birth. The adult exhibits dense haversian bone, indicative of intense remodeling throughout the entire section, that has eradicated all primary tissues. This thorough remodeling indicates a high metabolic rate and possibly a high body temperature, in agreement with recent isotopic findings. Histological data from a propodial of a fetal specimen is still under preparation, and will be compared to the neonatal and adult sections. It is expected that the fetal section will exhibit radial vascularization and fibro-lamellar tissues reflecting rapid intrauterine growth, and that it will lack birth-related LAGs.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

AIRFLOW SIMULATIONS IN THE ANTORBITAL SINUS OF *ACROCANTHOSAURUS*. TESTING THE POTENTIAL FOR THEROPOD PARANASAL SINUSES TO FUNCTION AS ACCESSORY COOLING STRUCTURES

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The nasal vestibule of most dinosaur species underwent both absolute and relative expansion in conjunction with increases in body size. Such a trend is hypothesized to have been a response of the thermoregulatory system to the increased heat stress placed on the brain by an ever-increasing body. However, theropod nasal vestibules exhibit little to no relative size increase with body size and would have been decreasingly effective at air conditioning as body size increased, rendering the clade as a unique outlier to this trend. In contrast, the paranasal sinus system is extensively expanded in Theropoda, and the antorbital sinus often displays a relative increase in size along with increasing mass. Based on these trends, we hypothesize that the antorbital sinus may have provided a compensatory function to nasal air conditioning. However, to do so, the antorbital sinus must be open to a steady stream of air during respiration. To test this hypothesis, we modeled the nasal passages and paranasal sinuses of the megapredatory allosauroid theropod *Acrocanthosaurus atokensis*. Airflow was simulated across a range of potential breathing rates representing restful respiration. Our results indicate that the large antorbital sinus of *Acrocanthosaurus* was able to accept a steady stream of slow-moving air, yet this stream varied depending on ostium placement and was often limited solely to airflow during inspiration. These results were compared to key species from other theropod clades that independently acquired gigantism including the abelisaurid *Majungasaurus crenatissimus* and the coelurosaurian *Tyrannosaurus rex*. Comparative analysis reveals that the antorbital sinus could have functioned as an accessory air conditioner, augmenting the blood cooling effect of the nasal passages and aiding in cephalic thermoregulation. The presence of largely unidirectional airflow in the antorbital sinus would have ensured that only cool air flowed through the sinus. Air circulation may have been further enhanced via bellows-like movements between the antorbital sinus and the suborbital diverticulum powered by the abduction-adduction cycles of the feeding apparatus. A steady source of cool air could have been used as a heat sink for blood coming from the body core, providing a source of cooled blood to moderate brain temperatures.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

USING FOSSIL VERTEBRATES TO DATE EARLY EOCENE TECTONOSEDIMENTARY ACTIVITY IN THE GREYBULL/BASIN AREA OF NORTHWEST WYOMING

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Laramide deformation of the lower Eocene Willwood Formation in an 800 km2 area of the eastern Bighorn Basin was controlled by westward movement along the Rio Thrust Fault (on the east) and uplift of the anticlinal Fivemile Trend (on the south). Basinward tilting, gentle folding, normal faulting, and the generation of inter- and intraformational angular and erosional unconformities resulted from distinct pulses of Laramide deformation that are dated by relating the youngest deformed rocks to a temporal matrix of more than 1,000 stratigraphically correlated fossil vertebrate localities and derived Willwood Formation faunal biohorizons, and by correlating the faunal ages of the biohorizons with approximate absolute dates for the Paleocene–Eocene boundary (56.33 Ma), the C24R to C24N geomagnetic reversal (53.57 Ma). Within the study area, angular/erosional unconformities occur locally between the Paleocene Fort Union Formation and the Willwood Formation, and within the Willwood Formation where as many as three unconformities are developed. A major tectonically generated intraformational Willwood angular unconformity occurs at the top of Biohorizon A (55.24–55.06 Ma), marks what may be the last deformation on the Rio Thrust, and is defined by deposition of a multistory-multilateral sandbody and associated avulsion deposits above truncated folded and faulted rocks. Biohorizon B (54.09–53.94 Ma) may record the last folding along the Fivemile Trend, also marked by multistory-multilateral sandbody development above deformed rocks. The timings of episodes of Rio thrusting and uplift along the Fivemile Trend correlate with intraformational Willwood scour systems south of the Fivemile Trend that have been related to the sequential uplift and southerly overthrusting of the Owl Creek Mountains. These data suggest a temporal relationship between structural elevation of the east-west trending Owl Creek Mountains and the border fold belt of the more north-south oriented middle and southern Bighorn Mountains. We hypothesize a strong and potentially causal relationship between mammalian faunal turnover and tectonic activity in the southern and eastern Bighorn Basin and the Wind River Basin.

Grant Information
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Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

NEW ADDITIONS TO THE LANCIAN MAMMALIAN FAUNA FROM SOUTHWEST NORTH DAKOTA

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Gaining a detailed understanding of the geographic and temporal variations between latest Cretaceous mammalian faunas within the Western Interior Basin requires specimens to be associated with precise stratigraphic data. While those data are available for specimens collected in some geographic areas (e.g., several prolific localities in Montana), only a few mammal-producing localities are documented in such detail from The Hell Creek Formation of North Dakota. Work at two sites in southwestern North Dakota in 2015 by the North Dakota Geological Survey (NDGS) resulted in the discovery of some important new mammal specimens. Those specimens were collected from previously documented localities for which the stratigraphic position is precisely recorded. The most productive site, NDGS L229 (= PTRM V98027) is situated 12.02 meters below the K/Pg boundary and produced 14 mammal specimens that are referable to at least five species, two of which are first occurrences for North Dakota. The first new occurrence is a partial right dentary with preserved m1 of the multituberculate *Essonodon browni*. The other first occurrence consists of six specimens (five isolated lower molars and a partial left maxilla preserving M2 and M3) referable to the marsupial *Glasbius twitchelli*. Another important specimen (NDGS 1719) was collected near locality NDGS L10173 (= PTRM V88002). The bone horizon at that locality is positioned 2.72 meters below the K/Pg boundary, and NDGS 1719 was collected as float approximately one meter below that horizon, marking the lowest possible stratigraphic position. NDGS 1719 is also referable to *G. twitchelli* and consists of a right dentary preserving p2–m4 and alveoli for p1 and the canine, making it the most complete dentary yet referred to that species. NDGS 1719 is stratigraphically the highest mammal specimen referred to a specific taxon yet reported from North Dakota. Both *E. browni* and *G. twitchelli* are considered unique occurrences for the Lancian North American Land Mammal 'age,' with *G. twitchelli* stratigraphically restricted to the latter portion of the Lancian in areas where good stratigraphic controls are available for paleontological localities. These discoveries expand our knowledge of the Lancian fauna from southwestern North Dakota, aid comparisons to other well-sampled faunas from the Western Interior Basin, and demonstrate that further work is needed to ensure our understanding of the Lancian fauna from North Dakota is comprehensive.

Poster Symposium I (Wednesday–Thursday, October 26–27, 2016, 4:15–6:15 PM)

EXCEPTIONALLY COMPLETE IN SITU SKELETON OF AN ADULT EARLY EOCENE NOTHARCTINE EUPRIMATE

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Despite the fact that Eocene notharctines are some of the most abundantly preserved early primates, study of their postcranial anatomy has been limited by the lack of relatively complete specimens preserving all appendicular segments and vertebral columns. Further, hands and feet are rarely preserved completely or in articulation, which prevents study of serial variation in digit morphology and proportions. Such information would add greatly to our understanding of adapiform locomotion and phylogeny. While there are several fairly complete, articulated European adapiform skeletons, crushing obscures their morphological details and some are sub-adults. Here we report the discovery of a relatively undistorted, fully adult skeleton of an adapiform that is the most complete yet recovered in many ways. The specimen was found in the Grizzly Buttes area (middle of Bridger 2 [Br2]) from a locality situated approximately 23 meters below the Church Butte tuff (48.27 Ma). It includes a skull, shoulder and pelvic girdles, nearly complete and partly articulated vertebral column, complete fore- and hind limb elements, semi articulated right and left hands, and a number of pedal digit rays, totaling >120 identifiable bones. The specimen was collected in blocks of unweathered matrix that were CT scanned to generate a digital in situ record prior to preparation. After preparing the skeleton in relief and microCt scanning it, we extracted an in situ digital model of the animal for study. The specimen has been preliminarily identified as *Notharctus* cf. *tenebrosus* based on craniodental features, but postcranially it is possibly the smallest notharctine individual yet recovered from Br2. Despite small size it has relatively large canines, contradicting sexual dimorphism. Preliminarily, it appears to be the first reported *N. tenebrosus* specimen preserving all appendicular segments, such that intermembral index (IMI) can be computed. The specimen confirms a very low IMI (like living primates that cling and leap on vertical supports) as suggested previously by composite estimates. Preserved hand elements indicate that the combined length of phalanges from digit 3 is less than from digit 4, suggesting a strepsirrhine-like pattern of overall digit lengths. Information from this individual and a growing collection of new specimens under study is beginning to clarify the phenetic affinities of notharctines to other primates, to enrich assessments of locomotion and behavior in notharctines, and to fill in gaps in our understanding of early primate evolution.

Grant Information
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Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

JAW ONTOGENY OF THE LATE DEVONIAN "*T. REX*", WITH IMPLICATIONS FOR FEEDING STRATEGIES AND LIFE HISTORY OF THE ARTHRODIRE *DUNKLEOSTEUS TERRELLI*

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Although the body size and jaw anatomy of the fully grown arthrodire, *Dunkleosteus terrelli,* strongly suggests that it was an active predator in the Late Devonian Appalachian Basin, it is unclear what niche(s) the juveniles would have occupied during maturation. Many extant (e.g., the white shark *Carcharodon carcharias*) and extinct (e.g., the ichthyosaur *Stenopterygius*) top predators undergo niche shifts during growth related to body size and ontogenetic changes in the jaws. To test for ontogenetic signals in *D. terrelli* related to possible niche shifts, eight morphologic parameters were analyzed from a growth series of 58 complete infragnathals (lower jaws; 48 to 560 mm) collected from the Late Devonian (Fammenian) Cleveland Shale Member of the Ohio Shale and fit to linear regressions versus total infragnathal length. Slope differences, interpreted as relative growth rates, indicate that the infragnathals became more elongated and disproportionately deeper in the anterior portion as they grew, consistent with absorbing relatively greater impact force, and slower angular but greater tangential velocities at the fang. The cutting length of the jaw shows a change in slope at a jaw length of 300–350 mm that is consistent with a transition from a pince-and-slice- to a chopping-bite style.

These changes in proportions of the infragnathals led to an increasingly powerful bite at the expense of speed of jaw closure as *D. terrelli* grew. This suggests that, while juvenile *D. terrelli* would have been effective predators at all body sizes, with increasing size they likely shifted from a diet of small, fast, and lightly armored prey to large, heavily armored prey. Thus, juvenile *D. terrelli* would likely have been mesopredators, feeding on small sharks, palaeoniscids, or thylacocephalans, but preyed on in turn by large sharks and other arthrodires, including *Dunkleosteus*. A survivorship curve based on the growth series suggests a low juvenile mortality rate for *D. terrelli*, similar to other top predators. However, this similarity could be influenced by preservational or collection biases, or juvenile *D. terrelli* may have preferred shallower, nearshore environments and, thus, been less likely to have been preserved in the Cleveland shales. Although the time for *Dunkleosteus* to reach its mature length is unknown, the ontogenetic change within the infragnathals suggests that, like a mature *Tyrannosaurus rex*, the deep, powerful jaws and large body size of a fully grown *Dunkleosteus* would have insured its position as the apex predator of the Late Devonian seas.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

A RARE ABNORMALITY IN A HADROSAUR DENTAL BATTERY FROM THE DINOSAUR PARK FORMATION (UPPER CAMPANIAN) OF ALBERTA, CANADA

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The first Canadian pathologic hadrosaur dentary was described in 1902 by Lawrence Lambe; however, the pathology remained undescribed until 1930. This particular dentary had an abscess at mid-length, with bone deposited on the lateral surface to incorporate the abscessed pocket. Moodie suggested this was caused by an injury followed by infection, which led to the middle of the jaw and tooth rows becoming vertically shortened along with premortem tooth loss. Other pathologic hadrosaur dentaries have been described; however, like the previous example, these anomalies appear to be related to fractures or other injuries to the jaw rather than being developmental in nature.

For pathologic specimens not caused by trauma, only a few have been described for hadrosaur teeth. An isolated tooth (TMP 1985.036.0161) is dorsoventrally compressed, and workers suggested this abnormality was developmental. There have also been a few instances of *Gryposaurus* teeth (AMNH FARB 5465) where the median carina is split into two. This split has been attributed to either a pathological cause, or as the emergence of a primitive character-- the latter having greater acceptance. Tooth pathologies are rare to observe in hadrosaur dental batteries because these teeth fit into a tightly packed pavement. They are constantly replaced, and consequently a potentially pathologic tooth would have been quickly removed. For these reasons, an abnormality affecting an entire tooth row, as seen in UALVP 55133, is an exceptional discovery.

This dentary is the first-ever described pathologic specimen of this kind. A tooth row at the posterior end of the dental battery has split into two thinner tooth rows within the space of one. The teeth of these smaller tooth rows are anteroposteriorly compressed, yet retain the same height as those in adjacent tooth rows. The teeth occupying each of these two tooth rows have rotated, and developed their own distinct median carina and denticles. The teeth in the alveolus immediately posterior to the split row are slightly curved posteriorly, while the other surrounding tooth rows are unaffected. The anomaly stands out from other dental battery pathologies as it endures the constant tooth replacement, as can be seen in the occlusal surface. Unlike other hadrosaur tooth pathologies, the entire tooth family is affected, signifying it as a developmental abnormality, which could have been caused by aberrant tooth replacement. This discovery is noteworthy as it has implications for the development of the hadrosaur dental battery.

Technical Session XIX (Saturday, October 29, 2016, 2:00 PM)

NESTLED AMONG DINOSAUR EGGS: NEW *ALPHADON* SPECIMENS FROM EGG MOUNTAIN AND THEIR IMPLICATIONS FOR METATHERIAN EVOLUTION

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The origin of marsupial mammals remains elusive. Previous cladistic analyses of stem marsupialiforms and marsupials have commonly shown a tree topology in which (i) an early split separated Late Cretaceous Asian and North American stem taxa from Paleogene South American (SA) stem taxa, and (ii) crown marsupials nested within SA stem taxa—an arrangement congruent with the distribution of living marsupials. However, cranial fossils are sparse for North American (NA) stem marsupialiforms, and thus many characters in these phylogenetic data matrices are unscored for these taxa. This lack of cranial data likely impacts the phylogenetic resolution among NA stem marsupialiforms and possibly biases broader patterns of metatherian phylogeny.

Here, we report new skull fossils of the Late Cretaceous NA stem marsupialiform *Alphadon halleyi* discovered at the Egg Mountain (ca. 75.5 Ma; Judithian) site near Choteau, northwestern Montana. Famous for its dinosaur eggs, this site has also produced nearly complete skulls and skeletons of lizards and mammals. The new specimens include paired maxillae with an associated partial dentary, a nearly complete dentary with associated partial maxillae and upper dentition, and a nearly complete skull. Micro-computed tomography data from these specimens reveal previously unknown anatomical details, including a frontal-maxillary contact and the exposure of both lacrimal foramina on the face, making *Alphadon* one of the most anatomically well-known skulls of a Cretaceous metatherian. Having relatively conservative dental morphology, *Alphadon* has previously been viewed as a probable evolutionary link between more basal Cretaceous therians and more advanced crown marsupials. Thus, it might shed light on the morphological and ecological (in terms of feeding) evolution of marsupials. We conducted a parsimony analysis of 156 craniodental characters and 46 taxa, including deltatheroidan metatherians and marsupialiforms from NA, SA, and Asia. Our strict consensus tree agrees with previous analyses in separating NA and SA stem marsupialiforms, but, in contrast with those analyses, marsupials are nested within NA stem marsupialiforms. These results imply that between the Santonian–early Paleocene (85–65 Ma), Marsupialia either originated in NA or its closest NA marsupialiform relatives dispersed into SA and marsupials evolved soon after.

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Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

A LATE RECORD OF *URSAVUS* (URSIDAE) FROM THE RATTLESNAKE FORMATION (EARLY HEMPHILLIAN, LATE MIOCENE) OF OREGON

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The Rattlesnake Formation of eastern Oregon is early Hemphillian in age (~7.5–7.05 Ma) and records a diverse mammal fauna, particularly among carnivorans, from a mixed sagebrush steppe and woodland environment. Here, we describe previously unpublished fossil material of *Ursavus* that represents a late occurrence of the taxon in North America, extending the temporal range to include the late Miocene and Hemphillian. This specimen is a nearly complete dentary with the canine and p4 through m2. The alveoli for p1–p3 are also present. The specimen is identified as *Ursavus* based on the combination of large alveoli for p1 and p2, a double-rooted p3, lack of a pre-metaconid (in contrast to *Ursus*), and lack of a tremarctine cusp. Other North American *Ursavus* fossils described to date are highly fragmentary or worn, and the Rattlesnake specimen is one of the most complete representatives of the genus on the continent. Carnivore diversity recorded in the Rattlesnake Fauna is the highest known of its age in North America; the addition of *Ursavus* to the fauna brings the total number of carnivorans to fifteen, with three bears represented: *Ursavus*, *Indarctos oregonensis*, and *Plionarctos*.

Poster Symposium II (Friday–Saturday, October 28–29, 2016, 4:15 PM)

OLD SITES–NEW TECHNOLOGIES: REEVALUATION OF THE MORRISON FORMATION: FROM HISTORIC EXPEDITIONS TO NEW SCIENTIFIC DISCOVERIES

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The Morrison Formation, a 1.5 million square kilometer “sheet” of unique and variable sediments, extends over much of the western half of North America. Beginning with the early expedition reports of the West (e.g., Macomb and Hayden surveys) and the major fossil discoveries in 1877 in Wyoming and Colorado, research on the Morrison Formation has greatly influenced our views of the diversity of terrestrial life that existed during the Late Jurassic Period (late Oxfordian - early Tithonian). Since the late 1800s, tens of thousands of fossils and hundreds of skeletons (both partial and complete) have been recovered for institutions throughout the world. Over 140 years of extensive collecting and studying this material has resulted in one of the world's best known prehistoric terrestrial faunas; ranging from algae, cycads, and bivalves to mammals, pterosaurs, and dinosaurs. Due to the unit’s variability and large aerial extent, there is still a wealth of information hidden in its layers. New survey and dating techniques are employed alongside traditional paleontological prospecting and collection methodologies, as sites are revisited and previous stratigraphic and faunal correlations reevaluated.

Advances in preparation tools, consolidates, and transportation have resulted in paleontological resources being more efficiently removed from the field and stored in collections than in the past. Advances in analytical techniques have changed dramatically; allowing for a new information (e.g., phylogenetic, ontogenetic, pathologic, and ethologic) to be obtained, as both old and new specimens are analyzed geochemically, biomechanically, and cladistically, along with X-ray computed tomography, laser scans, and bone histology techniques. In addition, technological advances have changed the way specimens from the Morrison Formation are documented at quarry sites, tracksites, and museum collections utilizing state-of-the-art, 3D digital data capture methods like photogrammetry and unmanned aerial systems. Old sites like the *Dystrophaeus* locality in Utah and the eastern Cope/Marsh Como Bluff sites in Wyoming are being revisited and new fossiliferous material being recovered. Also, as archival records of earlier discoveries (e.g., Bone Cabin Quarry, *Stegosaurus longispinus* Quarry, etc.) are reevaluated, new interpretations, and discoveries have followed. Current research is providing new information about the complexities of the Morrison Formation ecosystem and the “life and times” of the organisms that lived there.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

NEW WOMBATS FROM RIVERSLEIGH, NORTHWESTERN QUEENSLAND, INCLUDE POUCH YOUNG

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Despite an estimated molecular divergence date of 40 million years (middle Eocene) between wombats and their closest living relative, the koala, the fossil record of wombats is poor. The two oldest described wombats, *Nimbavombatus boodjamullensis* and *Rhizphascolonus crowcrofti*, are both early Miocene in age. The former is known from maxillae, upper cheek teeth and isolated lower molars from Riversleigh in northwestern Queensland. The latter is known only from three isolated teeth from central Australia. Here we describe additional specimens of *Rhizophascolonus* from Riversleigh that are late Oligocene to middle Miocene in age as well as at least one additional species. Excitingly, the new specimens show an ontogenetic range from pouch young with occlusal cusp details intact to fully adult specimens with heavily worn teeth.

The unworn teeth from Riversleigh are compared with those of pouch young from two extant wombat taxa and the extant koala. In addition, comparisons of quantitative and qualitative characters of all known *Rhizophascolonus* specimens with the extant

koala and other wombat taxa reveal a large degree of variation in the sample of *Rhizophascolonus* teeth from Riversleigh. However, the number of species of *Rhizophascolonus* present is difficult to ascertain and it is not inconceivable that there is only one or two highly variable species present.

Despite uncertainty at the species level, these new specimens provide an unprecedented insight into this enigmatic group, and we can now start to reconstruct intrafamilial relationships with a greater degree of confidence. Furthermore, occlusal morphology can now be used to help clarify interfamilial relationships in the suborder Vombatiformes, which in addition to wombats and koalas, includes five additional extinct families.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

NEW SPECIMENS OF *TROODON FORMOSUS* HIND LIMBS FROM THE FOX HILLS FORMATION OF SOUTH DAKOTA

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Two new specimens, tentatively identified as *Troodon formosus* in the absence of skull material, consist of incomplete femora and tibiae. The two specimens are catalogued in the University of Kansas Museum of Natural History as KUVP 67265, and were collected by the Black Hills Institute from the Upper Cretaceous (Maastrichtian) Fox Hills Formation twelve miles north of Faith, South Dakota in 1980 and donated to the KUVP. The specimens are of particular importance because the head and articular surfaces of the femur are preserved in both individuals, features that are not well preserved in other specimens of *Troodon formosus*. The femur of the larger of the two individuals consists of the head and curving shaft, 106.4 mm in length, with well preserved muscle scars with deposited quartz minerals in exposed pores. Based on the pattern of muscle scars (i.e., the adductor ridge and parts of medial and lateral supracondylar lines), the specimen preserves approximately 2/3 of the original length of the femur, with an estimated body length of 1.33 m. The second incomplete femur, 67.8 mm long as preserved, shows extensive damage towards the proximal end just below the head and greater trochanter. The shaft of this individual also exhibits a slight curvature. Again preservation of muscle scars indicates that approximately 2/3 of the femur is preserved, estimated body length of 0.85 m. Both femora show robust and blocky heads as well as preservation of the fovea on the posterior surface, and neither possess much of a neck between the head and the greater trochanter. In cross sectional view, the larger femur and tibia exhibit unusual pores, not uniform in diameter, occupying the outermost part of the medullary cavity, filled with quartz minerals. The smaller individual does not appear to exhibit these pores.

Technical Session XIV (Friday, October 28, 2016, 1:45 PM)

EVOLUTIONARY CHANGES IN THE FEEDING APPARATUS OF THE EARLY PERMIAN SPHENACODONTID SYNAPSID *DIMETRODON* IN THE CONTEXT OF THE ESTABLISHMENT OF MODERN TERRESTRIAL ECOSYSTEMS

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The early Permian is marked by a 30 million year period during which the first terrestrial vertebrate high-fibre herbivores appear and begin to dominate terrestrial ecosystems in terms of both biomass and taxonomic diversity. The appearance of large-bodied herbivores initiated an 'evolutionary arms race' between predator and prey that likely had a substantial impact on the apex predators of early Permian terrestrial ecosystems, thereby offering a unique scenario for examining the dynamics of predator-prey relationships on an evolutionary timescale. *Dimetrodon* was the most speciose, abundant, and longest-lived (25 million years) sphenacodontid synapsid apex predator of the early Permian. Due to the known link between feeding apparatus form and function, I examined the changes and evolutionary patterns in the feeding apparatus of *Dimetrodon* during the establishment of modern terrestrial ecosystems. I performed morphologic descriptions of fossil specimens and a histological examination of tooth tissues, which revealed a change in tooth and jaw architecture in *Dimetrodon* through time. I show that the tooth crown morphology increases in complexity; the latest species develop true denticles along the carinae (ziphodonty), which is the earliest occurrence of ziphodonty in the terrestrial fossil record. The tooth roots simplify in morphology through time with a loss of plicidentine and an increase in length. Concomitantly, tooth counts decrease while the jaw becomes more robust in the latest species. These changes in morphology allowed for a more efficient and powerful bite in the latest species of *Dimetrodon* when processing large prey items. This indicates that *Dimetrodon* became a more efficient predator through time, and was able to access a wide range of prey items at a diversity of body sizes. Changes in the feeding apparatus of *Dimetrodon* coincide with faunal transitions and body size changes in large-bodied early Permian amphibians and herbivores. Diadectids and edaphosaurids decline in diversity while new data show that caseids diversify and increase in body size to be greater than 1000 kg, larger than their carnivorous coevals. This study documents for the first time evolutionary patterns in the feeding apparatus of a long-lived carnivorous taxon in a non-analogue terrestrial ecosystem. Morphological adaptations for efficient carnivory evolved during the establishment of modern terrestrial ecosystems and have since evolved convergently numerous times among more recent vertebrate apex predators.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

ARTICULATED TELEOST FISH FROM THE PISCES POINT LOCALITY, LATE CRETACEOUS, SCOLLARD FORMATION, ALBERTA, CANADA, AND THE IDENTIFICATION OF ISOLATED ELEMENTS FROM VERTEBRATE MICROFOSSIL LOCALITIES

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Teleosts of the Late Cretaceous of the Western Interior are well represented by isolated elements preserved in vertebrate microfossil localities but articulated specimens are rare. Since diagnoses of fossil teleosts are largely based on features of the whole skeleton, few of the isolated elements, although morphologically distinctive, can be identified at low taxonomic levels. A locality in the late Maastrichtian Scollard Formation of Alberta called Pisces Point is exceptional in preserving a diverse assemblage of articulated teleosts. Since vertebrate microfossil localities are present in the same formation, as well as contemporaneous formations from Montana and Wyoming, the articulated specimens from the Pisces Point locality provide a unique opportunity to identify isolated elements. Teleosts present in the Pisces Point locality include an esocid and two osteoglossomorphs. The articulated esocid from the Pisces Point locality matches that of members of the Esocidae in being elongate and having dorsal and anal fins located far posteriorly and thus can be included in that family. Esocids were previously recognized in the Late Cretaceous on the basis of dentaries and palatines showing a diagnostic tooth implantation. The articulated specimen from the Pisces Point locality allows other skeletal elements from the microvertebrate sites to be identified as esocid, and together these allow the stratigraphic and geographic distribution of the family in the Late Cretaceous of the Western Interior to be constrained. Based on samples from vertebrate microfossil localities in the Cenomanian to late Campanian of Utah, the late Campanian to late Maastrichtian of Montana, and the late Santonian to late Maastrichtian of Alberta, esocids first appear in the late Santonian. In Utah, they are absent in early Santonian localities but are present in the late Campanian, and are dominant members of the teleost assemblage through to the end of the Cretaceous. Isolated elements of the ostoglossomorphs can also be identified based on comparison with the articulated specimens from the Pisces Point Locality.

Grant Information
Royal Tyrrell Museum Cooperating Society

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

PHYLOGENETIC RESPONSE TO ENVIRONMENTAL CHANGE IN NEOGENE AND QUATERNARY CROCODYLIANS FROM THE VICTORIA AND TURKANA BASINS OF KENYA

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Historically, crocodiles found in the late Cenozoic of East Africa were viewed as ancestral (or even referable) to modern species. Recent work reveals unexpectedly high extinct diversity and a surprisingly complex phylogenetic history in the region, with a major turnover in crocodylian faunas during the Miocene and protracted reduction in diversity related to changes in rainfall and vegetation.

Early Miocene sites in the Lake Victoria and Lake Turkana Basins of Kenya preserve tomistomines, true gharials possibly related to South American gryposuchines, and osteolaemines—*Brochuchus*, an unnamed large generalized form, and longirostrine *Euthecodon*. At late Miocene sites such as Lothagam, the only osteolaemine is *Euthecodon*. A tomistomine ("*Eogavialis" andrewsi*), an extinct sharp-nosed crocodile (*Mecistops*), and two extinct species of *Crocodylus*—among the oldest *Crocodylus* known from Africa—occur at these sites. One is either *Crocodylus checchiai*, also known from the late Miocene of Libya, or a close relative; the other is related to post-Miocene species of *Crocodylus* from eastern Africa. Diversity declines thereafter; Pliocene and early Pleistocene localities (e.g., Kanapoi, Koobi Fora) have only three species (*Crocodylus thorbjarnarsoni*, *Euthecodon brumpti*, and an unnamed species of *Mecistops*), and *Mecistops* is absent in the Late Pleistocene.

The osteolaemine *Rimasuchus lloydi*, formerly thought to have a widespread distribution throughout Africa during the late Cenozoic, is not currently known from East Africa. From a phylogenetic perspective, the only crocodylian currently found in the region—the Nile crocodile, *C. niloticus*—is ancestrally African, but it has no close fossil relatives in the Victoria and Turkana Basins, suggesting that it dispersed to the region late in the Quaternary.

Although changes in lake salinity or pH might have played a role, changes in rainfall and vegetation are the most likely causes of these changes. Decreased moisture levels would have reduced the forested settings favored by living osteolaemines and, eventually, available fluviolacustrine habitat in general.

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Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

REVISITING CASEID PHYLOGENY: AN ALTERNATIVE TREATMENT FOR MORPHOMETRIC CHARACTERS

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Continuous morphological characters are a source of great debate, with disagreements surrounding the appropriateness of their use in phylogenetic analysis and their treatment in such analyses. Such characters have recently been used in analysing the relationships of caseid, a long-ranging group of herbivorous Palaeozoic synapsids belonging to the paraphyletic group known as pelycosaurs. However, a number of possible shortcomings were identified in the handling of continuous characters in the analyses, including the use of gap weighting to discretise the characters (a method which can lead to taxa with significant differences in a measurement being assigned the same character state) and potential issues with redundancy and character non-independence. Therefore an alternative treatment for these characters is suggested. First, rather than use gap weighting, the continuous characters were analysed in the program TNT, in which the raw values can be treated as continuous rather than discretised. Secondly, prior to the phylogenetic analysis, the continuous characters were subjected to a principal component analysis, and then the principal components were included in the character matrix rather than the raw measurements. Analysing the original data in TNT produced little difference in the results, but using the principal components as continuous characters instead of the raw ratios resulted in alternative positions for the problematic taxa *Caseopsis agilis*, *Ennatosaurus tecton*, and *Caseoides sanangeloensis*. The differences are judged to be due to the reduced redundancy of the characters, the smaller number of principal components not overwhelming the discrete characters and the use of a scaling method which allows principal components with a higher variance to have a greater influence on

the analysis. The positions of highly fragmentary fossils depend heavily on the method used to treat the missing characters in the principal component analysis, and so this method should be used with caution for analysing very incomplete taxa.

Technical Session XI (Friday, October 28, 2016, 8:30 AM)

AN OPERCULATE CHONDRICHTHYAN FROM THE FAYETTEVILLE SHALE (UPPER MISSISSIPPIAN, ARKANSAS, USA)

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The Fayetteville Shale of Arkansas (Chesterian, Upper Mississippian) has yielded a diversity of invertebrate and plant fossils over the past 50 years, but the fishes of this formation are relatively understudied. We describe a particularly unusual cartilaginous fish represented by two specimens. This shark possesses a gill cover, which is rare among chondrichthyans. Identifying endoskeletal features in fossil Chondrichthyes is dependent upon the degree of calcification, and previously described shark opercula (in *Triodus* and *Tristychius*) have both now been debunked. Cartilaginous gill covers are present in all modern chimaeras, and the presence of an operculum may be a primitive or independently derived trait. We utilize computed tomographic scanning to compare this shark gill cover to that of fossil and extant holocephalans, and place this discovery in context within the evolution of Chondrichthyes.

Technical Session VII (Thursday, October 27, 2016, 1:45 PM)

QUANTIFYING INTRASPECIFIC MORPHOMETRIC VARIATION IN PUTATIVE DISPLAY STRUCTURES IN ORNITHISCHIAN DINOSAURS

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Phenotypic variation is the basic material upon which selection acts, and as such quantifying this variation, within a population or species, is an integral aspect of evolutionary biology. In a palaeobiologic context, intraspecific variation can often be regarded as merely an obstacle to robust taxonomy. However, when sufficient fossil samples do exist morphometric variation in extinct taxa can be quantified, and used to test inferences regarding taxonomy and palaeobiology. Primarily, overall levels of variation in well-sampled fossil taxa can be compared to predicted levels based on extant analogues to aid in species demarcation. Additionally, levels of variation can be contrasted between different skeletal regions, testing functional hypotheses. Specifically, anatomical features strongly tied to mechanical functions (such as feeding and locomotion) are predicted to have high levels of constraint and low variation. Conversely, features not strongly tied to a mechanical function, but that have evolved in the context of socio-sexual display, are predicted to have higher rates of variation.

Levels of variation were quantified using the coefficient of variation (CV) of linear morphometric variables in a number of well-sampled and taxonomically robust ornithischian taxa. The primary dataset consists of skulls of the horned dinosaur *Centrosaurus apertus*, with secondary datasets also including *Protoceratops*, *Lambeosaurus*, and *Corythosaurus*. These results were then compared to extant amniote analogues, including mammals, birds, and squamates.

Ranges of overall variation in ornithischian species are higher than those of mammal or bird species, but on par with the sampled squamates. These results may be due to strongly determinate growth and/or developmental constraint seen in mammalian and avian species. At the regional scale, levels of variation for the putative ornamentation structures (i.e., frills, horns, crests) are significantly higher than those for the remainder of the skull. Regardless of the overall level of variation, measurements of ornamental structures show a consistently higher amount of variation (~2-3 times) than those of the rest of the animal, across Ornithischia and all extant analogues.

In the context of other results suggesting these same structures are ontogenetically delayed, positively allometric, and highly species-specific, these data provide support to the hypothesis that the evolutionary driver of these bizarre structures is selection for socio-sexual display.

Grant Information

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Preparator's Session (Thursday, October 27, 2016, 11:30 AM)

PREPARATION AS INTERPRETATION IN THE STUDY OF FOSSIL VERTEBRATES

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Natural history specimens experience a transformative path from the field to the collection, and these changes continue through the museum life of the object. Fossils specimens are typically mechanically or chemically prepared from the rock in which they are preserved prior to study. These techniques shape our interpretation of the morphology of extinct life, yet the basic methods are infrequently documented in the laboratory or collections and rarely reported in the scientific literature. A case study of one specimen from Petrified Forest National Park illustrates the impact that paleontological methods bear on identification of fossil materials.

PEFO 31205 represents a partial skull of a pseudopalatine phytosaur collected from the Sonsela Member of the Upper Triassic Chinle Formation. Originally described as the first occurrence of the genus *Nicrosaurus* from Arizona, and the second from North America, this taxonomic identification was based on the condition of the skull upon discovery, partly weathered out of a large block of coarse sandstone exposing a portion of the left lateral view of the posterior skull. The original research team and park resource managers determined that it was not feasible to collect the skull in this remote area of the park, thus it was described in situ. The interpretation was therefore based on unprepared material, in which much of the anatomy present was obscured by matrix.

Subsequent collection and preparation of the skull revealed that much of the skull roof, and posterior skull, including the upper part of the braincase, were preserved. As a result of this preparation, a phylogenetic analysis including the newly exposed morphological characters, particularly the projection of the external nares above the skull roof and the width of the posterior squamosal process in lateral view, recovers the specimen as the sister taxon to *Machaeroprosopus buceros* and therefore distinct from the predominantly European genus *Nicrosaurus*. As a result, biostratigraphic correlations of *Nicrosaurus*-bearing rocks to the Chinle Formation are no longer supported by this specimen. This case study illustrates the effect that paleontological methods can have on scientific interpretation affecting taxonomic, biostratigraphic, and biogeographic hypotheses by demonstrating the transformative effect that preparation has on available data. It likewise reinforces essential preparation competencies such as understanding of fossils as geological and biological data, as well as recording and reporting of methods applied to specimens.

Preparator's Session (Thursday, October 27, 2016, 9:30 AM)

PRECISION, ACCURACY, AND REPRODUCIBILITY OF RESEARCH-QUALITY PHOTOGRAMMETRIC MODELS OF VERTEBRATE MICROFOSSILS IN THE 0.5–2 MM SIZE RANGE

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I have refined my protocol to produce 3D photogrammetric models of vertebrate microfossils using inexpensive equipment and readily available software to the point where it is now possible to build research-quality digital models. Here I present a method to confirm that sufficient photographs have been taken to produce a good model and test the ability of my protocol to yield 3D models that are precise, accurate, and reproducible. My test object for this study was an upper second molar of a shrew (*Sorex* sp.) with an occlusal area of approximately 1 mm2. I used three series of 220 focus-stacked images to build the initial specimen models. I randomly subsampled each of the image sets three times by increments of 10% and built new models for each subsample (84 models total). Fitting a mechanistic growth model to a plot of the number of photographs used versus the calculated Dirichlet normal energy (DNE) of each model yields a curve that approaches an asymptotic value for each series and indicates when sufficient photographs have been used. For two of these series the DNE curves leveled out at approximately 50% of the initial number of photographs. One series failed to approximate the asymptote. I then performed a 3D geometric morphometric analysis to assess the precision and accuracy of each of these models relative to a series of models in which I exaggerated the length and width by increments of 5%. On scale, each of these steps represents a difference of approximately 50 microns. A plot of PC1 vs PC2 of the Procrustes transformed data reveals that all models generated from subsamples of 50% and higher, including those from the series that failed to reach the asymptote of the DNE curve, form a single tight cluster that lies far from the nearest exaggerated model. These data suggest this method can yield precise models with an error rate of less than +/- 2%. While the method remains labor intensive, the fact that research-quality digital models of sand grain sized specimens can be produced with equipment costing less than $1500 has the potential to significantly lower the bar of entry to working with these types of 3D data.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

INTERNAL PNEUMATIC STRUCTURES IN CERVICAL VERTEBRAE OF THEROPOD DINOSAURS

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Studies of pneumatization evaluating the distribution of axial diverticula regarding non-avian dinosaurs focus mainly on the presence or absence of pneumatic features in theropods. Internal pneumatic structures are classified as apneumatic, camerate and camellate organization. Here we analyze a µCT-scan from a noasaurid (DGM 929-R) and review the literature on this subject. We were able to expand the previous classification of the internal organization of pneumatic structures, and recognize six morphotypes by combining features observed in the centrum and neural arch (cen/na) as follows: acamerate/acamerate (A/A), camerate/procamerate (C/PrC), camerate/camerate (C/C), polycamerate/procamerate (PoC/PrC), polycamerate/polycamerate (PoC/PoC) and camellate/camellate (Cm/Cm). A/A mainly occurs in basal saurischians, and is charaterized by having trabeculae not connected to foramina; laminae and shallow fossae might be present.. C/PrC was recovered from the basal tentanuran *Sinraptor* and has wide camerae in the centrum, displaying at most three chamber generations, and show deep fossae in the neural arch. C/C is present in the spinosaurid *Sigilmasaurus*, where the neural arch presents camerae linked to fossae via foramina and the pedicles are apneumatic. PoC/PrC was found in one noasaurid (DGM 929-R), where the centrum displays at least three camerae generations, that get more ramified towards the articular facets. The neural arch in this morphotype also presents wide and deep fossae that are connected via foraminae, as well as pneumatic pedicles. PoC/PoC is observed in the ornithomimosaur *Archaeornithomimus*, where the neural arch is composed by camerae generations (the polycamerate condition), and presets pneumatic pedicles. Cm/Cm was recovered in the coelurosaurs *Acrocanthosaurus*, *Aerosteon*, *Siats*, *Itemirus* and birds. Chamber generations in Cm/Cm are not clear and the pneumatic areas are connected via pedicles. In some birds, the camelate pattern is expanded, reducing the bone thickness. Those morphotypes represent a small sample of diversity of internal structures that can occur in theropods. Despite the small sample analyzed so far, our results indicate a diversity of internal pneumatic structures in theropods that were not previously recognized. Future studies might even expand the diversity of the pneumatic patterns present in dinosaurs.

Grant Information

FAPERJ, A.S.B. and A.W.A.K.; CNPQ, A.W.A.K.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

BRAINS BEFORE BRAWN: NEUROSENSORY EVOLUTION IN TYRANNOSAUROID DINOSAURS

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Tyrannosaurids— the familiar dinosaur group including *Tyrannosaurus*, *Albertosaurus*, *Alioramus*, and kin—occupied the apex predator role in Asia and North America during the latest Cretaceous. It has long been thought that sophisticated senses and distinctive brain and endocranial morphologies were among the keys to tyrannosaurid success. Little is known, however, about how these giants developed many of their signature neurosensory features as they evolved from small-bodied, basal tyrannosauroids that originated more than 100 million years before *T. rex*. We present new data on the endocranial and neurosensory anatomy of three basal tyrannosauroids that form an evolutionary sequence on the line to large-bodied tyrannosaurids: the dog-sized Early Cretaceous *Dilong paradoxus*, the horse-sized mid-Cretaceous *Timurlengia euotica*, and *Bistahieversor sealeyi* from the Campanian (Late Cretaceous), one of the closest outgroups to Tyrannosauridae that approaches the latest Cretaceous giants in size. The S-shaped endocast with small olfactory extensions and limited cranial sinuses of *Dilong* bear little resemblance to those of tyrannosaurids, but are more similar to other generalized coelurosaurs. Several characteristic tyrannosaurid neurosensory features begin to appear in the moderately-sized *Timurlengia*, which already possesses a tubular endocast with a pronounced midbrain peak and an inner ear with an elongate cochlea well-tuned to low frequency sounds, all previously thought to be unique to the largest, latest Cretaceous species. *Timurlengia*, however, retains a primitive set of pneumatic sinuses surrounding the brain and ear, and it is only in *Bistahieversor* in which the tyrannosaurid condition of larger and more numerous sinuses appears, most prominently the huge subcondylar recesses and enlarged anterior tympanic recess that invades much of the prootic near the ear. This new information indicates that tyrannosaurids evolved from distant ancestors with a fairly standard coelurosaurian neurosensory apparatus, and then developed their keen hearing and uniquely shaped brain at moderate body size, long before developing into giants. These features may have predisposed tyrannosauroids to become successful apex predators when the opportunity arose. It was only at this point—when they had grown large and ascended to the top of the food chain—that more extensive cranial sinuses developed, perhaps to lighten the skull, cool the brain, and/or to maintain or increase the ability to hear low frequency sounds at larger size.

Grant Information
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Preparator's Session (Thursday, October 27, 2016, 8:00 AM)

REMOVAL OF A COLUMBIAN MAMMOTH SKULL FROM AN IN-SITU BONEBED

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In July 2016, a Columbian mammoth skull with one intact tusk was removed from the in-situ bonebed at the Mammoth Site of Hot Springs, SD. The decision to remove the skull, which was located in a high density area of the bonebed, was based on largely health and safety concerns. The skull sat atop a tall pedestal of sediment with slanted bedding planes, consisting of layers of dense clay-rich sediment interspersed with thin layers of sand. Potential failure of the pedestal could have caused irreparable damage to the skull and upwards of two dozen surrounding specimens, including several tusks and a second skull. The safety of staff and volunteers working in the area was also a concern. The entire removal process took over three weeks. Surrounding specimens needed to be protected from numerous hazards including heavy foot traffic during the project, tool damage, damage from falling tools or sediment, and damage from support ropes attached to the skull. Those specimens deemed at greatest risk of damage were protected by temporary plaster jackets, others were covered in padding. A metal support frame was installed around the skull, part of which was welded in place inside the bonebed. The metal frame was incorporated into the plaster jacket surrounding to the skull. The skull was successfully removed using a built-in overhead crane with a one ton lift capacity.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

OSTEOLOGICAL INDICATORS OF PREY SIZE PREFERENCE IN THE FORELIMBS OF FELIDS AND NONAVIAN THEROPOD DINOSAURS

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As obligate bipeds, nonavian theropod dinosaurs freed their forelimbs for non-locomotory uses, including a likely role in prey capture. Modeling forelimb function has proven difficult due to a lack of extant analogs. Among modern animals, one of the few groups that use their forelimbs in prey capture are cats. Felids of all sizes use their forelimbs to varying degrees in prey subjugation and capture, ranging from quick swipes at small prey to extended grappling with larger prey animals. A previous study showed that aspects of the morphology of forelimb elements can serve as indicators for prey size preference in cats, despite the forelimb's prominent role as a locomotory structure. To investigate this relationship in theropods and its similarity to that in cats, we performed phylogenetic principle components analyses on a set of forelimb indices that were previously found to be functionally relevant to forelimb use and prey size preferences. The patterns found in cats and theropods show broad congruence. Among cats, most taxa with large prey specialization show strong separation along the first and second principle components (PC) axes from small or mixed prey specialists, which are weakly separated and show a general gradation. Large tyrannosaurids, *Torvosaurus*, and *Acrocanthosaurus* occupy a region that is similar to that of large-prey-specialist cats, and are well separated from other theropods along the first two PC axes. Among both taxonomic groups, species occupying this region showed relatively short and robust forearms, as well as long olecranon processes, robust metacarpals, and large radial and metacarpal distal articular surface areas. Large-prey specialist cats were also found to exhibit increased humeral robusticity, and relatively large humeral epicondyles and distal articular surface area. These results suggest that some theropods can be classed as large prey specialists that used their forelimbs in prey capture. The grouping of tyrannosaurids with larger-forelimbed taxa such as *Acrocanthosaurus* and *Torvosaurus* in the large-prey-specialist region supports previous hypotheses of a functional role for the reduced forelimb in prey capture. Early dinosaur taxa (e.g., *Tawa*) are grouped in the small-prey-specialist region, whereas coelophysoids show indicators that they may have had a diet of mixed-sized prey. The similarity in the patterns between theropods and cats suggests that theropods may have engaged in similar forelimb-based behaviors in predation, such as grappling with large prey or swiping at small agile prey.

Poster Symposium I (Wednesday–Thursday, October 26–27, 2016, 4:15–6:15 PM)

***HYRACHYUS EXIMIUS* FROM THE MIDDLE EOCENE LOWER WASHAKIE FORMATION ABODE TOWN MEMBER OF WYOMING AND ITS BEARING ON THE ORIGIN AND EARLY DIVERSIFICATION OF RHINOCEROSES**

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Continued poaching and illegal hunting have brought living rhinoceroses to the brink of extinction, yet despite their limited numbers today, the fossil record of rhinoceroses is exceptional. The group originated and quickly diversified during the Eocene epoch, with some of the oldest members of the group known from Bridgerian and Uintan Land Mammal Ages of North America, around 47 to 46 million years ago. *Hyrachyus* is a widespread Bridgerian early rhinocerotoid with a phylogenetic position at the base of a crown group that includes four families: the true rhinos (Rhinocerotidae), the running rhinos (Hyracodontidae), the swamp rhinos (Amynodontidae), and the Asian giant rhinos called Indricotheres (which includes *Paraceratherium*, one of the largest land mammals to have ever existed). Recent field work in the Bridgerian/Uintan Washakie Formation in Wyoming by Utah State University has uncovered a well preserved skull of *Hyrachyus eximius* from the lower Washakie Formation. Previously, the species was known from only isolated teeth and fragmentary bones from the Washakie Formation. However, many complete specimens are known from the Bridger Formation. The new specimen corroborates biostratigraphic evidence that the lower Washakie Formation Abode Town Member is Bridgerian in age, likely equivalent to the Bridger D horizon of the Bridger Formation. In contrast, the upper Washakie Formation Abode Town Member is early Uintan in age and contains the early members of each of the Rhinocerotidea families, including the hyracodontid (*Triplopus*), the amynodontid (*Amynodon)*, and the early true rhinocerotid (*Uintaceras*). The upper Washakie Formation temporally spans the time period when the four early groups of rhinoceroses differentiated near the Bridgerian and Uintan boundary, 46.5 million years ago. The new specimen lacks the anterior dentition, premaxilla, and nasals, but includes the upper left molars, zygomatic arches, orbits, frontal and parietal bones, basicranium, and occipital region. The specimen is well preserved with little deformation. The specimen is the best known specimen of *Hyrachyus* from the Washakie Formation and compares well with skulls known from the Bridger Formation.

Grant Information
Research was self funded.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

JUVENILE APPALACHIAN NODOSAUR MATERIAL (NODOSAURIDAE, ANKYLOSAURIA) FROM THE LOWER CAMPANIAN LOWER MOOREVILLE CHALK OF ALABAMA

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Late Cretaceous dinosaur remains are rare in the eastern United States relative to localities in the west. Armored dinosaur specimens, especially those representing juveniles, are relatively uncommon components of dinosaurian assemblages even in Laramidia. Here we describe Appalachian nodosaur material from Alabama that includes a juvenile specimen, which is one of the most complete ankylosaur specimens from Appalachia to date. It was most likely recovered from marine sediments of the lower Campanian Lower Mooreville Chalk (the CC17 biozone based on nannofossil correlations) in west-central Alabama. The specimen includes a basicranium, partial maxilla and right dentary, scapular fragments, partial right ilium, the left half of a cervical neural arch, and numerous vertebral central from the sacral through caudal regions. The basioccipital-basisphenoid suture is open, and the basisphenoid is complete. Although the maxillae are ornamented, only incipient osteodermal sculpturing is visible on the mandible. There is little dorsoventral flexion to the ilium, a condition more similar to adult nodosaurids. The only smaller nodosaur specimens known are a neonate (described as a "scuteling") from the upper Albian Paw Paw Formation of Texas and *Propanoplosaurus* from the lower Aptian Patuxent Formation of Maryland. The preservation of disarticulated cranial elements with the Alabama and Texas specimens warrants a review of validity of *Propanoplosaurus*, which was described as a neonate with a fully-fused and ornamented skull. *Texasetes*, named largely on postcrania, which has been suggested to be synonymous with *Pawpawsaurus*, may also be in need of revision. Additional field work may recover more nodosaurid material from Alabama, which has considerable ontogenetic and paleogeographic significance.

Technical Session VIII (Thursday, October 27, 2016, 3:30 PM)

USE OF AUTOMATED THREE-DIMENSIONAL MORPHOMETRICS TO DETECT TAPHONOMIC BIAS: FOSSIL ARVICOLINE RODENT TEETH AS A CASE STUDY

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Biases induced by taphonomic processes are common within vertebrate paleontology, whether they be related to deformation due to burial, damage due to transport, or damage incurred during deposition. One of the newest quantitative methods in vertebrate paleontology is the use of three-dimensional µCT scans combined with an approach called Automated 3-Dimensional Geometric Morphometrics (A3DGM). This approach (A3DGM) uses a published algorithm to automatically place a user-defined number of morphometric data points an even-distance from one another on a three-dimensional surface. No a priori assumptions about the utility of landmarks are made by A3DGM, and therefore, it is possible to reduce or remove researcher-introduced measurement bias. However, it is unclear how potential taphonomic damage to specimens may influence the results of A3DGM-analysis. Here, I present the results of a test of how random taphonomic damage may influence A3DGM-analyses. I constructed a dataset using 13 µCT-scans of fossil lower first molars from *Lemmiscus curtatus*. To test for taphonomic bias, I produced three datasets. The first dataset was the entire 3D mesh of the tooth (full), the second was a 3D mesh that deliberately cropped out broken portions of the tooth leaving a large portion of tooth crown (high), and the third dataset cropped out broken portions of the teeth and deliberately standardized the crown height of the teeth to be cropped at the enamel-dentine junction (low). I then investigated the resulting datasets through regressions of principle component scores and matrix correlation tests. Results indicate that the full dataset, with all taphonomic effects present, does not have a significantly different signal than the high or low datasets. The full dataset has a slightly expanded range of variance compared to the high and low datasets. This is interpreted as increased noise due to taphonomy. These results match the previous conclusion that unless taphonomy is stereotyped (i.e., all fossils are damaged in similar ways), morphometric analyses only become noisier without altering biological signal. My results indicate that with simple statistical tests potential taphonomic bias introduced into A3DGM-analysis can be identified and corrected easily, allowing continued developmental of this powerful quantitative tool.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

OSTEOHISTOLOGY OF *NIOBRARASAURUS COLEII* (DINOSAURIA, NODOSAURIDAE)

BUSKUSKIE, Thomas R., Fort Hays State University, Hays, KS, United States of America; WILSON, Laura E., Fort Hays State Univ, Hays, KS, United States of America

Few studies have investigated the osteohistology and ontogeny of nodosaurids due to the fragmentary nature of many nodosaur fossils and lack of juvenile specimens. Past studies have focused on using the degree of fusion in osteoderms and vertebral elements to identify juvenile remains, and there has been only one osteohistologic study examining a growth series of specimens identified to a single species. This study presents new research on the bone growth and ontogeny of nodosaurids by examining the osteohistology of two specimens identified as *Niobrarasaurus coleii* from the Late Cretaceous Smoky Hill Chalk of Kansas. FHSM VP-14855, the holotype, is represented by four nearly complete limbs, portions of the pelvic girdle and skull, and numerous osteoderms. A second specimen, FHSM VP-13985, consists of only a right radius and ulna smaller than these elements in the holotype. The original description of FHSM VP-13985 considered it as a juvenile *N. coleii* based on size and similar morphology to the holotype. The elements selected for this study are the right radius and ulna from both the holotype and juvenile as well as the right femur, tibia, humerus, and an osteoderm from the holotype. The tibia and humerus of the holotype have compact cortices and more cancellous medullary regions when viewed macroscopically. In addition, the radius and ulna are characterized by extensive secondary osteons with little to no primary bone tissue remaining and a cancellous medullary region. In contrast, the majority of the cortex in both the radius and ulna of the smaller specimen consists of longitudinal vascular canals in a woven fibered matrix with two growth marks visible in the radius and at least one in the ulna. Both the radius and the ulna also show evidence of resorption cavities and a cancellous medullary region as in the holotype. None of the sectioned elements display any evidence of an external fundamental system (EFS), indicating that neither specimen was a skeletally mature individual at the time of death. The presence of primary bone tissue and growth marks along with the lack of an EFS supports previous claims that FHSM VP-13985 is a juvenile. Although FHSM VP-14855 also lacks an EFS, the greater degree of secondary bone tissue indicates that it is likely a later ontogenetic stage than the juvenile, though still not skeletally mature.

Grant Information

Western Interior Paleontological Society Karl Hirsch Memorial Grant to Thomas R. Buskuskie

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Technical Session V (Wednesday, October 26, 2016, 1:45 PM)

THE FIRST GLOBAL-SCALE PHYLOGENETIC NETWORK BIOGEOGRAPHY ANALYSIS OF LATE PALEOZOIC AND EARLY MESOZOIC TERRESTRIAL VERTEBRATES AND THE INFLUENCE OF MASS EXTINCTIONS ON ANIMAL DISTRIBUTION

BUTTON, David J., University of Birmingham, Birmingham, United Kingdom; BUTLER, Richard J., University of Birmingham, Birmingham, United Kingdom; LLOYD, Graeme T., Macquarie University, Macquarie University, Australia; EZCURRA, Martin D., Museo Argentino de Ciencias Naturales "Bernardino Rivadavia", Buenos Aires, Argentina

The Triassic was a pivotal time in the evolution of life, recording the biotic recovery from the end Permian mass extinction. However, the presence of Pangaea complicates our understanding of biogeographic processes during this interval. Although this would mean few physical barriers to dispersal, faunal provinciality may have been driven by latitudinal and seasonal climate variation. The overlap between contemporaneous faunas can be quantified as the biogeographic connectedness (BC), the density of links in a taxon-locality network. Recent work has identified a reduction in BC in the Middle Triassic relative to the late Permian in southern Gondwana. This has been used to argue for the breakup of a cosmopolitan Early Triassic 'disaster fauna', a result of the end Permian mass extinction, at this time. However, it is unknown if this local signal is representative of global trends and BC during the Early and Late Triassic has yet to be quantified. In addition, calculation of BC to-date has not included phylogenetic information, instead treating taxa as independent entities. This likely underestimates the links between localities and renders results sensitive to taxonomic lumping or splitting and temporal differences between sampled localities.

We address these problems by employing a novel method incorporating phylogenetic information into the calculation of BC by weighting links between taxa according the phylogenetic distance between them. Bias due to increasing distance from the root through time is avoided by truncating the maximum length of branches prior to the start of each time bin by a constant, k. This method is applied to a time-calibrated supertree and global occurrence data of 1085 terrestrial amniote species, pooled into nine distinct biogeographic regions. The phylogenetic BC of this network was calculated for eight time bins from the late Permian through to the end of the Early Jurassic. Results are sensitive to variation of k, but consistent patterns emerge. Global BC values remain high from the late Permian through to the end of the Ladinian, but decrease strongly in the Late Triassic and continue to decline in the Early Jurassic. These results demonstrate that a mainly cosmopolitan fauna was maintained until the end of the Middle Triassic, longer than suggested by previous studies. This discrepancy may be due to differences between local and global patterns. In contrast, high provinciality occurs across the Triassic–Jurassic boundary indicating that biogeographic responses to mass extinctions are not uniform in terrestrial faunas.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

LINEAR MORPHOMETRIC ANALYSIS OF BEAK ECOMORPHOLOGY IN AVIAN AND NON-AVIAN DINOSAURS

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An edentulous rostrum covered by a keratinous rhamphotheca evolved repeatedly within Theropoda. In avialans, it was a key innovation that lightened the skull and allowed for a vast array of morphological and dietary specializations. The correlation between beak morphology and diet has a long history of study in birds, but research has been more limited in both depth and scope in non-avian theropod dinosaurs. Here, we analyze the correlation between beak morphology and diet in extant avialans to make predictions about the diets of extinct theropods and generate testable hypotheses for future research.

We used a portable x-ray scanner to digitally image skulls of extant avialans (n=57) in lateral and ventral views. Extinct taxa were chosen that show three-dimensional preservation of the skull. When possible, published measurements were used; in the absence of appropriate measurements, published images were analyzed using ImageJ. We measured rostrocaudal length, dorsoventral depth, and mediolateral width of the edentulous rostrum at the naris. X-ray images of skulls allowed for direct measurement of the maxilla and premaxilla visible beneath the keratinous sheath. Dietary information was collected from the Cornell Lab of Ornithology resource All About Birds. Primary diet was scored using seven binary dummy variables and was classified as consisting of mostly: aquatic invertebrates, terrestrial invertebrates, aquatic vertebrates, terrestrial vertebrates, seeds, other plant material, and other. We ordinated extant data using Principal Components Analysis (PCA) in PC-ORD and calculated PC scores for extinct data manually in R.

A randomization test (r=1000) indicates that only the first axis was significant ($p<0.001$), explaining 95.2% of the variance in morphospace. Beak length was the largest contributor to PC axis 1, with an R^2 of .995. Beak depth and width had R^2 values of 0.274 and 0.213 respectively, also to PC 1. Diet 1 (aquatic invertebrates) was the most closely correlated with PC 1, with an R^2 value of 0.127. These data indicate that beak morphology is significantly correlated with diet, but that the effect size is small and that simplistic metrics of beak shape (i.e., length, width, and depth) derived from extant avialans may be insufficient for predicting diet in extinct taxa. Shape quantification using trait-based or geometric morphometrics approaches are necessary to develop robust metrics for refined dietary interpretations of beaked, extinct theropods.

Technical Session XVIII (Saturday, October 29, 2016, 3:45 PM)

ECOLOGICAL ONTOGENY AND FUNCTIONAL CHANGES IN THE GROWTH OF TYRANNOSAUROIDS

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Renewed efforts to understand tyrannosaur phylogeny and diversity have produced many new discoveries that have added to the diversity of fossil taxa, resolved evolutionary relationships, and revealed morphological variation due to ontogeny. This new wealth of data has now made it possible to begin broadly characterizing ecological relationships among likely conspecific taxa and among adults and juveniles in certain lineages. The latter is especially intriguing because of the dramatic shifts in morphology between adult and juvenile tyrannosauroids, which may imply substantial change in lifestyles and ecological niches through ontogeny. To assess this, we analyzed the hindlimbs (to characterize changes in locomotor performance), teeth, and the maxilla (to characterize changes in skull shape) among several different genera of tyrannosauroids, including those with known ontomorphs (e.g. *Tyrannosaurus, Daspletosaurus, Tarbosaurus*). The results show that tyrannosauroids underwent a series of ontogenetic changes that have implications for interpreting their ecology. As a whole, tyrannosauroids show a consistent trend of decreasing cursoriality with increasing body size (NPMANOVA: $F=3.08$, $p=0.004$) and this trend is mirrored in several genera (e.g. *Gorgosaurus*, *Tarbosaurus*, *Daspletosaurus*, *Tyrannosaurus*) where there are ontomorph specimens. This pattern suggests juveniles could have occupied a different predatory niche than the adults (pursuit predator vs. ambush predator). Several genera also show

ontogenetic change in dental morphology from narrower, blade-like teeth to more robust ones with significant changes seen within *Tyrannosaurus* (p=0.001), *Daspletosaurus* (p=0.02), *Albertosaurus* (p=0.04), and *Gorgosaurus* (p=0.02), which suggest differing feeding strategies for adults and juveniles. Further support is provided by a significant difference in maxilla shape in *Tyrannosaurus* between long, narrow-snouted juveniles and the deep-snouted adults (NPMANOVA: F=8.59, p=0.046). These trends suggest that predatory niches are likely to have been partitioned ontogenetically. The ecological coexistence of several tyrannosauroid taxa in North America during the Campanian may have been facilitated by ontogenetic niche partitioning. Ecological ontogeny is likely to have given *Tyrannosaurus*, the last remaining North American taxon of the lineage, a broad niche during its reign in the Maastrichtian.

Symposium I (Wednesday, October 26, 2016, 11:15 AM)

OSTEOCYTES AND BLOOD VESSEL-LIKE MICROSTRUCTURES FROM THE EOCENE, MESSEL PIT LOCALITY, GERMANY. INSIGHTS IN TERMS OF THEIR MORPHOLOGICAL AND CHEMICAL CHARACTERIZATION.

CADENA, Edwin, Yachay Tech, San Miguel de Urcuquí, Ecuador

Messel Pit fossils are well known because of their exceptional preservation, at least macroscopically speaking. Here I explore and report the preservation of osteocyte-like and blood vessel-like microstructures from the bone of Messel Pit specimens, samples analyzed include the turtles *Allaeochelys crassesculpta* and *Neochelys franzeni*, the crocodylian *Diplocynodon darwini*, and the pangolin *Eomanis krebsi*. Morphological characterization of these microstructures was performed using transmitted-light microscopy, and Field Emission Scanning Electron Microscope (FESEM). A first attempt to characterize their elemental composition was carried out using a Phenom ProX desktop scanning electron microscope (LOT-QuantumDesign) equipped with a thermionic cerium hexaboride (CeB_6) source and a high sensitivity multi-mode backscatter electron (BSE). In terms of the morphology, the osteocyte-like and blood vessel-like microstructures are constituted by a thin layer (~50 nm thickness), external and internal mottled texture with slightly marked striations. Circular to linear marks are common on the external surface of the osteocyte-like microstructures and are interpreted as microbial troughs. Elemental composition shows iron (Fe) as the most abundant element found in the osteocyte-like and blood vessel-like microstructures, but not in the bone matrix or collagen fibril-like microstructures. The results presented here establish a promising background for studies on preservation of biomolecules (proteins or DNA) in Messel Pit fossils, which are currently under development, including testing of specific proteins-antibodies, as well as mass spectrometry.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

THE ANATOMY OF THE NASAL SALT GLAND OF EXTANT BIRDS AND ITS RELEVANCE FOR INFERRING THE BEHAVIOR AND HABITAT PREFERENCES OF EXTINCT BIRDS AND OTHER ARCHOSAURS

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The kidneys of extant sauropsids (birds, crocodylians, turtles, lepidosaurs) tend to be less efficient at removing excess salt from the blood than are those of mammals, and consequently, sites of extrarenal salt excretion are common in sauropsids. In birds, the nasal gland is involved with concentrating and excreting salt from the blood. In many marine birds (e.g., charadriiforms, procellariiforms), the nasal gland is hypertrophied and occupies a supraorbital position, but other positions are known in birds, such as within the orbit (e.g., suliforms). The basic physiology of avian nasal salt glands was been well-understood for generations, but the detailed anatomy, particularly with regard to its osteology, is poorly documented. We present the results of our preliminary survey of nasal gland structure in birds to better resolve the osteological correlates of the gland, its ducts, and its vascular supply. The resulting osteological correlates allow a more rigorous and informed assessment of the presence, position, and size of the nasal gland in extinct birds, potentially allowing rough assessments of salt loads and hence habitat preferences (e.g., marine vs. terrestrial). The extant studies emphasize marine and aquatic birds (e.g., albatrosses, shearwaters, gulls, gannets, cormorants, anseriforms), among others, drawing on the following anatomical approaches: (1) gross dissection, (2) diceCT (iodine enhanced microCT), and (3) radio-opaque vascular injection followed by microCT. These studies allow not only detailed information about the relevant soft tissues and their osteological correlates, but also permit quantification of gland volumes and other metrics for comparative analysis. These extant studies shed new light on the interpretation of the nasal glands of extinct birds. Study of original fossil material and microCT scan data provide more refined information on the nasal glands of the Cretaceous marine toothed birds *Hesperornis* and *Ichthyornis*. The flightless diver *Hesperornis* had enormous nasal glands, suggesting that it was forced to drink seawater exclusively, whereas the volant and hence more vagile *Ichthyornis* had smaller salt glands, suggesting that it perhaps also had access to fresh water sources. The Paleogene anseriform bird *Presbyornis*, typically regarded as aquatic, also was sampled and provides new evidence for a more modest nasal salt gland. These findings may have bearing on more distantly related aquatic and marine archosaurs, such as pterosaurs.

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Technical Session I (Wednesday, October 26, 2016, 11:45 AM)

BENEATH THE SHEATHS: DO HORN CORES OF BOVIDS (ARTIODACTYLA, MAMMALIA) REPRESENT LIVING HORN SHAPE IN GEOMETRIC MORPHOMETRIC ANALYSES?

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Bovid horns are composed of a solid bone core covered in a keratin sheath and have evolved to wildly varying shapes in extant and extinct taxa, ranging from smooth spikes to crenulated coils. Hypothesized explanations for this disparity in bovid horn shapes all rely on their in-life uses as weapons for intrasexual combat or as visual cues for species recognition or female mate choice. These explanations all assume that selection acts not just on the horn core but also on the keratin sheath, which is the part of the structure an animal would interact with physically or visually. The keratin sheath rarely preserves in the fossil record, however, leaving only the bone core to provide evidence of horn shape in extinct taxa. Including fossil taxa in geometric morphometric studies of the evolution of horn shape disparity thus requires the assumption that the horn core adequately represents the overall shape of the horn even when the horn sheath has embellishments or extends beyond the horn core. To test the hypothesis that geometric morphometric methods are capable of distinguishing between taxa when horn sheaths are absent, 53 crania were digitized from four extant taxa with and without the horn sheath present for a total of 106 specimens. Type 1 landmarks were placed on supraorbital foramen, at the intersection of the sutures between the frontal and nasal bones, on the external acoustic meatus, and on the point where the suture between the frontal bones meets the occipital bone. Horn shape was captured with 5x5 grids of semilandmarks anchored by the type 1 landmarks. A discriminant function analysis was performed on all 106 specimens to assess if the sheathless specimens grouped with their conspecifics with sheaths. Procrustes distances were calculated between specimens with horn sheaths present and absent both within and between each species to quantify whether horn cores represented overall horn shape and whether shapes differed significantly between species. Results indicate that sheathless specimens group more closely with sheathed specimens of the same taxon. Likewise, the Procrustes distances between horn cores and horn sheaths within each species were significant but smaller than the distances between species. These results suggest that horn core shape sufficiently captures horn sheath shape, thus allowing the inclusion of fossil taxa in studies of horn shape disparity and improving the ability of these tests to represent the full evolutionary history of bovids.

Technical Session II (Wednesday, October 26, 2016, 11:15 AM)

***TETRAPODOPHIS AMPLECTUS* (CRATO FORMATION, LOWER CRETACEOUS, BRAZIL) IS NOT A SNAKE**

CALDWELL, Michael W., University of Alberta, Edmonton, AB, Canada; REISZ, Robert R., University of Toronto at Mississauga, Mississauga, ON, Canada; NYDAM, Randall L., Midwestern Univ, Glendale, AZ, United States of America; PALCI, Alessandro, Flinders University, Adelaide, Australia; SIMOES, Tiago R., University of Alberta, Edmonton, AB, Canada

A very tiny fossil specimen (195mm TL) of a long bodied (~160 presacrals), long tailed (~112 caudals), limb-reduced, squamate was recently described as the first known four-legged snake, *Tetrapodophis amplectus*. Snake affinities were proposed based on 24 features, of which only 13 were actually tested in that phylogenetic analysis. First hand examination has produced counter observations and interpretations to both morphology and proposed affinity. We find the skull to be long, the mandible straight, there is no subdental ridge, an intramandibular joint is not preserved, the teeth are not snake-like, and are taphonomically displaced not recumbent. The high precloacal vertebral counts are not exclusive to snakes (eg., dibamids ~135; amphisbaenians ~175), zygosphenes are not observed, the neural spines are tall, rib heads are not tubercular, "lymphapophyses" are expanded sacral processes, and scales are not present. New anatomical observations include a high cervical count, features of the suspensorium, orbit size and margin, an elongate retroarticular process, position of the splenial apex at the terminus of the tooth row, enlarged first metapodials, reduced carpal and tarsal ossification, intercentra in the neck and tail, and reduced limb articulation surfaces. The skull and skeleton are not snake like. The original phylogenetic analysis found snakes and *Tetrapodophis* as sister to the Mosasauria, but concluded burrowing habits and origins for snakes. The hypothesis of a burrowing habit for *Tetrapodophis* is falsified by both phylogeny and morphology. The limbs are very small, lightly constructed, show delayed mesopodial ossification similar to a variety of aquatic reptiles, along with enlarged first metapodials, elongate phalanges, and weak girdles. The limbs were ineffective paddles, and the tail was long (burrowing snakes have very short tails, as do amphisbaenids and dibamids), which we interpret as indicating that *Tetrapodophis* employed anguilliform locomotion in water or on land. It had large eyes and has small fish-like vertebrate bones in its gut, not large mammals. Evidence for anatomies consistent with constriction are not observed.

Technical Session XVI (Saturday, October 29, 2016, 8:30 AM)

QUANTITATIVE BIOSTRATIGRAPHY AND FAUNAL TURNOVER OF THE ARIKAREEAN-AGED CABBAGE PATCH BEDS OF WESTERN MONTANA (RENOVA FORMATION)

CALEDE, Jonathan J., University of Washington, Seattle, WA, United States of America

During the Arikareean (30–18.8 million years ago [Ma]), archaic mammalian faunas dominated by extinct families started giving way to more modern faunas including families still around today. The determination of the tempo and mode of this transition has relied mostly on the qualitative study of the appearance and extinction of large mammals in the Great Plains and Oregon. Here, I present analyses of the biostratigraphy, turnover rates, and faunal similarities through time of a series of vertebrate microfossil assemblages rich in small mammals (sample size ~1,000 specimens) from the Cabbage Patch beds of western Montana. Combined with a new chronostratigraphic framework, these data provide a quantitative assessment of the tempo and mode of faunal change in the Rocky Mountains, a region geographically intermediate between Oregon and the Great Plains.

My results support the division of the beds in three biostratigraphic units (lower, middle, and upper Cabbage Patch). Turnover rates and taxonomic dissimilarity between assemblages are highest at the transitions between these units. Novel taxa, including many immigrants from Asia, are found in the oldest assemblages of the beds, suggesting that the transition to modern faunas was already initiated by around 30 Ma in the Rocky Mountains alike in Oregon and the Great Plains. Many taxa present only in the lower unit of the beds represent outgoing lineages—holdovers from archaic faunas. A few of these archaic taxa survive into the upper unit of the beds in deposits as young as ~25.6 Ma. The most dramatic faunal change is observed between the lower and the middle units of the beds, suggesting a major turnover event locally around 28 Ma, coincident with the transition between the early early and the late early Arikareean and major turnover events in Oregon and the Great Plains. The faunas from the middle and upper units of the beds

are very similar; they are only differentiated by a few species. The transition between archaic and modern faunas in western Montana is not associated with a major change in species richness or evenness. My results suggest that the faunal turnover events of the early Arikareean, associated with previously underestimated immigration events from Asia, were critical to the initiation of the transition from archaic to modern North American faunas. This work also provides the data necessary to future analyses of the biogeographic affinities of the rich mammalian faunas of Montana and the pattern of faunal exchange into and within North America.

Technical Session I (Wednesday, October 26, 2016, 8:30 AM)

DIETARY RECONSTRUCTIONS OF *MAMMUTHUS* AND *MAMMUT* SPECIES USING DENTAL TARTAR AND MESOWEAR ANALYSES

CAMMIDGE, Tasha S., University of Calgary, Calgary, AB, Canada; KOOYMAN, Brian, University of Calgary, Calgary, AB, Canada; THEODOR, Jessica M., University of Calgary, Calgary, AB, Canada

The end-Pleistocene mass extinction event (~11,000 years ago) caused many mammals with a body mass over 55 kg to go extinct, a size-selectivity not seen in other extinction events. Comparisons of diet before and after this event provide insight into how large mammals dealt with, or will deal with, changing ecosystems. Pre- and post-glacial paleodietary reconstructions using dental tartar and mesowear analyses were conducted on 74 specimens of *Mammuthus* and 34 specimens of *Mammut* from Alaska, Alberta, California and Nevada. Dental tartar analysis involves scraping a small piece of dental tartar from the tooth, dissolving it in hydrochloric acid, and examining and identifying the phytolith and starch fossils remaining in the sample. Mesowear analysis of elephants compares the relative amount of wear on enamel and dentin by measuring angles between enamel bands, and provides information about the abrasiveness of the diet. Morphological differences of teeth from *Mammuthus* and *Mammut* prevent mesowear analysis from being conducted on *Mammut* specimens. These analyses demonstrate that pre- and post-glacial samples differ in their dietary composition, while dietary abrasiveness shows little change. Mesowear analysis of *Mammuthus* molars also demonstrates that diet abrasiveness did not vary across the western portion of North America. Furthermore, adult and juvenile organisms had a similarly abrasive diet, suggesting that, similar to modern elephant species, juveniles consume the same plants as adults. Dental tartar analysis also demonstrates that dietary composition was similar across western North America, and confirms that juvenile and adult proboscideans have similar composition of plant fossil deposits in their dental tartar. Comparisons of dental tartar from pre- and post-glacial time periods show a change in diet, with post-glacial diet becoming more similar for both species in question. While most other research has focused on investigating pre-glacial megafauna, this study compares both pre- and post-glacial samples to test whether there is any evidence of dietary change. Furthermore, this study highlights important differences between mesowear and dental tartar analyses, most pointedly the differences in the sensitivity of these methodologies. Dietary reconstructions of *Mammuthus* and *Mammut* indicate that general abrasiveness of the diet did not differ between pre-and post-glacial time periods. However, dietary composition differed and may have contributed to the extinction of megafauna at the end of the Pleistocene.

Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

AN UNUSUAL ELASMOSAURID (SAUROPTERYGIA, PLESIOSAURIA) FROM THE UPPER CRETACEOUS (UPPER CAMPANIAN–LOWER MAASTRICHTIAN) BEARPAW FORMATION OF SASKATCHEWAN

CAMPBELL, James A., University of Calgary, Calgary, AB, Canada; SATO, Tamaki, Tokyo Gakugei University, Koganei City, Tokyo, Japan; TOKARYK, Tim T., Royal Saskatchewan Museum's T. rex Discovery Centre, Eastend, SK, Canada; ANDERSON, Jason S., University of Calgary, Calgary, AB, Canada

Plesiosaurs are documented from marine sediments of the upper Campanian–lower Maastrichtian Bearpaw Formation of Saskatchewan, Alberta, and Montana, which were deposited during the last major transgression of the Western Interior Seaway (WIS) of North America. Plesiosaurs from this formation are currently represented by the elasmosaurids *Albertonectes vanderveldei*, *Terminonatator ponteixensis*, and a new taxon from Montana, as well as the polycotylid *Dolichorhynchops herschelensis*. Collectively, these taxa represent the latest occurring plesiosaurs in the WIS.

This study presents a re-description of an unusual plesiosaur specimen from the Bearpaw Formation of Saskatchewan (RSM P1034.1). This specimen was originally noted as preserving both mandibles, 67 vertebrae (61 cervicals, five dorsals, one caudal), ribs, girdle element fragments, epipodials, and phalanges. It was also noted as having an unexpected combination of elasmosaurid postcranial (i.e., high cervical count, with ventrally notched, oval, and amphiplatyan articular faces), and non-elasmosaurid cranial features: the mandibles have a short, elasmosaurid-like symphysis, but have a prearticular shelf and a low tooth row, which are both known from non-elasmosaurid plesiosaurs (e.g., polycotylids, pliosaurids, and cryptoclidids). Despite its unusual morphology, the incomplete nature of RSM P1034.1 precluded its referral to either a known (e.g., *Aphrosaurus*) or new taxon. Within Elasmosauridae, the cervical count and dimensions of RSM P1034.1 are more consistent with Styxosaurinae, which is restricted to WIS deposits, than with Aristonectinae, which is known only from the southern hemisphere.

A recently re-discovered humerus belonging to RSM P1034.1 adds valuable anatomical data to this specimen, puts previously indeterminate epipodial elements into a better context (i.e., as the radius and ulna), and weakens the case that this specimen is referable to a previously known, Upper Cretaceous taxon. The humerus has a nearly straight anterior margin and a moderately pronounced posterior extension on the distal end, unlike the condition in '*Hydralmosaurus*' = *Styxosaurus*, as well as an epipodial foramen between the radius and ulna, unlike in *Aphrosaurus*. These new data support RSM P1034.1 as belonging to a new taxon, and contributes to our understanding of plesiosaur diversity in the WIS. The combination of elasmosaurid and non-elasmosaurid features on this specimen is not well understood, but likely has important implications for plesiosaur evolution.

Grant Information
NSERC PGS-D (J.A.C.)

Technical Session II (Wednesday, October 26, 2016, 11:30 AM)

A REVIEW OF SPATIAL AND TEMPORAL DISTRIBUTIONS FOR NON-OPHIDIAN OPHIDIOMORPHS

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As defined, Ophidiomorpha includes dolichosaurids, pontosaurs, adriosaurs and ophidians. The non-ophidians, the 'dolichosaurs', are small-bodied aquatic forms that lived in shallow seaways, rivers and reef environments. Preservational, geographic, and taphonomic biases in this group make trends in biodiversity difficult to assess. This is exemplified by the fact that the majority of the described species are monotypic and known only from single specimens, imparting very little information on morphological or spatial variation. Fortunately, recent finds have dramatically altered traditional views of the stratigraphic distribution and global range of the dolichosaurs. Previously, knowledge of this group consisted primarily of Cenomanian and Santonian finds, but some of the latest discoveries are from sediments as old as the Aptian or Barremian, and as young as the Campanian or even Maastrichtian. This indicates that our understanding of the evolution of this group needs to be re-evaluated, as they show a much more temporally diverse pattern than previously indicated. Spatially, dolichosaur diversity is concentrated in the Western Tethys (Southern Europe and the Levant), but specimens have also been reported from North America, Japan and Australia. Several studies have also referred fragmentary material from Patagonia and Central Asia to the Dolichosauridae. Though biogeographic patterns and processes remain obscured by preservation bias, some general patterns are clear. Early pythonomorph diversity is highest in the Western Tethys and this is the likely area of origin of ophidiomorphs, including dolichosaurs. A rapid radiation in the upper Early Cretaceous likely had *Coniasaurus*-like forms expanding their range across the Tethys and making multiple independent freshwater incursions in areas as far away as Japan and Australia. The North American radiation likely happened later, in the early Late Cretaceous. Understanding the occurrence of this group through space and time is critical to the study of their evolution and adaption, including evolutionary drivers and their aquatic radiation.

Technical Session XI (Friday, October 28, 2016, 10:15 AM)

DIETARY SELECTION IN LAMNIFORM SHARKS ACROSS THE CRETACEOUS–PALEOGENE BOUNDARY

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Ecological diversity is difficult to reconstruct in the fossil record owing to the low preservational potential of biological interactions. As a result, patterns of biodiversity over time have been largely limited to taxonomic and general morphological patterns that are indirect in their ecological significance. To this end, sharks can serve as a model system with which to investigate ecologically-relevant morphological patterns given that they are: (1) ecologically and morphologically diverse today; and (2) preserve a rich fossil record of teeth. Based on an extant data set of lamniforms (mackerel sharks), we estimate the diets of fossil lamniforms across the end-Cretaceous extinction event and test the hypothesis that extinction dynamics in this clade were diet selective, specifically against pelagic macropredators (i.e., feeding on other large vertebrates).

The study adopts a data set of 71 teeth that correspond to eight extant species of lamniforms spanning almost all living families, and for which gut content-based diets are known. A redundancy analysis (RDA) was performed to ascertain the relationships between morphological proxies (based on a Generalized Procrustes analysis of a 30 semilandmark curve) and diet. The teeth of 662 fossil lamniforms, spanning the Maastrichtian–Paleocene (landmarked as above), were then projected onto the canonical axes of the RDA to generate dietary continua that could be investigated across the boundary.

The RDA recovered a strong overall relationship between lamniform tooth morphology and diet in which morphology explains approximately 90% of diet. Of the projected fossil dietary RDA axes, only axis two showed a significant shift between the Maastrichtian and the Danian. Diets along the second axis reflect a gradient from highly piscivorous species, through cephalopod consumers, macropredation, and to planktivorous forms. The shift across the Cretaceous–Paleogene extinction event corresponds to decreases in, and hence supposed selective pressures against, both macropredation and planktivory. This conforms to previous studies that noted major loses in both primary food-sources during this interval. Accordingly, our study supports a non-random, selective extinction of lamniforms across the end-Cretaceous event, and moreover, reveals that morphological adaptation associated with piscivorous diets (i.e., highly-crowned, pointed teeth), played a major role in the survival of sharks into the Cenozoic.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

A NEW GIANT TITANOSAUR FROM THE LATE EARLY CRETACEOUS OF PATAGONIA YIELDS LIGHT INTO TITANOSAUR BODY SIZE EVOLUTION

CARBALLIDO, Jose L., Trelew, Argentina; DIEGO, Pol, Trelew, Argentina; OTERO, Alejandro, La Plata, Argentina; CERDA, Ignacio, Cipoletti, Argentina; SALGADO, Leonardo, General Roca, Argentina; GARRIDO, Alberto, Zapala, Argentina; RAMEZZANI, Jahan, Massachusetts, MA, United States of America; CÚNEO, Nestor R., Trelew, Argentina; KRAUSE, Marcelo, Trelew, Argentina

Sauropod evolution is characterized by an incredible size increment, which is specially notable in titanosaurs, a derived Cretaceous clade that include some of the largest terrestrial vertebrates ever found. This is especially true amongst South American titanosaurs, such as *Argentinosaurus* or *Puertasaurus*. Despite the importance of such giant forms for better understanding titanosaur evolution, our understanding of their anatomy, phylogenetic relationships, and body size evolution remained obscure mainly due to the incompleteness of the most gigantic titanosaurs. A discovery recently made in

the late Albian of Patagonia allows for the first time a better understanding of some of the major questions in the evolution of giant titanosaurs. At least six different specimens were found in a floodplain deposit in the upper section of the Cerro Barcino Formation. The taphonomic analysis indicates that the specimens were not transported and buried at the site in at least three different episodes. Based on bone morphology, all of the specimens can be confidently assigned to a single new titanosaur taxon, characterized by autapomorphic characters such as a vertical prezygodiapophyseal lamina in anteriormost dorsals, hyposphene-hypantrum restricted to D3-D4, extremely wide and incipiently bifid anterior caudal neural spines, and femur with a straight distolateral edge. The new species is represented by an isolated tooth, 9 cervical, 9 dorsal and 24 caudal vertebrae, sternal plates, scapula-coracoid, humerus, ulna and radius, ischium, pubis, femur and fragments of the tibia. The completeness of the new taxon allows body mass estimation through volumetric and circumference methods, yielding a body mass of 52 and 69 tons, respectively. Phylogenetic analysis recovers the new titanosaur as a taxon closely related to other giant Patagonian titanosaurs such as *Notocolossus*, *Argentinosaurus*, *Futalognkosaurus* and *Puertasaurus*. Histological analysis made in the preserved humeri and femora indicates that all the specimens are young adults. Discarding abiotic factors raises the question of the causes that resulted in such an amazing concentration of giant sauropod specimens.

Grant Information
Egidio Feruglio Foundation
FONCyT PICT 0736 (D.P.), 0378 and 0668 (J.L.C.)

Romer Prize Session (Thursday, October 27, 2016, 10:15 AM)

EVOLUTION OF THE ARCHOSAURIAN SHOULDER JOINT AND THE FLIGHT STROKE OF *ARCHAEOPTERYX*

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Archosaurs are a remarkable group of animals that exhibit a diverse locomotor repertoire at the shoulder (glenohumeral) joint, from quadrupedal alligators and dinosaurs to flying pterosaurs and birds. The origin of avian flight, despite a multitude of exciting new fossils, remains both controversial and inextricably linked to the unresolved question of active flight in *Archaeopteryx*. Here I address this question through an integration of theoretical, anatomical, experimental, and comparative approaches. First, I established a standardized, joint-based approach for analyzing skeletal anatomy and motion (kinematics), which served as a comparative framework throughout. A high-resolution 3D reconstruction of the *Archaeopteryx* flight apparatus was then created, through multiplanar x-ray microtomosynthesis of the Thermopolis specimen (WDC-CSG-100). Results provide resolution to controversial aspects of *Archaeopteryx* anatomy that are critical for assessing flying ability, such as the precise orientations of the scapula, glenoid, and wing, along with the range of motion and articular topology of the glenoid.

Next, in order to inform and constrain the reconstruction using extant phylogenetic bracketing, I investigated the *in vivo* glenohumeral kinematics and muscle activity in alligators (*Alligator mississippiensis*) during high and low walk, using marker-based X-ray Reconstruction of Moving Morphology (XROMM) and electromyography. Findings confirm the presence of an active, protractor muscle-based stabilization mechanism, which has evolutionary implications for the ancestral archosaurian shoulder. Data were also compared to published XROMM kinematics from a flapping bird (*Alectoris chukar*) during ascending flight and wing-assisted inclined running. Results confirm the hypothesis that the glenohumeral motions of these disparate archosaurs are fundamentally similar, despite moving against very different media. The aforementioned joint-based approach also provided a framework for "scientific motion transfer." This tested whether the *in vivo* motions are consistent with the range of motion in *Archaeopteryx*, and provided empirical, phylogenetic constraints for reconstructing glenohumeral motion. Findings reveal that the *Archaeopteryx* glenoid permits most humeral excursions from both extant archosaurs, and also indicates a more avian motion path. Ultimately, these anatomical and experimental lines of evidence demonstrate that *Archaeopteryx* was kinematically capable of performing an active flight stroke.

Grant Information
National Science Foundation (GRFP, EAR), Brown University, National Geographic Society/Waitt Foundation, Sigma Xi, Society for Experimental Biology, FEI

Technical Session VI (Thursday, October 27, 2016, 10:45 AM)

AFTER THE BONE MOVES: ACTUALISTIC EXPERIMENTS AND COMPUTATIONAL FLUID DYNAMICS ON STATIONARY BONE IN A WATER FLUME

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The use of water flumes in taphonomic studies have been primarily variations of the Voorhies bone transportation experiments. An oval recycling flume (water depth = 30 cm, width 75 cm) with a moveable bed load of medium-grained quartz sand (0.33 mm, phi = 1.3) was used to explore pre- and post-transport events, particularly turbulence around bone, bed migration, bed erosion, sediment deposition, and bone burial. Streaming smoke in a wind tunnel and computation fluid dynamics were used to interpret and visualize turbulence around bones. Bones (single and articulated) used include dinosaurian casts and real mammalian and large reptilian bones. Most experiments were conducted in the dune migration phase (water velocities 0.5–1 m/s), but at velocities where the force of the water did not exceed resistance of the bone (gravity and friction) to movement (< ~0.7 m/s). Some experiments were conducted in the lower ripple migration phase (< 0.5 m/s).

A process model was developed for stationary bones, which are instream obstacles that induce local, complex, 3-D flow dynamics. In general, a water mass approaching and passing a bone is subjected to flow separation around the bone, flow constriction, and acceleration. This produces an upstream high pressure zone, downflows, and vortices (with flow reversal near the bed), causing bed shear stress that induce horseshoe or crescentic scour adjacent to the bone due to bed erosion. Past the bone, the water mass undergoes flow deceleration, water recirculation (turbulence eddies), reattachment, low pressure zone (drag), and sediment deposition. Bone shape and its angle relative to the flow influences scour geometry. The size and depth of the scour is determined by the strength of downwelling and associated vortices, and these in turn are determined by flow velocity and flow depth. Bone angle relative to flow is dependent on the pressure gradient, which in turn is determined by flow velocity, bone shape and bed topography.

Scour plays a crucial role in bone burial, especially in the dune migration phase, by undercutting bone on the upstream side causing it to settle into the bed by rotation or sliding; such bones may dip upstream. Drag on the downstream side causes sediment deposition on the lee side, but burial by migrating bedforms is the most important method of burial. Bone may be repeated buried and exposed with the migration of dunes. However, each episode of scour may lower the bone deeper into the bed so that it essentially buries itself. In summary, bones set up the condition for their own burial in a fluvial channel.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

TOWARD UNDERSTANDING PHYLOGENETIC AND ONTOGENETIC TOOTH LOSS IN ARCHOSAURIA: DOCUMENTING PATTERNS OF TOOTH REPLACEMENT IN *TYRANNOSAURUS REX*

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Ontogenetic tooth loss in the upper and lower tooth rows of *Tyrannosaurus rex* is best explained as the result of a growth-related increase in tooth size, but additional perspective might be gained by examining the pattern of tooth replacement (i.e, odd-even replacement waves, number, direction) in ontogenetic and phylogenetic contexts. In general, the snaggle-toothed condition of tyrannosaurids is typical of carnivorous archosaurs, and the pattern is well established for crocodylians (odd-even waves, bidirectional or patternless). Specifically, among tyrannosaurids, the pattern is only known for the holotype of *Albertosaurus libratus* (odd-even waves, cephalad). Presumably, the shared presence of odd-even waves in a cephalad direction is the plesiomorphic condition for Crocodylia + Dinosauria.

To that data set is here added the patterns from a growth series of *T. rex* that is based on four specimens, including subadults (BMRP 2002.4.1, CMNH 7541, LACM 28471) and an adult (AMNH FARB 5027). These were compared with the outgroup (crocodylian) and ingroup (*A. libratus*) conditions. It was found that *T. rex* has odd-even waves of tooth replacement, as is seen in crocodylians and *A. libratus*. In the upper tooth row of *T. rex*, the direction of the replacement waves in the earliest growth stage is caudad, whereas a cephalad direction occurs in later growth stages; a cephalad direction is also seen in adult *A. libratus*. However, the switch in *T. rex* is the opposite of what is seen in crocodylians, where a cephalad direction is seen early in growth and later assumes a caudad direction. In the lower tooth row of *T. rex*, cephalad waves occur in all growth stages; this direction is also seen in adult *A. libratus*.

It has been hypothesized that the switch in crocodylians is caused by the addition of teeth to a tooth row of fixed length. *T. rex* establishes the opposite end of the spectrum, where the loss of tooth positions does not affect the direction of replacement waves. Ergo, ontogenetic tooth loss and the change in direction of waves are independent events. If the switch from caudad to cephalad in the upper tooth row is not an artifact (LACM 28471 is incomplete), then it is difficult to explain without a larger, comparative data set. These results provide the framework for a complete survey of tooth replacement in derived tyrannosauroids (*Bistahieversor* + Tyrannosauridae), where it is predicted that in all species (1) the upper tooth will ontogenetically switch from caudad to cephalad replacement waves, and (2) the lower tooth row will have cephalad waves throughout growth.

Technical Session XVIII (Saturday, October 29, 2016, 2:15 PM)

THE THEROPOD DINOSAUR *ELAPHROSAURUS BAMBERGI* JANENSCH, 1920, FROM THE LATE JURASSIC OF TENDAGURU, TANZANIA

CARRANO, Matthew T., Smithsonian Institution National Museum of Natural History, Washington, DC, United States of America; RAUHUT, Oliver W., Bayerische Staatssammlung fur Palaontologie und Geologie, Munchen, Germany

Thanks to a recent exhibit renovation, we had the opportunity to extensively study and document the anatomy of the holotype of *Elaphrosaurus bambergi* Janensch, 1920, from the late Kimmeridgian of Tendaguru, Tanzania. As a ceratosaur and the only Jurassic theropod from Gondwana known from more than isolated remains, it offers important phylogenetic and biogeographic information. This is especially true given discoveries of new and unusual ceratosaurs such as *Masiakasaurus*, *Limusaurus*, and *Spinostropheus*.

Elaphrosaurus exhibits several unusual osteological characters: extremely elongate and constricted cervical vertebrae; an expansive pectoral girdle; a highly modified humerus; a proportionally small ilium; very elongate hind limb elements; and a very small ascending process of the astragalus that is fused to the tibia. These allow us to exclude the referral of any materials from outside Tendaguru to *Elaphrosaurus*, and of any other species to the genus.

Elaphrosaurus also shares many derived characters with noasaurids, including very elongate cervical and dorsal vertebrae; low, rectangular mid-caudal neural spines; the presence of only the anterior centrodiapophyseal lamina in the proximal caudals; a wide, U-shaped notch between the glenoid and the anteroventral coracoid process; a laterally flared iliac postacetabulum; a flat anterior distal tibia; and a reduced metatarsal II shaft. Our analysis placed *Elaphrosaurus* within a dichotomous Noasauridae, as part of a Jurassic subclade that otherwise includes taxa from eastern Asia.

The results further indicate that many forms previously considered to be basal within Ceratosauria are in fact abelisauroids, and that substantial phylogenetic and biogeographic diversity likely remains to be discovered. Within Abelisauroidea, both the noasaurid and abelisaurid radiations were long-lasting and substantial, but had largely retreated to Gondwana in the Cretaceous from their original, more cosmopolitan, distributions.

Grant Information
Deutsche Forschungsgemeinschaft, RA 1012/1-1 (to Oliver Rauhut)
The Volkswagen Foundation, I/84 640 (to Oliver Rauhut)

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

THE GENUS *RHYNCHOTHERIUM* (MAMMALIA, PROBOSCIDEA) IN THE HEMPHILLIAN–BLANCAN (NALMA) OF CENTRAL MEXICO

CARRANZA-CASTAÑEDA, Oscar, Centro de Geociencias-UNAM, Juriquilla, Mexico

As a result of research in the Neogene deposits of central Mexico, an abundance of fossil materials have been collected that have been referred to *Rhynchotherium*; however, due to the lack of diagnostic features of this material and inaccuracies in the ages and localities assigned to it, it is difficult to accurately determine whether these fossils actually belong to the genus *Rhynchotherium*, or if they belong to *Cuvieronius* or *Gomphotherium*.

Research in the basins of central Mexico has resulted in the recovery of more complete fossil material accompanied by information on stratigraphic level and isotopic ages of the fossil beds. In the state of Michoacán, in La Goleta Fauna, a complete cranium and jaw of an adult individual were collected in the early Blancan deposits (3.6 Ma). This skull was referred to *Rhynchotherium falconeri* because of the features of the jaw, which include a symphysis that is downturned by 60°, an anterior border of the ascending ramus that is 90° relative to the occlusal surface, a complete m2–3, an alveolar ridge that is wider transversely at m3, and incisors with wide enamel bands on the outside. The skull is complete, only the tusks are missing. Another complete jaw of a juvenile individual from the early Blancan of Miraflores, Baja California Sur, was collected. This jaw is likewise characterized by a symphysis that is downturned by 60° and an anterior border of the ascending ramus that is angled at 90°; and the complete tusks exhibit enamel on the outside. The similarity between the juvenile and adult jaws demonstrates the constancy of ontogenetic characters.

In the San Miguel Allende basin, in the early Blancan deposits (3.6 Ma) of Arroyo Belen, another cranium and jaw were collected. The symphysis of this jaw is oriented downward and the anterior border of the ramus has a wide angle at 110°; m1, m2 (complete) and m3 are present, and there is enamel outside the tusk. These features correspond to *Rhynchotherium*; however, the presence of m1 and the angle of the ascending ramus are similar to *Rhynchotherium tlascalae*.

In the white layer of Rancho El Ocote (Hh4), an additional adult jaw with m2–3 was collected. The symphysis is incomplete but is angled less downward, the anterior border of the ramus is more open, and no tusks are present.

In the Tecolotlán basin, state of Jalisco, another jaw was found associated with the late Hemphillian. The jaw lacks teeth but the tusks are present with enamel bands, the horizontal ramus is slender and slightly long, the symphysis is oriented downwards at an angle of 45°, and the anterior border of the ascending ramus is angled at 110°.

The jaws from San Miguel de Allende and Tecolotlán, with associated fauna and isotopic ages,are tentatively assigned to *Rhynchotherium browni*, although they sharesome features with *Rhynchotherium tlascalae.* Morecomparisons will be necessary to more accurately determine their taxonomic position.

Grant Information
PAPIIT Project IN109814

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

FOOT MORPHOLOGY OR EXIT FEATURE: A CT PERSPECTIVE ON HITCHCOCK'S DINOSAUR TRACKS

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Edward Hitchcock's initial examination and subsequent publications of Early Jurassic dinosaur tracks from the Connecticut River valley paved the way for future ichnological studies. Following Hitchcock's approach, the view of tracks as representative of foot structure has remained relatively uncontested. For some footprints, however, outward appearances can be deceiving. For example, in 1848, Hitchcock was intrigued by a raised feature between the toe and heel impressions in his ichnogenus *Triaenopus*. He speculated that the trackmaker's pedal elements were connected "as to constitute an arch, or even to form an angle, [...] so that when the mud was impressed by the heel and the toes, it would be crowded upwards between them." Taking surface morphology at face value, Hitchcock believed that track topography provided an "accurate view of the character of the bottom of the foot."

We used high-resolution CT imaging to reconstruct internal structures in specimens first described by Hitchcock 175 years ago. Using manual segmentation, we traced different laminae and cracks based on light/dark banding to assess the direction of sediment and foot movement. Our reconstructed internal contours reveal shapes strikingly different from external surfaces, which suffer damage by splitting. We propose that Hitchcock's elevated area is not evidence of an anatomical arch, but a truncated exit feature formed as the foot was extracted out of the soft substrate. Enigmatic features of other ichnotaxa also arose from the interaction of morphology and movement. We hope that these findings will encourage more careful study of the mechanistic origin of footprint morphology, as well as demonstrate the usefulness of CT for the study of tracks.

Grant Information
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Technical Session XI (Friday, October 28, 2016, 11:45 AM)

SWIMMING IN TWO OCEANS: TROPICAL AMERICAN CHONDRICHTHYAN PALEODIVERSITY AND FAUNAL TURNOVER BEFORE AND AFTER THE RISE OF THE PANAMA ISTHMUS

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"Tropical America " is at present characterized by high marine chondrichthyan diversity. The origin and evolution of this fauna must have been greatly impacted by the uplift of the Central American land bridge during late Neogene, as well as other events related to Caribbean biotic and abiotic factors. The palaeontological contribution to understand these changes should be fundamental, but fossil chondrichthyans from the region are fragmentary and incompletely studied. Based on extensive new and published data on fossils, the Miocene–Pliocene chondrichthyans from Tropical America were investigated. We describe fossil assemblages from more than 20 geological formations of Brazil, Colombia, Ecuador, Panama, Peru, and Venezuela, and compiled them with ~40 geological units. The faunal data were standardized at the generic level, with the intention of diminishing distortions caused by taxonomic and nomenclatural uncertainties. Preliminary results show a paleodiversity characterized by 64 genera (37 "families") of both shallow and deep water affinities, with representatives of Chimaeriformes, Hexanchiformes, Squaliformes, Echinorhiniformes, Pristiophoriformes, Squatiniformes, Heterodontiformes, Orectolobiformes, Lamniformes, Carcharhiniformes, Rajiformes, and Myliobatiformes. Taxonomic commonality between chondrichthyan faunas from the tropical Eastern Pacific and Western Atlantic is observed until Pliocene times, as a result of the faunal interchange before the definitive closure of the isthmus. A younger regional or complete extirpation in many chondrichthyan genera from Eastern Pacific and Western Atlantic is recorded. A comparison between Neogene fossil assemblages and current chondrichthyan diversity around the Panamanian Isthmus reveals that three genera became regionally extinct in the Eastern Pacific, and two in the Western Atlantic. Moreover, another 12 genera became extinct in both the Eastern Pacific and Western Atlantic oceans. The assemblages document both nearshore and deep sea environments. Some include rare fossils, such as sawfishes of exceptional complete preservation, and some the oldest records of some taxa such as that of Megalodon from Colombian and Venezuelan basins.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

A TAXONOMIC AND GEOGRAPHIC STUDY OF HERMANN KARSTEN'S XIX CENTURY PALEOVERTEBRATE COLLECTION FROM THE NORTHERN NEOTROPICS

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During the mid-19th century, the German naturalist and explorer Hermann Karsten (1817–1908) conducted a 12-year exploration (1844–1856) in the territories of Ecuador, New Granada (now Colombia) and Venezuela, resulting in detailed descriptions of the botany, geography and geology of these regions. With his return to Germany, abundant geological, paleontological and living plant specimens were brought to and deposited in European museums and botanical gardens. Part of the fossils collected by H. Karsten included Cretaceous ammonites from the Andes of Colombia and Venezuela, which were studied by him and the renowned German paleontologist Leopold von Buch, including the first fossil species ever to be described from Venezuela [*Ammonites* (= *Anapuzosia*) *tucuyensis*]. The H. Karsten's vertebrate collection was never illustrated or subjected to a taxonomic study. Moreover, many of the H. Karsten's original fossil vertebrate specimens have been repeatedly mentioned in scientific publications with incorrect taxonomic and provenance information. Karsten's fossil vertebrate collection is housed in Museum fûr Naturkunde of Berlin and, more than 160 years after its entry into the museum's collection, we have finally completed an accurate taxonomic revision of all of the specimens, which comprise cranial and postcranial elements of Megatheriidae, Mylodontidae and Glyptodontidae (Xenarthra), ?Toxodontidae (Notoungulata), Gomphotheriidae (Proboscidea) and several indeterminate mammal remains. The provenance of many of the specimens can be inferred based on existing notes and/or our current knowledge of localities and geological formations in the relevant regions.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

TETRAPOD WORLD: EARLY EVOLUTION AND DIVERSIFICATION (TW:EED) PROJECT FIELDWORK: CONSOLIDATION OF DAMP SPECIMENS FOR TRANSPORTATION USING PRIMAL WS 24 AND FABRIC BANDAGES AS FIELD JACKETS

CARRIO, Vicen, National Museums of Scotland, Ediburgh, Scotland

The TW:eed Project is funded by the UK Natural Environment research Council (NERC). It is a major collaborative study of fossils and environments from the earliest Carboniferous (360–345 million years ago) when tetrapods were beginning to move from water onto land. Recently a number of sites found in Northumberland and the Borders Region of Scotland have generated not just tetrapods, but also fish, plants and arthropods. One such site was in the bed of the Whiteadder River.

Last summer part of the River was barricaded off and pumped out to allow access to the fossiliferous beds. Sedimentary logs, photographs, and a 3D laser scan of the dig site were done during all stages. Slabs from the most significant beds were collected, wrapped, and transported back to the lab to be examined and prepared.

Problems arose as soon as the material was extracted from the wet siltstone. The matrix dried out very quickly and immediately needed consolidation to prevent the fossils from crumbling. Primal WS 24 (an acrylic copolymer colloidal diluted at 10 to 15 parts water to one part liquid) was used as a consolidant. Fragile pieces were consolidated using different concentrations and reinforced with out-of-date medical bandages saturated with Primal WS 24 as jackets to protect the slabs during transportation to the lab. The fabric bandages were faster and simpler to use on the large number of small specimens than conventional plaster jackets, and had less impact on the environment. Acid-free paper, plastazote foam, and bubble wrap were used to give extra protection and padding to the material for transportation.

Once in the lab, after the specimen was dried, the bandages were easily removed. Acetone was used to remove the Primal WS 24, which is not re-soluble in water. Paraloid B72 at 10/90 w/w in acetone was used to consolidate the material after removal of the bandages.

There are still nearly 1000 specimens to prepare.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

FIRST DESCRIPTION OF AN ARTICULATED MANUS OF A HEGETOTHERIINE NOTOUNGULATE, BASED ON A SPECIMEN FROM THE MIDDLE MIOCENE OF QUEBRADA HONDA, BOLIVIA

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Hegetotheriids were small to medium-sized South American endemic ungulates of the suborder Typotheria, and their fossil record extends from the early Oligocene to the early Pleistocene. The family is traditionally divided into two subfamilies, Pachyrhukhinae and Hegetotheriinae, though the monophyly of the latter is still uncertain. Most of the skeleton has been described for some species of both groups, but the manus has only been documented in pachyrukhines. In this study, we provide the first description of the manus of an hegetotheriine based on UTAF-V-001591, a well-preserved partial skeleton of *Hemihegetotherium trilobus* from the middle Miocene (Laventan South American Land Mammal Age) Quebrada Honda Fauna of southern Bolivia. The manus of this specimen preserves two carpals, metacarpals (Mc) II–V, all phalanges of digits II–III, and a partial proximal phalanx of digit IV. It also includes a partial mandible (confirming its identification as *H. trilobus*), an articulated pes (with the cuboid, metatarsals (Mt) II–V, and phalanges of digits III–V), and several partial limb bones. The manus of *H. trilobus*, like that of the pachyrukhines *Pachyrukhos*, *Propachyrucos*,and *Paedotherium*, is tetradactyl with three relatively robust digits (II, III, IV), a reduced digit V, and apparently no pollex. Manual digit reduction could have occurred either early in the evolution of hegetotheriids (prior to the divergence of these two groups) or in parallel in hegetotheriines and pachyrukhines. A mesaxonic pes with robust Mt II–IV, reduced Mt V, and no digit I has been documented in the hegetotheriines *Prohegetotherium*, *Hegetotherium*,and *Hemihegetotherium achataleptum* and the pachyrukhine *Pachyrukhos*. (*Propachyrucos* and *Paedotherium* are also tetradactyl but have digit proportions that are less strictly mesaxonic.) The overall form of the pes of *H. trilobus* resembles that of *H. achataleptum.* Although Mt V has not previously been reported in *H. achataleptum*, facets on Mt IV of this species have been interpreted as suggesting a small Mt V was present. This interpretation is supported by the articulated pes of this specimen of *H. trilobus*, which preserves a small Mt V. In addition to clarifying the anatomy of *H. trilobus*, the specimen described here will provide new data for studies of the functional morphology of hegetotheriines and may yield characters useful for clarifying phylogenetic relationships among hegetotheriids.

Grant Information
NSF EAR 0958733, NGS 8115-06 (National Geographic)

Technical Session XX (Saturday, October 29, 2016, 2:30 PM)

JUST HOW DIFFERENT? QUANTIFYING VERTEBRAL DIVERSITY IN TEMNOSPONDYLS

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The size and shape of vertebrae within the vertebral column are influenced by ecology and phylogeny, in addition to body size. Parameters such as total vertebral number, degree of regionalization, dimensions and angles of vertebral processes have been correlated with locomotor type, performance, and axial mobility. Despite studies across a wide range of extant taxa, and a history of vertebral morphology changing to suit new forms of locomotion, these data have not been expanded towards understanding basal tetrapod biomechanics. Yet, this ancestral assemblage underwent major biomechanical innovations which enabled the evolutionary water–land transition, critical to the explosive diversification of land vertebrates. Temnospondyls were a diverse set of stem-amphibians that arose in the Middle Mississippian (346 Ma) and went extinct in the Early Cretaceous (120 Ma). Early works on temnospondyls described and categorized their diversity of ecologies, habitats, and gross morphologies, including complex vertebral morphologies. However, no study has quantified temnospondyl vertebral diversity in, or addressed their effects on, biomechanical metrics such as overall spinal stiffness, or lever arms of epaxial musculature. We conducted a 2D geometric morphometric study of shape differences and investigated the biomechanical consequences of pre-sacral vertebral morphology in the temnospondyls by calculating, plotting, and analyzing principal components to determine disparity patterns. We document the diversity of the intercentra and neural spines. Principal components separate the temnospondyls into clusters consistent with their phylogeny and, biomechanically relevant, habitat. The clade Rhachitomi had terrestrial and aquatic members that clustered with other temnospondyls of similar habitats but in different clades. This project lays the groundwork for a series of quantitative studies to understand differences within this diverse group and to better understand key innovations in the axial column for terrestrial locomotion.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

THE VERTEBRATE ASSEMBLAGE OF THE MADSEN BONE BED, LOWER JUDITH RIVER FORMATION (MCCLELLAND FERRY MEMBER, CAMPANIAN), NORTH-CENTRAL MONTANA

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The Judith River Formation is a relatively poorly sampled geologic unit in comparison to other formations deposited in the Campanian of North America. The formation is chronostratigraphically and lithostratigraphically equivalent to the uppermost Foremost and Oldman Formation in Alberta. The lower half of the Judith River Formation, the McClelland Ferry Member, was deposited during the regressive phase of the western interior sea, and as such records the transition from marine to non-marine environments. The fauna of this unit is particularly poorly sampled. Here we report on the vertebrate assemblage of a recently excavated bonebed in the upper, sandy interval of the McClelland Ferry Member located near Malta, Montana. Approximately 70 vertebrate fossils were collected from the multi-taxic bonebed. The site is mixed and includes both macrovertebrate and microfossil components, but majority of the fossils collected are larger than 5 cm. The bones were identified to the lowest taxonomic level and an illustrated faunal list has been compiled. The fossils originated from a diverse set of terrestrial and freshwater species. Of the bones excavated, 42% belong to hadrosaurid dinosaurs, 23% belong to saurischian dinosaurs, 23% belong to Testudines, and 10% belong to crocodilians. Stratigraphically, the site occurs in strata that are equivalent to the Comrey Sandstone zone of the Oldman Formation, allowing comparison of this fauna with sites in Alberta, which are located over 100 km further west. The single sampled microsite from the Comrey zone in the Manyberries region of Alberta has a greater relative abundance of fish and salamanders, with hadrosaurs being the most abundant reptile. However, the difference in fossil size distribution of these two sites may account for some of the differences in faunal composition. The microvertebrate fauna of the lower McClelland Ferry Member of the Judith River Formation is reasonably well documented, but there are few, if any, microsites known from the upper portion this member, which records the maximum regression of the western interior sea. The analysis of the Madsen Bonebed contributes new data on the faunal composition and paleoecology of the Judith River Formation.

Technical Session VIII (Thursday, October 27, 2016, 3:45 PM)

FIRST COMPLETE SKULL OF A FOSSIL FLYING SQUIRREL FROM THE MIOCENE OF CATALONIA

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Flying squirrels (Sciuridae: Pteromyini) are relatively common and diverse in the European Miocene, although they are mostly known from isolated cheek teeth, mandibles and maxillary fragments. Due to the lack of postcranial material, their inclusion into the Pteromyini has been questioned, because truly diagnostic characters only occur in the carpus. Here we report two skulls that, on the basis of dental morphology, are assigned to *Miopetaurista neogrivensis*, a large-sized 'flying' squirrel known from the middle to early late Miocene of Eurasia. The recovered material comes from sites ACM/C5-D1 and ACM/C8-Af of Abocador de Can Mata, located in the Vallès-Penedès Basin (Catalonia, Spain) and with an age of 11.6 Ma. Although the skulls are almost complete, both are crushed, either dorsoventraly or laterally in a slightly oblique angle. The main fragments are only slightly displaced and not plastically distorted. To reconstruct the original skull shape, these specimens were micro-CT scanned and the different bone fragments were digitally individualized. The virtual models of each fragment were then matched with one another by fitting the fractures so as to reconstruct uncrushed bones, mirroring them when required. Finally, a complete 3D model of the undistorted skull was generated as a composite of the models of the two specimens. In addition, CT-scanning enabled the observation of the internal morphology of key anatomical structures, such as the tympanic cavity. The robust appearance of the skull is very similar to that in extant large-sized squirrels, particularly the flying squirrels *Aeromys* and *Petaurista*. Furthermore, it shares with those taxa a short and wide rostrum, and short and robust postorbital process. Other details are strikingly similar, such as the inflation of the bulla, the presence of a marked jugal process in the zygomatic arch and the number of septa (2 to 3) in the tympanic cavity. Most of the smaller flying squirrels show more elongated muzzles, longer postorbital processes and a higher number of septa. Pending the study of postcranial material, the remarkable number of similarities indicates that *Miopetaurista* is indeed a flying squirrel.

Grant Information
Ministerio de Economía y Competitividad (CGL2014-5472-P, RYC-2013-12470 to ICV) and Generalitat de Catalunya (2014 SGR 416, 2014–BP-A 00048 to JF)

Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

USING ICHNOFOSSILS AND PALEOSOLS TO RECONSTRUCT THE MIDDLE MIOCENE PALEOENVIRONMENT OF QUEBRADA HONDA, BOLIVIA

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The Neotropics are home to exceptional levels of mammalian diversity, but few fossil-producing localities document the history of this unique fauna. La Venta, Colombia, and Quebrada Honda, Bolivia are well-sampled, roughly contemporaneous (13–12 Ma) sites that preserve the remains of many extinct nonvolant Neotropical mammals (59 and 30 genera, respectively). Almost no mammalian genera are shared between the two sites, and this could reflect climate and/or habitat differences. In this study, we use paleopedology and ichnology as independent lines of evidence to elucidate the habitat of Quebrada Honda and test this hypothesis. The paleosols of Quebrada Honda are weakly to moderately developed and composed primarily of brown-to-red silts, silty sands, and mudstones. They are interpreted as Entisols and Inceptisols that formed in floodplains. The suite of ichnofossils present within the paleosols include cm- to dcm-scale, horizontal-to-vertically oriented mottled, passively filled burrows, and cm-scale subvertically-oriented meniscate and pelleted back-filled burrows. Horizons of *Celliforma* and *Coprinisphaera* are present in the paleosols, as are dcm-scale calcified burrows with cylindrical chambers. These ichnofossils are interpreted as dwelling, feeding, and breeding structures of solitary social insects, and dwelling structures of small mammals, respectively. Rhizoliths include mm-scale rhizotubules, cm-scale rhizohaloes, and dcm-scale rhizocretions. The rhizotubules and rhizohaloes are interpreted as roots of grasses and other small herbaceous plants while the rhizocretions

are interpreted as taproots of medium to large plants such as shrubs and trees. Together, paleosol and ichnofossil data suggest that Quebrada Honda fossils were preserved in savannahs proximal to alluvial systems in a seasonal, humid to sub-humid climate with mean annual precipitation (MAP) of ca. 1000 mm. This inferred paleoenvironment differs from that of La Venta, which has been reconstructed as a mixture of river-associated tropical forests and successional stages thereof with MAP of 1,500–2,000 mm, and indicates that dissimilar habitats could account for many of the differences between the mammal faunas of these two important fossil sites.

Grant Information
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Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

SOFT TISSUE RECONSTRUCTION AND VISUAL FIELDS OF DINOSAURS AND THEIR EXTANT RELATIVES

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The visual abilities of dinosaurs as they relate to ecology and behavior have been the subject of recent interest. Reconstructing orbital soft tissues has received little attention, and, if not taken into account, the eyeballs of dinosaurs may be mis-sized or positioned inaccurately, leading to poor estimates of visual fields and spurious conclusions about behavior and ecology. Intact heads of 15 species of avian, crocodylian, and squamate specimens were subjected to high-resolution, iodine-enhanced microCT scans (diceCT), and several dozen additional avian specimens were microCT scanned without diceCT. Orbits of specimens were dissected to validate the CT studies and to identify the osteological correlates for orbital soft tissues, including the extraocular muscles, cranial nerves, Harderian gland, lacrimal gland, nasal gland, eyelids, supraorbital membrane, subocular ligament, and nasolacrimal duct. Soft tissues, endosseous labyrinths, and cranial endocasts were segmented in Avizo and soft tissues were modeled in Maya. Eyeball size was measured directly and compared with estimates using regressions from the literature based on optic nerve foramen diameter and other measures. To assess which proxies for eyeball size are most robust (and hence useful for restoring extinct taxa), different estimates of eyeball size and position were modeled in Maya for each extant sample taxon based on several different criteria (including diameters of the orbit, scleral rings, and optic nerve foramina). To test these proxies, eyeball models were re-inserted along with accessory orbital soft tissues into digitized skulls. If the digital models of the eyeball accessory tissues, and/or bones overlapped, the model was rejected as an overestimate. The results indicate that reconstructing accessory soft tissues in the orbits of extant diapsids can provide upper limits on estimates of eyeball diameter and axial length whereas lower limits are currently less constrained (although under study). Optical parameters including focal length and monocular visual field, which depend in part on eyeball size, shape, and position, were modeled based on these constraints. Visual fields based on these optical parameters were modeled and tested against empirical measurement of visual fields in the literature. The outcomes of these extant studies will subsequently inform reconstructions of dinosaur visual abilities in a later phase of this project.

Grant Information
Ohio University Graduate Student Senate Original Work Grant (internal funding)

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

BRIDGING THE GAP BETWEEN ASIAN AND EUROPEAN FAUNA WITH THE GAZELLES OF THE CHU FORMATION IN THE KOCHKOR BASIN, KYRGYZSTAN

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Kyrgyzstan has a very limited published vertebrate fossil record, despite the Neogene terrestrial sediments that blanket much of the country. Recent fieldwork in Kyrgyzstan has produced a large number of fossils, and here we describe new bovid material from the Kochkor Basin of Kyrgyzstan that we can confidently assign to *Gazella*. Most Neogene fossil sites in the Kochkor Basin are ungulate dominated, and gazelles are currently the fourth most common taxon after *Chilotherium* (rhino), *Hipparion* (horse) and *Pliocervus* (deer).

The *Gazella* sample from Kochkor contains over a dozen horn cores, a partial skull, multiple jaws and teeth and extensive postcranial material, all of which are consistent in size, suggesting the presence of only one species of gazelle. *Gazella* is found in several localities and strata, but all are confined to the late Miocene Chu Formation from horizons estimated to be roughly 7 million years old from biostratigraphic and paleomagnetic dating.

The specimens are significantly smaller than previously collected *Gazella* material from other parts of Central Asia, which is mostly assigned to *Gazella dorcadoides*. The type material for *G. dorcadoides* is larger, more robust, and has more posteriorly curved horn cores than the Kyrgyz specimens. The Kyrgyz *Gazella* material is also significantly smaller than gazelle material of the Chinese 'Hipparion Faunas' typically used for comparison. We hypothesize that the *Gazella* from Kochkor Basin is a new species, representing an earlier evolution of a smaller-bodied lineage adapted to high elevation and cold.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

A TALE OF TWO TEMNOSPONDYL-DOMINATED FAUNAL ASSEMBLAGES FROM THE MIDDLE TRIASSIC OF CENTRAL INDIA

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Denwa Formation of Central India has yielded a Middle Triassic faunal assemblage dominated by the temnospondyls. It is divided into the Lower, Middle, and Upper Denwas among which the Middle and the Upper part yield vertebrate fossils. The Upper Denwa Formation has red mudstones, calcirudites and greenish silt-fine sand alternations whereas the Middle Denwa Formation is dominated by violet mudstones along with fine sand and heterolithics. The temnospondyl fossils present in those two types of mudstones are markedly different by their sizes. The violet mud dominated Middle Denwa comprises primarily of *Cherninia denwai* among the temnospondyls along with a few remains of dicynodonts and rhyncosaurs. The red mudstone bearing Upper part of Denwa has *Cherninia denwai* and *Stanocephalous crookshanki* along with rare dicynodonts, fish scales, and archosaur remains. At least three new species of temnospondyls, that are yet to be identified, are also present there. The temnospondyls belonging to the violet mud is larger and robust, up to nearly 1 m in skull length while the same in overlying red mud looks impoverished with maximum skull length of the temnospondyls hardly reaching 0.5 m. The thickness of the bones of the skulls or interclavicles is almost 1 cm at places within violet mud of Middle Denwa while that within the red mud of Upper Denwa is merely 0.2 cm. Specimens of *Cherninia* present both in violet and red mud, also maintain size discrepancy. The sedimentology of the two units does not show any major differences in the depositional pattern. Only the red-coloured mudstones and the presence of calcirudites are specific to the Upper part of Denwa. The geochemistry of the red mudstones, not very directly though, indicates a hot, semi-arid climate. Also the presence of calcirudites in the Upper part of Denwa Formation is suggestive of intermittent periods of aridity. Layers of fish scale beds alternating with temnospondyl rich red mudstones are also indicative of intermittent aridity. The presence of fewer amounts of unioid bivalves in the red mud than in the violet mud further indicates unfavourable habitat conditions. On the contrary numerous roots and rootlets are present in the violet part indicating more vegetation. The lack of nutrient supply combined with higher aridity of climate is perhaps accountable for the distinctly smaller size of temnospondyls in the red mudstone dominated Upper Denwa Formation in contrast to the robust temnospondyls present in the milder climate, more nutrient and favourable condition bearing violet mudstone of Middle Denwa Formation.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

EARLIEST CARBONIFEROUS DIPNOI: POST-HANGENBERG RECOVERY AND THE DAWN OF A NEW ERA OF LUNGFISH.

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A new specimen of a large skull from lowest Tournaisian deposits (VI palynozone, less than 1 my from the Devonian–Carboniferous boundary) of southern Scotland represents the earliest occurrence of a dipnoan following the Hangenberg extinction event in the Famennian. Comprising a near-complete cranial dermal skeleton, the arrangement of the skull roofing bones resemble that of the well-known Carboniferous genus *Ctenodus*. Alongside other dipnoan remains, including toothplates, operculi, isolated skull bones and post-cranial material, the fossil record of lungfish in 'Romer's Gap' can now be demonstrated to comprise a diverse and morphologically disparate fauna indicating rapid post-extinction recovery and niche partitioning by the middle-upper Tournaisian (CM palynozone). The resemblance of the new specimen to *Ctenodus* implies that lungfish skull morphology was evolving at a slower rate than tooth morphology. The new lowest Tournaisian specimen does not exhibit reduction of skull roofing bones seen in younger Carboniferous and more recent lungfish whereas new Tournaisian lungfish dentitions are highly variable in form. Diversification of lungfish dentition is associated with the contemporaneous appearance of the earliest record of an established brackish to freshwater bivalve fauna, a possible key food source for lungfish. Furthermore, the new material from the lowest Tournaisian is large with estimates of full body size ranging between 20 cm to exceeding 1 m in length. Tournaisian lungfish were among some of the largest organisms to inhabit the waters in the post-Hangenberg extinction world and demonstrate a trend in increasing body size following extinction rather than body size stasis or reduction as previously proposed for sarcopterygian taxa at this time.

Grant Information
Callidus Services Ltd.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

THREE DIMENSIONAL MORPHOMETRIC ANALYSIS OF THE CRANIAL ONTOGENY OF *MASSOSPONDYLUS CARINATUS* BASED ON CT RECONSTRUCTIONS

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Understanding ontogenetic variation in dinosaurs is necessary because it informs taxonomic hypotheses, elucidates larger macroevolutionary patterns, and allows for the inference of behavioural traits such as parental care, feeding and locomotion. *Massospondylus carinatus* Owen 1854 is an emblematic South African basal sauropodomorph dinosaur, and it presents an ideal study system for dinosaurian cranial ontogeny because it has a range of referred specimens aged from hatchling to adult. This study reconstructs individual skull bones of a size series of *M. carinatus* using CT scans and qualitatively and quantitatively assesses the ontogenetic variation between these bones. The results show clear differences in the development between facial bones and braincase bones (both in the amount of growth and in the correlation between size and shape). Several morphological differences are also identified between juveniles and adults. There is a possibility that several species are represented in the *M. carinatus* sample, based on both the qualitative and quantitative assessments.

Grant Information
DST-NRF Center of Excellence in Palaeontolongy; Palaeontological Scientific Trust Scatterlings of Africa; University of the Witwatersrand

Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

A NEW ASSEMBLAGE OF MOSASAURS FROM THE UPPER CRETACEOUS SAVOY PIT, AUSTIN CHALK, NORTH TEXAS

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We describe an assemblage of mosasaurs from the Savoy Pit of Fannin County, in northeastern Texas. The site was excavated in 1940 by the Works Progress Administration (WPA) in conjunction with The University of Texas Bureau of Economic Geology. Based on field notes from the WPA, specimens were recovered from the Upper Cretaceous (Coniacian) Austin Chalk, approximately 7 m above the contact with the Eagle Ford Shale. Previously published taxa from the site include *Ichthyornis* and fish such as *Belonostomus* and *Laminospondylus*. Other fossils that were discovered at the site include crustaceans and asteroids. Additionally, the Savoy Pit yielded several specimens of mosasaurs. Those specimens include both isolated elements and associated skeletons that have yet to be described.

We scored material from the Savoy Pit using a combination of published and novel morphological characters and compared our results to over 200 other mosasaur specimens. We then ran a phylogenetic analysis to hypothesize the taxonomic composition of the assemblage. We identified at least three mosasaur taxa from the Savoy Pit assemblage, including *Tylosaurus nepaeolicus*, a russellosaurine identified from a frontal similar to that of *Russellosaurus coheni*, and an undetermined basal mosasaurine. The latter taxon is exemplified by an associated, partial skeleton that includes a quadrate, maxilla, and vertebrae. That specimen exhibits a unique combination of characters that include synapomorphies of Mosasaurinae (e.g., dorsally constricted suprastapedial process and a striated tympanic rim on the quadrate) and character states observed in russelosaurines (e.g., an elongate stapedial pit).

The presence of a russellosaurine similar to *Russellosaurus coheni* represents a potential range extension of that lineage into the Coniacian. The basal mosasaurine fills a stratigraphic gap in the record of that clade between *Dallasaurus* in the Turonian and *Clidastes liodontus* higher in the Coniacian. Our study not only presents new data that are critical to understanding the distribution and evolution of mosasaurs, but also highlights the continued importance of WPA excavations during the Great Depression to our understanding of the fossil record, particularly in Texas.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

THE ANATOMY OF *NOTOCHELONE* LYDEKKER, 1889 AN EARLY CRETACEOUS PROTOSTEGID (TESTUDINES) FROM AUSTRALIA AND ITS BEARING ON THE ORIGIN AND EARLY EVOLUTION OF SEA TURTLES

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The skeletal material of *Notochelone* sp. kept at The Natural History Museum in London (NHMUK) and Queensland Museum (QM) in Brisbane was collected in 1978 from sites in northwestern Queensland. The specimens derive from the Toolebuc Formation and the Allaru Mudstone, which are of middle-late Albian age and were deposited in a restricted shallow offshore marine environment. The NHMUK and QM collections contain six skulls, together with a number of incomplete shells and isolated bones that have never previously been described. We therefore utilized this material to document the morphology of *Notochelone*, and in particular NHMUK PV R11977, a fully prepared skull and associated shell and axial elements that provides new insights into the anatomy, taxonomy and phylogeny of protostegid sea turtles. Novel cranial and postcranial character states were found to be shared by protostegids and crown chelonioids. In addition, braincase osteology was reconstructed from CT scans – amongst the first undertaken for any protostegid.

This new data elucidates the problematic monophyly of advanced sea turtles, which contests the placement of protostegids as either early members of the chelonioid radiation or a completely separate lineage of marine basal cryptodires that manifest extreme convergence on crown sea turtles. Furthermore, molecular clock divergence estimates for the sea turtle crown are highly controversial, being pushed back by more than 35 million years if protostegids are considered to be stem chelonioids. Our phylogenetic reassessment of *Notochelone* confirms this scenario, and suggests that protostegids constitute a sister to crown-sea turtles in accordance with molecular hypotheses.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

A NEW LOOK AT THE LATE CRETACEOUS LIZARD *DICOTHODON BAJAENSIS* FROM THE EL GALLO FORMATION, BAJA CALIFORNIA, MÉXICO

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Polyglyphanodontini is a Late Cretaceous group of North American lizards that is mainly known by isolated teeth and jaw fragments. Polyglyphanodontini include the following genera: *Bicuspidon*, *Dicothodon*, *Paraglyphanodon*, *Peneteius* and *Polyglyphanodon*; *Polyglyphanodon sternbergi* is the most complete; also, this speciemen is the best known Late Cretaceous lizard form North America. The phylogenetic relationships of this tribe are controversial, with membership in either Teiidae or Scleroglossa.

As a result of a collaborative research project initiated in 2004 in the El Gallo formation, in the area of El Rosario, Baja California, well-preserved remains of *Dicothodon bajaensis* were recovered.

Dicothodon bajaensis was first described based on three isolated teeth and a fragmentary jaw with two posterior teeth. The newly discovered material of *D. bajaensis* includes elements of the skull, fragmentary upper and lower jaws, and articulated and disarticulated postcranial elements, including vertebrae, limb bones, and pelvic and pectoral girdles.

A first phylogenetic analysis of *D. bajaensis* to determine its relationships within Squamata was carried out in TNT 1.1, a New Technology analysis using ratchet, sectorial search, and fusion trees; the matrix included 193 squamate taxa and 610 characters. The analysis resulted in four most parsimonious trees (L= 5309, CI= 0.186, RI= 0.784). A strict consensus tree recovered *D. bajaensis* within the Polyglyphanodontia clade, and as the sister taxon of *Adamisaurus magnidentatus*, a Cretaceous lizard from Mongolia. *D. bajaensis* and *A. magnidentatus* share three synapomorphies (number of dentary and premaxillary teeth; posterior extension of length of the maxillary teeth row, and crown height of maxillary teeth). The addition of *D. bajaensis* to the matrix maintains Polyglyphanodonta as a monophyletic clade and does not modify the relationship of this clade within Scleroglossa, as has been proposed in previous analyses.

This new material allows us to redescribe and propose a new diagnosis of *Dicothodon bajaensis*,which represents the second most complete lizard from the Late Cretaceous of North America.

Grant Information
APIIT IN 104506-2, IN 111209, IN 100913, and CONACyT Scholarship

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

EVOLUTION AND ECOLOGICAL ASSOCIATIONS IN HERBIVOROUS THEROPODS

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Theropod dinosaurs are inferred to have been ancestrally carnivorous and include numerous lineages specialized for hypercarnivory. However, increasing evidence suggests that several theropod clades convergently transitioned away from a carnivorous lifestyle to become herbivores or omnivores. The evolutionary drivers of these trophic shifts are unknown. Methods involving the use of the Paleobiology Database (PBDB) were used to test for the potential impact of ecological factors that may have affected the diversification of non-hypercarnivorous theropods, such as the diversity of other herbivorous vertebrates and of plants. After demonstrating feasibility of the proposed methods by using restricted parameters (solely considering oviraptorosaurian theropods from the Cretaceous of Asia and their contemporaries), said methods were applied to an expanded dataset including more than 500 taxa from 51 geologic formations. No statistically significant correlations were found between non-hypercarnivorous theropod diversity and that of plants, but overall diversity of non-hypercarnivorous theropods was found to positively correlate through space and time with the diversity of other herbivores. These results suggest that non-hypercarnivorous theropods did not strongly compete with contemporaneous herbivores. Instead, their diversity may have been promoted by the presence of other herbivores or by extrinsic environmental factors that favored herbivorous species as a whole.

Romer Prize Session (Thursday, October 27, 2016, 8:00 AM)

THE ORIGIN OF TOOTH REPLACEMENT: 3D SYNCHROTRON HISTOLOGY VISUALIZES THE DENTAL ONTOGENY OF THE SILURIAN STEM OSTEICHTHYANS

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Mechanisms of tooth replacement distribute incongruently among extant gnathostomes: a tooth-generating dental lamina exists in chondrichthyans and tetrapods but not teleosts, whereas tooth shedding by basal hard tissue resorption occurs in tetrapods and teleosts but not chondrichthyans. Theories about the evolution of tooth development have been biased towards the chondrichthyan conveyor-belt replacement as the primitive mechanism, since there has been no fossil evidence for the origin of osteichthyan tooth replacement until now. 3D virtual dissections with micron-scale resolution, based on propagation phase contrast synchrotron microtomography, reveal the growth history of the dentitions of *Andreolepis* and *Lophosteus*, 423 Ma Silurian stem osteichthyans close to the common ancestor of tetrapods and teleosts. Their marginal jawbones and “tooth cushions” (possible homologues of coronoids) shed teeth by in situ cyclic basal resorption, the earliest examples of osteichthyan-style tooth replacement. This occurred in broad multi-row tooth fields, including at sites separated from the margin of the bone by intervening teeth, showing that the production of replacement teeth must have occurred in pockets associated with each tooth, as in teleosts, not in a single deep dental lamina. This suggests that the functionally and anatomically similar laminae of chondrichthyans and tetrapods are convergent.

The marginal jaw bones of both genera bear an initial non-shedding "dentition" labial to the shedding tooth field, overgrown by later dermal ornament and probably not belonging to the oral domain, but bearing in vivo biting damage showing that they functioned as teeth. The most lingual of these odontodes have been resorbed apically and are overlain by shedding teeth. The first-generation teeth on the tooth cushions show site-specific semi-basal resorption in *Lophosteus*, leaving a basal dentine ring from each tooth, but fully basal resorption in *Andreolepis*. Resorption surfaces are compacted in the *Andreolepis* tooth cushion, as in crown osteichthyans, but stacked up by intervening bone of attachment in the other dentigerous bones of *Andreolepis* and *Lophosteus*. The disposition of the resorption surfaces relative to surrounding bone and dentine structures shows whether odontoclasts, osteoclasts, or both were active in resorption, allowing inferences to be drawn about cell behaviour and molecular processes during the development of the dentition. These data provide unique insights into the origin of osteichthyan tooth replacement.

Romer Prize Session (Thursday, October 27, 2016, 8:45 AM)

EAST ASIA IN THE EVOLUTION OF AMPHIBIANS IN THE MESOZOIC AND CENOZOIC: INFERRED FROM FOSSILS, MORPHOLOGY, AND MOLECULES

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The distribution of organisms is a result of both evolution and Earth history. A robust biogeographic hypothesis requires multiple lines of evidence: fossils, phylogeny, and geology, each providing a unique aspect of information irreplaceable by others. Over the years, the Mesozoic–Cenozoic beds of northern China and Mongolia have yielded an array of well-preserved salamander and frog fossils, representing a deep evolutionary history of the two major amphibian clades in East Asia. To understand the relationships and biogeographic implications of these fossils, I performed total-evidence phylogenetic analyses and biogeographic reconstructions in these two clades, respectively. The results for the salamander phylogeny show that the fossils from the Jurassic–Cretaceous of northern China represent the earliest members of many major crown clades, including the earliest cyptobranchid (*Chunerpeton*), the earliest hynobiid (*Liaoxitriton*), the earliest salamandroid (*Beiyanerpeton*), and the earliest sirenid (new species). Biogeographic analysis suggests that the crown-group salamanders originated in East Asia prior to the Middle Jurassic. The divergence between the two major suborders Cryptobranchoidea and Salmandroidea occurred in East Asia, and is not a vicariance event due to the breakup of Pangaea. Multiple dispersals to Europe and North America occurred in sub-clades of both suborders, resulting in the wider distribution today. On the frog side, taxa from the Early Cretaceous of northern China (*Callobatrachus*, *Mesophrys*, *Yizhoubatrachus*, and a new species) are outside crown families but show a combination of plesiomorphic and apomorphic characters, whereas other fossils from China and Mongolia (*Gobiates*, *Macropelobates*, and *Prospea*) are crown members of a group called Pelobatoidea, commonly known as spadefoot toads. Biogeographic analysis indicates that the primitive crown frogs are widely distributed across the Holarctic by the Early Cretaceous. The East Asian occurrences of spadefoot toads, which are absent from the area today, are a result of multiple dispersals throughout the Cenozoic. *Prospea*, closely related to modern North American spadefoot toads, suggests a dispersal event from North America to East Asia during the Paleocene, providing paleontological evidence for a Beringia land connection during that interval. In comparison, *Macropelobates* is closely related to modern European spadefoot toads, suggesting a Europe–Asia dispersal during the Oligocene after the Turgai strait became passable.

Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

ECOLOGICAL DYNAMICS OF MESOZOIC MAMMALIAN COMMUNITIES IN RESPONSE TO ABIOTIC AND BIOTIC CHANGES

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Both extinct and extant mammal communities show strong ecological responses to environmental changes, with both species composition and climate fluctuation playing important roles at both temporal and spatial scales. Yet at present, such dynamic responses have not been adequately investigated for mammalian communities in the shadow of the dinosaurs. We sampled Mesozoic mammal communities from the Upper Jurassic Morrison Formation and Lower Cretaceous Cloverly Formation of North America, incorporating data from the Late Jurassic of Portugal and the Middle Jurassic through Late Cretaceous of northeastern Asia, to study their ecological dynamics in response to abiotic and biotic changes. We also sampled 45 extant small-bodied mammal communities from tropical, arid, temperate, and cold environments worldwide as potential analogues to those extinct communities. We used body size, diet, and locomotor mode as three ecological parameters to quantify ecological structure and visualize ecospace occupation. Preliminary results indicate that Mesozoic mammalian communities from different environments had distinctive ecological structures. The ecological disparity and diversity of mammalian communities from the Morrison and Cloverly formations are relatively less than those of their counterparts in Portugal and northeastern Asia. Their small ecological disparity and diversity were driven by narrow body size range and limited dietary preferences, which were decoupled from their diverse locomotor modes in ecospace occupation. This decoupling paradigm occurred among all Mesozoic mammal communities and may reflect ecological pressures imposed by dinosaurs, thus helping to shape ecological structures of Mesozoic mammalian communities. It represents a marked difference from that of extant small-bodied mammalian communities. The strong relationships between ecological structure and environmental factors suggest that the spatial and temporal heterogeneity may also have played essential roles in shaping Mesozoic mammalian communities.

Grant Information
Smithsonian Institution Postdoctoral Fellowship

Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

SEASON OF BIRTH AND TIMING OF EARLY DENTAL DEVELOPMENT IN AMERICAN MASTODONS (*MAMMUT AMERICANUM*)

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Early-forming dental elements in mastodons (*Mammut americanum*) begin to mineralize in utero and continue growing for an extended period after birth. The dentin component of teeth is not reworked and forms through continuous apposition on the pulp cavity surface. As such, dentin in a mastodon calf's cheek tooth or tusk preserves a long interval of growth that spans the time of the individual's birth. In the dentin growth record, a neonatal line provides a precise marker of birth and can be used to establish timing of birth and dental development. Two deciduous tusks from the Ziegler Reservoir fossil site in Colorado and one deciduous second premolar from lower Michigan have neonatal lines visible in microCT and thin section. We serially sampled across the neonatal line for isotope analysis and analyzed growth increments to reconstruct timing of tooth and tusk development. Oxygen isotope profiles from dentin carbonate display changes that match the normal seasonal pattern documented from other tusks in each region. Neonatal lines in these specimens coincide with the portions of the isotope records that are thought to represent springtime $\delta^{18}O$ values. Spring season of birth fits expectations for mid-latitude mastodons and is consistent with the late spring/early summer timing of musth (a periodic physiological condition associated with mating in male elephants) that has been suggested for Great Lakes region mastodons. Springtime birth increases the odds that neonates of large animals from seasonal, temperate environments will encounter favorable environmental conditions in the months immediately following birth. It thereby increases a newborn's chances of surviving its first year by maximizing the time for growth before its first winter. Neonatal lines in these tusk and molar growth records also help us establish developmental timing of early-forming mastodon dentitions, thus enabling precise calibration of juvenile life history reconstructions. When present in cheek teeth, which are more frequently preserved than tusks, they could enhance our ability to study changes in juvenile life histories through time and in different environments. Such investigations contribute to our understanding of mastodon life history and provide ways to test hypothesized extinction mechanisms.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

NEW MATERIAL OF THE CENTROSAURINE *MEDUSACERATOPS LOKII* (DINOSAURIA, ORNITHISCHIA) WITH IMPLICATIONS FOR POSTORBITAL HORNCORE SIZE EVOLUTION IN BASAL CERATOPSIDS

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Originally, all ceratopsid material collected from the Campanian Mansfield bonebed from the Judith River Formation of Montana was referred to *Albertaceratops*. Subsequently, a parietal from the bonebed was made the holotype of the oldest known chasmosaurine, *Medusaceratops lokii*, in part because it only had three epiparietals, a typical number for chasmosaurines. We describe new material from the bonebed that unequivocally identifies *M. lokii*, and presumably all other ceratopsid material from the bonebed, as Centrosaurinae. A new composite reconstruction of the parietal, informed by a newly discovered posterior midline bar and subadult lateral bar, reveals *M. lokii* had a broad midline ramus (a synapomorphy of Centrosaurinae) and at least five epiparietals (ep) around the margin of the frill. From medial to lateral, the epiparietal ornamentation consists of a small procurving epiparietal (ep1), an anterolaterally curving pachyostotic hook (ep2), a smaller hook (ep3), and two unmodified triangular epiparietals (ep4 and 5), one of which may straddle the parietosquamosal contact. A phylogenetic analysis based on all available material indicates that *M. lokii* is more derived than *Albertaceratops*, and can be distinguished from it by the presence of the small, medially positioned ep1 and the presence of multiple pachyostotic hooks. One striking feature of *M. lokii* is a supraorbital complex with a massive postorbital horncore, associated with the vaulted forehead structure of basal centrosaurines. Although the largest long bones of *M. lokii* are no larger (in girth and length) than the largest equivalent elements of other centrosaurines (except large pachyrostrans), its postorbital horncore has the largest basal circumference known for any centrosaurine. These horncores are comparable to the largest postorbital horncores seen in non-Triceratopsini chasmosaurines (e.g., *Anchiceratops* and *Pentaceratops*). Additionally, multiple specimens of postorbital horncores show ontogenetic transformation from a small, triangular horn to an elongated, chasmosaurine-like horncore, with signs of significant reabsorption that reduced long (>500 mm) horns by more than one-half their length; such resorption is common in Centrosaurinae, but rarely documented in Chasmosaurinae. This suggests that the evolution of the centrosaurine postorbital horncore is not just a simple pattern of reduction in size from the basalmost (*Diabloceratops*) to the most derived taxa (Pachyrhinosaurini) where they are also modified as cranial bosses as adults.

Grant Information
The part of the described material that is housed in the Royal Ontario Museum is acquired as a gift of the Louise Hawley Stone Charitable Trust.

Technical Session XVIII (Saturday, October 29, 2016, 3:00 PM)

TWO NEW EARLY CRETACEOUS ALVAREZSAURIANS AND CONSERVED PATTERNS OF FORELIMB REDUCTION IN THEROPODS

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Alvarezsaurians are a group of basal maniraptoran theropods whose derived members show striking forelimb reduction. The discovery of *Haplocheirus* in strata of the Shishugou Formation fitted ghost lineage predictions that this clade had diverged by the earliest Late Jurassic, but recent investigations of theropod phylogeny have questioned its status as an alvarezsaurian. A complicating factor in studying alvarezsaurian phylogeny is the lack of transitional members from the Early Cretaceous.

Our excavations in the Tugulu and Bayangobi Formations of Xinjiang and Inner Mongolia, respectively, have recovered two distinct Early Cretaceous alvarezsaurians. We incorporate the anatomical information provided by these new specimens into a data matrix designed to test coelurosaurian relationships, and find support for a monophyletic Alvarezsauria containing *Haplocheirus*, and surprisingly *Aorun* and *Tugulusaurus*. The two new specimens are phylogenetically intermediate in position between Late Jurassic and Late Cretaceous alvarezsaurian taxa.

Using the limb length data provided by the new specimens, we investigate patterns of forelimb reduction in theropod dinosaurs. Forelimb reduction in theropods occurred at least five times independently. Each instance of limb reduction involved proportional shortening of the metacarpus and lengthening of the humerus. Moreover, all instances of forelimb reduction below a certain threshold length show significantly rapid but transient rates of reduction in the length of the radius relative to the humerus. This reduction suggests a conserved developmental pathway exists for limb patterning. These observations are best explained by the Activator-Inhibitor model, which in forelimb reduction predicts initial shortening of the metacarpus relative to the humerus followed by shortening of the radius.

Grant Information
PAST and its Scatterlings of Africa Programmes
DST/NRF Centre of Excellence in Palaeosciences
Kalbfleisch/Gerstner Scholarship (AMNH)

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

A NEW ACTINOPTERYGIAN FISH FROM THE UPPER DEVONIAN GOGO FORMATION OF WESTERN AUSTRALIA.

CHOO, Brian, Flinders University, Adelaide, Australia; LONG, John A., Flinders Univ, Adelaide, Australia; LU, Jing, Chinese Academy of Sciences, Beijing, China; GILES, Sam, Oxford University, Oxford, United Kingdom

Although actinopterygians (ray-finned fishes) are an extremely successful extant vertebrate clade, their early evolution during the Devonian remains poorly documented when compared with the other major osteichthyan group, the Sarcopterygii. Successive discoveries since the 1960s from the Upper Devonian (early Frasnian) Gogo Formation of Western Australia has revealed a greater diversity of actinopterygians than any other contemporary fossil assemblage, with four species in three genera currently described (*Mimipiscis toombsi*, *M. bartrami*, *Gogosardina coatesi,* and *Moythomasia durgaringa*). These articulated fossils are renowned for their exceptional preservation within limestone concretions, providing complete details of both their dermal and endoskeletal anatomy. An almost complete fossil fish, prepared from a nodule originally collected in 1990, represents the sole example of a new genus and species of Gogo actinopterygian. The new form possesses a degree of dermal ornamentation unknown in other early osteichthyans, with intricate spinose ornamentation on the skull roof, pectoral girdle and scales. Prominent rows of barbs are present on the lepidotrichia of all the fins. The braincase is particularly well preserved, with rendering via Mimicsallowing for comparisons with other recent studies of early actinopterygian neurocrania. While a preliminary phylogenetic analysis suggest a close kinship with the contemporary Gogo genus *Mimipiscis*, the braincase of the new fish displays some differences, including an enclosed bifurcation point of the lateral dorsal aortae and enlarged vestibular fontanelles. The relatively higher diversity of actinopterygians combined with the scarcity of certain other gnathostome clades at Gogo is perhaps an indicator of an early centre of diversication in Eastern Gondwana for the ray-finned fishes.

Grant Information
Funded by Australian Research Council Discovery Early Career Award DE160100247.

Romer Prize Session (Thursday, October 27, 2016, 12:00 PM)

PALEOECOLOGICAL RESPONSE TO CLIMATE IN EAST AFRICA IS LOCALLY SPECIFIC

CHRITZ, Kendra L., University of Utah, Salt Lake City, UT, United States of America

Paleontologists rely on paleoclimate reconstructions to provide an environmental context for organismal evolution. Occasionally, paleoecology is inferred from these climate archives in the absence of local quantitative data, and assumptions are made on local paleoclimate and paleoecology based on regional data. Such is the case with the Cenozoic paleoenvironmental record in East Africa, which is a fossiliferous region bearing the diverse evolutionary record of modern mammals, including the human lineage. An inter-basinal reconstruction of Holocene paleoecology in Kenya may clarify the relationships between climate and ecology in geologic time. I present a comprehensive paleoecological record of two lake basins: Lake Turkana in the north and Lake Victoria in the southwest. I generated stable isotopic data from archaeological tooth enamel ($\delta^{13}C$; n = 333) and leaf wax isotopes ($\delta^{13}C$; n = 18) as proxies for paleoecology, along with previously published isotopic and paleoenvironmental data (including pollen and paleo-lake depth). Climate near Lake Turkana responded abruptly to a weakening monsoon system, driven by decreasing orbital precession, at the end of the African Humid period (~11 to ~5.5 ka), whereas climate near southwestern Lake Victoria responded more gradually. I show that herbivore diet increased in C_3 intake over time in the Lake Turkana Basin, whereas both leaf wax biomarker and tooth enamel isotopes indicate an abundance of C_4 resources in the Lake Victoria Basin throughout the Holocene. These data do not support a uniform shift in ecology across Kenya in accordance with climate forcing, indicating that organismal responses to changing climate must be assessed basin-by-basin where fossils are found.

Grant Information
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Technical Session IV (Wednesday, October 26, 2016, 2:30 PM)

DIVERSITY OF CRANIAL TELESCOPING IN OLIGOCENE WHALES OF THE CHANDLER BRIDGE AND ASHLEY FORMATIONS OF SOUTH CAROLINA

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Cranial telescoping in whales represents one of the most radical reorganizations of the skull in any mammal, resulting in posterior displacement of the external nares and facial bones towards the top of the skull. Within toothed whales (Odontoceti), this is correlated with a dorsally oriented blow hole as well as muscles associated with the production of sound used in echolocation. Although all extant odontocetes display advanced telescoping, many fossil taxa show more intermediate morphologies. Our study examined the evolution of cranial telescoping in fossil odontocetes with an emphasis on whales from the Oligocene Chandler Bridge and Ashley Formations. These formations include some of the earliest known diverging odontocetes with a range of plesiomorphic skull morphologies. We laser scanned 16 fossil whale skulls from ancestral archaeocete whales with minimal cranial telescoping to taxa with advanced telescoping similar to that seen in modern dolphins. Generalized Procrustes analysis was performed on 204 landmarks and semi-landmarks placed on 3d models of the skull. The resulting Procrustes coordinates were then analyzed using PCA to determine the major sources of variation. Overall, 94% of the variation could be explained by the first four PCs. PC 1 explained 70% of the variation and represents spacing of points along the long axis of the skull (e.g., telescoping) and divides whales into three main clusters: archaic archaeocetes and toothed mysticetes with minimal telescoping, stem odontocetes with intermediate telescoping, including simocetids and xenorophids, and a diverse assortment of odontocetes showing advanced stages of telescoping. Additional PCs represent posterior expansion of the maxilla (PC2; 11%), position of the external nares (PC3; 9%), and position and size of the nasals (PC4; 4%). Our analysis indicates an unusually high degree of cranial diversity within the Oligocene with taxa showing primitive (toothed mysticetes), intermediate (simocetids and xenorophids), and advanced telescoping (agorophiids and waipatiids). Furthermore, when telescoping is traced onto a recent odontocete phylogeny, advanced telescoping either evolved at least twice, once in agorophiids and again in the lineage including waipatiids and all later diverging whales, or evolved once but was later lost in simocetids. Further analyses will expand our sampling of fossil taxa as well as incorporate data on extant whales to determine how telescoping impacted other aspects of cranial development, including modularity and asymmetry.

Grant Information
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Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

IN SITU FOSSIL VERTEBRATE EXHIBITS (ISFVE): A GLOBAL SURVEY OF THEIR DIVERSITY AND APPROACHES TO THEIR PROTECTION AND PRESERVATION

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Museums have been the bedrock of paleontological education and research since the earliest days when fossils were exhibited in cabinets of curiosities. While traditional museums are a powerful way of educating the public about paleontology, such fossils are seen removed from the context of their burial. Beginning in the 1950s at Dinosaur National Monument, a new approach was taken where fossils were exposed but left in situ and interpretation and research was built up around them in an enclosing building. Earth scientists perform research on ISFVE and their sedimentary context that is otherwise difficult to conduct from maps and field recorded data. Such sites will remain intact and preserved for any new research methods. Visitors, seeing the remains of ancient animals just as they were entombed, have a profound personal encounter with ancient life and deep time.

To date we have identified ~100 in situ fossil sites around the world, >50% containing vertebrates. These range from a few bones to mass accumulations of skeletons. All are in bas-relief, often extensively exposed. Fossil bones are especially vulnerable to weathering, erosion, vandalism, and theft and are enclosed within a shelter, usually a building. Most occurrences are in horizontal beds although some dip up to 60°.

Vertebrate traces are the most common ISFVE. One site preserves *Daemonhelix* burrows but most trace fossils ISVFE are trackways, usually of dinosaurs. Many sites are uncovered, some are protected by fences and open sided shade structures, and a few enclosed within buildings. Bedding orientation ranges from horizontal to near vertical. Some large trackway sites are accessible for research only through the use of climbing gear. The immense dinosaur track site Cal Orck'O in Bolivia is continually being damaged by collapse of softer layers.

Extreme measures are sometimes needed to protect the fossils. Because of weathering, the fragile Laetoli *Australopithecus* trackways were ultimately reburied. Chauvet Cave holds extensive 35 ka old Paleolithic cave art and cave bear skulls, skeletons, and tracks. To protect the art, the original cave was closed to the public, LiDAR imaged, and replicated in fiberglass several km away. The cave bear bones were molded and casts placed in the appropriate place in the "new cave."

All ISFVE face complex issues of conservation and preservation, such as crack growth, spalling of rock surfaces, overall stability, aging of consolidants and adhesives, and theft and vandalism. However, these threats are greatly amplified for ISFVE that are not within a building.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

ANALYSIS OF VENTILATORY RIB KINEMATICS VIA XROMM IN THE SAVANNAH MONITOR, *VARANUS EXANTHEMATICUS*: IMPLICATIONS FOR COSTOVERTEBRAL JOINT EVOLUTION IN SQUAMATES.

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Squamates use aspiration breathing, driving air into their lungs mainly by using costal expansion to generate negative internal pressures. Because squamates use lateral undulations to locomote, rib motions are thus responsible for both ventilation and locomotion in these animals. The vertebral ribs are single headed, permitting three degrees of rotation between the ribs and vertebral column. In this study, X-ray Reconstruction of Moving Morphology (XROMM) was used to quantify the three dimensional rib rotations in 3 individuals of *Varanus exanthematicus,* which are typically described as bucket-handle rotation about a dorsoventral axis, pump-handle rotation about a mediolateral axis, and caliper motion about a rostrocaudal axis. During deep breathing in standing and prone lizards, we found rib motion to include a mixture of bucket and pump handle motions. Although the vertebral ribs did not deform during ventilation or translate substantially relative to the sternal ribs, a thin segment of the sternal ribs deformed during each breath. Compared to standing breaths, the sternum and vertebral column move around a more acute angle during prone breaths, and the vertebral ribs exhibit a greater degree of bucket handle rotation in prone breaths compared to standing. These differences in kinematics between breaths during different postures may help to explain the evolution of unrestrictive costal joint anatomies in Squamata, as the joint design must permit variations in ventilatory and locomotor motions under different conditions and postures. We found most of the ribs of *V. Exanthematicus* to move during ventilation, unlike in iguanas. This difference in ventilatory strategy may reflect

differences in endurance, locomotor strategies, or lung designs between *Iguana* and *Varanus*.

Technical Session XI (Friday, October 28, 2016, 11:30 AM)

THE SABERTOOTH SALMON, *ONCORHYNCHUS RASTROSUS*, GETS A FACELIFT

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Oncorhynchus (*Smilodonichthys*) *rastrosus* was first named for its incredible premaxillary dentition. Each premaxilla bears an enormous conical tooth, originally reconstructed as canine-like and ventrally directed. However, this giant prehistoric salmon was mistakenly identified as saber-toothed. New, exceptionally preserved specimens from an unnamed latest Miocene or earliest Pliocene deposit in Central Oregon indicate that the premaxillary bones and their enormous dentition were directed laterally rather than ventrally; a feature never observed in any other salmonid. The result is a configuration akin to horns rather than fangs. Here we describe new observations on these additional fossils and contrast them to other Miocene specimens, as well as to modern Eastern Pacific species of *Oncorhynchus*. Newly discovered morphology includes the presence of accessory dentition on the premaxilla, posterior to the massive premaxillary horn, which is significantly smaller. There is no visible kype on the dentary. On the dentaries, the only teeth are minute, laterally directed and at the mesial ends. These observations, plus the inland freshwater locality and their skeletal maturity imply that these were upstream migratory fishes preparing to spawn. Yet it appears that the metamorphosed spawning morphology observed in modern species is not present. It is probable that some tooth resorption occurred given the paucity of teeth along the dentary, but the lack of outward evidence of a kype may imply a different strategy for indicating mate dominance. The elaborate premaxillary horns may have aided in fights for space or improved the ability to shovel gravel while making redd nests. Alternatively, the lateral teeth may have improved substrate contact allowing the fish to maintain position in stream environments. A preliminary likelihood analysis of a morphological character matrix with recoded dental characters continues to place *O. rastrosus* as a derived pacific salmon, most closely related to sockeye (*O. nerka*), but with an additional suite of autapomorphies.

Technical Session III (Wednesday, October 26, 2016, 4:00 PM)

IMMINENT COLLAPSE RESOURCE RELEASE HYPOTHESIS–EVIDENCE FOR A RAPID PRE-EXTINCTION PHENOTYPIC SHIFT IN BODY SIZE IN THE DODO

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The disappearance of the dodo (*Raphus cucullatus*), a large flightless columbid bird once endemic to the island of Mauritius, is one of the most widely recognized instances of human-induced extinction. However, surprisingly little is known of the biology and extinction of the dodo. We hypothesize that before human contact (preHC), dodo populations were at carrying capacity and dodos had attained optimal preHC body sizes, and that after human settlement in the 17th century, strong predation by introduced invasive species such as rats on eggs and juveniles rather than on adults increased the amount of resources per capita for surviving dodos. This provides a scenario for a counter-intuitive increase in body size and likely other potential health indicators in surviving members of a population that experienced rapid collapse during the less than 100 year period between human settlement and dodo extinction.

We selected 953 well-preserved elements for morphometric study out of approximately 2,000 preHC skeletal remains from the Mare aux Songes, a 4,200 yr old fossil concentration Lagerstätte. Two-step cluster analysis of up to 20 skeletal measurements, including length and mid-shaft circumference of the femur, tibiotarsus and tarsometatarsus, indicate the presence of two distinct size classes of near-equal numbers in preHC dodos, which we interpret as sexual dimorphism. Statistical comparison with all known post-human-contact (postHC) hind limb remains (n=3) shows that postHC specimens are significantly larger than preHC remains (asymptotic P value <0.007; Monte Carlo P value <0.002). The conservative reconstructed length of one postHC tarsometatarsus is more than 5 standard deviations larger than the mean large preHC morph. Power analysis supports the validity of the observations for the effect size observed.

To explain the large size of postHC remains we postulate that dodos experienced a rapid (<100 years) positive phenotypic shift in body size after the arrival of humans due to 'imminent collapse resource release.' Our hypothesis contrasts with rapid phenotypic reductions in body size recorded in extant vertebrate species, typically associated with predation and human-induced ecosystem disturbance.

Grant Information
National Science Foundation DBI 0743327

Technical Sesssion X (Friday, October 28, 2016, 10:15 AM)

A NEW NEOSUCHIAN CROCODYLIFORM FROM THE EARLY CRETACEOUS OF MEXICO PRESERVING A STERNUM, AND THE RELATIONSHIPS OF *ISISFORDIA* AND *SUSISUCHUS*

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A new neosuchian from fine-grained limestones in the Early Cretaceous (middle to late Albian) Tlayua Formation at Tepexi de Rodrígues, Puebla, Mexico is represented by two mostly complete skeletons. One is in articulation; the other is mostly disarticulated except for the skull. The latter specimen has been completely prepared using acetic acid. The rostrum of the new taxon is relatively long and flat with confluent, pear-shaped external nares, similar to those of *Isisfordia* (Albian–Cenomanian of Australia) and *Susisuchus* (early Albian of Brazil). The choana is bordered anteriorly by the palatine and thus lacks the pterygoid participation typical of eusuchians, and the vertebrae are amphiplatyan although some cervicodorsals have a very gentle posterior condyle with a concavity in the center.

The articulated specimen preserves nearly the entire sternum, the first record of a well-preserved sternum in a Mesozoic crocodyliform. Surprisingly, the elements of the prosternum and mesosternum are all bilaterally paired, unlike the single elements of extant crocodylian and adult birds but similar to non-avian dinosaur sternae. This may be related to the shorter coracoid and relatively lower glenoid fossa in the new neosuchian and non-avian dinosaurs, however other amniotes with short coracoids have unpaired sternae.

Phylogenetic analyses place the new taxon in relatively basal positions within Neosuchia along with *Isisfordia* and *Susisuchus*, following rescoring of the latter taxa based on examination of the holotypes by AHT. Previously *Isisfordia* was hypothesized as the most basal eusuchian and *Susisuchus* as the sister-group to Eusuchia. Parsimony analysis places these three taxa as paraphyletic at the base of a clade including hylaeochampsids but outside a clade including eusuchians, paralligatorids and goniopholids. Bayesian analysis instead places the three Early Cretaceous taxa in a clade that is sister to a clade including goniopholids, paralligatorids, hylaeochampsids and eusuchians. This result is similar to the previously published parsimony analyses following the re-examination of *Isisfordia*. However, for both of the present analyses support is weak among basal neosuchian clades.

Grant Information
NSF DEB 1257485 to AHT

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

PALEOENVIRONMENTS AND DEPOSITIONAL HISTORY OF THE SAUROPODOMORPH FAUNA FROM THE TRIASSIC–JURASSIC LEBOMBO-TSHIPISE BASIN OF SOUTH AFRICA

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The sauropodomorph fauna of the Triassic-Jurassic Elliot formation of South Africa's main Karoo Basin has undergone a taxonomic renaissance in recent years. Major investigations have reclassified the wastebasket taxon '*Euskelosaurus browni*' into several currently diagnosable genera. Furthermore, recent revision of the stratigraphic relationships of many of these taxa has challenged the concept of a more morphologically and taxonomically diverse assemblage of sauropodomorphs in the lower Elliot than the 'depauperate' Early Jurassic upper Elliot Formation. The latter formation is typically known for abundant remains of smaller-bodied, gracile sauropodomorph taxa such as *Massospondylus*. One explanatory model for these faunal differences in the Main Karoo Basin is linked to a depositional change from pedogenic floodplains of meandering rivers in the lower Elliot to more arid, flash-flood dominated fluvial systems in the upper Elliot.

Our recently conducted research in the neighboring and partially contemporaneous Lebombo-Tshipise Basin has found nodular mudstones, fine-grained silt and numerous paleosols. This confirms that the paleoenviromental trends in the Triassic–Jurassic deposits of the main Karoo Basin are geographically more widespread than previously established. Our project also recovered new fossils of sauropodomorph dinosaurs. Fossils from the same localities were assigned to the now invalid '*Euskelosaurus browni*' in 2001, but our preliminary comparative work indicates this find represents either a new species of sauropodomorph, or informative but currently unknown elements from a known species. Of primary interest is a volumetrically large, yet relatively elongate first metacarpal that suggests a more plesiomorphic manual morphology than any previously named Elliot Formation taxon. In presenting a morphological intermediary between the relatively plesiomorphic manual architecture of, e.g. *Plateosaurus*, and that of the large-bodied sauropodiform taxa typical of the Elliot Formation, this element sheds light on the timing of the major proportional changes of the sauropodomorph manus. These findings thus have bearing on the stratigraphic appearance and relative prevalence of the varied locomotory strategies that characterize Sauropodomorpha at the Triassic–Jurassic boundary.

Grant Information
DST-NRF Centre of Excellence in Palaeosciences

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

GLOBAL DIVERSITY PATTERNS OF LEPIDOSAURIA FROM THE TRIASSIC-OLIGOCENE: WHAT CAN THEY TELL US ABOUT THE LONG-TERM EVOLUTIONARY HISTORY OF THE CLADE?

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Lepidosauria is a successful extant clade represented by Squamata (lizards and snakes; >10,000 species) and the now-relictual Rhynchocephalia (tuatara; 1-2 species). It has a long evolutionary history beginning in the Triassic, and is represented by a vast array of fossil taxa, but long-term patterns of diversity have yet to be assessed, particularly in the terrestrial realm.

This study examines the diversity of terrestrial lepidosaurs, ranging from the Triassic-Paleogene (252-23 Ma), on genus-level occurrence data (1504 specimens representing 374 genera) obtained from the Paleobiology Database. In order to 'correct' for biases associated with face-value taxon counts, shareholder quorum sampling (SQS) is used to generate a diversity curve.

At substantial quorum levels (>0.5), a low Late Triassic diversity declines across the Triassic-Jurassic boundary. A decline is also observed across the Jurassic-Cretaceous boundary, but this is lost at higher quorum levels. A substantial high level of diversity is found for the Campanian, but this drops sharply into the Maastrichtian. A rise post-Cretaceous represents recovery from the K-Pg mass extinction, and this continues into the first half of the Eocene. Diversity falls again in the Late Eocene, but improves in the Oligocene (though not as strongly at higher quorum levels); this may represent the turnover event known as the "Grande Coupure".

The SQS results here are for a global lepidosaur record, however, and may not represent the state of diversity on individual continents. Data is highly skewed, with 40% of the specimens originating from the USA, a clear indicator of sampling bias. In addition, the majority of occurrences are from the Campanian-Maastrichtian and the Eocene (~60%) which may represent genuine high diversity or collector bias. It is important to therefore study diversity at a regional level, particularly to examine differential effects of extinction events on multiple continents.

Grant Information
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Symposium I (Wednesday, October 26, 2016, 8:45 AM)

BEYOND THE SEQUENCE: UTILITY OF PROTEIN MODIFICATIONS IN FOSSILS

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Although primary sequences, especially from DNA, have been used extensively in ancient molecular studies to investigate phylogenetic hypotheses, recent advances in mass spectrometry have led to a revolution in ancient protein (paleoproteomics) research. Proteins show a great diversity of modifications that significantly alter their structure and function, which have important implications for the biological systems of the organisms that produce them. These modifications occur post-translation, and can therefore only be detected through measurement of the protein itself and cannot be predicted from DNA sequence of the organism, or even primary sequence of the protein. Although these post-translational modifications (PTMs) can provide a wealth of information, proteins derived from fossils present an added dimension of difficulty in interpretation, in that these in vivo PTMs must be differentiated from alterations protein molecules incur from interaction with the burial environment; i.e., diagenetic molecular modifications. Few diagenetic changes have been characterized, despite decades of studies into protein preservation, because amino acid analyses use harsh treatment conditions that destroy most PTMs and can provide limited data on protein changes in the fossil record. Alternatively, examination of proteins at the peptide level with mass spectrometry permits the detection of PTMs that are typically lost during treatments for amino acid generation, allowing in vivo and diagenetic protein modifications to be distinguished. Here, we characterize proteins extracted from a relatively recent moa (~1000 years old; gen. sp. indet.; MOR OST-255) and a Pleistocene *Castoroides ohioensis* (NYSM VP-47), in which we detect both in vivo modifications (e.g., hydroxylation of proline, glycosylation) and modifications derived from diagenesis (e.g., protein truncation, dehydroxylation of proline). These two, relatively young specimens, provide a baseline for modifications we may expect to observe in protein sequences derived from older specimens.

Grant Information
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Technical Session IV (Wednesday, October 26, 2016, 3:30 PM)

HOW MUCH KELP COULD A SEA COW EAT? IDENTIFYING CARBON SOURCES TO SIRENIAN DIETS THROUGH AMINO ACID STABLE ISOTOPE FINGERPRINTING

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The discovery of Steller's sea cow (*Hydrodamalis gigas*) during the mid 18th century marked the first documentation of a species of sirenian inhabiting high latitude, kelp-dominated waters. This habitat preference suggested that the ecology, as well as the physiology, of *H. gigas* was radically different from that of all other extant sirenians, which are restricted to tropical/sub-tropical seagrass meadows and freshwater ecosystems. Unfortunately, the quick extermination of *H. gigas* by human hunting wiped out any chance for thorough scientific study of this unique marine mammal. Observations of kelp consumption made by Wilhelm Steller and other explorers suggest that kelp was part of the animal's diet, but identifications and descriptions of plants ingested by these animals are open to interpretation, leaving much doubt as to whether sea cows actually were significant kelp consumers.

We assessed the contribution of kelp to the diet of *H. gigas* by analyzing carbon isotopic composition ($\delta^{13}C$) of essential amino acids (EAA) in bone collagen. EAA are ideally suited as source tracers because sources that biosynthesize EAA—bacteria, fungi, vascular plants and algae—each have source diagnostic $\delta^{13}C$ EAA patterns or fingerprints. These fingerprints remain largely intact during trophic transfer because animals cannot biosynthesize EAA. Within aquatic primary producers, $\delta^{13}C$ EAA fingerprints can discriminate marine kelp from seagrasses, freshwater plants, and other macroalgae.

We sampled bone collagen from three species of sirenian—*H. gigas* (n = 7), *Trichechus manatus* (Florida manatee, n = 6), and *Dugong dugon* (Australian dugong, n = 3)—and compared $\delta^{13}C$ EAA fingerprints from these samples with those recovered from representative samples of modern kelp, other macroalgae, seagrasses, and freshwater plants. Specimens of *H. gigas* included historic material from the Commander Islands in the Bering Sea (~200 years old) and fossil material of late Pleistocene age from Monterey Bay, California. Using multivariate classification methods, we found $\delta^{13}C$ EAA fingerprints of *H. gigas* matched those of kelp, fingerprints for *D. dugon* grouped most closely with seagrass, and fingerprints for *T. manatus* were split between those grouping with seagrasses and others that clustered with freshwater plants. Our results suggest *H. gigas* was an important consumer within the kelp ecosystems that flourished along the North Pacific coastlines, and that this species favored kelp species over other producers available within these ecosystems.

Technical Session V (Wednesday, October 26, 2016, 2:30 PM)

CONTROLLING FOR THE SPECIES-AREA EFFECT REMOVES LONG-TERM DIVERSITY TRENDS IN MESOZOIC TERRESTRIAL VERTEBRATES

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Approximately half of the ~65,000 known species of extant vertebrates live on land. Whether this spectacular species richness (=diversity) arose via bounded or unbounded diversification processes remains controversial, with the dominant expansionist model positing exponential increases in standing diversity from the origin of tetrapods (~360 Ma) to the present day. However, a recent study applying sample-standardisation to Mesozoic–early Paleogene fossil occurrences contradicts this view, indicating at most a doubling of non-flying tetrapod diversity during the Mesozoic, despite the initial origins of hyper-speciose modern groups among squamates and mammals.

The species-area effect is one of the most pronounced and best-known macroecological scaling patterns, and plays an underappreciated role in biasing species richness estimates in the fossil record. Difficulty distinguishing between 'common cause' and 'record bias' hypotheses means that post-hoc corrections of richness estimates based on geographic spread cannot be applied with confidence. To resolve these issues, we applied equal-coverage subsampling (SQS) and another recent method (TRiPs) to the Mesozoic–early Paleogene dataset, in order to estimate the diversities of penecontemporaneous subsets of fossil collections representing fixed palaeogeographic spreads of 4,500 km (minimum spanning tree size). This approach ensures that spatial sampling remains constant over time and between geographic regions.

This procedure has a striking effect on estimated diversity patterns, revealing an essentially flat diversity trajectory, with standing diversity almost unchanged between the start of the Late Triassic and end of the Cretaceous. This analysis confirms an apparent increase in diversity across the K–Pg boundary, representing an abrupt quadrupling of diversity, although this increase may at least in part be an artefact of the greater diagnosability of Cenozoic mammalian taxa. Our results provide strong evidence for bounded diversification of non-flying Mesozoic tetrapods, and suggest that equilibrium levels were reset at a higher level in the aftermath of the end-Cretaceous extinction.

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Technical Session IX (Thursday, October 27, 2016, 3:15 PM)

RATES OF PHENOTYPIC EVOLUTION DURING THE FISH TO TETRAPOD TRANSITION: THE ELPISTOSTEGALIAN FAST-LANE

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Repeatedly during the evolution of life, the origin and early radiation of major clades have been preceded by periods of high rates of phenotypic evolution. The origin of tetrapods represents one of these major clades in early history of vertebrates. Over a period of approximately 90 million years, stem-tetrapod fishes have evolved from generalized aquatic sarcopterygian fishes to semi-aquatic or continental tetrapods. Structural disparity, body size increase, and morphofunctional changes related to this ecological shift paramount this transition. However, evolutionary tempo and modes have never been addressed comprehensively with this transition. Incorporating new morphological data from the first complete specimen of the elpistostegalian *Elpistostege watsoni,* from the Late Devonian Miguasha site in Quebec, Canada, we applied new Bayesian morphological clock approaches (BEAST 2) on 105 tetrapodomorph species coded for more than 420 characters to infer rates of anatomical changes along the stem-tetrapod lineage. During the Middle–Late Devonian, over a period of approximately 15 million years, two distinct events of increased phenotypic rates preceded the radiation of tetrapods: the first one is associated with the origin of elpistostegalians, while the second one corresponds to the origin of tetrapods itself. In contrast to a similar analysis on the origin of birds, which showed the dinosaur-bird transition occurring at the end of a long period of rapid evolution on the stem lineage, the elevated rates of evolution across the fish–tetrapod boundary are sudden and unprecedented.

Symposium II (Friday, October 28, 2016, 10:30 AM)

ALL CHANGE? PAIRED FINS AND THE NEW PHYLOGENIES OF EARLY GNATHOSTOMES

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The emergence of stable numbers, positions, and patterns of paired appendages is integral to both evolutionary and developmental origins of gnathostome body plans. Since 2009, a series of groundbreaking phylogenetic analyses have overthrown long-established ideas about the interrelationships of early, jawed vertebrates. From the

resultant string of superseding hypotheses, a new consensus has emerged, albeit weakly supported. This novel solution to questions about memberships of chondrichthyan, osteichthyan, and gnathostome stem lineages, provides a significantly revised phylogenetic context within which to test old and new ideas about paired fin evolution. Arguably, the outstanding features of the new trees are the transformed relationships of 'placoderms' and 'acanthodians'. Hypothesized 'placoderm' paraphyly and the discovery of post-pelvic claspers in multiple subclades suggests that several of the earliest jawed vertebrates had a constraint-breaking (or pre-constraint) three sets of paired appendages instead of the usual two. 'Acanthodians', well known to bear intermediate finlets along the flanks of many taxa, now appear to be exhibiting a derived condition restricted to a subset of chondrichthyan stem lineage genera. Consequently, fossils and phylogeny appear to be increasingly distant from Balfour's (or Thacher's or Mivart's) continuous lateral fin fold model, and, similarly, there is no pressing need to resurrect Owen's archipterygium or Gegenbaur's gill arch theory. However, trends from large-scale reviews of the sequence of vertebrate fin evolution seem to survive: midline fins precede paired fins, pectoral fins precede pelvics, and the dermal skeleton of fins (or keels) precedes an endoskeletal fin. Here we show that the predictive content of this seemingly robust result is limited. Recent analyses of second dorsal fin origin and diversity in teleosts demonstrate that patterns of skeletal character evolution in fins can be much more varied; that multiple paths are used to achieve similar morphological solutions. Finally, attention is drawn to the barely documented evolutionary history of actinopterygian pectoral fins, presenting new data on at least some of the likely conserved and derived patterns manifest in the model appendicular system(s) of *Danio*.

Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

MORPHOMETRICS ON A SMALL SCALE: USING SHAPE TO ASSIGN ISOLATED FOSSIL GAR SCALES TO SPECIFIC BODY REGIONS

COATS, Justin G., University of Wisconsin - Parskide, Glasford, IL, United States of America; NOTO, Christopher R., University of Wisconsin-Parkside, Kenosha, WI, United States of America

Isolated gar scales (Family: Lepisosteidae) are abundant in fossil deposits around the world, yet little is known about variation in scale morphology within individual gar or between taxa. Geometric morphometrics was used to assess scale shape variation to assign isolated scales to specific body regions and study potential taxonomic differences in shape.

A sample of 152 scales were removed from a preserved modern specimen, representing three body regions relative to the pectoral, pelvic, and anal fins. These are compared to a fossil sample of 190 fossil gar scales from the Late Cretaceous (Hell Creek Formation) and Eocene (Green River and Washakie Formations). An outline of 75 semi-landmarks were placed on digital photos using tpsDig, and analyzed with MorphoJ and Past3.

Principal Components Analysis shows that scale depth, length of the anterodorsal process, elevation of the dorsal peg, and degree of roundness explains 82% of the variation in morphology. Multivariate analyses show significant differences between the three body regions. Dorsal and lateral line scales are similar to each other, but both groups differ significantly from ventral scales, though this disparity dissolves as we progress caudally. Most fossil scales fall within the three body regions in modern gar, enabling specific anatomical locality assignment of isolated gar scales. Some differences in scale morphology between different times and localities indicate recognizable taxonomic variation exists, however further work is needed to confirm this. This method demonstrates that geometric morphometrics is useful in paleobiological studies on microsites where dissociated fish fossils are found in abundance. The assignment of isolated scales to specific body regions can aid in taxonomic identification and address broader microsite taphonomic questions.

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University of Wisconsin–Parkside: URAP Grant

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

MUSEUM ON THE MOVE: A FRAMEWORK FOR INCREASING SCIENTIFIC UNDERSTANDING THROUGH INQUIRY-BASED LEARNING

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The Natural History Museum of Utah's (NHMU) Museum on the Move program provides students across the state of Utah with a hands-on, inquiry-based learning experience with museum specimens. The program has been developed over two decades, and is tailored to support the fourth grade Utah Science Core curriculum, with each class visited being part of group investigations into one of four subjects: Utah's Fossil Past, Animal Adaptations, Rocks & Minerals or Archaeology. Each class takes part in a 90 minute session, facilitated by NHMU educators, exploring the scientific method, facts & inferences, and recording techniques. The students are tasked with researching the above topics, and are encouraged to discuss and debate research questions with their classmates using observations of 50+ museum specimens.

The Museum on the Move program is currently in its 20th Year, and continues to grow annually. Through funding provided by the Utah State Office of Education and the Utah State Legislature, the museum is able to visit every elementary school with 4th grade students in Utah over a three year rotation. Title I and schools in rural areas are visited every two years. As part of the NHMU's efforts to increase participation and identification with science in the communities of the western half of the Wasatch valley, 123 schools in this area are visited every school year. The program routinely visits over 24,000 students annually, with educators collectively travelling 25,000 miles over the course of a school year to visit over 300 schools, and around 1000 classrooms. Teacher feedback provided from each of these classroom visits demonstrates that most students in the outreach program are asking questions, sharing observations with one another, and engaging in scientific discussions—all key signifiers of active learning.

Here we present the scope of Museum on the Move's outreach during the 2015–16 school year, and its plans for further growth and development. We also present the framework for the program as an easily customized, scalable outreach plan for other institutions to implement and tailor for their local curriculum and students.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

DINOSAURS AS BIOCHRONOLOGICAL MARKERS IN THE EUROPEAN TITHONIAN–BERRIASIAN TRANSITION

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Dinosaur fossils are significant biochronological markers in facies that lack more accurate paleontological data, and can provide control of the geological age of these rocks. For example, the distribution of faunas of specific dinosaurs and their relationships to different types of rocks were used to define various members of the Cedar Mountain Formation in USA or to suggest a Cretaceous age (and not Jurassic) of some facies by the presence of ankylosaurs (most abundant in the Cretaceous). A similar practice has also been carried out in the Villar del Arzobispo Formation (Kidmmeridgian-Berriasian) of Spain by the presence of stegosaurids and diplodocins. This formation is known for the discovery of important dinosaur fossils; however, many papers have assigned to this formation facies belonging to other formations of a more recent age. These include rocks from the El Collado Formation (Barremian) in the South Iberian Basin, and from Villanueva de Huerva and El Castellar formations (Valanginian-Barremian) in the Maestrazgo Basin.

Recent research highlighted this problem in the the Villar del Arzobispo Formation in the Riodeva area (Teruel), through the discovery of the eusauropod *Turiasaurus riodevensis*, diplodocin sauropods, the stegosaurid *Dacentrurus*, basal ornithopods, and megalosaurid, allosaurid and dromeosaurid theropods. The correlation of the stratigraphic and paleontological data regarding other surrounding areas has revealed significant inconsistencies for some of the facies age dinosaurs included previously in Cretaceous formations mentioned above. Thus, new evidence indicates that the presence of stegosaurids (abundant in the Jurassic) in the putative Hauterivian-Barremian and basal macronarians sauropods like *Aragosaurus* (with similar characters to *Lourinhasaurus* in the upper Kimmeridgian-early Tithonian from Portugal), are in fact equivalent to the typical faunas of the Villar del Arzobispo Fm. and are middle Kimmeridgian to Berriasian in age. This proves that in Spain, as in other European countries, the purported Berriasian dinosaur assemblages show a clear Late Jurassic affinity. So, this seems to indicate that the drastic turnover of dinosaur fauna would be during the earliest part of the Early Cretaceous, and not in the Tithonian-Berriasian boundary.

Grant Information
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Technical Session XIX (Saturday, October 29, 2016, 3:15 PM)

EMERGENCE OF THERIAN MAMMAL GROUPS IN THE LATE CRETACEOUS OF NORTH AMERICA: NEW EVIDENCE FROM THE TURONIAN OF UTAH

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Cenomanian assemblages document the presence of basal metatherians in North America; eutherians, possibly represented in the Aptian–Albian, definitively appear by the late Santonian–early Campanian Aquilan North America Land Mammal Age (NALMA), where they are found together with advanced metatherian groups. Knowledge of mammals from the intervening Turonian (~91 Ma) of North America is substantially increased by new fossils from the Smoky Hollow Member of the Straight Cliffs Formation, southern Utah. The therian assemblage highlights a changing mammalian fauna and the emergence of taxa with close affinities to Late Cretaceous genera. The Smoky Hollow fauna bridges a gap between well-sampled faunas from the earlier Mussentuchit local fauna (Cenomanian) and the later Milk River and Eagle Formations (Aquilan). Elements of the fauna include the earliest record of identified eutherian clades in North America, as well as stagodontid, "pediomyoid" (?*Aquiladelphis* sp.), and alphadontid marsupialiforms. Of particular interest is the first appearance of advanced eutherians and possible placentals, as well as the presence of two stagodontids with divergent premolar morphology. These two new taxa share specializations seen with the Judithian NALMA sectorial stagodontid, *Eodelphis*, and the crushing stagodontid, *Didelphodon*, which document the rise of important dietary specializations found among Late Cretaceous mammals. As of now, it is unclear whether the similar morphologies represent a phylogenetic signal or homoplasy. ?*Aquiladelphis* sp. appears to be basal to the later well known species from the Aquilan, with plesiomorphic conditions such as its smaller size and less prominent stylar cusp C. The small alphadontids (ca. five species) appear to be morphologically similar to those present in the Aquilan of the Milk River and Eagle Formations. Overall, the new occurrences extend back the first appearance of these groups, suggesting that elements of the Late Cretaceous mammal fauna were present much earlier than previous evidence suggested. The appearance of advanced taxa may have resulted from in situ radiations (marsupialiforms) or an immigration event (or events) (eutherians).

Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

CHEMICALLY CHARACTERIZING THE DIAGENETIC ALTERATION OF BIOMOLECULES IN PROBOSCIDEANS

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Organic molecules are altered in vertebrate fossils during diagenesis and an understanding of how these molecules change is necessary in order to make

interpretations regarding the original organism. Original organic molecules, including DNA and amino acids, have been described in mammoth fossils. However, little is known about the degradation of organic molecules and how this varies in different depositional settings. Proboscideans (elephants, mammoths, and mastodons) have a good fossil record from a number of different depositional environments, including natural asphalt, sinkholes, and permafrost. In order to chemically characterize the preservation of organic material in bone, we analyzed modern, experimentally matured, and fossil specimens of proboscideans dating back ~55,000 years. Time-of-flight secondary ion mass spectrometry (TOF-SIMS) was used to identify and compare amino acids in fossil and modern elephant samples. TOF-SIMS preserves the surface of the sample and can, therefore, be used to analyze the spatial distribution of the amino acids in different areas of the fossil bone and variations in the rock matrix. Seven amino acids were detected in all the fossil samples and were absent in the sediment control samples. Additional amino acids were present in some fossils but absent in others. However, TOF-SIMS fragments molecules during data collection, creating the need to quantify fragmentation in order to make predictions regarding biomolecule presence and breakdown products. Therefore, amino acid fragments were also identified in the modern and fossil samples. Experimental maturation using a range of temperature and pressure variables was used to approximate diagenesis. Analyses were done for 24 hours at 100°C, 200°C, and 250°C on modern elephant bone. Seventeen amino acids found in modern bone were present in the samples matured at 100°C, but only five amino acids were still present in the elephant bone that was matured at 250°C. Additionally, amino acid fragments were identified using TOF-SIMS in all matured samples. Proboscideans are an ideal study group of fossils with an established record of organic preservation (i.e., aDNA, amino acids) enabling the development of methods to detect original organic material present in fossil bone, to quantify the variation between depositional environments, and to chemically characterize the biomolecules present. Based on our findings from the maturation experiments, amino acids may degrade in fossils in a predictable manner.

Grant Information
The Palaeontological Association, Stan Wood Award; Dr. Larry Agenbroad Legacy Fund for Research

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

THE ARLINGTON ARCHOSAUR SITE IN YOUR CURRICULUM—USING THE FOSSIL RECORD TO TEACH ACROSS THE SCIENCE DISCIPLINES

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The Arlington Archosaur Site (AAS) is a rare ongoing urban excavation located within the large Dallas-Fort Worth, Texas metropolitan limits. This unlikely location provides unique opportunities for public outreach, and offers educational opportunity for underrepresented groups in science as well as the general public. The AAS occurs within the exposed mid-Cretaceous Woodbine Formation and preserves a Cretaceous deltaic plain coastal ecosystem. The site shares the land with developers that appreciate its spectacular natural history and are assisting in its preservation. Researchers and volunteers continue to discover the fossil remains of dinosaurs, crocodiles, turtles, fish, lungfish, lizards, plants, and other yet to be named species members of an ancient coastal ecosystem. It is important to note that little scientific data from this time period (95 Ma) is currently known therefore, research from the AAS continues to fill in many missing gaps in the fossil record of mid-Cretaceous systems. Proximity to large cities along with their diverse populations, many educational institutions, and museums allow the AAS to be a handy resource for education and a point of interest to the community and public at large. Many educators fully realize the teaching potential of such a locality but struggle to use these local resources in their classrooms due to already over filled curriculum and time constraints in the average school day, which nearly eliminate possibilities for enrichment, field trips, and exploration of subjects that engage reluctant learners. So, how does an educator teach paleontology when it is not in the required curriculum or standards? Teach the past alongside the present! Most scientific disciplines parallel the fossil record and paleontological principles can apply to most lessons with a little creativity. For example, if studying food webs include at least one ancient ecosystem scenario using engaging predators, prey, and niches along with modern day examples. Elaborate on animal adaptations by including a few aquatic and terrestrial dinosaur adaptations that are well suited for their environment. Paleo Bellringers and Warm Ups are a consistent theme and offer some diversion to engage students. Consider using easy to identify microfossils (shark teeth) in matrix to practice microscope skills and other lab processes that are essential to every science curricula. There are many fun and engaging ways to include paleontology in today's classrooms that promote lifelong learning while achieving local and national standards.

Technical Session II (Wednesday, October 26, 2016, 8:45 AM)

FRAGMENTARY (AND COMPLETE) FOSSILS HELP RECONSTRUCT MONITOR LIZARD (SQUAMATA, VARANIFORMES) BIOLOGY AND EVOLUTION

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Varanidae (monitor lizards) includes a vast array of ecologically, morphologically, and genetically distinctive radiations dating back to the Late Cretaceous. *Varanus* proper spans more than four orders of magnitude in body size and includes more than 70 extant species constituting a majority of known varanid diversity. Numerous fossils of variable completeness have been referred to Varanidae. Although some of those have been criticized as non-diagnostic at the species level, phylogenetic analyses may help to place them within the 'family' or elsewhere within Varaniformes. We performed a combined genotype-phenotype analysis of 87 varaniforms (including 30 fossils), for 'necrosaurs,' lanthanotines, varanines, and basal taxa representing all of the putative modern radiations. Our analysis includes 485 morphological (skeletal, hemipenial, musculoskeletal, and other) characters, and mitochondrial and nuclear DNA. *Necrosaurus*, a 'telmasaurid' clade, and *Ovoo* were found to be successively more proximal varanid outgroups. Seven major varanid radiations were recovered, including lanthanotines, a *Saniwa* radiation, *Polydaedalus*, two Indo-Asian clades (IAC-A and IAC-B), and a large-bodied and a small-bodied Australasian clade. Our analysis confirms that some of the fossils are not diagnostic at the species level and are highly volatile within the cladistic topology (e.g., '*Varanus*' *hoffmanni*). By contrast, '*Iberovaranus*' *catalaunicus* (not diagnostic to species) is a member the primarily African *Polydaedalus* radiation and demonstrates dispersal of that clade into Europe by the Miocene. The diagnostic *Varanus darevskii* is also a *Polydaedalus* rather than being close to *Varanus* (*Psammosaurus*) *griseus*, and offers the first evidence of *Polydaedalus* in West Asia. *Varanus amnhophilis* demonstrates the antiquity and western extension of IAC-A during the Miocene. Indeed, our analysis suggests that no fewer than 12 *Varanus* lineages were present by the Miocene. This, along with the absence of definitive *Varanus* prior to the Miocene suggests rapid diversification of the clade in the late Paleogene, with Varanidae appearing by the Late Cretaceous.

Technical Session IV (Wednesday, October 26, 2016, 2:15 PM)

HETERODONT CONFUSION: A LATE OLIGOCENE PUTATIVE KEKENODONTID FROM NEW ZEALAND WITH COMMENTS ON THE TAXONOMY OF *SQUALODON GAMBIERENSIS*

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Many fossil cetaceans are known from isolated triangular teeth with multiple denticles ('cusps'). Such teeth have sometimes been used as type specimens in spite of uncertainty about diagnostic features. The enigmatic *Squalodon gambierensis* is one example. This late Oligocene toothed whale (Gambier Limestone, South Australia) is known only from the holotype specimen: a single molariform tooth. The denticulate and double-rooted tooth is reminiscent of Eocene basilosaurid archaeocetes, but its small size, lateral compression, and smooth enamel were considered to indicate the odontocete *Squalodon*. Squalodontids are archaic echolocating heterodont odontocetes with a late Oligocene to middle Miocene record; no squalodontid reportedly has a tooth like that of *S. gambierensis*. Rather, a new late Oligocene putative kekenodontid (relict archaeocete) from New Zealand (OU 22023, Geology Museum, University of Otago) preserves nearly complete dentition including a posterior cheek tooth nearly identical in crown and root morphology to *S. gambierensis*. Each cheek tooth is double-rooted with a small isthmus below the cemento-enamel junction and is recurved. The tooth crowns are transversely compressed with a triangular profile in labial and lingual views, characteristic of posterior cheek teeth in early heterodont cetaceans. The tooth crowns bear a similar number of accessory denticles on the anterior and posterior edges of the crown, namely three and four, respectively. OU 22023 also includes a partial skull with the right periotic and left tympanic bulla, a partial left mandible, and various postcrania. The elements are morphologically similar to the only named kekenodontid, *Kekenodon onamata*, in addition to other putative kekenodontids. Phylogenetic analysis supports inclusion of OU 22023 within the Kekenodontidae, which also includes *K. onamata* and the putative kekenodontids OU 22294 and OU 22394, confirming the reclassification of *S. gambierensis* as a kekenodontid. *Squalodon gambierensis* represents the first known kekenodontid outside of New Zealand, indicating that at least one kekenodontid ranged widely in the southwest Pacific.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

A NEW ALLIGATOROID FROM THE EARLY PALEOGENE BLACK PEAKS FORMATION OF TEXAS

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A new alligatoroid from Paleocene (Tiffanian) deposits in the Black Peaks Formation of Brewster County, Texas, is established upon two specimens that bear similarities to *Bottosaurus harlani* from the Late Cretaceous and early Paleogene of New Jersey. This would extend both the geographic and stratigraphic ranges of *Bottosaurus* into the later Paleocene of the Western Interior.

The new form is based on two specimens of different size. The larger individual consists of a mostly complete lower jaw and portions of the skull as well as postcranial material consisting of isolated elements of the limb girdles, limbs, and numerous vertebrae. The smaller individual preserves a snout and posterior portions of the skull. Both specimens suggest an animal with a comparatively short, flat, broad snout. The teeth preserved in the lower jaw resemble those of *B. harlani*—mesiodistal carinae are present throughout the dental arcade and posterior teeth are mediolaterally compressed. Both forms have a prominent U-shaped depression on the frontal bone between the orbits, but the depression is much deeper in *B. harlani* than in the Black Peaks form.

A phylogenetic analysis was conducted using Winclada and TNT. The matrix included 117 crocodylian taxa and 191 characters. *Bernissartia fagesii* was used as an outgroup to root the trees. The Black Peaks form is highly labile in resulting optimal trees, but is always a caimanine alligatorid. This may reflect a lack of recovered elements preserving synapomorphies diagnosing more inclusive caimanine groups. A sister-group relationship with *Bottosaurus harlani* cannot be discounted. It is unrelated to other North American caimanines, such as *Tsoabichi greenriverensis*, which suggests a more complex early biogeographic history for the clade than previously thought.

Technical Session XII (Friday, October 28, 2016, 3:30 PM)

POSTURAL CHANGES AND KINETIC COMPETENCY IN THE PALATES OF BIRDS AND OTHER DIAPSIDS

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Cranial kinesis, or lack thereof, is a fundamental characteristic of birds and other diapsids. During the origin of birds, major changes in the palate occurred that afforded early birds their derived form of hypermobility. However, little is known about the loading environment and potential excursions of modern bird palates let alone those of avian ancestors. During a gape cycle, different kinetic behaviors require elements of the palate to change posture. Thus, static models of hypothesized kinetic postures can be used to evaluate models of joint excursion, cranial forces, and feeding behavior. Here we evaluate kinetic capacity in models of extinct dinosaur (e.g. *Tyrannosaurus*, *Edmontosaurus*) and extant taxa (e.g. *Gekko, Gallus*, *Psittacus*) of variably known kinetic capacities. We developed 3D finite element models emphasizing reconstructed hypothesized kinetic behaviors of the palate. Palates were repositioned by 5° to recreate three hypothetical postures: neutral, propalinal (fore-aft), and pleurokinetic (pleurokinetic). Jaw and protractor muscles were mapped identically onto different postural models. 3D moments about the palatobasal, otic and jaw joint axes were calculated using BoneLoad computational modeling approaches, muscle orientations were tracked in the different postures, and force propagation through the models were evaluated using finite element analyses. We found palatal posture greatly affects both muscle orientation and loading of the bones in our modeled taxa, validating expectations for propalinal and pleurokinetic behaviors in parrots and geckos respectively. Our findings suggest the palate of *Tyrannosaurus* was more optimally organized for propalinal excursions, whereas the palate of *Edmontosaurus* corroborated previous hypotheses of pleurokinetic movements. These comparative biomechanical approaches will lead to new ways of evaluating hypotheses of cranial function in dinosaurs and other vertebrates.

Grant Information
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Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

INSIGHTS INTO THE PALAEOECOLOGY OF SOUTHERN SOUTH AMERICA DURING THE NEOGENE USING THE STABLE ISOTOPE ANALYSIS OF MAMMALIAN TOOTH ENAMEL AND DENTINE CARBONATE

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The Neogene mammalian faunas of South America present a unique situation with a host of endemic species that evolved in almost complete isolation from the rest of the world. With the Great American Biotic Interchange (GABI), the endemic ecosystems were confronted with an invasion of non-endemic placental herbivores and carnivores. To better understand these ecosystems and the impact of the GABI, a carbon and oxygen stable isotope study on tooth enamel and dentine was performed on 439 specimens belonging to 83 taxa (80 specimens for the Miocene, 108 for the Pliocene and 251 for the Pleistocene). Overall their chronological range spans from the early Miocene to the latest Pleistocene and early Holocene epochs (15 to 0.01 Ma) corresponding to the Santacrucian, Colloncuran, Huayquerian, Montehermosan, Chapadmalalan, Ensenadan and Lujanian South American Land Mammal Ages. This study yielded the following insights into the structure of these ecosystems.

Isotopic ranges over time show only slight shifts in both endemic and invasive herbivorous mammals and exhibit large overlap between groups. This suggests that diffuse competition was the rule in southern South America. This is in contrast to the situation of Neogene ecosystems in Europe or North America where niche partitioning defined ecosystem structure. This prevalence of diffuse competition seems to persist in southern South America throughout the Neogene, before and after the GABI.

The Miocene sparassodont (metatherian) predators are clustered according to their habitat rather than based on specific prey species preference. During the Pliocene the sparassodonts appear to be pushed to the fringes of the predator isotopic space, while the newcomer placental procyonids mainly occupy an isotopic range that was held by the endemic carnivorous species during the Miocene, even if both predator types occupy a broad spectrum of habitat during the Pliocene. Although their contemporaneity is difficult to prove due to the poor resolution of the available data, both groups may have competed directly with each other. This could have been a factor affecting sparassodont extinction. During the Pleistocene, predatory placental mammals exhibit an isotopic distribution pattern similar to that of Miocene sparassodonts. This provides insights into the possibility of an ecological replacement of metatherian predators by placental predators and whether or not this replacement was related to morphological convergence.

Romer Prize Session (Thursday, October 27, 2016, 10:30 AM)

THICK MOLAR ENAMEL AND INCREASED CROWN HEIGHT AS AN ADAPTIVE SIGNATURE OF NEOGENE ARIDIFICATION AMONGST KANGAROOS

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Changes in diet often characterize critical periods in the evolution of major mammalian groups. However, our understanding of the interplay between climatic events, dietary change and morphological evolution is based largely on ungulate and rodent herbivores. Responses amongst other mammalian groups are much more poorly understood limiting our capacity to predict biotic responses to dietary change. The most diverse living marsupial herbivores, the kangaroos and their close relatives (superfamily Macropodoidea), evolved independently in response to global shifts in Neogene climate that influenced herbivore evolution on other continents. However, in contrast to multiple ungulate and rodent groups, macropodoids never evolved very high-crowned molar teeth, which may indicate that they acquired novel dental adaptations in response to dietary change associated with aridification during the Miocene transition. In this study, I utilize the close ecomorphological relationship between molar crown height and diet in 33 living macropodoid species (n = 1106) to infer diet in >28 extinct taxa (n = 736) and thus phylogenetically reconstruct the sequence of dietary change within Macropodoidea. This analysis reveals that dietary transitions are highly ordered with little evidence for reversions to ancestral diets. Two distinct phases in macropodoid dietary evolution emerge: (1) a protracted early Neogene interval characterized by modest increases in crown height, acquisition of bilophodont molars, and dietary transition from a predominantly fungivorous to browsing niche; and (2) a rapid increase in maximum crown height across the Miocene–Pliocene boundary, closely aligned with global cooling and the emergence of grasslands in Australian ecosystems. Linear and three-dimensional measurements of molar enamel thickness derived from microCT scans (n = 324) reveal that thick molar enamel was a key innovation underpinning adaptive radiation within Macropodinae. These results emphasize the important role that evolutionary processes within stem lineages play in enabling subsequent adaptive radiations and also highlights the potential importance of enamel thickness as an adaptation to high rates of dental wear.

Grant Information
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Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

THE CAMPANIAN OF BLADEN COUNTY, NORTH CAROLINA: REASSESSMENT OF THE VERTEBRATE FAUNA OF PHOEBUS LANDING AND COMPARISON WITH THAT OF ELIZABETHTOWN

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For over 150 years, Phoebus Landing has been the primary location of late Campanian vertebrate fossils documented in North Carolina. Recent discoveries of similar faunal assemblages, in the form of microvertebrate/bonebed accumulations, have refined the Cretaceous record of North Carolina. Discovery of the Elizabethtown locality, a microvertebrate unit approximately 6 km northwest and updip from Phoebus Landing has permitted a more comprehensive faunal assemblage.

Although both bonebeds yield a diverse assemblage of fresh water, euryhaline, stenohaline, and terrestrial organisms, including bony fishes, sharks, turtles, squamates, crocodyliforms, and dinosaurs, the age and condition of the bone-bearing units come into question. The bonebed at Phoebus Landing is at the top of the Tar Heel Formation (early Campanian) and consists of highly abraded, oxidized, commonly more robust elements, suggestive of transport of the bonebed as bedload. The bonebed at Elizabethtown is at the top of the Bladen Formation (late Campanian) and is comprised of multi-sized, robust to gracile elements with little to no abrasion implying limited transport duration and distance from source area. Also, the Elizabethtown microvertebrate assemblage shows greater abundance and diversity compared to Phoebus Landing. This is interpreted to be the result of geologic processes acting upon and subjecting the bonebeds to variant depositional scenarios.

The Elizabethtown bonebed is located on a prominent escarpment 30.5 m above mean sea level, whereas the Phoebus Landing bonebed is located on the bank of the Cape Fear River at an elevation of 6 m above mean sea level. Over time, the river has eroded the escarpment thus contributing to redeposition of the upper-elevation bonebed at the lower elevation. A modern analogue exists at a nearby location, Walkers Bluff, a prominent feature where the river abuts the escarpment. When the river rises, it erodes the bluff and the bonebed, which is located at the top of the bluff, is redeposited at a lower level and on older strata. This study concludes that the older Phoebus Landing bonebed (early Campanian, Tar Heel Formation) was, at one time, the component of the younger (late Campanian, Bladen Formation) laterally extensive bonebed of Elizabethtown.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

A NEW RECORD OF A LARGE GAVIALOID (CROCODYLIA) FROM THE HELL CREEK FORMATION (UPPER CRETACEOUS) OF SOUTH DAKOTA, USA

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The uppermost Cretaceous (Maastrichtian) Hell Creek Formation has been intensely sampled due to interest in the understanding the K–Pg extinction event. Crocodylians reported from this formation include *Borealosuchus*, *Brachychampsa*, *Stangerochampsa,* and *Thoracosaurus*. Of these, *Borealosuchus* and *Brachychampsa* are known from largely complete and diagnostic material that has been described in detail. However, *Thoracosaurus*, a large-bodied, marine gavialoid, has only been reported in faunal lists, and is reportedly very rare relative to other crocodylians in the formation. Material from the Hell Creek Formation referred to this taxon was never illustrated or described. Here, we describe the first known associated skeleton of a large gavialoid consistent with the morphology of *Thoracosaurus* from the Hell Creek Formation. The fragmentary specimen was discovered in Perkins County, South Dakota and includes a partial splenial, one cervical vertebra, a cervical neural arch, a partial cervical centrum, and one dorsal vertebra. The splenial and dorsal vertebra are well preserved. The splenial has a long mid-line symphysis, indicating the characteristic "Y shape" as found in gavialoids, and unlike the other Hell Creek crocodylians. The vertebrae are procoelous, a characteristic of crocodylians and other eusuchians, and they closely resemble the morphology of vertebrae assigned to *Thoracosaurus* from the latest Maastrichtian and early Paleocene of New Jersey, Holland, and Sweden. The dimensions of the vertebrae indicate a substantially larger body size than other crocodylians in the Hell Creek Formation, but are similar in size to *Thoracosaurus*. Although referral of the new Hell Creek material to *Thoracosaurus* is not possible, it does confirm the presence of a large member of Gavialoidea in this unit. It expands the body size range and diversity of crocodylians in the Hell Creek Formation, and gives us better understanding of vertebrate diversity in this well-studied formation immediately preceding the K–Pg extinction event.

Symposium III (Saturday, October 29, 2016, 9:00 AM)

ORIGIN OF THE DUAL FUNCTION OF RESPIRATORY TURBINATES IN MAMMALS

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Respiratory turbinates—the naso- and maxilloturbinals—play an important role in heat exchange in mammals and are thought to be required for endothermy. Respiratory turbinates have two functions: at rest and during mild exercise, they reduce the loss of heat and moisture in expired air; and during increased activity or high ambient temperatures, they increase the loss of heat in expired air. The shift from one function to the other is accomplished by changing the pattern of airflow to and from the lungs. During heat conservation, the larynx is held in an intranarial position by the palatopharyngeal muscle, inspiration and expiration occur exclusively through the nose, and turbinates act as temporal countercurrent exchange sites. For heat dissipation, the larynx is withdrawn from the nasopharynx, inspiration occurs through the nose but expiration occurs through the mouth, which allows expired air to bypass turbinates and transfer metabolic heat to the environment. The Early to Late Triassic non-mammalian cynodonts had enlarged respiratory chambers most likely filled with cartilaginous turbinals. These were ideally suited to dissipate heat in the exceptionally warm and seasonal climate of the Late Permian and Early Triassic, provided exhalation took place mainly through the mouth as in panting mammals. In non-mammalian cynodonts, bony palates lacked features associated with the palatopharyngeal muscle in mammals, suggesting that they could not hold the larynx in an intranarial position. This leads us to conclude that the primary role of respiratory turbinates was heat dissipation.

In Late Triassic ictidosaurs and mammaliaforms, the pterygopalatine ridges form lateral borders to a narrow nasopharynx much as the pterygoid hamuli do in mammals, signifying the emergence of the palatopharyngeal muscle and an intranarial larynx. At this point, the respiratory turbinates, though still not ossified, may have assumed the additional role of conserving heat and water. Only in the earliest mammals did respiratory turbinates finally ossify. Ossification allowed their surface area to increase greatly, thereby improving the efficiency of heat exchange and allowing for elevation in metabolic rate both at rest and exercise.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

PHYLOGENETIC REASSESSMENT OF *CONCAVENATOR CORCOVATUS* (LOWER CRETACEOUS, SPAIN) AND ITS IMPLICATIONS FOR CARCHARODONTOSAURIDAE RELATIONSHIPS.

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The holotype of *Concavenator corcovatus* (MCCM-LH 6666) is an almost complete, articulated skeleton from Las Hoyas fossil site (Lower Cretaceous, Spain). Originally, this specimen was proposed as a member of Carcharodontosauria, and its position was swapped within the group as basal Carcharodontosauridae or basal Carcharodontosauria (Neovenatoridae+Carcharodontosauridae).

A new data matrix was compiled to reassess the phylogenetic relationships of *Concavenator* within Carcharodontosauria. The data matrix is composed of 58 taxa and 381 equally weighted characters, of which 25 are ordered. The characters were rescored and reviewed from direct assessment of fossil material or casts of 19 taxa.

The matrix was scored using Mesquite 3.01 and imported into TNT 1.5-beta. A heuristic tree search was performed to find all possible most parsimonious trees (MPTs). This MPTs were examined under strict consensus. Branch support in the hypotheses was tested using Bremer support values and resampling methods. Some constrained analyses were carried out to compare with previous phylogenetic hypotheses.

The analysis yielded 12 MPTs with 1138 steps; and Consistency and Retention indices are 0.386 and 0.683, respectively. The strict consensus tree shows an unambiguous basal position of *Concavenator* inside Carcharodontosauridae. Within this clade, *Concavenator* is positioned as more derived than *Eocarcharia*. *Concavenator* shares several synapomorphies with the carcharodontosaurids, such as an anteroventrally inclined anterior end of the junction between the medial wall and paradental plates in the maxilla, lacrimal contacting the postorbital, ventral process of postorbital anteroventrally angled, rugose dorsal surface of postorbital and a concavity in the middle of the proximal surface of the humeral head. Its position inside Carcharodontosauridae is strongly supported, with the highest values of branch support hitherto obtained. With respect to other carcharodontosaurs, the Argentinean taxa are the most derived carcharodontosaurins, with *Carcharodontosaurus* as their sister group. Megaraptors are obtained inside Neovenatoridae and not as tyrannosauroids. Sixteen additional evolutionary steps are required to place megaroptors as coelurosaurians.

The position of *Concavenator* as a basal carcharodontosaurid supports the hypothesis of the wide paleogeographic distribution of this group, and the probable existence of palaeogeographic connections between Gondwana and Laurasia at or near the beginning of the Early Cretaceous.

Grant Information

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Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

AN INTENSIVE MULTI-TAXIC STABLE CARBON AND OXYGEN ISOTOPIC ANALYSIS OF VERTEBRATES FROM A MICROSITE IN THE OLDMAN FORMATION (LATE CRETACEOUS) OF ALBERTA

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Stable isotopic analyses have been used to test a wide range of ecological questions pertaining to modern vertebrate groups, and closely related or ecologically similar fossil lineages. Applying these methods to considerably more ancient ecosystems, or to animals without direct modern relatives, has been more controversial. In particular, studies employing stable isotope techniques in deep-time contexts have been suggested to suffer from issues relating to diagenetic effects, and poor geographic or temporal sampling control. Previous stable carbon and oxygen isotope studies of Late Cretaceous dinosaurs have used tooth and bone samples from taxa such as hadrosaurids, ceratopsids, and tyrannosaurids from a range of stratigraphic and geographic locations in Montana and Alberta. These studies have suggested niche partitioning between hadrosaurids and ceratopsids across a given landscape or formation, along with the preservation of seasonal signals in hadrosaurids and tyrannosaurids suggesting a lack of long-distance migration in those taxa.

In order to provide further insight into these ecological interactions in latest Cretaceous dinosaurs and test the proposed habitat use differences in hadrosaurids and ceratopsids, C and O stable isotope measurements were taken from a large sample of material collected from a single vertebrate microfossil site from the Oldman Formation of Alberta. Vertebrate microfossil sites represent the finest level of geographic and temporal resolution possible for these types of community-level analysis in the Late Cretaceous vertebrate fossil record. The sample represents the most taxonomically comprehensive Cretaceous stable isotope study of a single site performed to date, with over 10 taxa analyzed from a wide range of dinosaurs and other vertebrates. Results indicate close clustering of analyzed samples with their respective taxa, suggesting that diagenetic overprinting, if present, is relatively negligible. Ceratopsids and hadrosaurids possess non-overlapping isotope ranges, providing further support to their differing preference for closed vs. open canopy environments. In addition, considerable differences in the isotopic ranges of *Troodon* and *Saurornitholestes* provides support for previously hypothesized differences in the ecology and diet of troodontids when compared to other small theropods. This study demonstrates the potential of concentrated stable isotopic analyses of well-constrained vertebrate microsites for future analyses of community structure and palaeoecology.

Grant Information

Natural Sciences and Engineering Research Council of Canada (T.M.C, F.J.L., D.C.E.)

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

ORBITAL MORPHOLOGY AND OPTIC CANAL SIZE DISTINGUISHES DIEL ACTIVITY PATTERN IN CARNIVORANS

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Living carnivorans are diverse in skull morphology, daily activity period, and feeding style. Because predation or nocturnal hunting is highly reliant on vision, we wished to determine if the bony morphology of the orbit were related to feeding activities. We photographed the skulls of museum specimens of 48 extant carnivore species (n = 225) and four Eocene-age canids and nimravids (n = 8). From this sample, we compared (1) the size of the orbit (measured from the postorbital process–dacryon) and the area of the optic canal, (2) the shape of the orbit using semilandmarks placed along tracings of the orbital rim, and (3) the relative proportions of the face, orbital region, and cranium of the skull overall. We compared these observations with the taxonomic affinity, diel activity pattern, and feeding style of these species.

The relative size of the optic canal showed significant family-level differences, mainly separating herpestids and phocids each from other groups ($F_{10,25}$ = 5.20, P = 0.0004). Diurnal species had relatively larger optic canals than nocturnal, crepuscular, and aquatic species ($F_{3,32}$ = 8.56, P = 0.0003). Our feeding style categories were not significantly related to the size of the optic canal, but diurnal hunters and more omnivorous species were characterized by somewhat smaller orbital diameters.

In terms of orbital shape, a generalized Procrustes analysis showed that living felids had less rounded, more inclined orbital rims while canids were more rounded and had larger lateral openings. Ursids had less rounded, more medially-indented, and still more open orbital margins. More complete orbits were typical of species whose skulls needed more bone to resist chewing forces. Small-bodied species were quite variable in appearance, probably depending on the hardness of their food.

Skull proportions showed that nocturnal hunters such as felids and genets had the shortest faces and longest crania overall, in contrast to *Canis* and *Ursus*, which had the longest faces but shortest crania. Herpestids, hyaenids, and mustelids were intermediate in these proportions. Using these baseline data on Eocene carnivorans, we found that the small canid *Hesperocyon* overlapped with both canids and herpestids, while the Eocene felids *Hoplophoneus* and *Dinictis* demonstrated early establishment of the typical 'cat-like' skull proportions and feeding behaviors.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

PHYLOGENETIC POSITION OF SOME FOSSIL SOFT-SHELLED TURTLES FROM THE CRETACEOUS AND PALEOGENE OF ASIA

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Attempts to understand the early diversification of soft-shelled turtles (Trionychidae) in a phylogenetic context remain frustrated, despite a wealth of fossils. We sought to determine whether broader sampling of the trionychid fossil record could improve and clarify relationships of other previously analyzed taxa. We added the following taxa to a published matrix based on data from other matrices, the literature and new observations: *Gobiapalone orlovi*, *G. breviplastra* (*G.*; both L. Cretaceous, Mongolia), *Ulutrionyx ninae* (*U. n.*; Oligocene, Kazakhstan), *Khunnuchelys kizylkumensis* (*K. k.*; L. Cretaceous, Uzbekistan), "*Trionyx*" *kansaiensis* ("*T.*" *ka.*; L. Cretaceous, Tajikistan and Kazakhstan), "*T.*" *kyrgyzensis* ("*T.* " *ky.*; E. Cretaceous, Kyrgyzstan), *Perochelys lamadongensis* (*Per. l.*) and "*Aspideretes*" *maortuensis* ("*As.*" *m*; both E. Cretaceous, China), and "*Amyda*" *gregaria* ("*Am.*" *g.*; Oligocene, China). We

also explored the effect of different algorithms (B – Bayesian; P – parsimony, strict consensus) and constraints (no constraint; constraint 1 = molecular scaffold; constraint 2 = constraint 1 + constraint *K. k.* + "*T.*" *ka.*) on results. Constraint 2 explored the effect of a previously published hypothesis that the skull-only *K. k.* and the shell-only "*T.*" *ka* belong to a single clade. Of the six analyses, five agree in a position of *G.* and *U. n.* close to Apalonina, four support a close relationship of "*Am.*" *g.* with *Chitra indica* + *Pelochelys bibroni*, three agree in a sister relationship of "*T.*" *ka.* and "*T.*" *ky.*, and three support "*As.*" *ma.* and *Per. l.* as close to or in one clade with Aspideritini and *Amyda cartilaginea.* The positions of "*As.*" *ma.* and *Per. l.* continued to be unusually derived in the tree when their relationships are resolved, despite the addition of more data from the fossil record. In constrast, "*T.*" *ky.* was resolved as a basal, stem-trionychine when other extinct, Asian trionychids were included in a parsimony analysis, but was placed in the derived phylogenetic position as other Early Cretaceous trionychids when analyzed on its own and when analyzed in a Bayesian framework. Other relationships between extinct, Asian taxa and extant taxa are consistent with molecular divergence date estimates. Overall, results are consistent with hypotheses that the major clades of modern trionychids were established in the Cretaceous of Asia, or, in the case of Gigantoestuarochelys, in the Paleogene.

Grant Information
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Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

A NEW PHYTOSAUR (DIAPSIDA, ARCHOSAURIFORMES) BONEBED FROM THE LATE TRIASSIC OF INDIA: TAPHONOMIC SIGNATURES AND BIOSTRATIGRAPHIC IMPLICATIONS

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Phytosaurs are an extinct group of quadrupedal archosauriforms that were widespread throughout the Late Triassic, constituting important biostratigraphic markers. Here we report a new phytosaur bonebed from the Late Triassic Tiki Formation of the Rewa Gondwana Basin, India. The bonebed covers an area of about 48 m^2 and is monotaxic, from which about 800 identifiable skeletal specimens have been recovered. Dominant skeletal specimens of the bonebed include 29% limb bones, 22% cranial material and 21% ribs. The specimens are well-preserved, mostly disarticulated and disassociated but in close spatial proximity to one another. The specimens show varying degree of weathering, breakage and deformation and minimal abrasion. 38% of the collected skeletal specimens belong to Voorhies Group I, 32% and 25% belong to Voorhies Group II and III, respectively, implying that the bonebed is autochthonous, though a low flow regime was prevalent as suggested by the thick mudstone deposit. The long axes of in situ skeletal specimens are oriented in two perpendicular directions, which strongly indicates a fluvial influence. The minimum number of individuals is calculated to be seven based on seven left astragala in the collection, though these are of different ontogenetic stages as implied by their size variations. The collection comprises 86% young along with 14% adult individuals . The formation of the phytosaur bonebed is attributed to biological aggregation, possibly due to a parental care system similar to that seen in modern-day crocodilian community, with a hydraulic overprint. Preliminary examination of the phytosaurs reveals that these were more advanced than the basal *Parasuchus hislopi* known from the lower part of the Maleri Formation of India, and belong to the subfamily Mystriosuchinae. Prior to this study, phytosaurs from the Tiki Formation were cursorily designated as *Parasuchus hislopi*. Based on *Metoposaurus-Hyperodapedon-Parasuchus* assemblage, the Tiki Formation was considered coeval with the lower part of the Maleri Formation and an early Carnian age was assigned to both the formations. However, recent recovery of new vertebrate fossil assemblage including the mystriosuchine taxon proposes that the Tiki Formation could be younger than previously suggested.

Poster Symposium II (Friday–Saturday, October 28–29, 2016, 4:20 PM)

THE ICONIC MESOZOIC MAMMALS: THE LONG SHADOW OF MORRISON MAMMALS ON OUR UNDERSTANDING OF EARLY MAMMALIAN EVOLUTION

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The Upper Jurassic Morrison Formation is famous for its dinosaur fauna, and the first Mesozoic mammals in North America were discovered in this unit as by-products of dinosaurs quarried by teams led by E.D. Cope and O.C. Marsh. The tiny mammals recovered during the closing decades of the 19th century had an oversized impact on the field and served as foundational specimens for Mesozoic mammals of the New World. The similarities and differences between the early Morrison and Victorian British localities supplied initial templates for our understanding of the diversity and distribution of Mesozoic mammals. Fifteen productive localities are distributed across the Western Interior from the Black Hills to southern Colorado and west into Utah; the most historically important of these are in Wyoming (e.g., Como Quarry 9). Although most Morrison mammals are known by jaws or jaw fragments, several important Mesozoic groups, such as docodonts, dryolestoids, and to a large extent triconodonts and symmetrodonts, were established based on Morrison material, shaping the perception of mammalian diversity on a global scale (northern continents in particular). Despite heavy sampling of coeval sites, the Morrison remains the most systematically diverse (at high taxonomic levels) assemblage of Jurassic mammals in the world. This remarkable diversity is likely due to the large geographical expanse of the unit, which encompasses paleoenvironmental variety and, possibly, small-scale time differences between localities.

Recent finds in China greatly expanded cranial and postcranial information for Jurassic mammals, which is rare to absent among Morrison taxa. However, the Fruita Paleontological Area (FPA) in western Colorado has yielded a skeleton of a mammal (the highly unusual *Fruitafossor*), as well as associated material of other small vertebrates. Morrison mammals are housed across at least a half-dozen major institutions and several of these collections are only partially studied; recent publications on classic material highlight the depth and potential of the historical collections. Several research groups are actively working at FPA and other Morrison microvertebrate localities, and we are currently searching for new microvertebrate sites focused on mammals. Even though the formation has been the center of paleontological work for nearly 150 years, ongoing study of existing collections and recovery of new material will keep Morrison mammals relevant for years to come.

Romer Prize Session (Thursday, October 27, 2016, 11:45 AM)

WHAT NORTH AMERICA'S SKELETON CREW OF MEGAFAUNA TELLS US ABOUT COMMUNITY DISASSEMBLY

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Functional trait diversity is increasingly used to model how future species extinctions and climate change will alter ecosystem function, but it is hard to ground truth these global scale models because we still do not understand how community disassembly affects functional diversity. The rules of disassembly, it seems, are not just those of community assembly run in reverse. We need large-scale studies that can track functional change through realistic extinction scenarios on relatively short timescales, data only the fossil record of the latest Quaternary can provide. After significant taxonomic revision and the creation of a new functional trait matrix, I followed functional diversity changes of the 94 largest North American mammals through the last 50,000 years covering the end-Pleistocene megafaunal extinction up to the present. Both multidimensional trait space and dendrogram based measures of functional diversity show that contrary to disassembly theory, functionally unique species are no more likely to go extinct than functionally redundant species. This causes total functional richness loss to be no worse than null expectations given species richness declines, suggesting that functional richness can be accurately modeled by taxonomic richness alone. However, although these functional richness declines fit null expectations, the position of the modern North American fauna in functional space relative to a pre-anthropogenic baseline is not random because certain functional traits like high body mass and poor climbing ability were selected against. I argue that instead of focusing on functional richness, an abstract concept whose values are highly dependent on methodological choices, we should pay more attention to a community's location in functional trait space, something that can be approximated by simple measures such as trait means. My research shows that the current large mammal fauna of North America is already highly denuded compared to pre-anthropogenic communities with many modern species growing increasingly functionally isolated. The largest drops in relative functional diversity are likely yet to come.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

RADIATION OF PLESIADAPID MAMMALS AT THE END OF THE PALEOCENE EVIDENCED BY NEW DISCOVERIES FROM THE LATEST PALEOCENE OF FRANCE: ONE MORE EXAMPLE OF BUSH-LIKE EVOLUTION

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Plesiadapidae are usually considered to be the closest relatives to the crown-group primates, despite their disappearance at the Paleocene–Eocene Boundary (PEB) in North America, right when the first euprimates appear. In Europe, however, the family survives a few million years after the PEB, though only represented by the genus *Platychoerops*. Because *Plesiadapis* was restricted to the Paleocene and *Platychoerops* restricted to the Eocene, a linear evolution was implied: the genus *Plesiadapis* was thought to give rise to *Platychoerops* at the PEB due to the particular environmental conditions of that time. However, one species of *Platychoerops* was recently described from the late Paleocene of Berru, France, casting doubts on this hypothesis. The recently discovered locality of Petit-Pâtis (Rivecourt, Oise, France) delivered for the first time the most diagnostic tooth of *Platychoerops* in the Paleocene, its long and derived I1. This discovery confirms the presence of the genus *Platychoerops* in the Paleocene and attests a quick diversification, bush-like radiation of the family into three genera, before the PEB.

The locality of Petit-Pâtis also delivered specimens referable to a new species morphologically intermediate between *Plesiadapis tricuspidens* and *Platychoerops antiquus*, with a critical I1 very similar to *P. tricuspidens* but closer to *P. antiquus* by its more molarized and proportionally larger p4; this latter derived character is shared with *Platychoerops*, so that the hypothesis of the North American species *P. cookei* being the most derived species of *Plesiadapis* and having given rise to *Platychoerops* can now be questioned, and a more geographically parsimonious hypothesis of a European origin of the European genus *Platychoerops* is supported.

Finally, the third European genus of Plesiadapidae, *Chiromyoides*, is also present in Petit-Pâtis, where it is represented by a new species characterized by a smaller size than *C. campanicus* and the presence of relatively large accessory cuspules aside the posterocone on I1. The specimens from Petit-Pâtis also confirm the hypothesis that *Platychoerops georgei* from the earliest Eocene is likely a composite species based on the assemblage of a few specimens from different localities of similar estimated age, most specimens likely belonging to *Plesiadapis* or *Platychoerops*, while the holotype (a short I1) belongs either to *Chiromyoides* or to *Plesiadapis*, its preservation state making the identification difficult.

Grant Information
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Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

THE TAPHONOMY OF A MIRED SAUROPOD DINOSAUR AT DOELLING'S BOWL BONEBED IN THE EARLY CRETACEOUS CEDAR MOUNTAIN FORMATION, EASTERN UTAH

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The Utah Geological Survey has been excavating the Doelling's Bowl bonebed (DBBB) in east-central Utah annually since 2005. The bones are found near the base of the lower Yellow Cat Member of the Early Cretaceous (Barremian; or older) Cedar Mountain Formation. DBBB is a multitaxic bonebed that crops out in an area of low relief and is estimated to cover an area of over 5000 m^2. Over 1500 individual vertebrate bones have been excavated, mapped, and collected to date from several excavation areas totaling 140 m^2. The most common fossils are those of iquanodontid dinosaurs, including many isolated and articulated elements belonging to juvenile animals. Ankylosaurs are present with abundant osteoderms, limb elements, vertebrae, a pelvis, and two diagnostic basicarania. Less common are fossils of theropod dinosaurs, including the holotype of the small dromaeosaur *Yurgovuchia doellingi*, crocodyliforms, and turtles. The bones are found in a green-gray sandy mudstone with traces of silcrete and sparse root casts along with abundant chert pebbles. In 2010, a partially articulated sauropod dinosaur was discovered eroding out of an arroyo in an area of the bonebed dubbed Gary's Island. Nearly every skeletal element of an individual sauropod has been recovered, including an articulated hind leg and a partial articulated forelimb. Many axial elements have been collected from every region of the vertebral column, including the articulated 10 terminal caudal vertebrae. Numerous disarticulated cranial elements have been recovered including a partial braincase, quadrate, dentaries, and postdentary bones. The articulated manus and pes extended through the sediment at an angle below the level of the majority of the skeleton, indicating that an individual sauropod became mired in soft sediment and died in place. After decomposition, many of the elements of the skeleton were scattered over an area of roughly 10 m^2. Several shed theropod teeth have been found in association with the sauropod skeleton but no evidence of tooth marks have yet been identified on any of the bones from this part of the quarry. There is minor plastic deformation of many of the bones that, along with sedimentological evidence, suggest that the area was waterlogged. The undersides of the recovered bones show more degradation than the upper surfaces, possibly as a result of grazing by invertebrates. The number of recovered elements makes this the most complete individual sauropod known from the Cretaceous of North America.

Technical Session XVIII (Saturday, October 29, 2016, 3:30 PM)

NOT SO FAST: A RE-EVALUATION OF CURSORIALITY IN THEROPODS

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Non-avian theropods range over 5 orders of magnitude in body size. This size range and their generally conserved body plans make them an ideal model system for the study of allometry and its effects on limb evolution in fossil clades. This has lead some to propose the use of the distal limb index (tibia + metatarsus) as an indicator of high speed running among several coelurosaurian groups, most notably Tyrannosauroidea and Compsognathidae. Here we re-examine theropod hindlimb segmental scaling using a dataset of 324 specimens of 126 distinct species across all major clades, dietary regimes and times. Using the complete dataset and a subset including only the largest individuals (both yield similar results), we find that herbivorous clades do not show a consistently different scaling relationship than that of carnivorous clades. Tyrannosauridae distal limbs scale consistently longer than those of similar sized Allosauroidea due to higher intercept values of similar scaling factors. Longer limbs decrease the cost of transport (COT) and thus large tyrannosaurids would be significantly more efficient at foraging than more basal lineages, including allosauroids. Given that large theropods are estimated to have had only moderate running ability, we suggest that factors such as foraging time and differences in hunting strategy may have a more significant role in altering limb allometry than top speed. Further, we show that small to mid-sized theropods, with a snout to vent length (SVL) between 200 mm and 1500 mm, had the highest variation in limb segment and relative total limb lengths. As this corresponds to the ancestral nodal SVL reconstruction for the major coelurosaurian lineages, it represents a critical size class for theropod evolution and diversification. Finally, across clades an increased distal limb index is not universally associated with elongated leg length. Composgnathids and dromaeosaurs, which have similar SVL and distal limb indices, may differ by 50% or more in relative and absolute hindlimb length. As hindlimb length is linked to stride length, COT, and running speed, these differences would likely significantly alter top speed potential and locomotion costs between lineages. These results urge caution when using distal hindlimb indices as the primary estimator of top speed potential in non-avian theropods and imply other ecological factors may have had a larger role in influencing this trait, similar to the patterns observed among extant mammals.

Technical Session V (Wednesday, October 26, 2016, 2:45 PM)

VERTEBRATE FAUNAL DYNAMICS DURING THE END-CRETACEOUS MASS EXTINCTION: A SYNTHESIS FROM THE FOSSIL RECORD OF NORTHEASTERN MONTANA, USA

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The Cretaceous-Paleogene (K–Pg) mass extinction (ca. 66 Ma) differentially culled vertebrate lineages, yet the process(s) leading to those extinctions is debatable. Previous analyses of the K–Pg event in terrestrial ecosystems have mostly focused on specific taxonomic components of vertebrate faunas (e.g., turtles). The resulting K–Pg patterns from those analyses have shown both similarities and differences across vertebrate taxa, which in turn have led to corroborating and conflicting interpretations of the timing and causes of the K–Pg mass extinction.

To provide a more comprehensive and internally consistent view of K–Pg vertebrate faunal dynamics, we investigated six ecologically and physiologically diverse taxonomic groups (actinopterygian fishes [F], lissamphibians [L], turtles [T], squamates [S], non-avian theropod dinosaurs [D], and mammals [M]) from a single study area. The dataset contains over 12,500 specimens from over 150 taxa from a temporally constrained succession of vertebrate microfossil localities in the Hell Creek and Tullock formations, northeastern Montana, USA. For each taxonomic group, we compiled taxonomic richness, composition, and turnover across ca. 2.2 Ma spanning the K–Pg boundary. For select taxonomic groups, we also calculated faunal evenness from six or more well-sampled fossil localities spread across four temporal bins. Our results show that taxonomic richness of each group was stable for the last 1.9 Ma of the Cretaceous, despite substantial taxonomic turnover among F, L, T, S, and M in the last 300–500 ka. Taken alone, these results would be consistent with a sudden pattern of extinctions due to the bolide impact at the K–Pg boundary; however, our results also show that several groups (F, L, and M) significantly declined in evenness in the last 300-–500 ka of the Cretaceous, a pattern which implies changes in community ecology, prolonged ecological decline, or both, perhaps due to decreasing local paleotemperatures or the global effects of Deccan Traps volcanism prior to the bolide impact. Our results also show that proportional extinction across the K–Pg boundary varied by taxonomic group (higher for S, D, M and lower for F, L, T), which might reflect extinction selectivity due to differences in physiology, diet, ecology, and/or habitat (e.g., terrestrial vs. aquatic) rather than a 'field-of-bullets' model. Taken together, our study adds to the growing body of evidence for a complex pattern of extinctions with causal mechanisms possibly operating before the K–Pg boundary.

Grant Information
UCMP Doris O. and Samuel P. Welles Fund to DGD.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

BONE HISTOLOGY REVEALS UNUSUAL LIFE HISTORY IN THE THEROPOD DINOSAUR *MAJUNGASAURUS CRENATISSIMUS* FROM THE LATEST CRETACEOUS OF MADAGASCAR

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Increasingly widespread sampling of the bone histology of nonavian theropod dinosaurs has suggested that fine-scale evolutionary body size changes largely result from adjustments to growth rate rather than growth duration. Studies have also highlighted the sensitivity of analyses to both the bone sampled and the sampling location within elements. Here we report on the histology of eight bones of a single individual of the abelisaurid theropod dinosaur *Majungasaurus crenatissimus*. Primary bone tissue is parallel-fibered to woven in organization, with abundant longitudinal and circular primary vascular canals. The degree of remodeling is highly varied within and among elements. The number of observable annual circumferential growth marks ranges from 5–15, many of which are double or triple lines of arrested growth. We fitted several growth models to growth mark circumferences for each of the eight bones and selected the best model for each bone using information criteria. The optimum growth model varies by skeletal element, reflecting a combination of intraskeletal allometry and differential preservation of the growth record due to varying amounts of remodeling and cortical drift. The growth model based on the tibia, the element that preserves the most complete record, indicates that *Majungasaurus* was one of the slowest-growing theropods yet identified, taking over two decades to reach a body mass estimated at 850 kg. This growth pattern is consistent with data from other abelisaurids and indicates that slow growth may be a derived characteristic of the group. In addition, slow growth in *Majungasaurus* may have been exacerbated by the harsh and highly seasonal Late Cretaceous ecosystem in which it lived.

Technical Session XVI (Saturday, October 29, 2016, 11:00 AM)

QUATERNARY FAUNAL REPLACEMENT IN NORTHERN CHINA BY PLIOCENE MAMMALS FROM THE TIBETAN PLATEAU

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Though distinctive in composition and habitat characteristics among extant Asian faunas, the modern Himalayan mammalian fauna is very similar to Quaternary faunas, such as the early Pleistocene Longdan fauna from the Linxia Basin of Gansu Province in northwestern China. We propose a replacement hypothesis and conduct faunal-level analyses to explain the chronological and geographical spread of Pliocene Tibetan mammals into northern China during the Quaternary. The Himalaya and Longdan faunas share the same or very similar species richness in Primates, Carnivora, Perissodactyla, and Artiodactyla, among which carnivores dominate in having 16 known species in Longdan and 14 in Himalaya. At the genus level, *Macaca*, *Marmota*, *Castor*, *Myospalax*, *Vulpes*, *Canis*, *Meles*, *Crocuta*, *Panthera*, *Felis*, *Lynx*, *Equus*, *Sus*, *Gazella*, and *Budorcas* from the Longdan fauna are extant. In the Linxia Basin, the Longdan fauna followed the Pliocene Shilidun fauna, but only four genera are shared between them, and seven genera (35%) from Shilidun survived into the Quaternary. The woolly rhino *Coelodonta nihowanensis* of the Longdan fauna had no predecessor in the Linxia Basin, and the acerathere rhino *Shansirhinus ringstroemi* of the Shilidun fauna became extinct before the Quaternary. On the other hand, the earliest known woolly rhino *C. thibetana* was discovered from the Pliocene Zanda Basin in the Tibetan Plateau, more than 1,600 km

southwest of the Linxia Basin. The Zanda Basin, located in the drainage area of the upper reaches of the Sutlej River in Nagri, southwestern Tibet, China, has produced the richest fossil mammal fauna known in the Tibetan Plateau. Seventeen genera (71%) of the Zanda fauna were present in early Pleistocene mammalian faunas in northern China. The Pliocene mammals of the Zanda Basin showed initiation of cold-adapted lineages that predated the Quaternary glacial fauna. These cold-tolerant species became widespread and replaced the Pliocene mammals of northern China that preferred a warm climate during the subsequent Pleistocene glaciation in the context of global cooling and expansion of cold habitats. These analyses indicate the Tibetan Plateau was a cradle for the Quaternary mammalian fauna in northern China.

Grant Information
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Technical Session XI (Friday, October 28, 2016, 12:00 PM)

APPLICATION OF TAXON INFLUENCE INDICES TO PALEONTOLOGICAL DATASETS: ROLES FOR BOTH NOVELTY AND IMPORTANCE

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Increasingly powerful imaging and processing methods have enabled greater amounts of character data to be derived from unusual, novel, and difficult to analyze specimens. A standard procedure is to place these specimens using a phylogenetic analysis under parsimony, and to contextualize the specimen's importance based on its inferred position relative to other known groups. However, the placement of such taxa, as well as the usefulness of the taxon for resolving relationships, may be influenced by the characters and taxa selected for the dataset, and less is known about how these factors interact with one another. To demonstrate the importance of considering these effects together, I apply the taxon influence index (TII) approach to produce a ranked list of taxon influence from a recently published *Tullimonstrum* dataset, accounting for model and topological uncertainty using a Bayesian approach. In contrast with the apparent anatomical novelty of the taxon, TII analysis places *Tullimonstrum* into the lower quartile in terms of taxon influence, suggesting that such apparent novelty, though critical for understanding the distribution of character mosaics and the timing of trait evolution, may not directly translate to inferential importance. Inferential importance, as estimated by values such as TII, should therefore be included in analyses presenting results on new taxon discoveries, for completeness. Procedures for calculating p-values for TII based on a bootstrapping approach are also discussed.

Grant Information
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Technical Session I (Wednesday, October 26, 2016, 9:15 AM)

TAPIRS AS MODEL ORGANISMS FOR UNDERSTANDING HOMINID EVOLUTION: THE FUNCTIONAL SIGNIFICANCE OF THE SAGITTAL CREST AS REVEALED FROM DENTAL MICROWEAR TEXTURE ANALYSIS AND FINITE ELEMENT ANALYSIS

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Paleoanthropologists have long debated the function of the sagittal crest in ancient hominids, including *Paranthropus boisei*, *Paranthropus robustus*, and *Paranthropus aethiopicus*. Early work dubbed *Paranthropus boisei* as 'nutcracker man,' suggesting that the pronounced sagittal crest aided in the consumption of hard objects such as nuts and plant underground storage organs. However, recent dental microwear texture analysis data has questioned this idea and instead suggested that *P. boisei* used its large molars and pronounced sagittal crest (and large temporalis muscles) to processes a greater volume of tough food items. Some have even suggested that *P. boisei* may have consumed grasses, as teeth reveal C_4 isotopic signals. While carnivorans are the focus of studies regarding the functional significance of the sagittal crests, less is known about how diet and sagittal crest formation correlates in herbivores. Tapirs are model organisms for examining if and how the textural properties of food consumed correlates with the development of sagittal crests, as some extant tapirs have highly developed sagittal crests (*Tapirus terrestris*) while others lack well developed sagittal crests (*Tapirus bairdii*). Further, some ancient tapirs (*Tapirus polkensis*) have variable sagittal crest development at a 'population' level. Here, we test the idea that sagittal crest development allows for reduced stress loads and the ability to eat harder objects via finite element analysis and dental microwear texture analysis, respectively. While sagittal crest development does reduce overall stress, it is not correlated with hard object eating. Instead, pronounced sagittal crests occur in the more folivorous and tough leaf eating *Tapirus terrestris*. Further, the variable presence of pronounced sagittal crests on *Tapirus polkensis* at the Gray Fossil Site does not appear to be either correlated with diet or used to consume hard food resources. Instead, *T. polkensis* consumed tough leaves, in contrast to tapirs that eat harder objects and lack sagittal crests (i.e., *Tapirus bairdii* and other Pleistocene tapirs). Collectively, these data suggest that in herbivores, pronounced sagittal crests may aid in the consumption of tough objects such as leaves and do not necessitate hard object feeding like they do in carnivorans. Pronounced sagittal crests in *P. boisei* may instead assist with the processing of tough leaves (including grass) as prior dental microwear studies suggest.

Grant Information
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Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

GIRLS LIKE DINOSAURS TOO! WAYS TO BETTER ENGAGE GIRLS IN PALEONTOLOGY

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We all love dinosaurs! Who doesn't? Yet, dinosaurs are all too often referred to as "he" and considered "boy" merchandise. As toy shops are becoming increasingly divided with girl and boy aisles, dinosaurs are being categorized as "boy" toys. As paleontologists, it is our responsibility to reduce the gender divide, encourage women in science, and not target only one gender when discussing dinosaurs. Here, we present preliminary results of studies regarding the gendering of dinosaurs (and other prehistoric taxa) and suggest ways in which we, as paleontologists, can improve our own communication about dinosaurs and other prehistoric animals to the public, especially children. When preschool aged children (ages 2–5) in a secular preschool in middle Tennessee were asked, "Do you like dinosaurs?" there was no significant difference in the number of boys and girls who answered affirmatively. While further work is needed to assess when and if this pattern drops off with increasing age, at an early age children are interested in dinosaurs. Further, when college students were asked to present on fossil organisms, 88% of students who presented on vertebrates referred to their taxon as "he." The 12% that did not, referred to their taxon as "it," and no students referred to their taxon as "she." Invertebrates and plants were not assigned genders by students. In subsequent years we will assign *Maiasaura* ("mother dinosaur") to see if this pattern changes. While these data are preliminary and require further study, we here mention key actions we can take to reduce the masculinization of dinosaurs. First, we suggest feminizing dinosaurs much like Lego® has done with their Lego® Friends series and similar to the female targeted STEM product, GoldieBlox™. Images that showcase dinosaurs in purple and pink colors can help entice girls into learning more about these fascinating creatures. Second, when performing outreach, discussing scientific papers in the media, and talking with school groups—showcase women. Girls need to see girls as paleontologists if they are to follow in their footsteps and see themselves as future paleontologists. Unfortunately, girls are rarely leads in kid TV shows, especially regarding STEM fields. Too often it is *Sid the Science Kid* not *Sydney the Science Kid*. Lastly, make students aware that in most cases sexes are fairly balanced in nature and that half of all fossils were likely females. Capturing a child's interest in dinosaurs, regardless of gender, may help reduce the gender gap in STEM fields—a goal we as paleontologists can aspire to help improve.

Grant Information
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Technical Session I (Wednesday, October 26, 2016, 8:15 AM)

BODY SIZE AFFECTS DIETARY INTERPRETATIONS BASED ON MESOWEAR OR STEREOSCOPIC MICROWEAR IN MAMMALS

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In mammals, tooth enamel is damaged as the abrasive components of ingested food are dragged or squeezed past opposing enamel faces. Crown morphology is the result of long-term selection for a general dietary regime over evolutionary time. Enamel wear records the most abrasive parts of the diet, such as bone or exogenous grit, that is ingested and chewed with the food. Among palaeontologists, various techniques are used to assess tooth wear, with the common goal to reconstruct the diets of fossil species and how they changed with the environment. Microscopic enamel wear—in other words, use wear incurred over a relatively short period of time—has been visualized or assessed using the scanning electron or confocal microscope at high magnification (~500×) or the stereomicroscope at lower magnification (35–70×). Additionally, macroscopic wear, which represents cumulative wear over a lifetime, has been categorized using the 'mesowear' technique. This optical method compares the sharpness of cusp tips as well as the relief of tooth crowns to determine if the multi-year diets of ungulate teeth were for more abrasive diets (grazing—blunt tips, low relief) or more attritive diets (browsing—sharp tips, high cusp relief).

Do short-term and long-term signals of enamel wear point to the same conclusions for diet? No. We compared the dietary conclusions reached using the stereoscopic microwear vs. mesowear methods for 33 species of artiodactyls and perissodactyls (n = 281). The youngest of these animals lived during the Whitneyan NALMA, several million years before the establishment of C_3-dominated grasslands in North America, so few of these species were expected to be committed grazers. When averaged to the level of the species (not the individual), both methods found a range of diets in our sample, with fair agreement in diets between the two methods. The shorter-term microwear informed more specific attributes of the diet than the 'browse vs. grass' spectrum of mesowear. However, we found that mesowear score was highly correlated with body mass (r_s = 0.486, P = 0.0023), so large-bodied species such as rhinocerotids were interpreted to have had more abrasive (grass) diets using mesowear than they did using stereoscopic microwear. Whether the result of absolute tooth size or differences in enamel thickness or microstructure, mesowear and microwear can reach divergent conclusions when interpreting larger herbivores.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

FIELDING YOUR FIRST COURSE: USING GOOD PLANNING TO ENHANCE STUDENT LEARNING AND POSSIBLY EVEN KEEP YOUR SANITY

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Graduate school is effectively an apprenticeship to enter a research career, but many new graduates will find employment away from museums or research-intensive universities. Paleontologists often work in undergraduate science departments, sometimes teaching courses for which their research training and content knowledge will have only

modest relevance. Utilizing research-based course design principles from the start improves success in terms of student learning, student perceptions of teaching and learning, and incorporation of one's own research into the course. Here, we summarize practical strategies for achieving successful course design in paleontology and introductory-level non-major courses taught by those with paleontology backgrounds. We also give specific examples of how we put these strategies into practice in our own teaching.

Determining goals for what students should learn by the end of the course is the starting point in "backward design," in which course planning is guided by desired outcomes rather than following textbook order and content without critical evaluation. This focuses on what students do to demonstrate their understanding, and how teaching and learning activities support student learning, rather than centering on what instructors do. Instructors should incorporate knowledge of common student learning difficulties with course concepts, representations such as graphs and evolutionary trees, and critical skills into learning and assessment activities. Once student learning goals are established, modes of assessment and learning activities can be more effectively planned, such as exams, projects, or long-form papers in which a student can demonstrate mastery. Some evolutionary processes and patterns can be effectively explored in online modules, some work better in lecture or in a laboratory setting.

We discuss assessment and test question design from multiple angles, considering pros and cons for each type of question. Strategies for making longer papers effective for student learning and more manageable to grade by instructors include multiple drafts per student with time for peer review before grading and evaluation with rubrics.

Teaching for paleontologists can be a joy but requires time and consideration to do well. Fortunately, it is a skill that is learned through practice, constructive feedback from peers and students, and mindful reflection and awareness of research on learning. We share our experiences and guidance from the literature on teaching and learning biology and geology.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

DINOSAURS, BIRDS, AND MEMES: UTILIZING A POPULAR MICROBLOGGING PLATFORM FOR PALAEONTOLOGICAL EDUCATION

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Social media outreach in the sciences has grown extensively in the past few years, with blogs such as Tetrapod Zoology and web series such as SciShow and Crash Course gaining popularity and acclaim. Tumblr, a microblogging platform, is extremely popular among individuals aged 15-25, allowing for new methods of scientific education to be used within these populations. Blogs covering the field of palaeontology have led to the growth of a fairly large community of around ten thousand individuals in over fifty countries. To evaluate the effect of scientific outreach on this community, we conducted a survey inquiring about topics such as individual understanding of various palaeontological subjects before and after their joining of the community. According to responses from over 400 participants, blogs dedicated to writing about palaeontology, answering questions from readers, and promoting scientifically accurate palaeoart have led to greater understanding on a wide variety of topics. Knowledge of the dinosaurian origins of birds has grown widespread within this community, along with a better understanding of phylogenetic methodology and evolutionary science. In addition, an appreciation for more scientifically accurate representations of prehistoric creatures in the media has increased due to outreach and commentary on media portrayals. One major advantage of the Tumblr community at large is the diversity in gender and sexuality: the largest portion of our audience is female, with LGBT+ individuals comprising a majority of the community. Given the underrepresentation of both women and LGBT+ individuals in the sciences, this outreach allows for more inclusivity and diversity within scientific communication and education. As the audience continues to grow over time, we hope to continue our progress and increase the scope of our educational topics.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

HOW DID *GIRAFFATITAN* SHAKE ITS TAIL? STUDYING SAUROPOD BIOMECHANICS VIA 3D MODELING TECHNIQUES

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Novel research technologies are improving and enhancing the classical approach to the study of sauropod biomechanics, helping us to better comprehend biological aspects of these giants. Thanks to 3D skeletal mounts we can assess postures and ranges of motion (e.g. with the CAD program McNeel Associates Rhinoceros 5.0. NURBS Modeling), but also muscle paths and simplified 3D volumetric models based on these 3D muscle volumes (Musculographics SIMM 7.0).

Although most of the biomechanical works about sauropods focus on the neck of these dinosaurs, several hypotheses have been published about the motion of their tails. Some hypothesize that sauropod tails did not show pronounced adaptation to torsion and flexion, and seem to have been carried in a horizontal posture. Others compared tail flexibility between several sauropod taxa, suggesting that diplodocoids used a stiffer proximal tail to support a long but quite flexible mid- and distal tail (i.e. "whip-lash" like), and other sauropods – e.g. Titanosauriformes – present a tail club specialization in which the proximal stiffness of the tail is even higher, and the range of club movement is more restricted. Other studies confirmed that zygapophyses work as a restriction to unwanted torsion rather than as a restriction to lateral flexibility of the axial skeleton.

Based on these premises the mobility of the tail of the Late Jurassic titanosauriform *Giraffatitan* has been assessed. The Museum für Naturkunde houses three caudal series, all of them well preserved and almost complete, that allow a comparative investigation. After digitizing all the specimens via photogrammetry, the files were imported into Rhinoceros 5.0, and the caudal vertebrae were aligned following a main program axis (in dorsal view of extension and flexion, and in lateral view for the laterally flexed tail). Then, the angles between consecutive vertebrae were measured for the flexed tail.

Giraffatitan was a sauropod capable of maintaining the tail in a horizontal posture naturally, but also had a significant range of lateral motion, especially in the anterior section of the tail. Compared to other sauropods, the shorter and more rapidly tapering tail showed no marked reduction in range of motion.

Grant Information
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Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

NEW ASSOCIATED BASAL SAUROPODOMORPH MATERIAL FROM THE LATE TRIASSIC LOWER ELLIOT FORMATION, KAROO BASIN, EASTERN CAPE

DINTER, Cory M., University of the Witwatersrand, Johannesburg, South Africa; BENSON, Roger, University of Oxford, Oxford, United Kingdom; MCPHEE, Blair W., University of the Witwatersrand, Johannesburg, South Africa; CHOINIERE, Jonah N., University of the Witwatersrand, Johannesburg, South Africa

South Africa's Late Triassic–Early Jurassic Elliot Formation is well known for its fossils of basal sauropodomorph dinosaurs in its upper strata. Despite more than a century of study, however, sauropodomorphs from the lower parts of the formation remain poorly known due to fossil scarcity or are represented by material of uncertain provenance and association.

We present a new, associated sauropodomorph specimen from the middle of the lower Elliot Formation. The material represents a single animal, and includes axial and appendicular bones. We present a preliminary description of the new specimen, and analyze its phylogenetic relationships by incorporating it into a data matrix of basal sauropodomorph dinosaurs.

Our preliminary results show that the specimen is not *Blikanasaurus* or *Plateosauravus*, two of the better known lower Elliot sauropodomorph taxa. It possibly represents a previously unknown species of *Melanorosaurus*. The discovery of an articulated lower Elliot sauropodomorph with precise provenance data helps us to refine our biostratigraphic interpretations for the Late Triassic.

Grant Information
NRF

Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

INVESTIGATING THE CRANIAL ANATOMY AND PARATYMPANIC SINUS SYSTEMS OF LOWER JURASSIC CROCODYLOMORPHA USING COMPUTED TOMOGRAPHY AND 3D DIGITAL MODELLING

DOLLMAN, Kathleen N., University of Witwatersrand, Johannesburg, South Africa; CHOINIERE, Jonah N., University of the Witwatersrand, Johannesburg, South Africa

Complete anatomical descriptions of basal crocodylomorph crania remain scarce in the literature. Most cranial descriptions include only dermal elements and exclude the braincase and internal structures. The development of CT scanning and 3D modelling technology has opened many avenues of study to paleontologists, including more complete description of the anatomy of previously unexposed cranial elements.

This study aims to augment information on the cranial morphology of two Lower Jurassic taxa: protosuchian *Protosuchus haughtoni* and sphenosuchian *Litargosuchus leptorhynchus*. Cranial material of these species was CT scanned and digitally segmented using VG Studio Max at the University of the Witwatersrand. Our anatomical results were used in two ways. First, the comparative anatomical information on these taxa enabled a revision of the cranial characters of basal crocodylomorphs. We amended these characters in a large phylogenetic dataset and present a revised hypothesis for the phylogenetic relationships of basal crocodylomorphs. Our results indicate that a monophyletic "Protosuchia" is positioned as sister to "Sphenosuchia" and excludes gobiosuchids which occupy a more derived position in the tree.

Second, these data enabled us to study the sinus systems of these early crocodylomorphs. The crania of basal crocodylomorphs have been labelled as 'highly pneumatic', but to date investigations into the intrusion of paratympanic sinus systems have remained descriptive. This study uses volumetric quantification methods available in VG studio max, specifically bone volume density (BV/TV), to evaluate changes in pneumatic intrusion of select crocodylomorpha taxa. The results indicate that there are changes in the extent of cranial pneumaticity, but that a set of homologous bones are selectively pneumatized across the crocodilian lineage.

Grant Information
Centre of Excellence in Palaeosciences
Palaeontological Scientific Trust

Technical Session II (Wednesday, October 26, 2016, 8:30 AM)

A DIVERSE SQUAMATE ASSEMBLAGE FROM THE PALEOCENE DEPOSITS OF QIANSHAN BASIN, CHINA

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The Paleocene squamate fossil record is very patchy outside North America, especially in Asia. Here we report on a diverse squamate assemblage from the Early-Middle Paleocene deposits of Qianshan Basin, Anhui, China, based on both new fossils

and re-evaluation of previously reported specimens using micro-CT scanning. The assemblage includes several acrodontans (*Qianshanosaurus huangpuensis*, *Tinosaurus doumuensis*, '*Agama sinensis*', an unnamed species), two varaniforms, one scincoid or lacertoid, and several indeterminate squamates (*Anhuisaurus huainanensis*, *Anqingosaurus brevicephalus*, *Changjiangosaurus huananensis*, and an unnamed changjiangosaurid). The recognition of Varaniformes in the Paleocene of Asia expands the biogeographic range of the group after the end-Cretaceous mass extinction. The morphology of *Anqingosaurus* (short snout, strongly interdigitated frontoparietal suture) suggests it may have been a burrower, exploring the subterranean environment. The unique posterior process of the angular in changjiangosaurids may reflect a specialization of the associated pterygoideus muscle, increasing its strength and therefore overall bite force. Compared with the Paleocene squamates from North America and Morocco, the Qianshan Paleocene squamate fauna is characterized by the absence of pleurodont iguanians (temporarily present in the Chinese Middle Eocene), Serpentes (regionally, snake remains from Kazakhstan and Pakistan), and Amphisbaenia. Compared with the diverse Late Cretaceous squamate assemblages from Asia, the Qianshan Paleocene squamates, together with squamates from other Asian Paleocene localities, demonstrate that major clades of squamates (Iguania, Anguimorpha, and either Scincoidea or Lacertoidea) survived the K/T mass extinction in this region. The fate of Gekkota remains unclear.

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Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

MASTODONS OF UNUSUAL SIZE: HOW DISTINCTIVE ARE WESTERN SPECIMENS OF *MAMMUT AMERICANUM*?

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Several authors over the years have suggested that individuals of *Mammut americanum* from California, and specifically from Rancho La Brea, tend to be smaller and have different tooth proportions than those from the eastern United States, but little corroborative data have been presented. To test this hypothesis, measurements were obtained from second and third upper and lower molars (maximum crown length and width) and femora (length, distal width, and minimum shaft diameter) from mastodons from various southern California localities, particularly Rancho La Brea and Diamond Valley Lake, then compared to specimens from elsewhere in North America.

Preliminary results indicate that mastodons from California, Idaho, and Utah tend to have molar crowns that are narrower for a given length than those from other areas. This trend is apparent in both upper and lower 2nd and 3rd molars but is most pronounced in the m3. In the m3, the difference in proportions becomes more pronounced with increasing crown length. Moreover, the CA-ID-UT populations are the only ones in which the average m3 crown is more than twice as long as wide.

In addition, there are indications that the size of the m3, particularly the width, does not track closely with body size. Diamond Valley Lake specimen WSC 18743 has a distal femoral width of 288 mm, which is larger than any other California mastodon and larger than the adult male mastodon from Watkins Glen, New York. The pelvic width of WSC 18743 is also greater than the Watkins Glen specimen. Yet the molars from WSC 18743 are not particularly long relative to other California specimens and are among the narrowest molars measured.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

THREE TAYASSUIDS FROM THE LATEST MIOCENE TO EARLIEST PLIOCENE (HEMPHILLIAN) GRAY FOSSIL SITE, TN

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Hemphillian localities are rare within the eastern United States, being predominantly restricted to Florida. The Gray Fossil Site (GFS), constrained to approximately 7 to 4.5 Ma, is one of the few sites that represent this time interval through the preservation of a diverse biota from a lacustrine setting. Flora identified within the site indicates that the GFS likely represents an oak-hickory forest. This forest is suggested to have potentially acted as a refugium for a variety of browsing animals during a time when grasslands were spreading elsewhere. Medium to large bodied taxa identified include tapir (*Tapirus polkensis*), Eurasian badger (*Arctomeles dimolodontus*), red panda (*Pristinailurus bristoli*), rhino (*Teleoceras* sp.), short-faced bear (*Plionarctos* sp.), alligator (*Alligator* sp.), megalonychid sloth, proboscidean, and multiple tayassuids. Tayassuid material is relatively rare at the site and consists of partial cranial and mandibular elements, isolated teeth, and disarticulated postcrania. Attritional deposition is suggested for the tayassuid material due to its fragmentary and disarticulated condition. This is in contrast to the abundant *T. polkensis,* which is considered to have been in direct proximity to the pond, due to the presence of more complete and articulated specimens. Despite the condition of the material analyzed, *Mylohyus elmorei* is identified based on fossils from the Bone Valley Formation of Florida. *Prosthennops* cf. *P. serus* and cf. *Catagonus* sp. are also identified through comparisons to material from the Tyner Farm locality of Florida and the Bone Valley Formation. An MNI of two individuals is recognized using dental elements for each of the three taxa, whereas the indeterminate tayassuid material comprises four individuals (two adult and two juvenile) using both dental and postcranial elements. The GFS represents the only site outside of the Bone Valley Formation with *Mylohyus elmorei*, rendering a substantial extension of the species' distribution. Recognition of *Prosthennops* extends the already widespread distribution of the genus into the Appalachian region. Sympatry of multiple tayassuid taxa within the GFS indicates the potential for niche partitioning.

Grant Information
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Technical Session XVII (Saturday, October 29, 2016, 12:00 PM)

FOSSIL COMPLETENESS IN UPPER CRETACEOUS MARINE REPTILES

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Mosasaurs and plesiosaurs cohabited the oceans during the Late Cretaceous (100.5-66Ma), occupying complementary niches. Mosasauridae appeared early in the Turonian and displayed rapid adaptations to the marine realm. Plesiosaurs convergently evolved forms similar to those of Early Jurassic forms. The plesiosaur record is quite different than that for Mosasauridae. Polycotylidae and Elasmosauridae evolved alongside mosasaurs, but polycotylids disappeared as mosasaurs diversified. Unlike mosasaurs and polycotylids, elasmosaurs are represented by non-diagnostic postcranial material and poorly preserved skulls. Little is known about fossil completeness in plesiosaurs, or its effect on macroevolutionary patterns or naming of plesiosaur taxa. Previously, we used a specimen-based substage analysis of fossil completeness to analyze the mosasaur fossil record.

Here, we apply similar methods to Upper Cretaceous plesiosaur fossils and compare to the mosasaur record. The Upper Cretaceous plesiosaur literature was reviewed and specimens were assigned a fossil completeness value (TCM). Scoring was based on completeness of anatomical regions including the skull, axillary and appendicular skeleton. The scores for individual specimens were binned in substages based on fossils identified specifically to that period. The average plesiosaur TCM for time bins was compared to plesiosaur specimen-based diversity using ghost ranges. Plesiosaur completeness was compared to sea level, diversity and mosasaur TCM.

Plesiosaur diversity dropped in the early Turonian as mosasaur diversity rose. Campanian plesiosaur diversity rose in combination with mosasaurs and peaked in the late Maastrichthian. Average plesiosaur TCM is higher than mosasaur TCM. Completeness measures of mosasaurs and plesiosaurs do not correlate. Plesiosaur diversity correlates highly with sea level, but plesiosaur TCM does not, and plesiosaur diversity does not correlate with TCM.

The plesiosaur specimen-based substage diversity increased along with mosasaurs into the late Maastrichthian with no pre-K-Pg boundary slowing. Sea level may have driven elasmosaur diversity. There seems to be no mechanism driving fossil completeness in marine reptiles. Fossil completeness does not bias naming of plesiosaur species. Sea level does not correlate with TCM in plesiosaurs or mosasaurs, unlike previous results in other fossil completeness analyses.

Technical Session XVII (Saturday, October 29, 2016, 8:15 AM)

AN EXCEPTIONAL NEW THALATTOSAUR (REPTILIA) FROM THE UPPER TRIASSIC (NORIAN) HOUND ISLAND VOLCANICS OF SOUTHEASTERN ALASKA

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Thalattosaurs are a poorly known and exclusively Triassic clade of secondarily aquatic marine tetrapods. To date, the clade is restricted to low paleolatitude deposits in the eastern and western Tethys (the alpine region of Europe and China, respectively) and the eastern Pacific (western North America). Five species are currently described from North America, which are known entirely from incomplete or disarticulated material. In May 2011, the skeleton of a small (1.5 m), well preserved thalattosaur, UAMES 23258, was recovered in a calcareous shale unit of the Hound Island Volcanics of southeast Alaska. The Hound Island Volcanics are part of the allochthonous Alexander Terrane and were deposited far offshore of North America within a volcanic island arc complex at low paleolatitudes (19° ± 10° N). Based on conodont and bivalve biostratigraphy, the specimen is middle Norian in age.

UAMES 23258 is significant in being the most complete and only fully articulated thalattosaur specimen known from North America. Being Norian in age, it is also one of the stratigraphically youngest yet found. UAMES 23258 represents a new taxon with an autapomorphic rostral morphology. Both the premaxilla and dentary are straight and remarkably pointed anteriorly. The dentary and maxillary teeth are gracile and recurved; however, the anterior third of both the upper and lower jaws are edentulous. The specimen also preserves a small but distinct temporal fenestra, scleral ossicles and a well-developed hyoid apparatus. The postcranium includes a very short cervical region, a reniform radius, relatively poorly ossified metapodia, tall neural spines, numerous extremely fine gastralia and also two gastric masses in the abdominal cavity. Phylogenetic analysis does not nest UAMES 23258 within longirostrine askeptosauroids, rather, it is recovered as a basal thalattosauroid, a clade that includes all other known North American taxa, as well as those with a ventrally deflected rostrum. The occurrence of UAMES 23258 within an accreted island arc terrane that was formerly situated far from the coast of western North America supports the biogeographic hypothesis that such terranes played an important role in facilitating the widespread inter-tropical distribution of the clade across Panthalassa and throughout the Tethys.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

THE CROCODYLIAN DEATH ROLL: THE UTILITY OF MULTIPLE MODERN ANALOGUES IN PALEONTOLOGICAL RESEARCH OF BEHAVIOR

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The death roll is an iconic, if understudied, behavior within Crocodylia. Among living members of the clade, death rolling previously was documented in only seven species, all of which exhibit the broad snout morphotype often associated with a more generalist feeding strategy. This suggests that dietary specialists, and especially the slender-snouted crocodylians that focus on smaller prey, do not exhibit this behavior. Subsequently, this behavioral pattern has been projected onto a number of more distantly-related crocodyliforms, particularly those with slender snouts. However, it is unclear if the link between snout shape and death roll behavior represents a true signal, and one which can be applied to fossil crocodylians, or if the observed pattern is an artifact of limited observations. In order to test this potential link between form and function, death roll behavior was surveyed across captive animals representing 22 of the 24 living species (all of the generally recognized species of crocodylians excluding *Crocodylus acutus* and *Gavialis gangeticus*). Two types of stimuli were used to prompt this behavior: presentation of a food item affixed to a rope or catch pole, and capture with a catch pole. These stimuli were meant to explore whether animals would death roll when feeding/attacking and attempting escape in response to conflict. Of the species studied, only *Paleosuchus palpebrosus* failed to death roll during numerous repetitions of both stimulus types across several individuals. All remaining species tested exhibited the behavior, including *Tomistoma schlegelii* (both stimuli), *Mecistops cataphractus* (bait stimulus), *Crocodylus johnsoni* (escape stimulus), and *Crocodylus intermedius* (both stimuli). Our results suggest two conclusions regarding this behavior. First, death rolling is not solely a feeding behavior, and is also exhibited during inter- and, likely, intraspecific conflict as a means of escape, as supported by previous observations of animals in the wild. Second, neither the relative slenderness of the snout nor associated dietary preferences predict which species will and will not death roll. This case study demonstrates the importance of foundational ecological research across multiple available species when using modern animal analogues in studies of behavior in the extinct groups.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

ROOT MARKS IN THE CLASSROOM: A STUDENT SCIENCE APPROACH TO ACTUALISTIC TAPHONOMIC RESEARCH

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Combining experiential learning with original research in classroom settings can be beneficial for students and scientists alike. Students gain a scientific mindset by directly applying the scientific process on real world questions and data collection. Researchers are able to collect large datasets by crowd sourcing analyses and observations across wide geographic swaths. Vertebrate paleontology enjoys an elevated level of interest from and engagement with the public compared to many scientific disciplines. However, capitalizing on this interest to involve K–12 students in authentic research poses challenges. Here we present a pilot study of root mark formation on modern bones that addresses the challenges encountered when translating taphonomy research to K–12 classrooms in Tennessee and North Carolina. Sectioned cow bones were buried at controlled depths in flower pots, and subjected to the following treatments: no plants (control), fescue (*Festuca* sp.), Bermuda grass (*Cynodon* sp.), carrots (*Daucus carota*), and sunflowers (*Helianthus* sp.). Fourth through eighth grade students and teachers cared for the specimens and collected information related to plant growth and maintenance, including water measurements and times, light and dark cycles, and height of individual plants. These tasks were incorporated into existing assignments and required curriculum standards. At set periods ranging from one to eight months, bones were exhumed. Half were set aside with surrounding sediment and plant material for microbiological analysis to be performed by an undergraduate student researcher. The remaining samples were cleaned and returned to the K–12 students for observation and discussion. Challenges encountered during this research included heightened insect activity, indoor climate fluctuations, differential success of growth across plant types in the classroom setting, and regularity of plant care (related to school holidays, etc.). Despite these complications, bone samples across controlled depths, times, and plant taxa were successfully collected for both microbiological and visual analysis providing proof of concept for large-scale research on root mark formation.

Technical Session XVI (Saturday, October 29, 2016, 9:30 AM)

APPLYING THE ECOLOGICAL CORE–TRANSIENT SPECIES PARADIGM TO PLIO–PLEISTOCENE FOSSIL MAMMALS IN THE OMO–TURKANA BASIN, EAST AFRICA

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In this research, we apply the core-transient species paradigm to large mammal data (> 4.5 kg) from the Koobi Fora, Nachukui, and Shungura Formations of the Omo-Turkana Basin, which straddles the Ethiopian-Kenyan border and spans 4.5–0.5 Ma. Vertebrate paleontologists are interested in why species persist in the fossil record, and modern ecologists are also interested in the question of persistence (on time scales of 10^{-1}–10^{1} years). Ecologists have developed a conceptual framework in which species in a community can be divided into two groups: 1) core species that are temporally persistent and 2) transient species with sporadic occurrences over time. For ecologists, core species are locally abundant and specialized and well-adapted to local conditions, whereas transient species are opposite in all respects. In contrast, macroevolutionary research has shown that generalist mammals have the lowest extinction risk (and highest persistence) on time scales of 10^{6}–10^{7} years. Thus, there is an apparent contradiction between neo-ecology and macroevolution in which specialists persist on neo-ecological time scales and generalists persist on macroevolutionary time scales. Using the Turkana Basin Database and Omo American Database, we accounted for differential sampling based on taphonomic, taxonomic, and collecting issues. Species were assigned to core or transient groups based on whether they occupied more or less than 50% of the members in each formation. Results show 19% of mammal species as core in both the Koobi Fora and Nachukui Formations, while 26% are core in the Shungura Formation. Among all species shared by the three formations, 41% are core species. A random Poisson model shows this number of observed core species is not unexpected, but Monte Carlo analyses show the core species are non-randomly distributed across taxonomic families. Specifically, more giraffids than expected suggests something unique about this clade imparting high persistence on its constituent species. We also analyzed whether particular functional traits were associated with core or transient species. Results show there are no specific traits (such as diet) associated with core species, but on average, each does seem to be more specialist than generalist, providing an interesting correspondence with the predictions of modern ecological studies. We further hypothesize that the core group of species represents the stable part of the metacommunity that can disperse to and from a local community during times of short-term stress and, therefore, survive regionally.

Grant Information
Research was supported by NSF DGE-0801634.

Technical Session XVI (Saturday, October 29, 2016, 9:45 AM)

PALEOECOLOGICAL ANALYSES OF FOSSIL BOVIDAE FROM PLIOCENE HOMININ SITES FROM THE OMO-TURKANA BASIN, EASTERN AFRICA

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Australopithecus anamensis, possibly one of the earliest fully bipedal hominins, lived in eastern Africa around 4 million years ago, but fossil remains associated with this species are relatively rare and have only been found at a handful of sites in the region. Three main fossil sites in the Omo-Turkana Basin (Kanapoi, Allia Bay and Mursi) preserve sediments from about 4 million years ago. However, the abundance of hominin fossils at these sites is extremely variable: the majority of the fossils attributed to *Au. anamensis* have been found at Kanapoi (c. 70%), some have been discovered at Allia Bay (c. 30%), and no hominin remains have been found so far at Mursi. Preliminary paleoecological analyses suggest that there were differences in the environments of these three sites. This project tests hypotheses relating hominin abundance to habitat and answers the following questions: What were the paleoenvironments of *Australopithecus anamensis* in the Omo-Turkana Basin and how did they vary among sites? This project uses a multiproxy approach to analyze the bovid fossils at each site to reconstruct the paleoenvironments. The study combines taxonomic identifications, postcranial ecomorphology analyses, assessment of the mesowear of the teeth and stable isotopic data. Overall, the analysis of the bovid remains from Allia Bay reveals a mosaic environment that is intermediate between the more open site of Kanapoi and the more forested site of Mursi. The bovid community composition is significantly different at all three sites. When classified into diet categories, browsers are more common at Mursi then at the other sites and grazers are the most common at Kanapoi. Similarly, carbon isotopic ratios are generally more depleted at Mursi, intermediate at Allia Bay and less depleted at Kanapoi. Allia Bay mesowear scores are also indicative of a mosaic habitat: both an attrition dominated diet and a mixed diet are common in the assemblage. However, the results of the ecomorphological analysis of the astragali suggests a more forested habitat, similar to that of Mursi. Analysis of the complete fauna will provide further insights into the possible relationship between habitat and the abundance of these early bipedal hominins on the landscape.

Grant Information
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Poster Symposium I (Wednesday–Thursday, October 26–27, 2016, 4:15–6:15 PM)

REVISED MAMMALIAN FAUNA FROM THE SAND WASH BASIN AND ASSESSMENT OF AN EARLIEST UINTAN AGE

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The fossil fauna of the Sand Wash Basin in northwestern Colorado was originally thought to be late Bridgerian (Br3) in age. More recent revisions of the fossil mammals from the Sand Wash Basin have suggested either that the fossil material spans the Bridgerian–Uintan boundary or is entirely early Uintan in age. The current consensus supports a faunal age of earliest Uintan (Ui1b) for the entire Sand Wash Basin, despite a lack of stratigraphic control and a mammalian fauna of poor taxonomic resolution. New fossil collecting efforts in the Sand Wash Basin in the summer of 2015 resulted in the recovery of fossil taxa previously unknown from the area, especially microfauna, and more specimens of some previously reported taxa. Taxa newly reported from the Sand Wash Basin include *Apatemys* sp., the creodont *Sinopa major*, the ischyromyid rodents *Pseudotomus horribilis* and *Microparamys minutus*, and a small sciuravid resembling *Pauromys*. New specimens confirm the presence of two larger sciuravid rodents, *Tillomys senex,* and a larger, more derived species, the ischyromyid *Thisbemys corrugatus*, and an omomyid primate similar in size to *Omomys carteri*, although the rare and fragmentary nature of the dental and postcranial specimens precludes a confident allocation. An updated and revised faunal list of the Sand Wash Basin mammals reinforces a faunal age of Ui1b and extends the range of *P. horribilis* from Br3 to Ui1b.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

PREDICTING VISUAL ABILITIES AND BEHAVIORS IN EXTINCT BIRDS BASED ON BRAIN ENDOCASTS

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Avian brain endocasts are relatively faithful representations of the external morphology of the brain, and in extinct birds, they are the only source of information on brain anatomy. As such, they are often used to infer behaviors in extinct birds. However, the correlations between brain structures and behaviors in extant birds are based on volume, whereas the size metric for brain structures available from endocasts is surface area. The assumption has been that the surface area of an endocast structure is a fair proxy for the volume of the underlying brain structure, but this is problematic. First, the endocast only allows measurement of the surface area of externally-visible portions of

brain structures. Additionally, a statistical relationship between surface area of an endocast structure and volume of the brain structure has not been established. The optic lobe, which overlies the optic tectum, and the Wulst, which overlies the hyperpallium, are good candidates for this study due to their presence on avian brain endocasts across a broad taxonomic sample. The volume of the retinorecipient optic tectum has been correlated with visual abilities, but other deeper structures within the optic lobe may also influence its size. The hyperpallium is part of the avian thalamofugal visual pathway and is involved in higher-order visual processing as well as somatosensory and motor pathways. These brain-endocast structure complexes are variable in size among birds, but the relationship between any brain structure and its endocast counterpart is unknown. To assess this relationship, optic tectum and hyperpallium volumes of 20 extant avian taxa were compiled from the literature and collected from existing histological series. Endocasts of the same species were generated from CT scan data of their skulls, and the surface areas of the corresponding endocast structures, the optic lobe and Wulst, were measured using Avizo and Maya. For each species, the volumes of the brain structures were regressed on the surface areas of the endocast structures. These preliminary results indicate that there is a positive relationship between endocast structure surface area and brain structure volume in the studied vision-related structures, which was then used to predict the volumes of these brain structures in five extinct avian taxa (*Archaeopteryx*, *Dinornis* sp., *Lithornis*, *Presbyornis*, and "*Buteo*" *grangeri*). The taxonomic sample will be expanded in the future to strengthen these relationships and extend the study of brains and behavior in birds into deep time.

Grant Information
National Science Foundation Graduate Research Fellowship (DGE 1060934 to C. M. Early)

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

A NEW PLASTOMENINE (TESTUDINES, TRIONYCHIDAE) FROM THE MILK RIVER FORMATION OF ALBERTA (LATE CRETACEOUS: SANTONIAN)

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The pre-Campanian trionychid fossil record in North America is comprised of fragmentary specimens, which can often only been identified as Trionychidae indet. Here, we describe a new species of plastomenine soft shell turtle from the Santonian-aged Milk River Formation of southern Alberta, dated at ~84 Ma, based on an incomplete shell (ROM 56647). Plastomeninae, a trionynchid clade known only from the fossil record, is classically distinguished by the complete suturing of its plastral bones along the midline, a crescent- shaped entoplastron, and enlarged eighth costals. ROM 56647 consists of the posterior half of the carapace, a partial nuchal, a complete xiphiplastron, and partial hyo-hypoplastron, and a fragment of a femur. The specimen has a unique combination of plastomenine and more basal trionychid characteristics, in addition to autapomorphies that suggest it is a novel species. It has a completely fused and relatively slender hyo-hypoplastral bridge, a bow-shaped nuchal, a distinctly straight pygal notch, a domed carapace, extensive plastral callosities and sculpturing, a posteriorly notched xiphiplastron, and enlarged tubercles with smaller intermittent shallow pits across the dorsal carapace. Autapomorphies include the bow-shaped nuchal, posteriorly notched xiphiplastron, enlarged carapacial tubercles, and its straight pygal notch. Phylogenetic analysis places ROM 56647 in a polytomy with Gilmoremys, Plastomenus, and a clade of Hutchemys spp within Plastomeninae. The morphological distinctiveness, together with its age, support the recognition of ROM 56647 a new species. As the oldest trionychid that can be described to the species level in North America, ROM 56647 provides new insights into the early evolution and dispersal of Trionychidae from Asia into North America, and the biodiversity of its locality, Milk River Formation, during the Late Cretaceous.

Grant Information
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Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

LUNGFISH (DIPNOI, CERATODONTIFORMES) TOOTH PLATES FROM THE LATE CRETACEOUS (LATE SANTONIAN) TOMBIGBEE SAND MEMBER, EUTAW FORMATION OF ALABAMA AND MISSISSIPPI, USA

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Although dipnoans are currently extant in the Southern Hemisphere, they become extinct by the end of the Mesozoic in North America. Most of the fossil record for North American lungfishes comes from isolated tooth plates recovered from the western United States. More recently, lungfish tooth plates from the Cretaceous of New Jersey and Maryland have been identified, filling the geographic gap in the fossil record for dipnoans in North America. In the southeastern US, two tooth plates, one from Alabama and the other from Mississippi have recently been identified. The Alabama specimen was recovered from the late Santonian Tombigbee Sand Member of the Eutaw Formation in Greene County, Alabama. The tooth plate, tentatively referred to *Ceratodus*, has a smooth occlusal surface lacking any sharp transverse ridges. Laterally projecting crests at the labial margin of the tooth plate suggest that four, or possibly five, transverse ridges were present on the occlusal surface prior to wear. The second specimen was also recovered from the late Santonian Tombigbee Sand Member of the Eutaw Formation, in Lowndes County, Mississippi. This tooth plate, tentatively referred to *Potamoceratodus*, is a partial right prearticular with much of the symphyseal region present. Three distinct ridges are preserved anteriorly as well as the lingual origins of a fourth, which was severely truncated due to erosion.

These tooth plates represent the first records of lungfish of any geologic age from Alabama and Mississippi, are the second youngest specimens reported from North America, and extend the Late Cretaceous biogeographic range of dipnoans to the Gulf Coastal Plain of the United States.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

LIFE HISTORY ANALYSES OF WOOLLY MAMMOTHS FROM WRANGEL ISLAND AND CHUKOTKA

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The proximal portions of five isolated woolly mammoth (*Mammuthus primigenius*) tusks from Chukotka and Wrangel Island in northeastern Siberia were analyzed to extract life history information from the final years of growth. All five individuals have been identified as adults based on aspects of tusk morphology known to change throughout ontogeny, such as depth of the pulp cavity and proximal reduction of tusk diameter with advanced age. However, based on these features, there appears to be a range in ontogenetic age within the study sample. Given that none of these individuals are juveniles and that many adult proboscidean tusks display strong sexual dimorphism, we are able to identify all five individuals as female. Radiocarbon dates from the specimens reveal ages ranging from approximately 5,500 to 8,500 cal yr BP for the Wrangel Island specimens and 18,500 and 31,000 cal yr BP for the Chukotka specimens. X-ray microtomographic, serial isotope, and thin section analyses were carried out on each specimen to assess inter- and intra-annual variation in tusk growth. This variation is then used to interpret season of death and relevant life history information for each individual. Tusk samples were found to contain between five and nine years of growth, and based on comparisons with growth in previous years, all individuals were interpreted as having a winter season of death. Four of the five tusk samples show a sinusoidal change in annual appositional thickness over a period of approximately four to five years, which we interpret as calving cycles. The three Holocene Wrangel Island specimens show a decline in average annual growth rate through time and record overall thinner annual growth increments than the two late Pleistocene Chukotka specimens. However, controlling for ontogeny and for the shift to an insular environment (with an associated reduction in body size) calls the significance of this trend into question.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

NEW DINOSAUR REMAINS FROM THE CAMPANIAN QUSEIR FORMATION, WESTERN DESERT, EGYPT

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Late Cretaceous dinosaur remains from the Afro-Arabian continent are rare and mainly restricted to pre-Turonian horizons. Consequently, the discovery of new fossils from Upper Campanian (~73 Ma) deposits in the Western Desert, southern Egypt is very significant because it constitutes some of the first identifiable dinosaur material described from Afro-Arabia. The oases of Kharga and Dakhla, Western Desert, Egypt, preserve exposures of Campanian-aged Quseir Formation deposits. Numerous representative saurischian dinosaur fossils (30 specimens) have been collected from the Quseir Formation, including a variety of postcranial elements referable to Theropoda and Sauropoda. In the Tineida Research Area (Dakhla Oasis), isolated sauropod teeth, the proximal ends of an articulated sauropod tibia and fibula, an isolated sauropod tibia, and several caudal vertebrae representing both juvenile and adult individuals add significantly to the known latest Cretaceous diversity of Afro-Arabia. Although many of the caudal vertebrae are poorly preserved, five of them can be referred to Titanosauria on the basis of exhibiting procoelous centra and anteriorly displaced neural arches. In the Baris Study Area (Kharga Oasis), recovered dinosaur remains include a partial humerus and partial cervical vertebra of a sauropod dinosaur and an isolated proximal left fibula of a theropod dinosaur.

Given the extreme paucity of coeval occurrences elsewhere on the continent, the Dakhla and Kharga fossils provide an important glimpse into the diversity of dinosaurian assemblages in the region during the Campanian and are critical for comparisons with other Gondwanan materials known from this time. Titanosauria is a widespread group of dinosaurs and the last sauropod group to survive until the end of the Cretaceous in other parts of the world. Thus, these new findings indicate that northern African ecosystems also supported the group until the latest Cretaceous. At a finer level, these discoveries also assist in evaluating hypotheses regarding the development of continent-level provincialism as the African continent became increasingly isolated from the rest of Gondwana throughout the Cretaceous.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

A NEW AGNATHAN SUBFAMILY (HETEROSTRACI, CYATHASPIDIDAE) FROM THE LATE SILURIAN AND EARLY DEVONIAN OF THE WESTERN UNITED STATES AND THE CANADIAN ARCTIC

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The Heterostraci are a widespread group of armored jawless vertebrates that are particularly associated with shallow marine and brackish environments of the Old Red Sandstone Continent from the Early Silurian to the Late Devonian. Early Devonian faunas have been used to develop an extended correlation scheme for the western United States, although endemism has restricted the extension of this scheme outside the area and its correlation with the western European vertebrate zonal scheme. However, recent publications have demonstrated a connection between the western United States fauna and that of the Canadian Arctic, with the cyathaspid *Poraspis* being the first genus to be documented in both areas. The cyathaspids described here provide additional support for this connection. Three new species of a new genus of cyathaspid heterostracan are recognized from Early Devonian localities in eastern Nevada, western Utah, and in Death Valley, California. These are broad, flattened cyathaspids with lateral brims and fine

dermal ornament, that show a close relationship to the cyathaspids *Boothiaspis* and *Alainaspis* from the Late Silurian and Early Devonian of the Canadian Arctic. These taxa will be accommodated within a new subfamily within the family Cyathaspididae. This relationship supports previous evidence of faunal connection between the Canadian Arctic and the western United States and indicates dispersal around the Old Red Sandstone Continent from a center in the Canadian Arctic.

Isolated oral plates allow a reconstruction of the oral cover. A lateral plate, enclosing the supraorbital canal, is recognized for the first time within the Cyathaspididae, and it is shown that these species had an arrangement in which a large central oral plate was flanked by smaller oral plates. This is closest to the arrangement in *Poraspis*, thus supporting a close relationship with that genus, and increases our knowledge of the range of oral structures in the Cyathaspididae.

Poster Symposium I (Wednesday–Thursday, October 26–27, 2016, 4:15–6:15 PM)

CAN INFERRED ECOLOGY ELUCIDATE DRIVERS OF LIZARD EVOLUTION THROUGH EOCENE CLIMATIC TRANSITIONS OF THE WESTERN INTERIOR?

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Ecology correlates with morphology in many extant ectotherms. Prior studies have found correlation between large body size and temperature in fossil reptiles. Building on this, I ask whether specific features in fossil lizards correlate to known associations in extant lizards between morphological traits and ecological and environmental variables. I investigated the fossil record of North American anguid lizards, which were abundant through the Paleogene in the Western Interior basins, including large forms (skull length ≤ 125 mm) restricted to the Eocene. Anguid diversity tracks climatic changes through the Eocene; several genera occur in the Wasatchian but only one by the Chadronian (*Helodermoides*). Unlike large lizards today, their dentition suggests neither strict herbivory nor carnivory, and their ecological habits have not been rigorously tested.

I estimated snout-vent length (SVL) from skull material for large Eocene anguids (n = 40), including unexamined Washakie Basin material, based on measurements of the extant anguimorph *Heloderma* (n = 36), which has an equivalent skull/limb ratio (1.7). In a survey of all extant lizard clades for suitable ecological analogues, *Xenosaurus* and *Heloderma* (Anguimorpha) scored highest for similarity to large Eocene anguids in SVL, presence of osteoderms, body proportions, dentition, and environmental context.

Xenosaurus and all anguids have small, squared, monocuspate teeth. Like early Eocene anguids, it has a flattened skull and occurs in tropical closed forests. *Xenosaurus* therefore suggests that early Eocene large anguids were insectivorous, thermoconforming, and saxicolous. Some large extant lizards are also saxicolous (*Sauromalus*), so this is a plausible habit for large fossil anguids.

Heloderma matches large anguids in body proportion and reaches a closer maximum SVL (500 mm). It occurs in tropical dry forests and deserts, consistent with cooling and drying in the Western Interior basins through the middle to late Eocene. *Heloderma* is both arboreal and widely foraging, but arboreality is not consistent with a transition to open habitats through the late Eocene. *Helodermoides* also lacks the curved, serrated teeth with venom grooves found in *Heloderma*, and its deeper skull does not suggest a saxicolous habit. Its inability to evade or envenomate predators may have hindered *Helodermoides*. Future work will use independent lines of evidence from the environmental context of the late Eocene to test whether such factors contributed to the extinction of *Helodermoides* by the Orellan.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

NEW FRAMEWORK FOR SCIENCE COMMUNICATION ADAPTS STORY ART TECHNIQUES FROM FILMMAKING

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Scientists need to have excellent communication and presentation skills to convey their research to both academic and public audiences. This is one of the most important professional skills for science students to develop—especially students of paleontology, who must learn to convey the merit and impact of historical science in order to compete and gain prominence among other scientific fields. However, communication training is often underemphasized in science degree programs. Here we offer an approach that will both train science students to be effective communicators and entice students to develop those skills.

We present a framework that adapts story art techniques used in filmmaking for science communication. We draw parallels between storyboarding a film and creating an oral or poster research presentation. The framework first employs critical thinking questions to construct a storyline (e.g., Is the protagonist the scientist or the study organism? What does the protagonist want, and what obstacle is preventing that? What is the main theme of the story?). We then offer a suite of technical approaches to translate the storyline into visual presentation, including concepts such as information density (using a few salient points or images to convey extensive information), visual language (an image system to help the audience follow the story), editing (avoiding redundancy), and design (aesthetics for slides and figures).

As a pilot test of this idea, we offered a workshop for students and faculty at the University of California Museum of Paleontology in Berkeley. The workshop attracted 60 participants, ranging from undergraduates to emeritus faculty. The co-authors, who are story artists and animators, introduced the story art techniques; the group then discussed how those strategies could be used in science communication. Post-workshop surveys unanimously indicated that attendees gained practical tools and motivation to enhance their scientific presentations in a variety of formats.

In order to test the efficacy of this approach, the lead author, a doctoral student, used this framework to create a research presentation for a public venue. This format proved to be highly effective for communicating paleontological research to a general audience. We are now developing a guide that will be made available through an open access online platform. We are also developing expanded workshops for conference venues. This novel framework promotes creative and effective science communication for students and scientists at all professional levels.

Technical Sesssion X (Friday, October 28, 2016, 8:15 AM)

MACROEVOLUTION OF PARAREPTILIA

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Parareptilia is an extinct clade of early amniotes, once thought to be related to modern turtles. Despite its small size, the clade exhibits a wide range of ecological niches, exemplified by different dietary strategies (mainly herbivorous and insectivorous), different types of locomotion (quadrupedal and possibly facultative bipedal for terrestrial members; aquatic members are known as well) and disparate morphologies. Parareptiles show an extended evolutionary history ranging from the latest Carboniferous to the latest Triassic and were globally widespread. In spite of these properties, the clade has been largely neglected in recent macroevolutionary analyses.

Here we present a new analysis of diversity and body size evolution in parareptiles. The raw diversity curve shows several peaks and troughs during the Paleozoic, with the maximum number of species reached in the Wordian. A phylogenetic diversity estimate, based on a new informal supertree and a chronostratigraphically high-resolution dataset (at substage level) of all currently known species of Parareptilia, indicates, quite differently, a rather steady increase in diversity over time. Different from many other tetrapod groups, the overall diversity of Parareptilia was largely unaffected by the end-Permian extinction event. Indeed, both pure taxic and lineage richness count indicate a peak in diversity in the following Induan. This peak was followed by a relatively rapid decrease in diversity in the following substages. The clade was never able to attain its previous diversity during the rest of the Triassic and finally became extinct in the late Rhaetian.

An analysis of body size evolution was conducted, using femur length as a proxy for body size. Different models of continuous character evolution were fitted against the time-scaled supertree. Our analyses indicate that an "Ornstein-Uhlenbeck" (OU) model is favoured over competing models, closely followed by a "trend" model. Different body size proxies (femur length, estimated femur length and skull length) show slightly different results, which are probably related to small sample sizes. In most of the analyses, the OU model is recovered as the preferred model.

This analysis is part of a larger study aiming at disentangling the evolution of body size within early tetrapods *sensu lato*.

Grant Information

This work was supported by the Natural Environment Research Council [NE/L002434/1].

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

A BASAL DEINONYCHOSAUR FROM THE EARLY MAASTRICHTIAN, ANTARCTIC PENINSULA AND THE BIOSTRATIGRAPHY OF THE LATEST CRETACEOUS DINOSAUR FAUNA OF ANTARCTICA.

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Morphological and phylogenetic analyses of the theropod specimen from the Naze Peninsula, James Ross Island, Antarctica, resulted in a re-description of the early Maastrichtian specimen as a basal deinonychosaur. A previous description of this specimen referred it to the Dromaeosauridae. Particular character states of the Antarctic specimen differ from the dromaeosaurid norm, and referral to this family is not supported in the phylogenetic analysis based on distal hindlimb and pedal data. The lack of a distal, ginglymoid articular facet of metatarsal II signifies a placement at least within the Deinonychosauria, but not within Dromaeosauridae. The specimen also lacks an enlarged ungual of the second pedal digit and is surprisingly small in comparison with those of equivalently sized dromaeosaurids such as *Utahraptor*. A heuristic search revealed the Naze theropod to be the basal-most deinonychosaur, a sister taxon to all other deinonychosaurs (Troodontidae + Dromaeosauridae). A bootstrap search supports a trichotomy of the Antarctic theropod with the Troodontidae, and the Dromaeosauridae in 72% of all bootstrap replicates.

The biostratigraphy of all Late Cretaceous Antarctic dinosaurs indicates a near contemporaneous occurrence of most dinosaur species from the James Ross Basin. Three dinosaur taxa from the Cape Lamb Mbr. of the Snow Hill Island Fm., the elasmarian ornithopod, *Morrosaurus antarcticus*, the Naze deinonychosaur and the Cape Lamb hypsilophodontid, are associated with invertebrates of the *Gunnarites antarcticus* faunal assemblge and are within the more restrictive 50 meter stratigraphic range of the ammonite, *Diplomoceras lambi*. A Sr/Sr datum corresponding to an age of 71.0 Ma has been recovered from the upper part of the *Diplomoceras lambi* biostratigraphic range, resulting in these three dinosaur taxa being earliest Maastrichtian in age. Three other dinosaur taxa, the elasmarian *Trinisaura santamartaensis*, the ankylosaur *Antarctopelta oliveroi*, and a lithostrotian titanosaur have been described from the Santa Marta Cove area and the latest Campanian, Gamma Mbr. also of the Snow Hill Island Fm. These dinosaur species are associated with the first occurrence of the ammonite, *G. antarcticus*, at the very top of the Gamma Mbr. section within 150 meters of the Gamma Mbr. - Cape Lamb Mbr. contact with the base of the Cape Lamb Mbr. being assigned as the Campanian-Maastrichtian Boundary at 71.3 Ma. These six dinosaur species from the Antarctica likely occurred within a one million year time span from 71 Ma to 72 Ma.

Technical Session I (Wednesday, October 26, 2016, 11:30 AM)

CRANIAL MORPHOMETRICS AND DENTAL MEASUREMENTS CRITICALLY UNDERESTIMATE THE DIVERSITY OF FOSSIL ARTIODACTYL SPECIES

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A fundamental assumption of paleontology is that fossil species are diagnosable by bone structure alone, but this may not be the case for species that are closely related and geographically overlapping. Duiker antelope (Cephalophinae, Bovidae) are a modern

example of the worst-case scenario for paleosystematics: duiker species are ecologically and morphologically similar, with as many as eight living in the same geographic range. With such diversity and geographic overlap duikers also are an excellent test of whether cranial and dental morphology are adequate for species-level diagnosis in fossil artiodactyls.

I evaluated 70 skulls of 10 duiker species using 44 landmark characters gleaned from fossil systematics literature. I tested for classification errors using Discriminant Function Analysis (DFA) and Random Forest analysis (RF) in R. DFA was slightly more effective at classification than RF (81% accuracy vs. 69%). Misclassified specimens were not classified as sister taxa or as taxa similar in body mass, and 75% of misclassifications were between geographically overlapping species. Dental measurements showed similar low levels of accuracy (DFA = 72%, RF = 69%), but misclassified specimens were predominantly confused for other species similar in body mass. Histograms of dental measurements from six sympatric species show only three distinct size classes, and variance of combined samples was low (<10% Coefficient of Variation for six species). The low variation of multi-species dental samples and high classification error using cranial morphology suggests that paleosystematicists would be unlikely to reject a single-species hypothesis for these known multi-species samples. Character convergence towards the local ecosystem was so obfuscating that species with mitochondrial evidence of separation 8 million years ago were still misclassified by their similar ecosystem overprint.

Overall, detection likelihood of sympatric fossil duiker species even with a priori knowledge of species is low; if collected as a fossil sample, the species diversity of modern duikers would be dramatically underestimated.

Grant Information
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Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

DOCUMENTING AN EXTENSIVE TRACKSITE IN THE LATE TRIASSIC–EARLY JURASSIC NUGGET SANDSTONE AT DINOSAUR NATIONAL MONUMENT USING GIGAPAN LARGE PANORAMAS AND PHOTOGRAMMETRY

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The Late Triassic- Early Jurassic Nugget Sandstone represents the deposits of part of a vast erg. Although body fossils are scarce in the Nugget, many localities preserve ichnofossils. The Nugget is exposed over a large area within Dinosaur National Monument (DINO) and contains several track localities. One of these localities occurs on the dip slope of Nugget beds exposed approximately 160 meters along strike and across up to 40 meters of slope. This large outcrop exposes one of the intervals of horizontally-bedded interdunal sandstone facies that occur throughout the Nugget eolianites. It is probably the stratigraphically highest in the Nugget section, just below the overlying Carmel Fm., which is visible at the base of the slope. The tracks (*Otozoum*, *Eubrontes*, and *Anchisauripus*) occur at multiple levels within the approximately 2 meter thickness of this interdunal interval.

The erosional surface of the dip slope cuts across the interdunal interval at a low angle such that in several places surfaces that approximate bedding planes are exposed. These surfaces preserve tracks and trackways in plan view. Although some tracks are well preserved and show pads and claw impressions, most are distorted with a continuous gradation of quality from clear tracks to features that are doubtful as tracks. Two techniques have been applied to this locality to document the tracks and trackways using high resolution digital photography, Gigapan panoramas and photogrammetry.

Gigapan equipment and software permits a large number (several hundred in this case) of oriented photographs to be stitched together into a single large image that can be viewed in its entirety or in close up to the limits of resolution of the component images. Track locations that were mapped onto the component images in the field are included in the panorama. Such a document shows the location of individual tracks while preserving the larger scale spatial relationships among track concentrations on the outcrop.

Photogrammetry permits digital models of the surface of the locality or parts of it to be produced from a large number of sufficiently overlapping photographic images. The resulting model can be used as a representation of the surface and tracks for analysis or display.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

WHY GROW ARMOR AFTER THE PREDATORS ARE GONE? LATE ONTOGENETIC DEVELOPMENT OF CROCODILIAN OSTEODERMS WITH BEHAVIORAL IMPLICATIONS

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All extant, and most extinct, crocodilians possess bony carapaces made up of articulating osteoderms. These carapaces are most commonly described as defensive structures against predators. However, qualitative observations in the literature have suggested that the carapace of extant crocodilians does not fully mature into a completely imbricated structure until well after the hatchling stage, which is when the risk of predation is greatest. If osteoderms primarily serve a defensive function they may be expected to experience strong selection to appear earlier in ontogeny. However, many aspects of crocodilian locomotor, social, and feeding behavior are known to change markedly throughout ontogeny and would be expected to exert different kinds of selective pressures on crocodilians as they grow. Alternative hypotheses of osteoderm function can be tested in part by looking to see which of the aforementioned selective pressures shift at the same time as the osteoderm carapace fully develops. I examined CT scans of juveniles and adults of six species of extant crocodilians including a particularly well-sampled ontogenetic series of *Crocodylus niloticus*. Specimens were coded for total body length and degree of imbrication of osteoderms. Osteoderms were considered to have mature morphology when all nuchal and dorsal osteoderms were rectangular and fully articulated mediolaterally and overlapping craniocaudally. In all crocodilian species studied, osteoderms in different regions of the body begin ossification and achieve mature morphology at different times. A complete carapace is indeed only fully developed after the hatchling stage. The absolute body length at the time of carapace maturation varied by species due to species differences in maximum body length, but generally corresponded to a stage when individuals expand their range and resume interactions with larger individuals after having previously dispersed from a hatchling nursery. Thus, osteoderms form more effective armor when crocodilians reach body sizes at which they are less vulnerable to predation. Instead, the observed pattern is more consistent with osteoderms acting as defensive structures against large conspecifics. However, the proposed function does not preclude other as yet unidentified functions for these structures in adults or for smaller plates earlier in ontogeny.

Technical Session VII (Thursday, October 27, 2016, 3:30 PM)

WAVY ENAMEL IN HADROSAURID DINOSAURS WITH GRINDING DENTITIONS FUNCTIONED TO LIMIT FRACTURE DAMAGE THROUGH ENERGY-ROBBING CRACK DEFLECTION AND CHANNELING

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Reptiles (Sauria) rarely approached the biomechanical sophistication of feeding or dietary diversity seen in mammals. Their teeth are typically non-occluding, semi-conical to leaf-shaped structures with simplistic architecture composed of primitive amniote parallel-crystalite enamel surrounding an orthodentine core. Conversely, most mammals possess multi-cusped teeth that are drawn across one another during mastication and self-wear to their functional morphology. Mammalian enamel is complex, composed of prismatic enamel--a fiberglass-like composite composed of bundles of hard, brittle hydroxyapatite crystals surrounded by compliant proteinacous sheaths. Among the most sophisticated prism architectures is the modified radial enamel (MRE) of grazing ungulates whose coarse tooth surfaces enable the grinding of tough, abrasive laden plant matter such as grasses. MRE conveys exceptional fracture toughness and controlled fracture propagation minimizing damage to the brittle enamel crests. Hadrosaurids (duck-billed dinosaurs) are notable among reptiles in that they independently evolved self-wearing grinding dentitions. They also possess complex wavy enamel (WE), composed of folded layers of hydroxyapatite crystals whose biomechanical import is unknown. We tested the hypothesis that WE served an analogous biomechanical role to ungulate MRE. We: 1) tribologically modeled the effects on hadrosaurid occlusal surfaces should a section of enamel become fractured; 2) made polished cut-blocks using cheek teeth from a diversity of hadrosaurids, archosaurian outgroups lacking WE, and horse and bison; 3) introduced enamel fractures using indenters fitted with Vickers tips, documented crack patterns and used Watson's Two-Sample Test of Homogeneity to test for controlled-crack propagation; and 4) contrasted the results with regard to occlusal morphology and dietary inferences in phylogenetic and comparative contexts. Removal of enamel sections leads to aberrant self-wear to hadrosaurid chewing pavements inhibiting functionality. Non-wavy enamels show isotropic fracture patterns and catastrophic damage to the enamel shells. Hadrosaurid WE and prismatic ungulate MRE limit damage to the enamel crests through energy-robbing crack deflection at kinks in the enamel fabrics or at prism boundaries and channeling perpendicular to the enamel-dentine junction. WE represents an alternative, reptilian solution for damage resistance in grazing taxa, one that evolved tens of millions earlier than that of mammalian ungulates.

Grant Information
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Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

AN EMBARRASSMENT OF PALEONTOLOGICAL RICHES: 3D IMAGERY AND ASSOCIATED DATA FOR THE FOSSILS OF THE CARNEGIE QUARRY, DINOSAUR NATIONAL MONUMENT.

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Dinosaur National Monument is world renowned as one of paleontology's greatest windows into the world of dinosaurs. The remains of at least 500 individuals belonging to 11 species of dinosaurs, two species of turtles, one species of crocodile, and one species of the lizard-like sphenodonts have been found in the quarry sandstone. Spectacular skeletons excavated from the quarry have been viewed by tens of millions of citizens in dozens of museums across the country and around the world.

Historic excavations by the Carnegie Museum, USNM, and the University of Utah between 1909 and 1924, resulted in the collection and shipping of about 800,000 pounds of fossil bones. The major specimens have been described in scientific papers and monographs that remain benchmark publications. Some 1,400 bones uncovered between 1952 and 1994 remain in situ. But the vast majority of all the bones have neither been described nor figured. This project, a complement to the Digital Quarry Project, will make these important fossils easily accessible.

There are many historic maps, all incomplete, which complement one another as well as the bones of the present day quarry. We are working to digitize (1) all known excavation maps of the quarry (published and unpublished) made by several institutions (including multiple sub maps and maps of the contents of the fully prepared field jackets) and (2) develop the first detailed, 3D map of the current quarry face which contains some 1400 *in situ* bones. Many of the historical maps have been scanned and the current quarry face is being 3D modeled using two complementary methods, LiDAR and photogrammetry. The LiDAR model is complete and is based on 4.1 billion measurement points collected from 90 stations to minimize "gaps". We are working to develop the photogrammetric model, which will be combined with the LiDAR model. From this

dataset the individual bones will be mapped in both 2D and 3D to provide unrivaled views of bones that cannot otherwise be easily seen. Researchers will be able to take measurements with sub mm accuracy directly from the 3D images.

Each bone will be an object in a GIS system linked to multiple databases, with details on publications, photographs, taphonomy, taxonomy, repository data, insect traces and even data in the late Jack McIntosh's vast personal archive on the Carnegie Quarry. This wealth of new data will facilitate paleontological, geological and taphonomic studies of the Carnegie Quarry and we are working with The Digital Quarry Project effort to make the information available online to scientists and the general public.

Symposium II (Friday, October 28, 2016, 9:15 AM)

INTEGRATION OF THE MAMMALIAN DENTITION BY THE INHIBITORY CASCADE

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The evolution of precise tooth occlusion in mammals was a key innovation enabling effective processing of a wide variety of foods to fuel their high metabolic rate. Such exact occlusion likely requires tight developmental control over tooth size and shape as well as the coordination between upper and lower teeth. While the developmental origins of this innovation are still unclear, it has been attributed to the lack of molar replacement. We examine the developmental basis of occlusion using the evolutionary-developmental rule called the inhibitory cascade. The inhibitory cascade predicts that primary postcanine teeth form a linear pattern such that the middle tooth of a triplet is the average size of the teeth on either side. Often there is a change from increasing to decreasing size, indicating the presence of a reversal in the inhibitory cascade pattern, as previously shown in modern humans and hominins. A consequence of the inhibitory cascade is that teeth do not change in size randomly and so are integrated along the row. If both the upper and lower tooth rows were under the control of the inhibitory cascade, then relative changes in tooth size could be synchronised between the two. This coordination would result in the maintenance of occlusion during development, facilitating evolutionary change to more precise occlusion. We analysed relative tooth size in two major clades of mammals that diverged ~160 Ma, primates (including fossil hominoids and subfossil lemurs; n = 65 species) and marsupials (n = 70 species). The results show that the inhibitory cascade patterning is synchronised between the upper and lower jaws as evidenced by similarities in the slope and reversal point of the inhibitory cascade. This developmental coordination is present in all lineages of primates and marsupials and presumably throughout the diversity of mammalian dental phenotypes. Subfossil and modern lemurs show some exceptions to the inhibitory cascade in the deciduous premolars, but molars are well integrated in the manner of other mammals. Our results establish that the integration of mammalian teeth is largely controlled by the inhibitory cascade and has enabled more complex interdigitation that is part of precision chewing in mammals. This mechanism must have evolved very early in the history of mammals and is a fundamental reason for the success of mammals throughout the Cenozoic.

Grant Information
Australian Research Council FT130100968

Technical Session VII (Thursday, October 27, 2016, 2:00 PM)

NEW *STEGOCERAS*-GRADE PACHYCEPHALOSAURS (ORNITHISCHIA) REVEAL A LATE CAMPANIAN OF RADIATION OF DOME-HEADED DINOSAURS IN SOUTHERN LARAMIDIA

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Pachycephalosaurids are a group of bipedal ornithischians known from the Cretaceous of Asia and Western North America. They are reasonably diverse in Upper Cretaceous deposits of Northern Laramidia, where they are represented primarily by fragmented remains of their thickened cranial domes. In contrast, their fossil record is surprisingly sparse in coeval deposits of Southern Laramidia during this time. Here we report on two relatively complete, articulated pachycephalosaurid skulls from the upper Campanian strata of the Kaiparowits Formation of Utah and the Kirtland Formation of New Mexico that represent new species of *Stegoceras*-grade forms.

Both specimens consist of a complete frontoparietal dome and all of the peripheral elements from both sides of the skull, including the nasal. They exhibit a high degree of doming and lack a supratemporal fenestra, suggesting they represent mature individuals. As in *Stegoceras*, distinct grooves demarcate the nasal boss from the supraorbital lobes. Posteriorly, a small parietosquamosal shelf is present and ornamented with two large, hemispherical nodes that straddle the midline. Otherwise, the primary node row is indistinct laterally. This is unlike *S. validum*, where 6-8 prominent primary nodes traverse the squamosal bar in a single linear row. Corner nodes are absent in both specimens. The Utah specimen differs from the New Mexico skull in being about 20% larger, and by the derived presence of a strong midline contact between the squamosals that excludes the parietal from the posterior margin of the skulls. This feature occurs convergently in *Pachycephalosaurus*, but is an autaporphy of the new species. High-resolution CT scans show that in the New Mexico specimen the parietal is exposed as a thin slip of bone on the posterior margin of the parietosquamosal bar, which is most similar to *S. validum.* The New Mexico taxon is diagnosed by a unique combination of primitive and derived characters.

Preliminary phylogenetic analysis suggests that the new taxa form successive sister taxa to a clade consisting of Albertan taxa, including *S. validum,* from the Dinosaur Park Formation. The new taxa are slightly younger than *S. validum*, and indicate a previously undocumented radiation of *Stegoceras*-like forms occurred in Southern Laramidia during the late Campanian.

Technical Sesssion X (Friday, October 28, 2016, 11:30 AM)

LABYRINTH MORPHOLOGY OF THE EARLY JURASSIC STEM-TURTLE *AUSTRALOCHELYS* REVEALS NEUROANATOMICAL CHANGES ASSOCIATED WITH THE ORIGINS OF CROWN-GROUP TURTLES

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Turtles are an ecologically diverse group of animals with a body plan that is unique among vertebrates. Stem-group turtles of the Triassic and Early Jurassic document the evolutionary assembly of this body plan. *Australochelys africanus* from the Early Jurassic of South Africa provides key data on transitional morphologies, possessing many features of the modern turtle body plan, such as a tympanic middle ear and an akinetic skull. µCT scanning reveals key features of the holotype and only specimen of *Australochelys*. We interpret these features in context of a large CT dataset of c. 100 taxa of living and fossil turtles with diverse ecologies, and spanning a long interval from the Late Jurassic–Recent. The orientation of the labyrinth of *Australochelys* implies an anteroventrally downturned habitual head posture unlike other turtles. The labyrinth of *Australochelys* is similar to that seen in archosaurs (crocodylians, some dinosaurs) and early diapsids (e.g. *Youngina*), and differs strongly from the general shape of living and fossil members of the turtle crown-group. Crown-group turtle labyrinths are characterised by nearly symmetrical anterior and posterior semicircular canals (SSCs) of subequal length and degree of curvature, a low height-length ratio of the labyrinth, an angle between anterior and posterior SSC of more than 100°, and a lateral SSC that is parallel to the skull roof. In contrast, the labyrinth of *Australochelys* has a high height-length ratio, and the anterior SSC is longer and more strongly arched than the posterior SSC. Anterior and posterior SSC form an acute angle of 84°. Therefore, although *Australochelys* shares many derived features with crown-Testudines, aspects of its neuroanatomy seem to be plesiomorphic traits shared with archosauromorphs and early diapsids. The inner ear of *Australochelys* shows character states that are consistent with archosauromorph affinities for turtles: anteroposteriorly short confluent anterior and lateral ampullae, a vertically unexpanded saccule, a tall common crus, an ovoid form of the anterior SSC, and a low degree of curvature in the lateral SSC. Mesozoic crown-group turtles appear by the late Middle Jurassic and have a highly-conserved labyrinth morphology. This suggests that the morphological transition from an "archosauromoph" to a "chelonian" inner ear occurred in a relatively short amount of time relative to subsequent anatomical changes, a hypothesis that is supported by analysis of rates of evolution of discrete characters.

Grant Information
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Technical Session XVIII (Saturday, October 29, 2016, 1:45 PM)

SKULL ROOF AND BRAIN INTERRELATIONSHIP: MACROEVOLUTIONARY AND DEVELOPMENTAL PROSPECTIVES

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The brain has a primacy in both neural control and early cranial development. Birds are exceptionally large-brained reptiles. Although the evolution of the dinosaurian brain as an isolated structure has undergone extensive recent study, few works have addressed the larger-scale archosauromorph context of this evolution or the relationship between brain and braincase. We created a comprehensive dataset including not only Coelurosauria, but also pivotal taxa farther from the crown, notably early dinosaurs, stem-archosaurs, a lepidosaur, and the stem-diapsid Youngina, with the expectation of correlation between the skull roof and the brain. We also included embryos of *Anolis*, *Alligator* and *Gallus*, in order to test whether the relationship between the skull roof and the brain is the result of a deep developmental relationship. 3D morphometric analysis based on 32 landmarks placed on the endocast and skull roof recovers the stem diapsids, stem archosaurs and early dinosaurs tightly clustered. Birds are divergent. *Archaeopteryx* falls in an intermediate position between the two clusters. The presence or absence of a postparietal in early diapsids and stem-archosaurs does not affect the clustering. Heterochrony emerges as a major driver of skull roof and temporal region evolution in Diapsida. A correlation test performed between the fronto-parietal suture and the fore-midbrain boundary is statistically significant, with a shift between Coelurosauria and the more primitive taxa. The ossification pattern of the skull roof in embryos shows a one-to-one correspondence between frontal and forebrain on the one hand and parietal and the developing midbrain on the other. It is during ontogeny that the skull roof and brain become slightly decoupled. The skull tracks the development and evolution of the brain. Non-coelurosaurian taxa show a conservative skull roof and brain morphology, whereas a strong paedomorphic signal and hyperenchephalization are found in Eumaniraptora. Skull roof elements are extremely conservative, and there is little evidence for a wholesale restructuring of skull roof composition in birds as suggested by some recent developmental studies.

Technical Session XVI (Saturday, October 29, 2016, 8:45 AM)

UPDATED BIOSTRATIGRAPHY OF THE TURTLE COVE MEMBER (JOHN DAY FORMATION) IN THE JOHN DAY BASIN, OREGON

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The John Day Formation (JDF) in Oregon preserves a unique and remarkably complete record of volcanic and volcaniclastic sedimentary rocks spanning ~ 20 million years from 39.7–18.2 Ma. The Oligocene-aged Turtle Cove Member (TCM; 30.8–25.9 Ma) of the JDF preserves evidence of diverse mammalian communities perturbed by at least ten volcanic events in 400 meters of section, including five dated tuffs and the large Picture Gorge Ignimbrite (PGI). We identified 3,413 fossil mammal specimens from well-known sites within the John Day Basin. This sample included material from all stratigraphic units (A–K2) within the TCM of the JDF and many new specimens collected over the last 7 years, representing 96 species. We identified biozones using Unitary Associations (UA), a method of relative dating which utilizes graph theory to create statistically uniform biostratigraphic units.

Our study yielded more refined taxonomic ranges than previous studies because we were able to use newly measured species occurrences and a finer scale of geologic units. The biostratigraphic ranges of several taxa were updated from previous work, including expanded ranges (e.g., *Gentilicamelus*, *Hypertragulus hesperius*, *Nanotragulus planiceps*, *Eporeodon*, *Archaeolagus, Pleurolicus*, *Leidymys*, *Palaeocastor peninsulatus*, *Nimravus brachyops, Paraenhydrocyon josephi*, and *Desmocyon thomsoni*) and reduced ranges (e.g., *Archaeotherium caninus*, *Allomys*, and *Enhydrocyon*). New occurrences of taxa (e.g., *Stibarus*, *Leptochoerus*, *Sinclairella dakotensis*, and "*Cynorca*" *sociale*) were discovered through our reassessment of taxonomy and identifications. The last occurrence datum of several index taxa in the TCM do not occur at the Ar1-Ar2 boundary as expected (e.g., *Eusmilus*, *Perchoerus*, and *Agriochoerus*), but rather within Ar1. Five biozones were identified in this section using UA where only three North American Land Mammal Age (NALMA) subdivisions are currently recognized. These biozones suggest that the Wh-Ar1 boundary is younger than expected in the John Day Basin. Additionally, we were able to identify a previously unrecognized biostratigraphic boundary at the PGI from the UA biozone boundaries. The seemingly time transgressive NALMA boundaries in the TCM are likely a response to volcanic activity, regional climatic changes, and regional provincialism where local effects overprint continent scale events. Updated biostratigraphy for the TCM will facilitate comparisons with late Oligocene faunas from other sites in North America, many of which lack radiometric dates.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

FROM THE QUARRY TO THE CLASSROOM: A CASE STUDY IN FIELD- AND MUSEUM-CENTERED RESEARCH FOR HIGH SCHOOL STUDENTS

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The Raymond M. Alf Museum of Paleontology (Claremont, California) hosts a unique program that introduces high school students from The Webb Schools to the field of paleontology within a formal curriculum. The primary goal is to involve a broad variety of students—regardless of their career goals—in the authentic scientific process from discovery to formal publication. Starting with a month-long introduction during the ninth grade evolutionary biology class, students have the option to pursue advanced classes and fieldwork that culminate in original research with museum specimens. One important centerpiece in the program has been the "Cripe Site," a quarry within the Kaiparowits Formation (Late Cretaceous) of Grand Staircase-Escalante National Monument, Utah. Since its discovery by a high school student in 2005, the quarry has provided numerous student projects. Under the supervision of museum staff, students assist in collecting, preparing, and studying this multi-taxon bonebed. Students work collaboratively on the overall project, with each student focusing on a different taxon. General goals include taxonomic identification and taphonomic interpretation, among others. During the course of their studies, students have learned basic preparation, digitization (laser scanning and photogrammetry), anatomical identification, literature-based research, scientific writing, and professional presentation skills. Vertebrate taxa at the site include the turtle *Denazinemys*, an azhdarchid pterosaur, and tyrannosaurid and hadrosaurid dinosaurs. The tyrannosaur (probably *Teratophoneus*) includes hind limb elements and isolated teeth, with hopes for more diagnostic material in future quarrying. Postcrania from at least two individual hadrosaurs (one relatively small and one large) are in the assemblage, but cannot yet be identified beyond Hadrosauridae. Identified in the field as a small theropod, the associated azhdarchid pterosaur includes a scapula, coracoids, humerus, radius, metacarpal IV, and a femur. Through their coursework, students experience the challenges of original scientific research, such as incomplete or inaccessible primary literature (particularly relevant for common but infrequently illustrated postcrania) and unidentifiable or misidentified fossils in museum collections. Students also learn collaboration and perseverance skills that benefit them throughout their education and beyond.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

TRACKWAYS OF THE AMERICAN CROCODILE (*CROCODYLUS ACUTUS*), NORTHWEST COSTA RICA: IMPLICATIONS FOR ARCHOSAURIAN ICHNOLOGY

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Fossil trackways attributed to crocodylians and their kin are known from numerous Mesozoic and Cenozoic localities, prompting interest in traces of extant crocodylians for comparative purposes. We documented trackways of free-living American crocodiles on sandy beaches at the mouths of Tamarindo and Ventanas estuaries (Parque Nacional Marino Las Baulas, northwest Costa Rica).

We captured crocodiles from the same region to establish relationships between foot/footprint size and crocodile size. We estimated the size of one likely trackmaker using video shot from a drone above the swimming crocodile. Our trackmakers had estimated total lengths of 1–3 m, and more.

Crocodiles crossed the beach at night, in some cases possibly to reduce exposure to tidal currents, or to reach the ocean to feed. The best prints were made in wet sand, sometimes recording scale impressions of the foot sole. Trackway measurements were made from digital photographs taken in the field; overlapping images were merged to create 2D and 3D digital models of trackways.

Manus prints have five digits, with digits I–III bearing claw marks. Mean manus width (measured across the tips [as preserved] of digits I–V) of trackmakers ranged 9–16 cm. Pes prints have four digits, with claw marks on digits I–III. The pes is plantigrade. Claws generally dig into the substrate. Apart from claw marks, digit I and the heel of the pes are usually the most deeply impressed parts of footprints. Mean pes print length (as preserved) of trackmakers ranged 15–24 cm.

American crocodile trackways are wide-gauge, with prints of the left side widely separated from those of the right. Pes prints are usually positioned just behind ipsilateral manus prints of the same set, and may overlap them. Manus prints rotate outward with respect to the crocodile's direction of movement, while pes prints are nearly parallel to the direction of movement. Claw-bearing digits of both the manus and pes may create curved, concave-toward-the-midline drag marks as the autopodium is protracted. The tail mark varies in depth and clarity, and in shape from nearly linear to markedly sinuous. Sometimes the tail mark hugs the trackway midline, but sometimes it is closer to, or even cuts across, prints of one side.

Our observations indicate features that can be expected to vary among trackways made by conspecific crocodylians. American crocodile footprints and trackways are quite similar to those observed in other extant crocodylian species, indicating substantial trackway conservatism across the group.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

AN ANALYSIS OF SHAPE DIFFERENCES IN CROCODYLIAN DENTITION USING GEOMETRIC MORPHOMETRICS

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Crocodylians possess simple, conical-shaped teeth that do not contain the unique variety of cusps and shapes that are found in mammalian teeth. Therefore, identifying a tooth to a specific position or region within the crocodylian dental arcade is normally based only on the shape of a tooth. Anterior teeth tend to be longer, more slender, and sharper while posterior teeth are typically shorter, broader, and blunter. Most research on crocodylian dentition acknowledge these variations in shape, but there has yet to be any quantification of the variation. Studies have been focused on determining patterns of tooth replacement, tooth growth development and patterns in embryos and juveniles, tooth composition and attachment, and biomechanics of the skull and jaw. This study explores shape variation in the outline of crocodylian tooth crowns, as they relate to position within the arcade, using two-dimensional geometric morphometrics. Geometric morphometrics is an excellent technique to use in the analysis of tooth shape because differences between specimens resulting from rotation, translation, and size are removed, leaving only standardized shape data. Outlines consisting of 100 landmarks and semi-landmarks were collected from the labial/buccal surface of tooth crowns from *Crocodylus niloticus*, Procrustes superimposed, and subjected to a principle components analysis. PC1 accounted for 86% of shape variance. An anterior-posterior shape gradient was constructed using a multivariate regression of tooth shape onto tooth position within the dental arcade. Results show that there is a correlation between PC1 (shape) and tooth position ($R^2 = 0.64$, $p < 0.01$). ANOVA test showed significant differences in tooth shape between tooth positions ($p < 0.05$). There is a clear difference in the shapes of anterior versus posterior teeth with a gradual transition between the two. Further studies will use these results to explore to what degree the position of isolated teeth, which are commonly recovered at fossil localities containing crocodiles, can be estimated within the dental arcade.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

SIXTY YEARS OF CITIZEN SCIENCE: SIGNIFICANT DINOSAUR TRACKWAYS, CARBONIFEROUS FISH, INSECTS, AND AMPHIBIAN FOOTPRINTS FROM NOVA SCOTIA'S BAY OF FUNDY REGION.

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Eldon George began looking for beach shells and fossils in 1940 after experiencing a traumatic injury to his right arm when eight years old. He opened the Parrsboro Rock and Mineral Shop and Museum in 1948, and was then featured prominently in the 1957 National Geographic Magazine article, the Great Tides of Fundy. Eldon worked as a field geologist but he had a passion for museums and learning after working at the Nova Scotia Museum from 1966–67. Eldon has devoted over sixty years of discovering and collecting fossils and minerals from sites along the Fundy coast near his hometown of Parrsboro, Nova Scotia, and he received the Order of Nova Scotia in 2013. The Cumberland Geological Society purchased the Rock Shop in 2015 in order to build a permanent exhibit and Eldon is donating his collection of fossils to the Fundy Geological Museum. A preliminary inventory of significant specimens is offered here to encourage research interest in the specimens.

The inventory was developed with contributions from Beth Ann McCarthy and Dr. John Calder in 2003, Dr. Helen Tyson in 2008, and from subsequent consultations with Eldon George since August 2015. Initial taxonomic identifications had been suggested by Dr Donald Baird, Dr. Paul Olsen, and several other researchers who have collaborated with Eldon George. The initial list includes over 1500 fossil specimens collected between 1948 to 2004 from the Carboniferous and Mesozoic coastal exposures on the northern shore of the Minas Basin, Bay of Fundy. Approximately 20% of the specimens appear to be of high research and educational importance. The collection includes 150 specimens of fragmentary palaeoniscid and acanthodian fish from the local exposures of early Carboniferous Parrsboro, West Bay, and Horton Bluff Formations, including isolated fin spines, scales, well preserved jaws, and cranial material. A well preserved body fossil of a Carboniferous insect similar to *Stenodictya* and several isolated wing specimens are of high research interest. There are more than 300 trace fossils, including rare Eurypteryid traces, and Carboniferous to Mesozoic footprints, including *Pseudobradypus*, *Batrachichnus*, *Batrachopus*, *Grallator*, and *Otozoum.* The most famous specimen is "*the world's smallest dinosaur footprints*" mentioned in a Time Magazine article in 1986.

Eldon George is an accomplished citizen scientist who carefully maintained notes, examined specimens in detail, and collaborated with international researchers. An online index of important specimens will be made available on the Fundy Geological Museum website.

Symposium II (Friday, October 28, 2016, 11:45 AM)

QUANTIFYING MODULARITY AND RATES OF MORPHOLOGICAL EVOLUTION ACROSS ARCHOSAURIA USING PHENOMIC DATA

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The degree of covariation among phenotypic traits (i.e., integration and modularity) reflects genetic, developmental, and functional interactions and is thought to be a major factor shaping the evolution of morphological variation by affecting evolvability, evolutionary rate, and disparity. Despite its macroevolutionary significance, little is known about how modularity changes over large timescales and across clades, particularly as most work has focused on mammals. We evaluated large-scale patterns of modularity and integration in the cranium of modern and extinct archosaurs, incorporating a broad sample of over 160 bird species, 23 non-avian dinosaurs, and 25 crocodylomorphs. We quantified morphology on surface and CT scans using a high density of 3D anatomical landmarks and surface semilandmarks (706 total), allowing for a robust characterization of the full cranial phenome of each taxon. Covariance ratio (CR) tests indicate that all archosaurs exhibit significant modularity between the face and neurocranium, with greater independence between these two sub-regions than between random subsets of traits ($CR = 0.902$, $p < 0.01$). However, patterns and magnitude of modularity and integration were found to be heterogeneous across Archosauria. For example, CR score is highest in crocodylomorphs ($CR = 0.974$, $p < 0.01$) and lowest in avians ($CR = 0.907$, $p < 0.01$), indicating that birds have greater cranial modularity than their close relatives. Birds also exhibit the lowest levels of within-module integration in the face, both in comparison to the avian braincase and to other archosaur clades. This result suggests that a reduction in facial integration is one factor contributing to the high disparity in facial phenotypes observed across Avialae. We also evaluated rates of morphological evolution in each module and found an inverse relationship between integration and rate. For example, the face evolves 1.5 times faster than the neurocranium in crocodylians and two times faster than the neurocranium in birds. This pattern supports the hypothesis that integration can serve as a constraint on phenotypic diversification. Together, these results illustrate that cranial modularity and integration shift across major archosaur clades and that these differences may play a critical role in shaping patterns of trait variation and rate of evolution across archosaurs. Finally, the methods used here exemplify the utility of high-dimensional phenomic data for directly comparing complex patterns of shape evolution across morphologically disparate taxa.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

THE MOST COMPLETE EARLY EOCENE PRIMATE SPECIMEN FROM THE IBERIAN PENINSULA

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Early Eocene primates from Europe are mainly known by scarce and fragmentary fossil remains. This paucity increases the importance of each new finding, especially in the cases of well-preserved specimens. Here, a new adapiform mandible is reported, which represents the most complete early Eocene primate remain from the Iberian Peninsula. This specimen comes from a new locality situated at the Pyrenees (NE Spain) called Casa Retjo-1. The mandible preserves the alveoli of the canine and P_1, the roots of the P_2 and all teeth from P_3 to M_3 This new specimen can be confidently assigned to the genus *Agerinia* on the basis of the similarity of the height of P_3 and P_4 and several morphological traits of the molars, such as the protocristid subperpendicular to the lingual and buccal borders in the M_2 and M_3 and the short and broad talonid basin with rounded outline in the M_1 and M_2. Nevertheless, there are several differences between the new specimen and *Agerinia roselli,* the only species of the genus described to date. The specimen from Casa Retjo-1 clearly differs from *A. roselli* in the less molarized P_4 and in having a larger paraconid in the M_1 and a tiny one in the M_2, and therefore, it will most probably be described as a new species of *Agerinia*. Particularly, the better development of the paraconid is interpreted as a primitive character, suggesting that the new form from Casa Retjo could be a potential ancestor of *A. roselli.*

Grant Information

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Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

PALEOECOLOGY AND PALEOENVIRONMENT AT TWO LATE PLEISTOCENE NEANDERTHAL-BEARING SITES IN PINILLA DEL VALLE, SPAIN: STABLE ISOTOPE VALUES REVEAL NICHE CONSERVATISM

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Determining the environmental and ecological conditions in which Neanderthals typically lived and ultimately those in which they went extinct are important for understanding what factors, including the role humans (*Homo sapiens*) may have played, contributed to their demise. Fossil-bearing sites in the Calvero de la Higuera (Pinilla del Valle, Madrid, Spain) contain abundant faunal remains from at least four distinct localities of late Pleistocene age. Nearly all localities bear Neanderthal remains, and the time span represented by the localities permits examination of the ecological settings in which these ancient hominins lived. Here we analyze stable carbon and oxygen isotope values ($\delta^{13}C$ and $\delta^{18}O$) from the tooth enamel of large mammalian herbivores and carnivores from two of the Calvero de la Higuera localities, Camino (Level 5) and Cueva de la Buena Pinta (CBP; Level 3). Both localities were hyena dens and contain similar mammalian fauna. The $\delta^{13}C$ values from both localities ($N = 82$) imply that the ancient ecosystems were dominated by C_3 plants. The average $\delta^{13}C$ values from CBP are 1.7‰ higher than those found at Camino, indicating a more open environment during the time represented at CBP. Significant differences in $\delta^{13}C$ values among taxa at both localities shows resource partitioning. For herbivores, *Bos primigenius* shows the highest values and *Stephanorhinus hemitoechus* the lowest, suggesting they inhabited more open and closed environments, respectively. Carnivores typically showed similar $\delta^{13}C$ values, except hyena (*Crocuta crocuta*), which were lower and may support bone consumption. For $\delta^{18}O$ values, the only observed difference was between wolf (*Canis lupus*) and hyena at Camino. The higher $\delta^{18}O$ values associated with the wolf suggests that they inhabited more open environments, comparatively. The $\delta^{13}C$ and $\delta^{18}O$ values observed among all taxa within a locality were similar between Camino and CBP, supporting the idea of niche conservatism. Continued examination of the typical paleoecological and paleoenvironmental conditions in which Neanderthals lived provides a baseline for evaluating the conditions under which they went extinct.

Grant Information

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Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

MODERN TAPHONOMY OF FOUR SPECIES OF COLONIAL GROUND NESTING BIRDS: IMPLICATIONS FOR IDENTIFYING DEVELOPMENTAL STRATEGIES

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Taphonomy of extant birds in combination with similar studies of modern reptiles provides a range of models for the interpretation of reproduction in ancient archosaurs. Here we describe the reproductive assemblages generated by nesting American white pelican (*Pelecanus erythrorhynchos*), double-crested cormorant (*Phalacrocorax auritus*), and two gulls (*Larus*). Nest surveys focused on the abundance and orientation of associated skeletal and eggshell remains. A total of 25 gull, 25 cormorant, and 20 pelican nests yielded 171 invertebrate exoskeletons, 7,667 bones, and 2,174 eggshell fragments. Gulls constructed nests of sticks and grass, often lined with down feathers. Nests ranged in size from 19–67 cm in diameter and 3–5 cm in height. Avian elements were the most common (65.4%), with almost half consisting of gull bones. Cormorant nests were 20–30 cm in height, 34–50 cm in diameter and made from long sticks, bones, and man-made debris. Fish dominated (61.4%) the assemblage, followed by cormorant elements (15.5%). Pelicans made simple scratch or vegetation nests 40–77 cm in diameter and 3–4 cm in height and their assemblages were dominated by fish (49.0%) and rodent (25.6%) elements. Biological elements associated with pelican and cormorant nests occurred predominantly outside the nest (46-82%), whereas most gull nesting debris was found inside the nests where fragments from predated pelican eggs were most common. Eggshell fragment concave up (CU) and concave down (CD) orientations on the surface of gull nests matched a predated assemblage CU vs CD ratio. However, pelican and cormorant surface eggshell orientations were approximately 1:1. The difference between CU:CD ratios observed here and those at other avian colonies suggest alteration by trampling altricial young. Weathered bones in the subsurface assemblages of cormorant and pelican nesting sites, as well as multiple layers of predated eggshell in gull nests suggest an accumulation of material over several years. The amount of juvenile elements associated with pelican and cormorant nests compared to gull nests is much greater and correlates with higher mortality rates in altricial young. Compared to gull nesting sites, pelican and cormorant nesting sites are associated with significant amounts of prey items. Therefore, we suggest the orientation of eggshell, abundance of prey material, and the skeletal maturity of the young of the nesting birds can distinguish semiprecocial and altricial developmental strategies.

Grant Information

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Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

GEOCHEMICAL 'FINGERPRINTING' OF LATE PLEISTOCENE AGE VERTEBRATE FOSSIL REMAINS FROM KINGS CREEK, DARLING DOWNS, QUEENSLAND, AUSTRALIA

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The Kings Creek catchment, located in the Darling Downs, Queensland, Australia, contains multiple vertebrate fossil sites dating to the late Pleistocene. One site (QML796) within the Kings Creek catchment contains three fossiliferous horizons, each interpreted to have accumulated during flooding events. Previous analyses identified a progressive decline in biological diversity through the period of deposition; such a decrease cannot be explained by sampling and taphonomic factors. Overall, the fossils vary in color, texture and levels of abrasion within all three horizons, and it remains possible that some of the more heavily abraded specimens had been subjected to transport prior to final deposition. To test that hypothesis, trace element analyses were conducted on QML796 fossil material to geochemically 'fingerprint' and identify potentially reworked material. Certain trace elements initially absent in fresh tissues, such as the rare earth elements (REEs), are introduced and enriched during fossilization. Fossil REEs are, therefore, a useful proxy for interpreting fossilization settings and identifying reworked remains. Fossil REE concentrations indicate that all analyzed QML796 fossils were exposed to similar fossilization settings. Normalized fossil REE signatures were predominantly middle REE enriched with negative Ce anomalies, positive Eu anomalies and enlarged Y/Ho ratios. The consistency of normalized fossil REE signatures suggests a common origin for all fossils in the deposit; therefore, reinforcing previous taxonomic interpretations that QML796 preserved a progressive decline in the biological diversity of the Kings Creek catchment throughout the deposition of the site.

Grant Information

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Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

ON THE DIET OF *LEPTOMERYX* SP., LATE EOCENE OF NORTHWESTERN OAXACA, SOUTHEASTERN MEXICO

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In the last lustrum, a Paleogene fauna was recovered from an area in northwestern Oaxaca, southeastern Mexico, which includes specimens referable to at least five orders (Carnivora, Rodentia, Condylarthra, Artiodactyla and Perissodactyla), and its study is in progress. Specimens referred to *Leptomeryx* sp. (Leptomerycidae) are relatively abundant; it should be noted that this Oaxacan find is the southernmost record (~17° N Lat.) of this genus in North America. This taxon is thought to have fed on tree and shrub leafs and fruits, on account of its mesodont, seleniform molars, and is thought to have been an open country (savanna-like environment) dweller. We decided to test these tenets using carbon and oxygen stable isotope relationships in molar enamel samples of a specimen referred to this taxon.

The study area includes some 970 sq. km of rugged terrain within the Mixteca Region between 17°15'–17°32' N. Lat. and 97°28'–97°45' W Long.; within it, Cenozoic units unconformably overlie metamorphic, clastic and carbonate rock units of Late Paleozoic to Cretaceous ages, as well as the Mixteco/Oaxaca Terrane boundary. The Tertiary sequence includes seven lithostratigraphic units (four continental [two new], and three volcanic [all new]). The largely lacustrine/fluvial vertebrate-bearing unit also includes thin, felsic tuff sheets interbedded in this sequence, one such sheet yielded an ^{39}Ar-^{40}Ar age of 40.7 Ma (early late Eocene).

The isotopic analysis produced the following results: The $\delta^{13}C$ was -12.5‰ and the $\delta^{18}O$ was -4.1‰, thus indicating that *Leptomeryx* sp. fed on C3 plants and lived in a forest/savanna ecotone, as is the case in temperate North America. Palynologic evidence corroborates this interpretation, which coincides with the tenets mentioned above.

Romer Prize Session (Thursday, October 27, 2016, 9:45 AM)

MACROEVOLUTIONARY PATTERNS IN TOTAL-CLADE AVIALAE: THE COMPLEX EVOLUTION OF AVIAN BIOGEOGRAPHY, AND THE ORIGIN OF AVIAN FLIGHT

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Birds are among the most diverse and ubiquitously distributed tetrapod clades; they inhabit a myriad of different environments, and exhibit incredible disparity in their forms and lifestyles. Unraveling how, when, and why this diversity has arisen demands an appeal to the fossil record of crown birds (Neornithes), as fossils provide us with the only direct evidence of neornithine evolutionary history. Additionally, understanding the origins of the features that make birds unique—such as feather-assisted flight—forces us to look outside of Neornithes to the avian stem lineage, where the nature, timing, and order of character transformations are only accessible through fossils. Here, macroevolutionary patterns in Avialae are investigated first in terms of the radiation and biogeography of early crown birds, and second in terms of one of the most significant evolutionary transitions that preceded and enabled that radiation: the origin of powered flight.

The value of fossils in crown group macroevolutionary analyses is explored by investigating the affinities of *Foro panarium*, an enigmatic Eocene bird from western North America. Comprehensive phylogenetic analyses strongly support *F. panarium* as a total-clade turaco, a clade whose crown group is restricted to sub-Saharan Africa. *F. panarium* provides a striking example of the dynamic nature of avian biogeography, and a large-scale historical biogeographic analysis of extant and fossil crown birds reveals the critical importance of fossils in ancestral area reconstructions.

Next, methods of body mass estimation for fossil birds were revised with an unprecedentedly comprehensive allometric dataset, yielding equations that improve the precision of mass estimates and statistical prediction intervals. This dataset reveals the ratio between glenoid diameter and body mass as a previously overlooked osteological correlate of powered flying ability in crown birds. This ratio can be readily evaluated in fossils from the avian crown and its proximal stem, and reveals marked differences in the aerial capacity of crownward avialans such as *Ichthyornis*, and comparatively stemward taxa such as *Archaeopteryx*, corroborating recent evidence from feather and skeletal morphology. These data suggest that modern powered flight arose later in avian evolutionary history than previously assumed, and clarify the pattern by which flight—one of the most characteristic features of Neornithes—evolved along the avian stem.

Grant Information

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Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

NOTES ON THE BASICRANIUM, OCCIPUT, AND BRAINCASE ANATOMY OF *SAHITISUCHUS FLUMINENSIS* (CROCODYLIFORMES, NOTOSUCHIA) AND ITS PHYLOGENETIC IMPLICATIONS

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Sebecids are important components of the Cenozoic paleofauna and comprise a group of crocodyliforms that survived the K–Pg biotic crisis. Despite being relatively common in the fossil record, most specimens are fragmentary and known by rostral remains and isolated teeth. The recently described *Sahitisuchus fluminensis* (MCT 1730-R), from the Paleocene Itaborai Basin of Brazil, is an exception, with nicely preserved cranial material. New comparative analysis and CT-scan data show important anatomical features on the posterior region of the skull of *Sahitisuchus* that help understand the relationships between sebecids and other notosuchians. The occiput of *Sahitisuchus* is small and constrained between the high otoccipital bones. The taxon shows a depressed supraoccipital occupying most of the central area of the occiput and very short paroccipital processes. Enlarged elliptical posttemporal fenestrae are connected to the smaller orbitotemporal openings inside the supratemporal fossae, suggesting the presence of large-caliber temporal arteries and stapedial vessels. The basicranium is semi-verticalized and only resembles an eusuchian-like morphology in the vertical orientation of the basisphenoid. This latter bone is much higher in comparison with extant species. The trapezoid basioccipital has a 45° degree inclination that is also observed in peirosaurids and other sebecids (e.g., *Bretesuchus, Ayllusuchus*), although in *Sebecus* species they are even more verticalized. Other notosuchians, including baurusuchids, present the ancestral condition in which both bones are horizontally displayed and fully observed in palatal view. The openings for the cranial nerves are placed on the posteroventral plate of the otoccipital showing more oblique exits than in eusuchians, and the foramen for the hypoglosal nerve is smaller than the one for the vagus. The Eustachian system comprises a well-developed medial aperture facing ventrally, but the lateral foramina are poorly-preserved. A novel phylogenetic analysis with 666 characters and 108 taxa (six sebecids) does not recover a monophyletic "Sebecosuchia" (189 MPTs, 3568 steps). Sebecidae was recovered as the sister clade to Peirosauridae, within Notosuchia.

Grant Information

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Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

AN ECOMORPHOLOGICAL CHARACTERIZATION OF NORTH AMERICAN CENOZOIC MAMMALIAN EVOLUTIONARY FAUNAS

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Recent quantitative analyses of biodiversity dynamics in the Cenozoic of North America have shown that most of the complexity of the mammalian fossil record can be summarized in six sequential episodes of faunal associations (or evolutionary faunas); these faunas fit well with previously proposed 'Chronofaunas' based on qualitative assessments. Following their temporal distributions, they are recognized as follows: (i) Paleocene fauna, (ii) early-middle Eocene fauna, (iii) middle-late Eocene fauna, (iv) Oligocene fauna, (v) Miocene fauna, and (vi) Plio-Pleistocene fauna.

Here, we characterize the taxonomic components (genera) of each faunal association into different ecomorphs related to trophic types (i.e., specialized or generalized carnivores, animal or plant dominant omnivores, and folivore-frugivore, browser, mix-feeder, and grazer herbivores), locomotor modes (i.e., generalized quadrupeds, subcursorial, cursorial, and hypercursorial), and body size classes (i.e., <1,1–5,6–19,20–89,90–199,200–299,400–949,950–3000, >3000 kg), using Contingency Tables Analysis. By examining the adjusted residuals for the individual cells of each table, we explored the issue of whether these ecomorphological groups were randomly distributed over the evolutionary faunas, or whether each fauna had its own unique association of ecomorphological types.

The distribution of ecomorphs based on the abundance of genera for each trophic type, locomotor mode and body size class indicates that the distribution of mammalian ecomorphs is not random over time, but rather that each evolutionary fauna is characterized by a distinct association of ecomorphs that define its particular 'ecomorphological spectrum.' Furthermore, as the rise and fall of these faunal associations are correlated with the paleotemperature curve, we interpret the changes in ecomorphological diversity among faunas to be related to climatic perturbations and environmental change during the last 65 Ma.

Grant Information

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Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

MANUS AND PES JUVENILE HADROSAUR TRACKS (LOWER CANTWELL FORMATION, UPPER CRETACEOUS, DENALI NATIONAL PARK, ALASKA): IMPLICATIONS FOR BODY ORIENTATION IN JUVENILE HADROSAURS

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The posture of hadrosaurid dinosaurs has been a subject of significant discussion through the years. It is now generally accepted that adult hadrosaurs were facultative bipeds, while based on biomechanical grounds juvenile forms are hypothesized to have been bipedal.

Here we report on a paired set of manus and pes tracks from the lower part of the Upper Cretaceous Cantwell Formation in Denali National Park, Alaska, USA. These tracks were discovered in negative relief on the surface of a large float block of lower Cantwell Formation coarse sandstone high on a remote mountain slope. The lower Cantwell Formation is the only rock unit comprising the mountain, so the float block is confidently attributed to this formation.

The tridactyl pes track is bi-lobed while the manus track is lunate, morphology that is consistent with ichnofossils attributed to hadrosaurs, specifically the ichnogenus *Hadrosauropodus*. Subsequent field investigation revealed that the tracks are part of a larger bedding plane that contains numerous hadrosaur tracks of various sizes that record the actions of a multi-generational herd of these dinosaurs. While adult hadrosaurs typically reached body lengths of 1200 cm, the length of this small Alaskan pes impression is approximately 11 cm which provides a hip height estimate of approximately 44-45 cm for this trackmaker. While hypothesized through studies of skeletal anatomy, this paired set of impressions provides definitive indication that, like adult hadrosaurs, at least some juvenile hadrosaurs were facultative quadrupeds rather than obligatory bipeds regardless of their small body size.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

THE CROCODYLIAN SECONDARY PALATE DIRECTLY FACILITATES DUROPHAGY IN CONCERT WITH TENSED LIGAMENTS

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Extant crocodylians exhibit the greatest recorded bite forces, and large extinct forms such as *Deinosuchus* and *Purussaurus* exceed bite force estimates for nearly all other vertebrates. The secondary palate of crocodylians plays a role in subduing and dismembering large prey by facilitating increased bite force and decreasing torsional strain during the death roll. Observations of *Alligator mississippiensis* feeding on turtles, bite marks from *Deinosuchus*, and low rounded posterior teeth in many crocodylians indicate that durophagy has been common in the clade. *Alligator*'s secondary palate makes contact with its prey during such behaviors, suggesting that the palate assists directly with breaking turtle shells. We apply finite element analysis to a modeled cranium of *A. mississippiensis* with loadcases from several observed biting behaviors, including crushing posterior bites. Models include anatomically complete and simulated open-palate models, and different levels of hypothesized muscular pre-tension on the septum nasi. Contact of the prey with the secondary palate reduces overall cranium stress, and (surprisingly) a tensed septum nasi equalizes cranial stress well with a posterior bite. The secondary palate's contribution to durophagy in *A. mississippiensis* furthers our picture of versatility of the crocodylian feeding apparatus, and suggests further inference of high comminution performance in fossil taxa.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

RECENT RESEARCH IN THE MIOCENE PINTURAS FORMATION, SANTA CRUZ, ARGENTINA

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Fossils were first discovered from the valley of the Rio Pinturas in the northwestern corner of Santa Cruz Province, Argentina, by Carlos Ameghino in 1891. They were subsequently described by his brother, Florentino Ameghino. In the 1980s, expeditions from Stony Brook University and the Museo Argentino de Ciencias Naturales (MACN) made extensive collections from several horizons in the Pinturas Formation leading to the discovery and description of a large, stratigraphically documented, mammalian fauna, including four taxa of platyrrhine primates. Later expeditions from the Centro Nacional Patagonico (CENPAT) in Puerto Madryn and the Laboratorio de Investigaciones en Evolution y Biodiversidad at the Universidad Nacional de la Patagonia in Esquel have further expanded our knowledge of the mammalian fossils from this formation. Recent research activities have 1) clarified longstanding debates over the relative age of the Pinturas Formation and the more widespread Santa Cruz Formation; 2) expanded our knowledge of the age, provenance, and morphology of fossil sloths (Tardigrada) from the area; and 3) provided greater documentation of the morphology and stratigraphic distribution of fossil primates from the Pinturas. This additional material indicates that the primate diversity in the Pinturas Formation is almost certainly much greater than previously described. Moreover, paleontological research in other parts of Argentina and other parts of South America have expanded the diversity and distribution of fossil primates related to those first described from the Pinturas Formation.

Grant Information
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Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

GEOMETRIC MORPHOMETRIC ANALYSIS OF *MUSTELA* (MAMMALIA, CARNIVORA) FROM THE PLEISTOCENE (IRVINGTONIAN) OF PORCUPINE CAVE, COLORADO

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Mustelidae is a diverse family of mammals that exhibit remarkable intraspecific size variation and sexual dimorphism. Diagnostic characters of extant weasels are generally superficial, often using pelage and total body size to identify taxa. These attributes are not useful for paleontological morphometric analysis of mustelids. To date, there are few studies addressing osteologic apomorphies among weasel species. Osteological characters such as relative tail length and skull ratios are not always applicable to paleontological studies as complete and articulated skeletons are scarce among prehistoric assemblages. Recent efforts to curate massive unassociated vertebrate collections from the Irvingtonian Porcupine Cave locality at the Denver Museum of Nature & Science have underscored the need for new approaches to classify taxon. The taxonomic utility of geometric morphometrics was tested among species of North American weasels, employing two-dimensional landmarks on the craniomandibular remains of five extant weasel species: *Mustela nigripes* (black-footed ferret), *Neovison vison* (American mink), *M. frenata* (long-tailed weasel), *M. erminea* (short-tailed weasel), and *M. nivalis* (least weasel). Landmarks were registered on photographs of extant *Mustela* via the morphometric software tpsDIG2. Photographs were taken in three orientations including a ventral profile of the skull, along with lateral and occlusal orientations of the mandible and dentition. Digitization and orientation error were measured by photographing and marking duplicate sets of representative specimens, followed by a Procrustes analysis of variance (ANOVA). Principal component analysis (PCA) was used to test the craniomandibular region of weasels for taxonomical distinction in size and shape. Discriminant function analysis (DFA) was utilized to achieve species level classification amongst the five species of North American mustelid. The results of the DFA was then used as a training set to reassess taxonomic assignment of the Porcupine Cave mustelid material. Using PCA, species grouping was poorly defined, especially among smaller weasel taxa. DFA successfully differentiates between all five species of extant North American *Mustela* and the Porcupine Cave material, but suggests variance between modern and Irvingtonian mustelid taxa. We demonstrate that two-dimensional geometric morphometric analysis is useful in separating and diagnosing Pleistocene weasel taxa.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

A TRUE LEPORID FROM THE TIEN SHAN MOUNTAINS OF KYRGYZSTAN

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Lagomorphs, while sister to the diverse order Rodentia, have existed at relatively low diversity throughout their history. Central Asia is home to a substantial fraction of both living and extinct diversity in the form of pikas (Ochotonidae). Rabbits (Leporidae), which are more common and widespread in lower-elevation faunas, also have a presence in the Asian fossil record, albeit a limited one. Here we describe the first true leporid from Kyrgyzstan, based on a partial jaw, an isolated incisor, humeri and podial bones. The material was collected from the Mio-Pliocene Chu Formation of the Kochkor Basin, Kyrgyzstan. These leporid specimens are significant as some of the only small mammals known from an otherwise ungulate-rich (and as yet unpublished) fauna. In the small amount of published material from correlative deposits elsewhere in Central Asia (primarily from difficult-to-access reports and small-circulation journals), the only Lagomorpha previously known are ochotonids from the greater region that includes Kyrgyzstan. As several leporid species are today important parts of the local ecological communities, the Kyrgyz fossil leporid material will be key for understanding the evolution of local faunas. Kyrgyzstan is today, and has been for several million years, an area of high elevation and frequent seismic activity owing to the continued rapid uplift of the Tien Shan Mountains. Small mammals, such as the Kyrgyz leporid, respond to topographic and climatic changes faster than the predominant 'Hipparion Fauna' ungulates. As such, they are important first indicators of past ecological change.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

A WETLAND SMALL MAMMAL FAUNA FROM THE LATE MIOCENE OF YUNNAN, SOUTH CHINA

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Shuitangba is a late Miocene locality in Yunnan, China, and represents the northern limit of the Indomalayan biogeographic province of that time in South China. Shuitangba is in a sub-basin of the larger Zhaotong lignite basin, and its fauna with the ape *Lufengpithecus* is becoming a well-documented assemblage in South China for the equivalent of the Baodean Stage/Age of North China. Paleomagnetic data consistent with initial faunal analysis place the age of the fossil concentration at about 6.2 Ma, or middle Baodean. With other vertebrates (fish, wading birds, tapir, otter) the small mammals indicate a moist environment with emerging high species diversity. Black clays, abundant fossil wood, and mollusk-snail beds indicate accumulation in a wet habitat. As would be expected in a warm moist setting, the insectivoran component of the fauna is diverse. In addition to a hedgehog and a mole, there is a neomyine shrew and abundant *Anourosorex*, the Sichuan burrowing shrew. A derived form of *Alilepus* demonstrates the presence of Leporidae in the wetland habitat of Shuitangba. Sciurids are present, including *Sinotamias* and the flying squirrel *Pliopetaurista*. Shuitangba has a hamster-like cricetid and abundant murids, with good cranial material of the rat-like *Leilaomys*. Additional records are wet-habitat rodents: two species of bamboo rats and aquatic beavers. Bamboo rats have an extensive Indomalayan biogeographic record. Beaver remains are abundant

at the site and are comparable to living *Castor canadensis* in size. Gnathic remains of adult beavers are much larger than juveniles and subadults, after full eruption of the molars and emplacement of the massive permanent premolar that dominates the tooth row. This beaver lineage appears to be related to *Steneofiber*, a genus characteristic of older Miocene localities of Europe, and is one of several elements that appear to be derived from the Palaearctic province to the north. The Baodean age small mammal fauna of South China is characterized by insectivorans, *Alilepus*, murines, bamboo rats, and the *Steneofiber*-like beaver, and includes elements of both the Palaearctic and Indomalayan biogeographic regions.

Grant Information
NSF 1227927

Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

THE ECOLOGY AND EVOLUTION OF JURASSIC MARINE REPTILES

FOFFA, Davide, University of Edinburgh, Edinburgh, United Kingdom; BRUSATTE, Stephen, University of Edinburgh, Edinburgh, United Kingdom; YOUNG, Mark T., University of Edinburgh, Edinburgh, United Kingdom; DEXTER, Kyle G., University of Edinburgh, Edinburgh, United Kingdom

Jurassic marine ecosystems (ca. 201-145 million years ago) were dominated by three different lineages of reptiles – plesiosaurians, ophthalmosaurid ichthyosaurs and thalattosuchian crocodylomorphs. These groups often coexisted in the same environments and between them occupied the top levels of trophic food webs for over ~50 my. The morphologies of their skulls, mandibles and teeth have been often compared to those of modern aquatic tetrapods to infer feeding ecology. However these comparisons have rarely been tested in a quantitative way. We created a functional dataset, which includes over 40 taxa scored for a set of continuous and discrete characters, which are cranio-mandibular and dental features with known functional and biomechanical significance. We analyzed this dataset with multivariate statistics to assess functional similarities and differences in the marine reptile faunas between two well sampled Jurassic ecosystems: the Oxford Clay Formation (OCF – Callovian-early Oxfordian, Middle-Late Jurassic) and Kimmeridge Clay Formation (KCF - Kimmeridgian to Tithonian, Late Jurassic) of the UK.

Our results confirm qualitative observations that OCF and KCF ecosystem composition and structure were markedly distinct. The patterns of functional morphospace variation helps us to better understand the evolution of these clades over time. The transition from the Middle to the Late Jurassic involved a significant decrease in functional disparity for pliosaurids and, an increase for ichthyosaurs. We also detect that Late Jurassic metriorhynchids and ichthyosaurs shifted towards regions of 'functional' morphospace vacated by groups that had declining from the Middle Jurassic. Our results also show that phylogenetically closely related taxa preferentially cluster together, with minimal overlaps in the morphospace. This is intriguing, as it suggests that partitioning of functionally important morphological features, which may have been a driver of niche partitioning, may have been an important factor facilitating the coexistence of diverse marine reptile assemblages over tens of millions of years of evolutionary time.

Technical Session II (Wednesday, October 26, 2016, 12:00 PM)

A NEW LARGE SPECIES OF THE SNAKE *PALAEOPHIS* FROM THE LUTETIAN MARINE MARGIN OF THE CONGO BASIN, CABINDA, ANGOLA

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Numerous fossil localities were investigated in western central Africa during the Belgian expeditions that started in the 19th century. At least 47 localities were excavated or analyzed in the framework of Edmond Dartevelle's paleontological expeditions of 1933 and 1937-1938, producing a large and unique collection of Mesozoic-Cenozoic vetebrates from the margin of the Congo Basin along the coastal area of Angola to Gabon. Among them, snake vertebrae from the marine Paleocene-Eocene Landana section, Cabinda enclave, Angola have been referred to the aquatic snake *Palaeophis* aff. *typhaeus*. New investigation of the old Dartevelle's collections has led to relocation of a few undescribed snake vertebrae from Landana and the nearby locality of Sassa Zao, permitting a revision of *Palaeophis* aff. *typhaeus*. The results of this work indicate that all specimens from Landana originate from the same stratigraphic level (layers 31-32) and are of Lutetian age based on the rich associated elasmobranch fauna. The locality of Sassa Zao is also Lutetian based on elasmobranchs that are similar to those of layer 32 of Landana. All of the vertebrae, ten in total, can be attributed to a single large species of *Palaeophis*. The maximum width across the prezygapophyses is 35 mm and the maximum length of the centrum is 27 mm. The weak lateral compression of trunk vertebrae, low development of the pterapophyses, diapophyses not very low, and the marked lateral projection of the zygapophyses indicate that this species belongs to the 'primitive' grade of *Palaeophis* and thus differs from species of the 'advanced' group such as *P. casei*, *P. ferganicus*, *P. littoralis*, *P. toliapicus*, *P. typhaeus*, *P. grandis*, *P. tamdy*, *P. nessovi*, and *P. udovichenkoi*. Among 'primitive' grade species, it differs from the giant *P. colossaeus* by smaller size, proportionally longer vertebrae, the cotyle and condyle more oval in shape, and the zygosphene not larger than the cotyle; from *P. africanus* by the neural spine that does not approach the zygosphene and shorter hypapophyses that are not prolonged by a ventral carina; from *P. vastaniensis*, *P. virginianus*, and *P. zhylan* by less depressed vertebrae. In size and morphology it most closely resembles *P. maghrebianus* but differs by more developed hypapophyses and paradiapophyses that do not extend over the cotyle posteriorly. This new species was apparently poorly adapted to aquatic life and was more closely related to the North African Ypresian *P. maghrebianus* than to West African Lutetian species.

Grant Information
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Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

PALEOBIOLOGY OF *HUAYQUERIANA*, A LATE MIOCENE LITOPTERN FROM WESTERN ARGENTINA: INTERPRETING CONFLICTING SIGNALS FROM MORPHOLOGICAL ATTRIBUTES

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IANIGLA-PV 29, a well preserved skull of the macraucheniine litoptern *Huayqueriana* from the Huayquerías Formation (late Miocene), presents several morphological and paleobiological puzzles.

Nasal apparatus: The highly derived dorsal positioning of the macraucheniine external nares has provoked discussion for more than a century. MicroCT scanning of IANIGLA-PV 29 reveals simplified turbinate architecture and an air passageway oriented perpendicular to, rather than aligned with, the palate as in most mammals (including elephants). The primitive nasal vestibule is present, but only as a blind diverticulum within the rostrum. To a degree these innovations recall conditions in cetaceans and some other aquatically adapted taxa, but macraucheniine limb skeletons lack obvious adaptations for aquatic life. Orientation of the lateral semicircular canal relative to the skull base is ~26°, indicating that in life the head was habitually oriented much as in modern horses. If there was a proboscis, it would have been positioned frontally, not dorsally as in many reconstructions.

Endocast: Although the identity of the pathways of certain cranial nerves in litopterns have been disputed, conditions in *Huayqueriana* conform to those in other placentals. The orbitotemporal canal runs well below the rhinal fissure, along the lateroventral aspect of the piriform lobe instead of more dorsally. No functional consequences for this rearrangement are evident.

Body mass: Making size estimates for fossil taxa, especially those having no close living relatives, presents many difficulties. For IANIGLA-PV 29, conventional estimators, especially those employing dental measurements, yielded highly conflicting results (mean 400 kg; range 154–721 kg, prediction error >25%). Our preferred estimate of ~250 kg (prediction error ~6%) is based on an alternative approach utilizing centroid size of 36 3D cranial landmarks.

Longevity and diet: Advanced tooth wear implies that IANIGLA-PV 29 was senile at death. However, cementum line counts on a sectioned M2 are consistent with a 10–11 year lifespan, much shorter than its body mass would suggest. The late Miocene flora of western Argentina was dominated by xerophytic plants with thick foliar cuticles and hard-shelled fruits to combat desiccation, and perhaps excessive wear reflects a very abrasive diet. Oddly, unlike the vast majority of Neogene South American native ungulate lineages, litopterns did not develop euhypsodonty. There is no decisive evidence for the proposition that *Huayqueriana* (or any other litoptern) was a foregut fermenter.

Technical Sesssion X (Friday, October 28, 2016, 8:00 AM)

NEW INSIGHTS ON THE ANATOMY OF *PALEOTHYRIS ARCADIANA* USING MICRO-CT SCANNING

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Paleothyris arcadiana from the Middle Pennsylvanian of Florence, Nova Scotia, is one of the earliest and best represented examples of a basal eureptile. All of the 22 specimens held by the Museum of Comparative Zoology were collected from a single *Sigillaria* stump in 1956 and first described by Robert Carroll in 1969. Since then there have been no attempts to review the anatomy of this taxon, and there has been little change in character assessment for phylogenetic studies. Here we report on the results the analysis of computed-tomographic (muCT) data taken from three of the specimens held by the MCZ, consisting of two almost complete skeletons and a partial skull.

The scans reveal new details of the shoulder girdle, including a complete 3D rendering of the clavicle and, for the first time in any specimen of *Paleothyris*, the presence of a cleithrum in the holotype. The morphology of specific elements of the skull, such as the jugal, post-orbital and post-frontal are shown in detail. The results also highlight features of the maxillary dentition, suggesting lateral replacement of marginal teeth. Parallel ridges on the ventral surface of the paired frontals show a remarkable similarity with those of the captorhinid *Captorhinus aguti*. Results from the scan of the smallest individual suggest ontogenetic development in the morphology of the distal humerus, with the incomplete development of the supinator process, which is fully ossified in larger specimens.

Few studies have focused on the interrelationships of basal sauropsids, and the paraphyly of the 'protorothyrids' remains to be satisfactorily resolved. The new data provided by this study will prove useful in resolving uncertainties in basal amniote phylogeny.

Grant Information
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Technical Session IV (Wednesday, October 26, 2016, 3:15 PM)

EARLY MIOCENE SQUALODONTID *PHOBERODON ARCTIROSTRIS* (ODONTOCETI, PLATANISTOIDEA) FROM PATAGONIA AND PHYLOGENETICS OF THE PLATANISTOIDEA

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Shark-toothed dolphins (clade Squalodontidae) are pelagic, late Oligocene–late Miocene, long-jawed odontocetes with heterodont teeth. Most of the key named species

are from shelf strata around the North Atlantic Ocean and Mediterranean. Recent phylogenetic analyses place the group just basal to or in the Platanistoidea. One of the few named squalodontids from the Southern Hemisphere is *Phoberodon arctirostris* (Gaiman Formation, Burdigalian, early Miocene) from Patagonia, Argentina. The species, named in the 1920s, includes two informative types with longirostral skulls and postcrania, but lacking earbones and most of the basicrania. No new specimens have since been described, and the species has not been included in published phylogenetic analyses. A new specimen of *P. arctirostris* (MPEF-PV 10883; Playa Magagna, Chubut) allows a redescription and the first phylogenetic analysis for *Phoberodon*. The fossil, from the Gaiman Formation, comprises a partial skull, a partial mandible, vertebrae and ribs, and both scapulae, but no earbones.

The three *Phoberodon* fossils were used in a cladistic analysis based on a published morphological matrix totalling 84 taxa and 292 characters. *Phoberodon* has 49% missing data (particularly earbones, and also soft tissues). In the resulting strict consensus of 7488 equally-parsimonious trees, Platanistoidea includes Waipatiidae, Squalodelphinidae, and Platanistidae, defined by six synapomorphies, four of them related to the periotic. *Squalodon* is immediately basal to Platanistoidea, with *Phoberodon* in a more-basal polytomy with *Prosqualodon* and other stem Odontoceti. The iterPCR procedure did not identify *Phoberodon* as an unstable taxon. An implied weight analysis (K = 3) places (*Phoberodon*+*Papahu*)+*Squalodon* in the Platanistoidea; in other published analyses, *Papahu* is crownward of platanistoids. Results reiterate that the earbones (tympanoperiotics) and basicranium are important in odontocete morphological phylogenetics, and that taxa like *Phoberodon* that do not fully preserve these structural complexes commonly plot basal to their expected position. *Phoberodon* is for now a stem Odontoceti but is likely to move more crownward, clustering with *Squalodon*, as new material is added to analyses.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

PLEISTOCENE ICHNOFOSSILS AND THEIR IMPORTANCE IN RECONSTRUCTING MAMMALIAN HABITUAL CAVE USE

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For nearly 60 years, Pleistocene ichnofossils in the cave environment have been only anecdotally mentioned during exploration and description in obscure cave records and reports and have never received the attention they fully deserve. Ichnofossils in a cave setting are difficult to preserve and protect. In many cases, they are unintentionally destroyed by the casual cave explorer. Riverbluff Cave (southwest Missouri) was discovered during road construction in 2001 and was quickly gated. Access is limited to preserve the numerous fossil resources found within its more than 600 m of passage. The vast majority of ichnofossils in the cave are claw marks and dung from small mammals using the cave as a den, shelter, and/or as hibernacula. The claw marks have been assigned to raccoons, bobcats and a possible wolf. Notable, but poorly represented claw marks of a large cat have also been found. Based on the measurements (20 cm across), it falls well within the acceptable size of the American Lion (*Panthera leo atrox*); however, because only three separate claw marks have been recovered, direct evidence to its activities in the cave are undetermined at this time. The most impressive of the ichnofossils in the cave represent Pleistocene megafauna and give us a new perspective on their use of caves. These fossils include the flat head peccary (*Platygonus compressus*) and the giant short-faced bear (*Arctodus simus*). The flat head peccary left a series of large cloven-hoofed track ways and shallow bowl-shaped wallows representing numerous adult individuals. The floor of the cave is littered with dung containing plant fibers that have been tentatively associated with the peccary, and physical evidence suggests they used the cool cave clay to wallow. Large beds on the floor and ledges coupled with two distinct sizes of claw marks in and around the beds support the hypothesis that *A. simus* primarily used the cave to hibernate and rear young. Most beds contain a layer of dung probably associated with *A. simus*, deposited initially as a scent indicator to warn other bears of their territory. A predator/prey relationship exists in the cave between *P. compressus* and the *A. simus*. In one location, a collection of bear claw marks in association with a chaotic assemblage of peccary tracks suggests an ambush scenario. The ambush area is in close proximity to a peccary bone site consisting of one individual.

Poster Symposium II (Friday–Saturday, October 28–29, 2016, 4:23 PM)

***DYSTROPHAEUS VIAEMALAE* COPE FROM THE BASAL MORRISON FORMATION OF UTAH: IMPLICATIONS FOR THE ORIGIN OF EUSAUROPODS IN NORTH AMERICA**

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The only known specimen of the sauropod dinosaur *Dystrophaeus viaemalae* comprises fragmentary remains from the lower portion of the Upper Jurassic Morrison Formation of southeastern Utah. Named by E.D. Cope in 1877 based on a type specimen including an ulna, three metacarpals, half of a radius, and a fragment of scapula, *Dystrophaeus* came from a site originally discovered in 1859 by the Macomb Army Expedition. Thus, it is the first associated dinosaur skeleton discovered in western North America, yet it was subsequently largely forgotten. The type locality was eventually lost, and was only relocated in 1987; however, further excavation was inhibited by logistical difficulties in accessing the site.

Reinvestigation and further excavation of the type locality during the 2014–2016 field seasons has confirmed that the specimen is from the lower half of the Tidwell Member, making it one of the lowest stratigraphic occurrences of vertebrate fossils in the Morrison Formation. Preliminary U-Pb zircon dates indicate the site is Oxfordian in age, approximately 158 ± 3 Ma (consistent with previous $^{40}Ar/^{39}Ar$ ages for this unit); this age makes the specimen 4–8 million years older than other well-sampled Morrison sauropod assemblages from the Salt Wash and Brushy Basin members, and the oldest eusauropod skeletal remains from North America. The crevasse-splay sandstone in which the specimen was buried has yielded many more bones of the skeleton, most of them encased in a hard, iron-rich concretionary layer that slows preparation. New elements recovered in 2014–2016 (and identifiable specimens collected from the surface in 1989 that are now being studied) include most of the ilium, additional metapodials, caudal vertebrae, a tooth, and many as yet unidentifiable elements. The few previous studies that examined *Dystrophaeus* have hypothesized a variety of phylogenetic placements, including as a diplodocine, a dicraeosaurid, a camarasaurid, or an independent lineage. These new elements suggest that *Dystrophaeus* is not a diplodocoid, but whether it is a macronarian, or outside Neosauropoda, is still unclear. Continuing work on this important specimen should clarify its systematic position and give more information on this oldest of Morrison Formation sauropods.

Grant Information

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Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

UNAPPRECIATED HIGH CRANIAL DISPARITY IN STEM ARCHOSAURS PREDATED THE DOMINANCE OF THE ARCHOSAUR CROWN

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Archosaurs, the hugely successful group that includes modern crocodilians and birds as well as dinosaurs and many extinct clades, began to proliferate in the Triassic after the Permo–Triassic mass extinction, but are part of a broader radiation that began with the origin of the clade Archosauromorpha in the middle–late Permian. Previous research has mainly focused on the origin and initial diversification of archosaurs and their major subgroups (particularly dinosaurs), whereas non-archosaurian archosauromorphs have been largely overlooked in macroevolutionary studies. Here, we analyze the temporal pattern of cranial disparity of late Permian to Early Jurassic archosauromorphs using two-dimensional geometric morphometrics, allowing us to compare skull shape diversity between non-archosaurian archosauromorphs and archosaurs and between the crocodile and bird-lines of archosaurs (Pseudosuchia and Ornithodira). Shapes of hypothetical ancestors were estimated using a time-calibrated informal supertree and added to the dataset to compensate for poor sampling, which is a particular problem around the Permo–Triassic and Triassic–Jurassic boundaries. Non-archosaurian archosauromorphs showed an increase in cranial disparity from the late Permian to the Early Triassic, followed by an unappreciated high peak in the Middle Triassic, and then abruptly declined during the Carnian (Late Triassic). By contrast, cranial disparity of archosaurs rose from the Middle Triassic to the end of the Late Triassic, decreased around the Triassic–Jurassic boundary, but expanded again towards the end of the Early Jurassic. The Late Triassic archosaur peak is primarily based on high disparity values among pseudosuchians, while the re-expansion in the Early Jurassic results from a continuous increase of ornithodiran cranial disparity from the Carnian until the Sinemurian. Our study indicates that non-archosaurian archosauromorphs were highly diverse components of terrestrial ecosystems in the Early and Middle Triassic, predating the major radiation of crown group archosaurs. There was a gradual faunal replacement of stem archosaurs by the crown group (primarily Pseudosuchia) during the Ladinian and Carnian, including a short interval of partial overlap in morphospace during the Ladinian. In addition, simultaneous decrease of pseudosuchian disparity and increase of ornithodiran disparity across the Triassic–Jurassic boundary could be evidence for an opportunistic replacement scenario between the two major archosaur groups.

Grant Information

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Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

THE EVOLUTIONARY PROCESS OF REINFORCEMENT RECONCILES CONFLICTING FUNCTIONAL HYPOTHESES FOR BIZARRE STRUCTURES IN NORTH AMERICAN LATE CRETACEOUS DINOSAURS, EXPLAINS APPARENT ENDEMISM AS AN ARTIFACT OF VICARIANCE AND ANAGENESIS, AND SUGGESTS PRE K–PG DIVERSITY PATTERNS MAY BE PECULIAR TO NORTH AMERICA

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Much recent debate has concerned the function of 'bizarre structures' observed in Late Cretaceous dinosaurs of the North American Western Interior, with suggestion of a role in either species recognition, or mutual sexual selection. Improved understanding of phylogenetic, ontogenetic, stratigraphic, and geographic contexts reveals the curious finding that ornithischian sister taxa consistently exhibit cranial display organs which evolve continuously in opposite directions in morphospace. If bizarre structures evolved for mutual sexual selection, then this would well-explain the continuously changing morphology of display structures, but it would not explain why sister taxa exhibit opposite trends, nor why non-speciose clades exhibit relatively restricted adornments. Conversely, the species recognition hypothesis well-explains sister-taxon differences, but cannot account for why structures continue to evolve beyond the point at which a level of morphological distinction has been achieved. These opposing hypotheses are reconciled by the hypothesis that dinosaur bizarre structures evolved under the evolutionary process of reinforcement. Here, recently diverged sister-lineages can produce hybrids which are fertile but less competitive than pure breeds of either parent population; selection therefore favors opposite display morphologies in order to reinforce reproductive isolation, thereby avoiding hybridization. This finding is supported by morphometric and phylogenetic analysis of chasmosaurine ceratopsids, which reveals true speciation occurred before the middle Campanian, dividing Chasmosaurinae into two lineages with opposite morphological trajectories (including shallowing / deepening median embayment of the parietal). This finding is dependent on precise stratigraphic positioning

of taxa, based on radiometric dates which are recalibrated correctly here for the first time. Reinforcement may explain apparent latitudinal endemism, as during the upper Santonian - lower Campanian, the Western Interior Seaway directly abutted the Sevier thrust front in central Utah, briefly emplacing a geographic barrier separating northern and southern regions, and severely limiting habitat space in medium latitudes. This finding adds fuel to the argument that vertebrate diversity patterns seen in the Late Cretaceous of North America are an artifact of its peculiar geography (north-south orientation, orogenic activity and cyclic seaway transgression / regression), and may not be expected on a global scale.

Grant Information
Jurassic Foundation

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

CARNIVORANS AND CREODONTANS FROM THE EARLY EOCENE WASATCH FORMATION OF SOUTHWESTERN WYOMING

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Members of the Carnivora and Creodonta represent key components of early Eocene faunas from North America. However, outside the well-studied Bighorn Basin of northern Wyoming, little information on the occurrences of these groups is available. Information from geographic regions outside northern Wyoming must be gathered to better understand the evolutionary history of these groups from this interval of time, including body size and taxonomic composition. Here we report on carnivorous mammals from a series of screen-washed, stratigraphically well-constrained horizons from the early Eocene Main Body of the Wasatch Formation in southwestern Wyoming, spanning the middle part of the Wasatchian North American Land Mammal Age (Wa3–Wa5 biozones). More than 200 specimens have been recovered, including not only isolated teeth but almost twenty well-preserved dentaries and maxillae. Preliminary identifications include the oxyaenid creodont *Oxyaena gulo*, the hyaenodontid creodonts *Prototomus martis* and *Prototomus phobos*, the miacid carnivorans *Vulpavus australis*, *Uintacyon* sp., and *Miacis* sp., and the viverravid carnivorans *Viverravus acutus* and *Didymictis protenus*. Faunas from each of these horizons typically include at least five carnivores: a single oxyaenid, two hyaenodontids, two miacids and one viverravid. Body mass for these fossil species was estimated by applying regression parameters determined from extant carnivorans to the area of the lower first molar. We found that carnivores from the early Eocene of southwestern Wyoming range in size from 0.5 kg to 13 kg, which is comparable to carnivores from the Bighorn Basin; yet, in our sample many of the smaller taxa (i.e., those less than 1 kg) are better represented and larger carnivores (i.e., those more than 10 kg) are comparatively rare. These findings, including body mass estimates, new specimens, tooth positions, and taxa, greatly improve the previously limited information from North America and help us better understand the occurrences and distributions of carnivorous mammals outside the Bighorn Basin during the Wasatchian.

Grant Information
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Technical Session VIII (Thursday, October 27, 2016, 3:15 PM)

ECOLOGICAL BIOGEOGRAPHY OF MODERN NORTH AMERICAN RODENTS IN RELATION TO CLIMATE AND PHYSIOGRAPHY

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The species richness and ecological structure of modern North American mammals, in terms of diversity in body size and trophic categories, exhibit strong quantitative relationships at the continental scale with climate and physiography. Rodents comprise half of modern mammal species in North America, suggesting that patterns among rodents may substantially drive these relationships. Rodents also comprise ca. 18% of Cenozoic mammal species occurrences for North America in the Paleobiology Database. Since reliable quantitative techniques now exist for estimating body mass and trophic category for North American rodents, fossil assemblages can potentially be analyzed using the same ecological categories as for modern species. Thus, assessing the relationship between present-day ecological structure and environmental variability at the continental scale for rodents could provide valuable tools for paleoecological reconstruction. We analyzed species density of modern rodents and species richness in body mass, trophic, and locomotor categories in equal-area quadrats (150 x 150 km) in relation to measures of temperature, precipitation, evapotranspiration, and elevation and relief. A multiple-regression model of species density for all modern North American mammals on environmental variables is statistically significant and has high explanatory power (R^2= 0.88); a similar model for rodents is also significant and explains a similarly high proportion of variance in rodent species density across North America (R^2= 0.84). A redundancy analysis (or constrained linear ordination) using nine environmental variables explains 81% of variation in the distributions of rodents among body-size, trophic, and locomotor categories in quadrats, with median quadrat elevation, potential evapotranspiration, and maximum monthly temperature as the most important environmental variables. These analyses suggest that the ecological biogeography of modern North American rodents is closely tied to spatial variation in climate and physiography, and that ecological reconstructions of well-sampled fossil rodent assemblages can provide quantitative paleoenvironmental information.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

INITIAL ASSESSMENT OF PROJECT 23 SMALL MAMMAL DIVERSITY AND TAPHONOMY AT RANCHO LA BREA

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Since the discovery of fossils in the Rancho La Brea (RLB) tar pits over 140 years ago, collection and research of small mammal remains (e.g., rodents, soricomorphs, and lagomorphs) have been sparse relative to the Pleistocene megafauna. However, in 2006, the discovery of several new asphalt seeps presented new opportunities to study RLB microfauna with improved stratigraphic and temporal context. These deposits, salvaged and stored in 23 wooden crates, are now undergoing excavation with emphasis on acquiring representative plant, pollen, and small mammal data. We are now systematically analyzing these 'Project 23' biota to better understand ecosystem dynamics prior to the Last Glacial Maximum. Here we determine the small mammal fauna from the first Project 23 excavation, Deposit 1, which has been radiocarbon dated to approximately 40,000 cal yr BP. These data provide early indication as to whether Project 23 small mammal fossils are similar to other RLB assemblages and their modern analogues near Los Angeles. To date, we have identified at least one lagomorph and 10 rodent genera (*Sylvilagus*, *Spermophilus*, *Tamias*, *Thomomys*, *Dipodomys, Perognathus*, *Peromyscus*, *Onychomys*, *Neotoma*, and *Microtus*), all of which are currently distributed in southern California. We will continue to refine identifications to species level, as well as identify small mammal fossils from at least five additional Project 23 deposits. Stable carbon and oxygen isotope analysis will also be conducted to obtain dietary and environmental signatures from specimens within and among deposits. Results will ultimately be evaluated with plant, pollen, and megafauna data via food web models to shed light on comprehensive terrestrial biodiversity changes at RLB over the past 50,000 years.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

A NEW EOCENE VERTEBRATE LOCALITY, ROUZILHAC (MP 10–11, AUDE, FRANCE)

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The new vertebrate locality of Rouzilhac is located toward the base of the Mollasse de Carcassonne, not far away from Issel (Aude, France). The fossiliferous bed is a lens of unconsolidated conglomerate with gravels, sand and stromatolites (i.e., a typical river channel deposit). Its fauna includes mainly middle-sized and large vertebrates due to taphonomic conditions (high energy flow). The reptiles include four crocodiles (cf. *Iberosuchus crassiproratus*, *Diplocynodon* sp., aff. *Asiatosuchus* sp., *Pristichampsus rollinati*) and four turtles (*Neochelys*, *Trionyx* s. l., *Allaeochelys* n. sp., aff. *Hadrianus* sp). The mammals include two creodonts (*Oxyaenoides bicuspidens* and *Leonhardtina* cf. *gracilis*), a rodent (*Ailuravus* sp.), and two primates species (one *Europolemur* n. sp. and one species representing a new genus). The artiodactyls are diverse, including *Aumelasia* n. sp., *Protodichobune* sp., and a new species of *Lophiobunodon*. The dominant group of mammals is the Perissodactyla, with abundant remains of equids, which are referred to *Propachynolophus gaudryi*, *P. maldani*, *Pachynolophus livinierensis*, and cf. *Lophiotherium*. There is one rhinocerotoid, *Hyrachyus stehlini.* A relatively large assemblage of *Lophiodon* aff. *eygalayense* shows the high morphological variability, which has led to controversies concerning the number of species present at Issel. The many variations in the details and proportions of the upper premolars, the more or less triangular outline of the M3/, and the orientation of the posterolophid of the lower molars do not allow the separation of groups. We thus interpret the assemblage as pertaining to one species, which shows a marked sexual dimorphism. This species is more primitive than *L. tapirotherium* from Issel and also confirms previous studies that distinguished a group of forms present in the Paris Basin from a group of species present in southern France. Several vertebrate species are close to species known in the Paris Basin and in Germany, Messel or Geiseltal, providing arguments for a biochronologic dating. The two *Propachynolophus* fit in lineages that imply an age older than Messel (MP 11). We propose an age between MP 10 and MP 11, a large time interval corresponding to a 2 Myr hiatus between Cuisian and Lutetian localities in the Paris Basin.

Technical Session XIII (Friday, October 28, 2016, 3:15 PM)

STASIS IN LOCALITY-SCALE MAMMAL COMMUNITY STRUCTURE ACROSS THE PALEOCENE–EOCENE THERMAL MAXIMUM

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The long-term processes of speciation, extinction, dispersal, and immigration determine the composition of the regional pool from which local communities are drawn. Environmental filtering and competition then determine the composition of individual communities. The Paleocene–Eocene transition was marked by a rapid global warming event of 5° to 10°C (Paleocene–Eocene Thermal Maximum [PETM]; ~56 Ma) that followed an abrupt carbon isotope excursion lasting 21 kyr or less. During the PETM, mammals decreased significantly in body size due to both anagenetic (within lineage) evolution and immigration. Furthermore, the PETM is coincident with the immigration of the Perissodactyla, Artiodactyla, and Primates into North America from Eurasia. The PETM is thus ideal for understanding the role of immigration and morphological evolution in structuring terrestrial mammal communities. We assembled a database of 555 species and their associated body size estimates spanning the Puercan through Wasatchian. We also assembled a time-scaled composite phylogeny for all species in the sample. Tree topology was based on a recently published phylogeny of early Cenozoic mammal genera. Our database included the vast majority of species that cross the PETM in North America. Using the Net Relatedness Index, we calculated the phylogenetic relatedness of species across the PETM at both the regional (primarily the Bighorn Basin)

and locality scales. We also calculated body size disparity as the average of the pairwise differences among co-occurring species. We found that the entire mammalian fauna of North America became significantly more phylogenetically even throughout the Clarkforkian and across the PETM. This pattern is invariant to the tree dating method, uncertainty in tree topology, and resolution of the tree. The degree of change is greater than is observed between modern tropical and Arctic mammals in the Americas. However, average body size disparity was invariant. At the locality scale, phylogenetic community structure remained unchanged, but average body size disparity decreased significantly. A coincident increase in spatial faunal turnover (beta diversity) suggests increased niche partitioning in the spatial dimension that counteracted the dramatic changes apparent at larger spatial scales. We show that climate changes during the PETM decreased the importance of evolutionary relatedness in community assembly but that body size still played a key role.

Technical Session VII (Thursday, October 27, 2016, 2:45 PM)

ONE DINOSAUR IS NOT ENOUGH: *GRYPOSAURUS* (HADROSAURIDAE) BONEBED ILLUSTRATES MULTIPLE NON-PHYLOGENETIC SOURCES OF MORPHOLOGICAL DIFFERENCES

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Most dinosaur taxa suffer from small sample sizes. Descriptions of taxa based on single specimens may not be able to discriminate between morphological characteristics genuinely indicative of taxonomic distinction, and those arising from stratigraphic, geographic, taphonomic, ontogenetic, and individual variation. The hadrosaurid *Gryposaurus* encompasses multiple species, most of which are represented by isolated individuals of varying ontogenetic ages and geographic and stratigraphic positions. Thus, comparisons between skeletal elements of these species are hindered by multiple non-taxonomic sources of morphological differences. A monodominant bonebed in the Judith River Formation (Late Cretaceous: Campanian) of north-central Montana yielded 800+ elements representing 10+ individuals spanning 3 ontogenetic stages (juvenile, subadult, adult) of a new *Gryposaurus* species; thus, geographic, stratigraphic, and phylogenetic differences are not factors in this sample. This bonebed enables comparisons of ontogenetic changes within a single species, as well as highlighting individual variation among members of the same ontogenetic stage. All specimens of each cranial and postcranial element were compared (n = 2 to 12), and apparent morphological differences were attributed to taphonomic breakage, direction of diagenetic compression, ontogeny, and/or intraspecific variation. Characters previously considered phylogenetically significant for hadrosaurids are here shown to be invalid. Previous phylogenetic analyses included five ilium characters that are problematic for taxonomic purposes: preacetabular process angle (intraspecific); depths of preacetabular process and central ilium (diagenetic compression); anteroposterior and dorsoventral extent of supraacetabular crest (taphonomic breakage and diagenetic compression). Six dentary rostral process characters are similarly problematic (taphonomic breakage and diagenetic compression), as are scapula anterior constriction depth (ontogenetic), ulna robusticity (intraspecific), and metacarpal robusticity (ontogenetic or intraspecific). Thus, multiple sources of apparent morphological differences need to be evaluated before interpreting them as taxonomically significant. Numerous pairs of dinosaur taxa were recently hypothesized to represent ontogenetic stages within single species; consideration of taphonomic alteration and individual variation could synonymize many more taxa.

Grant Information
Geological Society of America, N. Myhrvold, D. Sands, E. Short, D. Wagoner, Royal Ontario Museum

Poster Symposium II (Friday–Saturday, October 28–29, 2016, 4:27 PM)

SAUROPOD AND THEROPOD MOVEMENT AND HABITAT PREFERENCES OVER DIFFERENT PARTS OF THE MORRISON BASIN: INSIGHTS FROM CARBON, OXYGEN AND STRONTIUM ISOTOPE RATIOS OF TOOTH ENAMEL

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The study of dinosaur behavior during the Jurassic can be somewhat frustrating, as there are no close modern relatives to serve as analogs, and because the fossil record of dinosaurs is characterized by significant taphonomic filtering. Therefore it is useful to have additional tools to try and answer questions related to their movement, diet and ecology. One such set of tools are those of stable isotope geochemistry, in particular carbon, oxygen and strontium isotope ratios of tooth enamel. These ratios are influenced by the ratios of food and water ingested by the animals, which in turn vary significantly over terrestrial landscapes. As a result it is possible to make inferences regarding dietary and habitat preferences of Jurassic dinosaurs during their lifetimes.

To illustrate the potential of stable isotope methods as a tool for studying Jurassic dinosaur behavior, data are presented from a number of different taxa (e.g. camarasaurs, diplodicods, allosaurs), along with data from authigenic carbonates, from several localities across the Morrison basin (e.g. Fruita, CO; Vernal, UT; Thermopolis, WY; Picketwire CO). Isotopic comparisons among authigenic carbonates and sauropods indicate that some populations of these animals undertook seasonal migrations to highlands west of the Morrison basin, while others remained in the basin year-round. This difference in behavior appears related to the existence of lakes/availability of water. The movement of theropods roughly mirrors that of associated sauropods; in other words the carnivores follow prey rather than establishing home ranges. Nevertheless there is evidence that they did not spend time in exactly the same micro-environments as sauropods, with theropods preferring (forested?) stream settings and sauropods preferring (open?) lakeside settings.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

RETROVERSION OF THE PUBIS IN PTEROSAURIA AND ITS SIGNIFICANCE IN RECONSTRUCTING GAIT

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It has been demonstrated that the pelvis in archosaurs repeatedly shows convergence towards acquisition of an anteriorly projecting ilium and a retroverted pubis. Pterosaurs have independently evolved these features, with the anterior iliac process universal across the taxon and the retroverted pubis occurring in several taxa. The latter cannot be appreciated as readily in pterosaurs as in other archosaurs due to the fused nature of the ischium and pubis.

Geometric and linear morphometrics were used to quantify the shape and angle of the anterior margin of the pubis or puboischiadic plate. The angle and the PCA score were applied as end taxa to a reduced phylogenetic tree and nodes were reconstructed using least-squares parsimony. Retroversion is defined here as the anterior margin of the pubis subtending an angle of greater than 90° to the long axis of the spinal column.

By examining the pubis, it can be seen that it becomes retroverted not once at the base of the Pterodactyloidea, as is consistent with existing hypotheses on gait, but in several different lineages independently. Due to the constraints of flight, it is unlikely that this retroversion accommodated a more massive gut, as is the consensus in Ornithischia and Therizinosauroidea. Retroversion has been associated with increased femoral retraction in Maniraptora, and a similar function of the retroverted pubis in pterosaurs is hypothesized here.

As the pubis becomes retroverted, the surface area caudad to the femur increases and surface area craniad to the acetabulum is reduced. Accordingly, moment arms of femoral protractors originating from the puboischiadic plate are reduced, and in some cases come to function as additional adductors. By contrast, the adductors are brought immediately ventral to the acetabulum, giving them greater mechanical advantage. This shape change is likely enabled by the expansion of the hip protractors onto the anteriorly expanded ilium. In terms of gait, a strongly retroverted pubis is unlikely to correspond to a vertical clinging style of arboreality, as the caudally rotated retractors are at an extreme mechanical disadvantage. This suggests either a terrestrial mode of locomotion, or a horizontal substrate arboreality. In addition, strong femoral retractors and adductors played a crucial role in developing and maintaining tension in the wing membrane, and in maintaining its planform and preventing collapse of the wing.

Poster Symposium I (Wednesday–Thursday, October 26–27, 2016, 4:15–6:15 PM)

UINTAN CREODONTS FROM THE UINTA BASIN WITH A DESCRIPTION OF THE POST-CRANIAL SKELETON OF *OXYAENODON*

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During the middle Eocene of North America, creodonts continued their decline in diversity, which began in the earliest Eocene and led to their eventual extinction in North America by the middle Oligocene. Despite the decline in taxonomic diversity, creodonts of the Uintan (the middle Eocene NALMA) were morphologically disparate, representing an array of dental morphologies and a corresponding range of dietary ecologies. Finds from the Uinta Basin, UT Uintan age deposits have also yielded relatively complete postcranial remains. In the Uinta Basin, creodonts are represented by at least five genera—the proviverrines *Proviverra* and *Prototomus*, the limnocyonines *Limnocyon* and *Oxyaenodon*, and *Apataleurus*, whose family affiliation is unclear. A previously undescribed specimen of *Oxyaenodon* includes nearly complete upper and lower dental rows and much of the post-cranial skeleton, including the hindlimb, which was previously unknown for this genus. The post-cranial skeleton is similar to *Limnocyon* in being relatively generalized but is more gracile with a higher crural index. Limb proportions overlap with those of living ambulatory terrestrial and scansorial carnivores and are outside the range of groups with more specialized behaviors such as terrestrial cursors and arboreal carnivores. Among modern carnivore groups, Uintan limnocyonines most closely resemble mustelids in postcranial morphology. The new samples from the Uinta basin also allow for comparison of the creodont communities from the Uinta Basin to other fauna of similar age—San Diego, CA and Trans-Pecos, TX. This comparison shows that creodonts tend to be spottily distributed with few taxa shared between the various localities. This is in contrast to carnivoran taxa, which have more widespread distributions. This may be an artifact of poor sampling and little taxonomic work on creodonts at the other two Uintan localities, or this may demonstrate that Uintan creodonts had smaller populations that did not range far across the continent, which may be a sign of their eventual demise.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

SPINA BIFIDA IN THE EARLY TRIASSIC DICYNODONT THERAPSID *MYOSAURUS GRACILIS*

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Spina bifida ('split spine') is a birth defect resulting in an incomplete closing of the vertebral column, which is likely caused by a combination of genetic and environmental factors. It is a common pathology among humans, also occurring in other vertebrates, but has only very rarely been reported in fossils, previously restricted to Pleistocene and Holocene age. Here we report a case of spina bifida in the dicynodont *Myosaurus gracilis* from the Lower Triassic *Lystrosaurus* Assemblage Zone of the South African Karoo Basin. Dicynodont anomodonts are the most abundant and taxonomically diverse clade of Permian–Triassic tetrapods that evolved many different ecomorphs, including fully terrestrial, semi-aquatic, arboreal, and fossorial forms. Some of the most specialized dicynodonts are the small, burrowing cistecephalids. *Myosaurus*, also known from Antarctica, has frequently been recovered as their sister taxon and, therefore, is crucial to understanding the evolution of fossoriality in the clade. For this purpose we CT scanned

the largest and most complete specimen of *Myosaurus* (BP/1/4269), consisting of a 4.1 cm long skull and the anterior part of the postcranium, including part of the vertebral column, ribs, a virtually complete pectoral girdle (with both scapulae, procoracoids, coracoids, clavicles, an interclavicle, and a sternum), and two partial humeri. The postcranium of *Myosaurus* is characterized by a reduced number of cervical vertebrae, a well-ossified pectoral girdle, but an overall slender morphology lacking greatly enlarged processes for muscle attachments, indicating that *Myosaurus* was possibly a rather facultative burrower without the extreme mole-like specializations seen in cistecephalids. The CT scan further revealed the vertebral pathology known as spina bifida, here characterized by split neural arches in the axis and cervical 3, coupled with a spondylolisthesis (displacement of the vertebral centrum) in the axis—a frequent association also reported for humans. Moreover, the cervical series is strongly amphicoelus to notochordal, which, however, likely represents a phylogenetic signal rather than an association with the reported pathology.

Technical Session XV (Saturday, October 29, 2016, 10:45 AM)

COMPLEX, INTERDIGITATED SUTURES WITHIN SAUROPOD VERTEBRAE PROVIDED STABILITY IN SUPPORT OF LONG, HEAVY NECKS

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Sauropod dinosaurs achieved extreme body sizes via rapid and sustained growth, permitted in part by the delayed fusion of neurocentral sutures, which are the synchondroses between the separately ossified neural arch and centrum. Because the cartilage joining unfused sutures is more susceptible to dislocation than the bone that replaces it during fusion, these joints represent points of weakness in a growing animal. In sauropods, the neurocentral sutures are complex and interdigitated. Experimental studies of living taxa indicate that sutural complexity is correlated with the magnitude of stress the suture must resist. We explored this relationship in sauropods by measuring sutural complexity in the articulated presacral vertebrae of *Spinophorosaurus nigerensis* (body length ca. 13 m). Complexity was calculated two ways: (1) the ratio of the total length of the suture to the straight-line length between its endpoints and (2) the fractal dimension of the suture. The pattern of complexity in the neurocentral sutures indicates that stress increased proximally along the neck, reaching its peak in the anterior dorsal vertebrae before decreasing towards the sacrum. We interpret this stress distribution to reflect the proximal increase in the weight of the neck and the posterior decrease in the size of the dorsal ribs. In cervical vertebrae, the amplitude and orientation of sutural interdigitations confer resistance to anteroposterior translation of the neural arch relative to the centrum; in dorsal vertebrae, the interdigitations primarily resist lateral rotation. This pattern is consistent with the fact that an elongate cervical vertebra affords a greater mechanical advantage to resist lateral rotation of the neural arch relative to the centrum. The comparatively short dorsal centra confer less resistance to this rotation, which is in part generated by broad transverse processes that generate torque on the neurocentral junction. The patterns and structures described in *Spinophorosaurus* are similar to those previously recognized in *Alligator*. Complex neurocentral sutures may represent an archosauriform adaptation that facilitated the acquisition of large adult body size.

Poster Symposium I (Wednesday–Thursday, October 26–27, 2016, 4:15–6:15 PM)

REVISED HIGH RESOLUTION STRATIGRAPHY OF BRIDGER FORMATION IN GRIZZLY BUTTES AREA OF SOUTHWEST WYOMING

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The Bridger Formation is well known for its tractable stratigraphy, broad geographic exposure, and dense fossil record. The entire Bridger Formation is about 600 meters thick and represents a time interval of about 3.5 million years (49 Ma to about 45.5 Ma). Fossil assemblages from the lower Bridger Formation (~49 to 47.7 Ma) document the most diverse North American mammalian communities seen in the Cenozoic, occurring on the cusp of climatic decline at the end of the Early Eocene Climatic Optimum (EECO; 52–50 Ma). Samples from the upper Bridger Formation document a dramatic crash in mammalian diversity corresponding to the establishment of substantial global cooling and drying following the EECO beginning at about 47.7 Ma. Stratigraphic intervals representing individual Bridgerian biochrons can be up to 300 meters thick and represent time intervals of more than 1 million years. Evolution and diversification of lineages has been effectively documented at the broad levels of Biochrons Br-1 through Br-3 but within-biochron patterns are under developed. Br-2 (corresponding to the lithostratigraphic interval Bridger B) is represented by about 200 meters of section spanning a time period from 49 to 47.7 Ma. Mixing of specimens taken from across such a long interval may be partially responsible for obscuring temporal patterns in the assemblage. Specifically, the exceptionally large size range of specimens assigned to the euprimate genus *Notharctus* from Br-2 may be attributable to the coeval existence of multiple sympatric species, sexual dimorphism, or temporal trends in lineage size. To rule out one or more of these possibilities, better stratigraphic resolution is needed. To improve stratigraphic resolution in Bridger B, we used a differentially corrected GPS to trace marker beds recognized by previous researchers. We identified these marker beds based on descriptions in the literature, as well as by uploading digitized, georeferenced geologic maps to our GPS unit and navigating to the beds. We present new maps and meter levels for broadly separated notharctine-bearing localities. Preliminary results (n = 9 localities) suggest that *Notharctus* increased in body size over Br-2, implying that the large range of tooth sizes is an artifact of time averaging. We are currently developing a larger sample to test this hypothesis through the collection of new material and the incorporation of earlier localities into our stratigraphic framework.

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Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

THE FIRST OVIRAPTOROSAUR (DINOSAURIA, THEROPODA) BONEBED: INSIGHTS INTO SOCIAL BEHAVIOUR IN A MANIRAPTORAN THEROPOD

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A monodominant bonebed of *Avimimus* from the Nemegt Formation of Mongolia is the first oviraptorosaur bonebed described and the only recorded maniraptoran bonebed from the Late Cretaceous. Sedimentological data suggests that the assemblage represents a reworked deposit of skeletal material. Remains of at least 18 individuals are present, composed mostly of hindlimbs but also including parts of the skull and mandible. Cranial elements recovered from the bonebed provide insights on the anatomy of the facial region, which was formerly unknown in *Avimimus*. Both adult and subadult material was recovered from the bonebed, but no small juvenile material is present. Combined with the taphonomic evidence, this suggests that *Avimimus* engaged in social behaviour in which adults and subadults grouped to the exclusion of smaller individuals. This social aggregation may be explained either as lekking behaviour or, more likely, as flocking for predator avoidance. Therefore, the association of *Avimimus* specimens in the bonebed may be interpreted as the first evidence of birdlike flocking behaviour in a maniraptoran. Gregarious behaviour in ornithomimids and oviraptorosaurs may be an adaptation for predator avoidance to compensate for ontogenetic constraints on locomotion.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

THE DEEP HOMOLOGY OF THE ZYGOMA

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The zygomatic bone (also known as the malar) is the cornerstone of the craniofacial skeleton, which plays a vital role in maintaining the facial contour, protecting the eye, supporting the muscles of facial expressions, and withstanding forces incurred during jaw movements. Establishing the homology of the zygoma (jugal) and tracing its origin and early evolution represents a complex issue because of large morphological gaps between various groups of vertebrates. Using recent paleontological findings, we trace the deep homology of the zygoma in stem gnathostomes (ostracoderms and placoderms) and discuss its homology and modifications in crown gnathostomes (acanthodians, chondrichthyans, and osteichthyans). The discovery of the placoderm *Entelognathus* from the Silurian of China has extended the origin of the zygoma to basal jawed vertebrates (placoderms) as early as the Silurian period (about 423 million years ago). In *Entelognathus*, the zygoma was joined by a new set of bones (premaxilla, maxilla, and lacrimal), marking the first appearance of the typical vertebrate face found in tetrapods including humans.

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Poster Symposium II (Friday–Saturday, October 28–29, 2016, 4:25 PM)

BIPEDAL ORNITHISCHIAN DINOSAURS (HETERODONTOSAURIDAE AND ORNITHOPODA) FROM THE MORRISON FORMATION (UPPER JURASSIC) OF THE WESTERN UNITED STATES OF AMERICA

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In the late 1870s, Professor Othniel Charles Marsh of Yale College in New Haven, CT, described bones on a block of Morrison sandstone (Upper Jurassic) from CO as *Nanosaurus agilis*, a small ~1 m long basal bipedal ornithischian dinosaur of uncertain relationships. He also erected the Ornithopoda, to which he referred 8 species from Como Bluff (CB) WY, the basis for 3 valid genera: *Othnielosaurus, Dryosaurus* and *Camptosaurus.*

The cranial anatomy of the "hypsilophodontid" *Othnielosaurus consors* (~2.2 m long) is poorly known but new specimens from WY support the identification of referred small teeth from CB as those of juvenile individuals and provide information on the skull. Skeletons of an *O. consors*-like taxon, *Drinker nisti*, were found in burrows at CB in the 1980s.

Differences between the bones and teeth of the holotype of *Dryosaurus altus* (~3m long, Dryomorpha) and a referred articulated skeleton from Dinosaur National Monument (DNM) UT, indicate that the latter may represent a separate taxon.

Ink and wash drawings prepared for Marsh in the 1880s allow a description of the postcranial anatomy of the basal ankylopollexian *Camptosaurus dispar* (~5m long) comparable to that given for *D. altus* in 1981. The holotype from CB includes a dentary but a fairly complete cranial restoration is possible based mostly on the skull of the holotype mounted skeleton of "*C. medius*" from CB, the cranial bones of which were entombed in plaster from the 1920s to the 1980s.

The large holotype pes of "*C. amplus*" (~7.5 m long) from CB was recently re-described as that of the theropod dinosaur *Allosaurus* (with a pedal ungual of a juvenile neosauropod). A large partial skull from CO, long referred to "*C. amplus*" and assumed to be from the Morrison Formation, is from the Lower Cretaceous and it was re-described in 2006 as the basal styracosternan *Theiophytalia kerri*.

C. aphanoecetes, based on an articulated postcranial skeleton from DNM, is the type species of the basal styracosternan *Uteodon*. Although the only proposed autapomorphy

was based on a referred DNM braincase of *Dryosaurus* sp., an isolated DNM jugal is distinctive.

Comparisons of the specimens of *C. dispar* and *D. altus* from CB with those from the higher stratigraphic level at DNM (*C. aphanoecetes*, *Dryosaurus* sp.) and those from the Upper Jurassic of England (? *Camptosaurus* or *Cumnoria prestwichii*) and Tanzania (? *Dryosaurus* or *Dysalotosaurus lettowvorbecki*) raise questions about balancing similarities and differences in taxonomic decisions.

The small ~1 m long heterodontosaurid *Fruitadens haagarorum* was described from CO in 2009.

Technical Session II (Wednesday, October 26, 2016, 11:45 AM)

MORE THAN ONE? THE HIDDEN DIVERSITY OF THE LIMBED SNAKES OF LA BUITRERA (CANDELEROS FORMATION, EARLY LATE CRETACEOUS), ARGENTINA

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Najash rionegrina, the only limbed snake described from La Buitrera, northern Patagonia, Argentina, provides rare insights on the anatomy of Cretaceous snake evolution in southern continents. It also addresses a number of important characters and character states that have traditionally been considered key synapopmorhies in supporting various phylogenetic schemes for snakes and their kin. *N. rionegrina* was diagnosed from an articulated postcranial skeleton with rear limbs, and associated cranial fragments. Subsequent fieldwork has produced six new skulls (7 total), some associated with postcrania, from a series of localities widely separated (up to 30 km), and along a stratigraphic interval through the last 70 m of the Candeleros Formation. The skulls and postcrania share a common general morphology; skull lengths range from small (~2cm) to large (~6-8 cm) and may well represent an ontogenetic series within the same species. Alternatively, the range of skull sizes, when linked to variation in postcranial anatomy (e.g., overally vertebral morphology, presence or absence of hypapophyseal keels/haemal keels, height of neural spines, etc.), also suggests that skull and postcranial variation might be explained by the presence of multiple species in the "La Buitrera Paleontological Area Assemblage" (LBPA). In short, the "LBPA Assemblage" is not necessarily an assemblage from a single population preserving juveniles and adults of a single species, but may be suggestive of a cluster of closely related species. These species, forming the "*Najash*-assemblage", share numerous features of the skull and skeleton in common with the younger "*Dinilysia*-assemblage" (Río Colorado Formation, Argentina). These data support the presence of a Gondwanan lineage of closely related snakes.

Technical Session V (Wednesday, October 26, 2016, 3:15 PM)

DISCRETE MODELS OF CORRELATED EVOLUTION ARE PRONE TO FALSE POSITIVE RESULTS

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Correlation of traits among organisms is commonly performed without regard to evolutionary history, but the common ancestry of life violates the underlying statistical assumption that trait values are independent. Over the past 20 years, a suite of methods have been developed to address this assumption. However, recent studies have shown that such methods are prone to false positive results under certain conditions. For example, two synapomorphic traits that share an evolutionary origin on the same branch of the phylogeny tend to support a model of correlated evolution using standard methods despite only having a single origination (dubbed "Darwin's Scenario"). The correlation between a trait with multiple originations/losses in a clade and one with only a single origin is dubbed the "Unreplicated Burst Scenario." Current methods also tend to support models of correlated evolution in this scenario. In both cases independent evolution (convergence) has not supplied sufficient sample sizes to support hypotheses of correlated evolution—both have inflated error rates. The purpose of this study is to extend these analyses to determine whether three other phylogenetic methods (reversible jump, threshold, and phylogenetic generalized linear mixed models) are also prone to inflated error rates for these two scenarios. We simulated trait data for the two previously mentioned scenarios for 100 trees with 100 taxa each, and tested for correlations among traits using reversible jump, threshold, and phylogenetic generalized linear mixed models. Under the threshold model, little to no variation in one variable should explain the variance in the other variable. However, we find that the threshold model has elevated rates of error (Darwin's Scenario: R^2_{median} = 0.47, 25% quartile = 0.38, 75% quartile = 0.55; Unreplicated Burst Scenario: R^2_{median} = 0.36, 25% quartile = 0.23, 75% quartile = 0.49). The phylogenetic generalized linear mixed model also yields false positive results in the Darwin's Scenario ($p_{avg} < 0.001$) and in the Unreplicated Burst Scenario ($p_{avg} < 0.05$). These results underscore the importance for understanding the biological and evolutionary context of traits in the application of phylogenetic comparative methods.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

NEW SPECIES OF THE STEM SEAL *ALLODESMUS* FROM THE MIDDLE MIOCENE TOPANGA FORMATION OF ORANGE COUNTY

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The stem phocid *Allodesmus* is the best-known fossil pinniped. Currently six species are recognized from the middle Miocene of California (3 spp.) and Japan (3 spp.), with additional reports from Washington and Baja California, Mexico. The California species occurred during the Middle Miocene Climatic Optimum (MMCO), a time of heightened ecological productivity, and had overlapping distributions with other species of large pinnipeds (odobenids). Here we report on new material from the middle Miocene Topanga Formation of Orange County (housed at the Natural History Museum of Los Angeles and the Cooper Center). Within the past three years, this unit has also produced important new fossils of stem walruses as well as *Eotaria crypta*, the oldest known stem sea lion. The new material of *Allodesmus* from the Topanga Formation includes material from two different sites that can be assigned to the same species by sharing diagnostic dental characters and skull morphology. Specifically, the diagnostic characters include a bilobed P1 and a broad rostrum. We also refer a lower jaw that exhibits a doubly rooted m1 and absence of m2, a plesiomorphic and a derived character, respectively, that distinguishes this taxon from most other species of *Allodesmus*. These skulls from the Topanga Formation display certain differences indicative of sexual dimorphism, with the presumed male morphotype having a sagittal crest and being slightly larger than the presumed female morph. A comparison to other species of *Allodesmus* shows that the specimens from the Topanga Formation of Orange County represent an undescribed species, seemingly more close to *Allodesmus courseni*. This discovery increases the known diversity of *Allodesmus* during the MMCO and, along with the recently described *E. crypta*, further highlights important differences between the middle Miocene sites in Orange County and the well-known pinniped fauna from the Sharktooth Hill Bonebed.

Technical Session VIII (Thursday, October 27, 2016, 3:00 PM)

THE VOMERONASAL GROOVE IN FOSSIL PRIMATES

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Extant primates vary dramatically in the presence and development of the vomeronasal system (VNS), a subsystem of olfaction largely responsible for detecting social pheromones and anti-predator chemical signals. While strepsirrhines retain a fairly primitive VNS, tarsiers and platyrrhines are characterized by a reorganization of the sensory epithelium in the vomeronasal organ (VNO), and catarrhines have lost the requisite neuroanatomical components for vomeronasal function altogether. While it seems apparent that a reduced reliance on vomeronasal olfaction would have characterized the common ancestor of catarrhines, few studies have addressed VNS variation in extinct primates, which could help elucidate the timing and context of the loss of this system.

In recent work, we have identified an osteological correlate of the VNO, allowing us to use a paleontological approach toward understanding primate VNS evolution. The soft-tissue VNO is surrounded by a cartilaginous or bony capsule that forms a gutter-like groove on the maxilla, a feature which preserves in fossils. A strong positive relationship exists between the length of the VNO and the gutter it forms on the palate, which we term the vomeronasal groove (VNG). Additionally, the length of the VNG, when adjusted for body size, significantly correlates with the proportion of intact vomeronasal receptor genes across extant mammals. Thus, the VNG can be a reliable osteological proxy for the VNO.

We investigated cranial material of fossil primates for the presence or absence of a VNG using microCT scans. The VNG was present in a broad taxonomic range of primate fossils, including plesiadapiforms, adapiforms, omomyiforms, stem and crown anthropoids, and early stem catarrhines. Plesiadapiforms and adapiforms have a distinctly longer VNG, whereas the VNGs in omomyiforms, early anthropoids, and stem catarrhines are shorter and more shallow. The VNG persists as a relatively small gutter in the stem catarrhine *Aegyptopithecus zeuxis* and is absent in the Miocene cercopithecoid *Victoriapithecus*. These results suggest that the VNO may have remained functional in basal members of the Catarrhini and was only lost in more recently derived lineages. Further exploration of the VNG in fossil primates will lead to a more thorough understanding of past sensory environments and their ultimate effects on sensory specializations of extant lineages.

Grant Information
This project was funded by NSF Grants 0966166 (NYCEP IGERT) and 0961964 (DDIG).

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

FOOTPRINTS ARE NEITHER BONES NOR FEET: PROBLEMS WITH TRACK "PRESERVATION" AND THE MOLD-BASED PARADIGM

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Vertebrates moving across deformable ground leave behind valuable clues about behavior, pedal anatomy, and *in vivo* limb function (gait, speed, posture, movement, loading). Over our years studying dinosaur footprints and reading the ichnological literature, we've encountered several terms that have persistently caused confusion. In our opinion, among the most problematic are the extremely common forms of the word "preserve," which are directly relevant to track formation, fossilization, collection, and analysis. Herein, we maintain that "preservation" and "preserved," as currently used to assess specimen quality (well preserved, poorly preserved, etc.), are doing more harm than good. More importantly, terminological ambiguities regarding "preserve" are not just semantic trivialities, but also symptoms of more fundamental conceptual difficulties.

A fossil bone's preservation quality connotes *fidelity to its condition at death*. The ichnological tradition is for preservation quality to denote a specimen's *fidelity to pedal anatomy*, but footprints are not feet. Instead, a track's preservation quality is best assessed by its *fidelity to its condition after formation*. Tracks do not exist prior to formation, yet the incorrect notion that all tracks would be clear replicas of the foot if only foot kinematics and substrate weren't there to "mess things up" is insidiously pervasive.

At the heart of our concerns is a central pillar of ichnology—morphological variation among tracks. Accurate interpretation depends on being able to correctly attribute the overall shape, specific features, and minute details of specimens to their underlying causes. We introduce a hierarchy of factors responsible for generating

diversity in track morphology. This variation scheme highlights the need to restrict over-used "preserve" words and to develop a new set of terms to better describe the full morphological range of fossil track material. We advocate moving away from the prevailing, mold-based paradigm of track formation to a more realistic, flow-based model. A perspective emphasizing the intimate association between form and formation has significant implications for the day-to-day practice of footprint-based paleontology—how we search for, measure, describe, understand, and ultimately "see" tracks.

Grant Information
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Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

ANALYSIS OF THE SKELETAL ANATOMY OF THE BASICRANIUM AND AUDITORY REGION IN THE METACHEIROMYID PALAEANODONT *METACHEIROMYS* (MAMMALIA, PHOLIDOTAMORPHA) BASED ON HIGH-RESOLUTION CT-SCANS

GAUDIN, Timothy J., University of Tennessee Chattanooga, Chattanooga, TN, United States of America; WIBLE, John R., Carnegie Museum of Natural History, Pittsburgh, PA, United States of America; ROSE, Kenneth D., Johns Hopkins Univ, Baltimore, MD, United States of America; EMRY, Robert J., Smithsonian Institution National Museum of Natural History, Washington, DC, United States of America; SPAULDING, Michelle, Purdue North Central, Westville, IN, United States of America

The Palaeanodonta are a group of burrowing mammals with reduced dentitions from the Paleogene of Laurasia. They are likely the sister group of the living pangolins, and though they are uncommon as fossils, they include some very well preserved material. We have analyzed skulls of the best preserved palaeanodont genus, the metacheiromyid *Metacheiromys,* recovered from Bridgerian NALMA (middle Eocene) deposits in western North America, in order to better understand the details of its cranial anatomy, in particular the basicranial and auditory region, and further clarify its relationships to modern mammals. This study is the first to employ high-resolution CT-scans and image analysis to reconstruct the detailed anatomy of the petrosal and its adjacent elements, including endocranial surfaces and ear ossicles, in a palaeanodont. These scans have allowed us to correct earlier misinterpretations of the anatomy of this region—for example, we refute prior claims that *Metacheiromys* had a perbullar internal carotid artery passing through a foramen in the medial wall of the entotympanic. The carotid actually perforates the entotympanic and enters the tympanic cavity through a small opening in its posterior wall and traverses a shallow but distinct transpromontorial sulcus, giving rise to a small stapedial branch laterally, resembling in this respect its older relative *Palaeanodon*. The foramen in the medial wall of the entotympanic is for the inferior petrosal sinus. *Metacheiromys* shows several derived resemblances to pangolins, including a small ossified tentorium and a large epitympanic sinus. It has several features that appear convergent with xenarthrans, including a large entotympanic element and a distinct, triangular, anteroventral process of the tegmen tympani. It also shows several features consistent with its fossorial lifestyle, most notably, an enlarged mallear head. A bulbous mallear head has been previously reported in epoicotheriid palaeanodonts, where it is grossly enlarged as in modern golden moles, but its presence in *Metacheiromys* suggests it was a general feature of palaeanodonts, presumably facilitating low frequency hearing in underground habitats.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

A NEW, DIVERSE MICROVERTEBRATE LOCALITY FROM THE LOWER CHINLE FORMATION OF SOUTHEASTERN UTAH (USA)

GAY, Robert J., Museums of Western Colorado/Dinosaur Journey, Grand Junction, CO, United States of America; JENKINS, Xavier, Estrella Foothills High School, Goodyear, AZ, United States of America; ST. AUDE, Isabella, Mission Heights Preparatory High School, Casa Grande, AZ, United States of America; AZOUGGAGH, Diana, University of Texas San Antonio, San Antonio, TX, United States of America

In the spring of 2014, students from Mission Heights Preparatory High School in southern Arizona discovered a new microvertebrate locality while prospecting the Chinle Formation at Comb Ridge in southeastern Utah. Within a year of its discovery, the site had yielded the first evidence of the poorly-understood archosauriform *Crosbysaurus* from the state. Since that point the site, named The Hills Have Teeth, has yielded numerous new specimens, providing a unique look at the terrestrial fauna of the Late Triassic in southeastern Utah.

Overall, The Hills Have Teeth locality has produced a fauna generally similar to those recovered in Arizona, New Mexico, and Texas; dominated by phytosaurs (35% of the recovered fauna, n = 42) and non-archosaurian archosauriforms (34% of the recovered fauna, n = 41). Within the non-archosaurian archosauriforms are several specimens that can be referred to taxa at the generic level. These include *Crosbysaurus* (n = 4) and *Protecovasaurus* (n = 1). While a small portion of the fauna, these are nonetheless significant as they represent the first occurrences of these taxa from Utah. Among true archosaurs, several unambiguous theropod dinosaur teeth have been recovered from at least two taxa; *Coelophysis* sp. and a second, *Eodromaeus*-like form.

Compared to localities further south and east, The Hills Have Teeth lacks significant freshwater vertebrate or invertebrate remains. Whereas up to 65% of microvertebrate remains from other sites in the southwestern United States are freshwater organisms, The Hills Have Teeth has thus far produced only two unambiguous aquatic remains; a partial hybodont shark cephalic spine (cf. Lonchidiidae) and one actinopterygian isolated scale. Indeed fish fossils are relatively rare across Comb Ridge, which is even in contrast to other areas in southern Utah such as Indian Creek and Lisbon Valley to the north and northeast. This may be the result of sampling bias, as intensive screen washing of matrix has only just begun. This work, in addition to future fieldwork at Comb Ridge may further increase the diversity of taxa known from this under-studied area.

Grant Information
Funding was provided in part by grants from Canyonlands Natural History Association.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

LOCAL RESOURCE, LOCAL OUTREACH: EDUCATING STUDENTS ABOUT PALEONTOLOGY IN THEIR OWN BACKYARDS

GAY, Robert J., Museums of Western Colorado/Dinosaur Journey, Grand Junction, CO, United States of America

Mesa County, Colorado, has some of the richest paleontological record from the last 220 million years of Earth's history. Anchoring the eastern end of the Dinosaur Diamond, the Grand Valley contains many well-known paleontological attractions. These include the famous Upper Jurassic Mygatt-Moore Quarry and the surrounding Rabbit Valley area, the Fruita Paleontological Area, Dinosaur Hill, Riggs Hill, and the Cenozoic Douglas Pass and DeBeque canyon localities. Despite the preponderance of local paleontological resources, most local students are only aware of these resources through school visits to the local museum, Dinosaur Journey. Although state standards explicitly address geological systems and dating, as well as interpreting past environments, most classroom instruction does not focus on ways to locally teach this content.

In response to this, Mesa County Schools District 51 (D51), the Bureau of Land Management (BLM), and the Museums of Western Colorado's Dinosaur Journey (DJ) have come together in a unique manner to create opportunities for students in western Colorado's Grand Valley to learn about the paleontology of their immediate surroundings. Using casts of BLM specimens, along with original fossils from the area, students have a hands-on experience with the prehistory of the area. Included in the kit are also digital materials that have been duplicated for public education through the museum website.

This approach to paleontology education differs from most other education outreach attempts as it explicitly connects local students to the local paleontological history. Most museums are not located in such a fossil-rich environment and instead interpret the paleontological history of a state or region, leaving a disconnect between students and their local history. It is hoped that by using local resources with local students, the museum, the BLM, and District 51 will see greater engagement with paleontology in the area. Indeed this is already happening, as new partners such as Colorado Parks and Wildlife, are seeking similar methods of engagement with their public land users. It is our hope that this increased engagement will in turn lead to greater stewardship and awareness of paleontological resources around the world.

Grant Information
Outreach materials and salaries have been funded by grants from the BLM and Mesa County Schools District 51.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

DESCRIPTION OF MATERIAL FROM A POTENTIAL NEW SPECIES OF METOPOSAUR FROM THE PETRIFIED FOREST NATIONAL PARK, AZ, USA

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Metoposaurids are Late Triassic temnospondyl amphibians characterized by broad, flat skulls, laterally placed orbits in the rostral half of the skull, cylindrical intercentra, and heavy ossification of the skeleton. Two species of metoposaur are commonly recovered from the Chinle Formation of the Petrified Forest National Park (PEFO): the larger *Koskinonodon perfectus* and the smaller *Apachesaurus gregorii*. Material of large metoposaurs is more abundant in the lower units of the Chinle (late Carnian), while material of smaller ones is more abundant in the upper units (early Norian). This is proposed to be associated with the hypothesized Adamanian–Revueltian faunal turnover, which is thought to be the result of regional desiccation and reduction of aquatic habitats.

In October 2013, a team from the Natural History Museum of Los Angeles County (LACM) recovered a partial metoposaurid skull from the Lot's Wife Beds (lower Sonsela Member) of the Chinle Formation exposure within the park. This stratum underlies the Jim Camp Wash Beds, in which the Adamanian–Revueltian boundary occurs. The specimen is the only metoposaurid skull known from the Lot's Wife Beds, which are relatively sparse in vertebrate remains compared to other strata, and the majority of large metoposaurid specimens in the park come from lower strata, primarily the Blue Mesa Member. The specimen contains well-preserved dentition, as well as the honeycomb ornamentation on the dorsal portion of the skull that characterizes temnospondyls. Most of the original sutures are unidentifiable because of post-mortem weathering and slight displacement of some elements along their sutures. The specimen features several traits characteristic of *K. perfectus*: a large skull, a well-developed tabular horn, a deep otic notch, and a lacrimal that enters the rostral margin of the orbit. However, its dentition is uncharacteristic of that of the species in that it lacks the anterior vomerine tusk and the arrangement of vomerine teeth around the choana. Based on comparison with other large metoposaurs, the lack of these features does not appear to be ontogenetic or due to sexual dimorphism. These characteristics, along with the specimen's stratigraphic position, support a taxonomic reevaluation and reclassification of metoposaurs in the Petrified Forest National Park.

Poster Symposium II (Friday–Saturday, October 28–29, 2016, 4:17 PM)

EMERGING DATA ON THE MORRISON FLORA: OPULENT CONIFER FORESTS OR A HINTERLAND XERISCAPE FOR THE SAUROPODS?

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To interpret the Morrison flora is to understand the food ecology of the giant sauropods, their habitats, and the Late Jurassic ecosystem of North America. In the past, it was suggested that the Morrison sauropods were low-browsing "fern-grazers" of mesic habitats or of semi-arid "savannah" of unspecified herbaceous vegetation with scattered tree ferns and conifers. Other studies provided evidence for a mesic, temperate to tropical flora. It is possible that a range of plant communities thrived under slightly different conditions, varying in response to local environments, landforms, and paleolatitudes, during the 7 million years of Morrison Formation depositional time. One way to better understand regional vegetation and herbivorous dinosaur feeding habits is to focus on a more restricted stratigraphic interval and geographic area. Here I report on fossil conifers (cones, wood, logs) from the terrestrial members of this formation in eastern Utah. Most

fossil cones come from the Brushy Basin Member, or from its boundary with the underlying Salt Wash Member, while fossil wood is found in both members. In general, the fossil megaflora throughout the Morrison Formation shows a taxonomic composition of up to 75% woody plants, mostly conifers. Specifically, fossil cones from throughout eastern Utah pertain to a diversity of conifers (Araucariaceae, Pinaceae, Cheirolepidiaceae) and represent mixed conifer forests. Widespread, species-diverse conifer forests are also documented by abundant fossil wood in Utah and the rest of the formation. Analysis of newly discovered araucariaceous logs with steady growth and no annual rings indicates a lack of climatic seasonality and no water stress, i.e., mesic conditions. Large fossil logs yield a living tree height of at least 25 m. The logs support reconstruction of a forested landscape of robust (not stunted) trees, and tall conifer forests likely dominated Morrison landscapes in Utah. Habitats of extensive conifer forests would have offered greater quantities and a steadier food supply for the gigantic sauropods than fern prairies or semi-arid vegetation, as well as shelter for smaller animals. Nutritional studies confirm that conifer leaves, especially araucariaceous, could have been among the top food sources for fully grown sauropods. Thus, the diet of Morrison sauropods may have depended to a great extent on conifer foliage. Based on emerging data, it is also well likely that mixed conifer forests formed the framework of dinosaur habitats and were the major primary producers of the Morrison food chain.

Technical Session II (Wednesday, October 26, 2016, 9:45 AM)

EVOLUTIONARY INSIGHTS FROM THE PINEAL FORAMEN

GELNAW, William, THE UNIVERSITY OF TEXAS AT AUSTIN, AUSTIN, TX, United States of America

Examining fossils in a phylogenetic context reveals that the pineal foramen was independently lost four times in early amphibians, at least twice among synapsids, and as many as sixteen times among diapsids. Furthermore, the pineal foramen appears to have been regained at least five times throughout tetrapod evolution. When present, the pineal foramen contains a photosensitive organ that helps entrain circadian cycles, such as sleep, to the rhythm of day and night by telling the pineal gland when to produce melatonin based on the amount of ambient light. In animals that don't have a photoreceptive pineal organ, information about ambient light is passed from the eyes to a set of pacemaker neurons in the brain, called the suprachiasmatic nucleus, which tells the pineal gland when to produce melatonin. However, independent losses of the pineal foramen suggest non-homology of suprachiasmatic nuclei in the brains of different clades. Why then do separate lineages lose the photoreceptive pineal organ and evolve a similar alternative mechanism? In the fossil record, loss of the pineal foramen frequently coincides with closure of the lateral wall of the braincase, reduction of the limbs, and shifts to aquatic or fossorial habits. The idea that fossoriality is a driver of pineal foramen evolution is a new hypothesis. To test its relevance relative to prevailing hypotheses that ambient light and temperature are drivers of pineal foramen size, I examined modern skinks, which exhibit continuous variation from a well-developed pineal foramen to no pineal foramen, and for which precise climate data is known. I found that for most clades, the pineal foramen evolved randomly within a set of constraining boundaries regardless of latitude or climate. However, in clades that are specialized burrowers, the evolutionary constraint on minimum size appears to be lifted, and the pineal foramen shrinks and disappears. Fossoriality is certainly not the only driver of pineal foramen evolution across Tetrapoda, but is capable of explaining a large proportion of instances in which it disappears.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

TESTING THE PALEOBIOGEOGRAPHICAL HISTORY OF MESOEUCROCODYLIA (CROCODYLOMORPHA, CROCODYLIFORMES) USING RASP (RECONSTRUCT ANCESTRAL STATE IN PHYLOGENIES) SOFTWARE

GEROTO, Caio F., UNIP, Bauru, Brazil

The historical biogeography of Mesoeucrocodylia has been understood, with few exceptions, purely by strict interpretation of the fossil distribution, without any support of methodology to test the hypotheses made. As a result, vicariance is the most accepted process to explain the mesoeucrocodylian speciation and the Notosuchia and Sebecia radiation, both here referred to a clade named Gondwanasuchia, from the South American portion to the African portion. The use of computational tools to test the distribution of these taxa help validate or refute those hypotheses. In this contribution I used a matrix with 94 crocodylomorph taxa and 351 characters. The gondwanasuchian taxa were distributed between 19 areas, which are equivalents to the geological units where the fossil were recovered. The aim of this research is to test the role of vicariance, dispersion, and extinction in gondwanasuchian mesoeucrocodylian distribution and to determinate the ancestral area for this group. The matrix was submitted to a Bayesian Binary Markov Chain Monte Carlo analysis (BBM) from RASP software (Reconstruct Ancestral States in Phylogenies). The analyses were performed in all models (JC+G, JC, F81+G and F81) with 250,000 cycles. I allowed a maximum of 5 areas per node. The results point to a conflicting dispersal hypothesis in relation to the South American ancestral area. The Equals models (JC; F81) recovered a scenario in which the gondwanasuchian mesoeucrocodylians dispersed from Africa to South America by peripheral isolation. In this result, with a probability of 34.63% in JC and 27.39% in F81 that the ancestral area for all gondwanasuchians is the Iullemmeden Basin in North Africa. The Gamma model (JC+G; F81+G) found a dispersion from South American to African territories by peripheral isolation, with the ancestral area for all gondwanasuchian mesoeucrocodylians located in Neuquén Basin in Argentina with a high probability, JC 63.48% and F81 66.70%. Both results support a congruency between the continental rift in the Aptian–Albian interval and the cladogenesis of the families Araripesuchidae, Peirosauridae, and Trematochampsidae. In addition, the results demonstrate little contribution of vicariance in less inclusive clades. The majority of dispersal events concentrated especially inside the Bauru Group area, where the substantial amount of speciation in a short time probably points out to sympatric speciation.

Grant Information
CNPq (National Counsel of Technological and Scientific Development) PhD research scholarship (141177 / 2011 - 0).

Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

BONE HISTOLOGY REVEALS A DECREASE IN GROWTH RATE OF FLORIDA *ODOCOILEUS VIRGINIANUS* (MAMMALIA, CERVIDAE) OVER THE PAST 2 MILLION YEARS

GERWITZ, Andrew, Kent State University, Kent, OH, United States of America; GREEN, Jeremy L., Kent State University at Tuscarawas, Kent, OH, United States of America

Histological analyses of mammalian bones can offer insight into organismal responses to changing ecological conditions. Abundant Pleistocene to Holocene fossils of *Odocoileus virginianus* (Mammalia: Cervidae) from Florida offer a unique opportunity to study changes in growth within a mammal species in response to climate and environmental changes over the past 2 million years. To accomplish this, diaphyseal thin sections were created from 54 limb bones (humeri, radii, femora, tibiae) from four fossil sites in Florida. Each bone was classified into one of three ontogenetic stages (juvenile, sub-adult, adult) based on degree of epiphyseal fusion. Each fossil site was designated as either glacial or interglacial based on associated environmental and faunal data; glacial sites: Inglis 1A (ING) ~1.8 Ma, Coleman 2A (COL) ~0.5 Ma; and interglacial sites: Leisey Shell Pit 1A (LSP) ~1.5 Ma, Nichol's Hammock (NH) ~500 years. Primary cortical tissue and degree of vascularity were observed in each thin section, as were the presence of Lines of Arrested Growth (LAGs) and annuli. Changes in annual growth rate through ontogeny was calculated by measuring the distance between succeeding LAGs in the anterior region of femora and dividing the thickness by 260 days (estimated mean length of the growing season for cervids). Retrocalculation was used to compensate for the possible resorption of the first LAG in older individuals. Little to no differences in cortical histology or annual growth rates were observed among Pleistocene populations, regardless of glacial or interglacial designation. However, Pleistocene femora have higher early ontogenetic (first two years) mean growth rates (Year 1 - ING: 9.43 µm/day, LSP: 9.98 µm/day; Year 2 - ING: 8.00 µm/day) compared to the Holocene population (Year 1 - NH: 6.62 µm/day; Year 2 - NH: 3.95 µm/day). Slower juvenile growth rates in the Holocene population are in agreement with reduced vascularity in primary fibrolamellar bone and a greater abundance of parallel-fibered tissue observed in the outer cortex of NH bones when compared to those from Pleistocene populations. These findings suggest that juvenile growth rates in *O. virginianus* decreased through time, which may be a result of changes in quality and quantity of resources, although other geographical and paleoecological differences may also be influencing growth (interspecific competition, sexual dimorphism). A detailed analysis of bone growth from living *O. virginianus* across Florida may help elucidate the cause of intraspecific variation in growth among fossil populations.

Preparator's Session (Thursday, October 27, 2016, 12:00 PM)

PALEONTOLOGICAL EXHIBITS AT THE NATURAL HISTORY MUSEUM OF UTAH: AN OUTSTANDING EXAMPLE OF COLLABORATION WITH MUSEUM STAFF, VOLUNTEERS, GRADUATE STUDENTS, AND EXTERNAL INSTITUTIONS

GETTY, Mike A., Denver Museum of Nature and Science, Denver, CO, United States of America; LOEWEN, Mark A., University of Utah, Salt Lake City, UT, United States of America

The Utah Museum of Natural History (NHMU) features a large number of uniquepaleontological exhibits which were primarily developed in house as the resultof an outstanding collaboration amongst museum staff, volunteers, graduatestudents, and external contractors. This collaboration began severalyears in advance of the museum's public opening in 2011, during the earliestplanning stages. Specimens were selected by the paleontology staff tosupport story lines which were developed by museum paleontologists, graduatestudents and exhibit designers. Original specimens were prepared by staffand volunteers of several governmental and educational organizations. Molds andcasts were produced by several external contractors who worked closely withNHMU paleontologists to reproduce and recreate skeletons. These skeletonswere used by exhibit designers and curators to weave a story about the PastWorlds of Utah, illustrated through original material and supplemented withcast mounts derived from NHMU paleontology collections. NHMU volunteerpreparators were critical in providing exhibit ready material for mounting andmolding and casting. Original elements were carefully mounted by in-houseexhibition staff, external contractors, and rigging specialists with someassistance from NHMU paleontology volunteers. University of Utahpaleontology graduate students provided critical input in scientific content inthe exhibits which often highlighted their research specimens. Theexhibit features many specimens which were collected, prepared and described inthe decade leading up to the opening of the museum. These include manyspecimens from the Early and Late Cretaceous deposits of Utah including theCedar Mountain, Wahweap, Kaiparowits and North Horn formations, as well asJurassic specimens from the Navajo and Morrison formations. The mostoutstanding specimens from the exhibit that illustrate this collaborationinclude *Seitaad*, *Nothronychous*, *Falcarious*, *Gryopsaurus*, *Utahceratops*, several tyrannosaur specimens, and the wall of ceratopsians.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

THREE-DIMENSIONAL FISH FOSSILS FROM A TRIASSIC TEXAS POND: NOVEL ANATOMICAL INSIGHTS AND SYSTEMATIC PLACEMENT OF A NEW SPECIES OF REDFIELDIID FISH (OSTEICHTHYES, ACTINOPTERYGII)

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Fishes of the order Redfieldiiformes (~16 genera, 26 spp.) were a group of lower ray-finned fishes found globally in Triassic and Jurassic deposits. Most specimens are either laterally or dorsoventrally flattened when preserved and are rarely found uncrushed and in three dimensions. A recent reexamination of museum collections has produced several new partial specimens from a site in the Upper Triassic Dockum Formation in Howard County, Texas. These redfieldiiform specimens are exceptionally preserved in three dimensions, providing new insights into the anatomy of the skull. These specimens represent a new species diagnosable by a combination of unique traits found in the skull, including shape of maxilla, shape of preoperculum and associated cheek bones, pattern

and articulation of bones in the snout, and patterns of sensory line canals in the dermal skull bones. Specimens of this new species display novel patterns in the sensory line canals of the skull that have never been observed in any other redfieldiiform. This new species is placed within a phylogenetic hypothesis of evolutionary relationships of redfieldiiform fishes.

Grant Information
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Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

INCREMENTAL GROWTH LINES IN TEETH OF THE NORTH AMERICAN GLYPTODONT *GLYPTOTHERIUM TEXANUM* (XENARTHRA, CINGULATA)

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The dentition of the late Pliocene–early Pleistocene North American glyptodont *Glyptotherium texanum* consists of 32 submolariform and molariform teeth, eight in each jaw. Anterior teeth are incompletely trilobate, grading rearward to fully trilobate in the four posterior teeth. There are no incisiform or caniniform teeth, and the snout is edentulous. Recently collected cranial and dental material from central Mexico and southeastern Arizona includes dentition from babies, juveniles, and adults. All teeth were ever-growing (hypselodont). Growth kept pace with occlusal wear through rhythmic accretion in the pulp cavity. Teeth lack enamel, but contain a central osteodentine pillar with secondary branching into each lobe, surrounded by softer orthodentine and a rim of hard orthodentine. Cementum surrounded the orthodentine rim between the tooth and the bony alveolus in life, but is usually poorly preserved. Incremental growth lines (perikymata) in the orthodentine are expressed externally as faintly developed ridge-and-valley rings on the outer surface of the orthodentine rim, and in cementum with a coarser and less regular texture. Adult teeth display orthodentine growth lines with regular spacing of roughly 0.25 mm; thus, a single tooth 10 cm in length has approximately 400 incremental growth lines on the outer surface of the orthodentine rim. Spacing of incremental lines in juvenile teeth is greater, up to 1 mm, indicating faster growth. The oldest incremental couplets are at the occlusal surface, and the youngest are in the position of the pulp cavity within the alveolus. Spacing of the ridge-and-valley couplets on individual teeth ranges from monotonous and regular to variable and irregular. Incremental lines in inner cementum (contact with the external orthodentine rim) are similar in anatomy and spacing, whereas couplets on the outer surface of cementum (contact with the surface of the bony alveolus) are coarser and more pronounced. We postulate that the ridge-and-valley couplets of the external orthodentine represent diurnal rhythms, indicating a range of approximately 100–400 days of growth for a complete tooth. Spacing of the incremental lines in cementum is much coarser; each couplet represents multiple orthodentine couplets, perhaps marking a circaseptan rhythm. Differences related to regularity of incremental lines in orthodentine may be due to environmental or physiological controls, or both, that presently remain unresolved.

Grant Information
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Technical Session III (Wednesday, October 26, 2016, 2:00 PM)

CHANGES IN BRAIN SHAPE ACROSS THE THEROPOD-BIRD TRANSITION

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Although much of the early history of the avian flight apparatus (e.g. furcula, feathers, etc.) is now well understood, the role that neuroanatomy plays in this story is still under investigation. Recent studies of brain volume along the theropod lineage show that the hyper-inflated brains found within crown group birds evolved well before the diversification of the modern radiation and preceding the advent of powered flight. Therefore, the initial encephalization event either was an exaptation or independent of flight. Previous research also indicated that volumetric reorganization within the brain indicate more complex evolutionary patterns. In living birds, for example, the relative volumes of different neuroanatomical regions indicate differing patterns of change across the major clades. What still remains to be explored is how changes in shape interact with changes in overall brain volume. Here we analyze the fit of various multivariate evolutionary models to brain shape as determined by geometric morphometric (GM) data in order to test the hypothesis that brain shape conforms to the major divisions of avian diversity. Preliminary results indicate that the most likely evolutionary pattern (characterized by a multivariate Ornstein-Uhlenbeck model) of brain shape does not match the divisions of major avian clades. This result indicates that brain shape does not have a strong phylogenetic structure. Interestingly, our results also demonstrate that the shape of the brain has a divergent pattern from volume at the base of the crown group. Unlike the retention of the derived non-avian theropod condition that is observed within the volumetric data, GM data indicate that a major morphological shift occurs at the base of the modern radiation of birds. The disjoint between these two datasets implies that, although the volume of the brain is evolutionarily stable at this point, important structural changes may be taking place within the theropod brain.

Grant Information
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Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

NEWLY DISCOVERED PEDES OF TITANOSAURIAN SAUROPOD DINOSAURS FROM ARGENTINA YIELD NOVEL DATA FOR PHYLOGENETIC ANALYSIS

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Studies of titanosaurian sauropod dinosaurs have historically been hampered by missing morphological data. In particular, the pedal osteology of titanosaurs has been poorly documented, though this situation is beginning to change with recent discoveries. At present, there are more than 60 valid taxa of titanosaurs, with five of these being known from complete, articulated pedes: *Opisthocoelicaudia* from Mongolia and *Epachthosaurus*, *Notocolossus*, and two unnamed species (from the Agua del Padrillo and La Invernada sites, respectively) from Argentina. Pedal elements are known for many other titanosaurs, but none of these preserve the hind foot in its entirety.

Previous studies have recognized two titanosaurian pedal morphotypes, here termed 'long-footed' and 'short-footed.' In long-footed titanosaurs, the pes is strongly entaxonic, with the first four metatarsals exhibiting a significant increase in length and a concomitant decrease in robusticity from medial to lateral. This general pattern is present in medium-sized titanosaurs such as *Epachthosaurus*, *Opisthocoelicaudia*, and the Invernada and Padrillo forms, as well as in some larger taxa with slightly less complete pedes (e.g., ?*Alamosaurus*, *Mendozasaurus*). For example, in the Invernada titanosaur, the ratios of the minimum circumferences of metatarsals II–V to that of metatarsal I (here termed the 'robusticity index' or RI) varies from 0.82 to 0.64. The Padrillo taxon departs slightly from this pattern in having an unusually robust metatarsal V (RI = 0.91). Conversely, short-footed forms possess metatarsals that are all roughly the same length and robusticity, resulting in a hind foot that is comparatively shorter and more mediolaterally symmetrical than those of other titanosaurs. This morphology is currently observed only in the gigantic titanosaur *Notocolossus*, in which metatarsals II–V all have an RI of greater than 0.70.

The phalangeal formulae of titanosaurs may also hold evolutionary significance, in that among sauropods, phalangeal reduction reached its extreme in this group. The phalangeal formula of *Epachthosaurus* is 2-2-3-2-0, but in more derived taxa such as *Notocolossus*, the Padrillo and Invernada titanosaurs, and (probably) *Mendozasaurus*, this formula is reduced to 2-2-2-2-0 via the loss of a phalanx on digit III.

In sum, recently discovered, complete titanosaurian pedes from Argentina exhibit substantial morphological variation, providing new sources of potentially informative characters relevant to the continued elucidation of titanosaur phylogeny.

Grant Information
Facultad de Ciencias Exactas y Naturales, UNCUYO, CONICET PIP, ANPCYT-PICT-2011-2591 (Argentina) / Carnegie Museum of Natural History (United States of America)

Technical Session VII (Thursday, October 27, 2016, 2:15 PM)

MAPPING AND VISUALIZING THE COMPLEX INTERNAL ANATOMY OF PACHYCEPHALOSAUR DOMES

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The frontoparietal dome in pachycephalosaurids expands dramatically during ontogeny from a flat-headed to a domed state. This expansion results in the formation of zonal bone tissue characterized largely by differences in relative vascularity or void space, mean vessel diameter, and a micron to sub-micron network of vessels with intimately associated fibers. Previous studies demonstrated that (1) void space identified in CT scans is a suitable proxy for relative vascularity and (2) a decrease in relative vascularity correlates with the development of the dome in *Stegoceras* during ontogeny. We use a novel script written in MATLAB adapted from an algorithm for human cortical bone imaging to quantify this observed decrease in relative vascularity, identify where it occurs in the dome, and measure how it compares across three different zones of density in the expanding dome, using digital reconstructions of the internal vascularity from high resolution CT and synchrotron micro-CT scans. Morphological landmarks enable a precise slice-by-slice comparison between skulls.

Dome growth proceeds anteroposteriorly in *Stegoceras*: the frontals inflate first, followed by the parietal. Image thresholding showed that void space decreased from 20% in AMNH 5450, a "flat-headed" juvenile *Stegoceras validum,* to 7.3% in ROM 53555, a more mature ontogimorph, as dome thickness and size increased in an ontogenetic series (n=3). We confirm the presence of three histological zones within the thickened and inflated dome. In some pachycephalosaurs, the percent vascularity plotted against the CT slice number(s) shows a clear distinction among these zones. Conversely, other specimens show more poorly defined zonal boundaries and a more consistent percent vascularity overall. This pattern most likely reflects differences in ontogenetic development. Alternatively, this arrangement suggests divergent growth strategies among taxa. LAGS appear to preserve the silhouette of pre-and post-expansion of the frontoparietal into a dome. Zones of denser bone can be traced readily through the interior of the dome to the sulci-covered dorsal surface of some juveniles.

The new method provides a complete assessment of vascularity throughout the dome. Landmark standardization allows multiple ontogimorphs and species to be visualized and compared simultaneously. Preliminary visualization of vascular network architecture in three dimensions shows even more promise for modeling growth dynamics in pachycephalosaurid domes, as well as other fossil vertebrate bones.

Grant Information
National Science Foundation EAR-1053370, Digital Cranial Atlas of Pachycephalosaurid Dinosaurs, M.B. Goodwin, PI.

Technical Session XV (Saturday, October 29, 2016, 11:00 AM)

CHARACTERIZING AFRICAN CRETACEOUS CONTINENTAL FAUNAS: PALEOBIOGEOGRAPHICAL PATTERNS AND NEW INSIGHTS FROM SUB-SAHARAN AFRICAN TITANOSAURIAN SAUROPOD DINOSAURS

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Continental Africa has been proposed to play a significant role in the evolution and distributional patterns of terrestrial faunas during the tectonically active Cretaceous Period. Yet, the African continental fossil record pales in comparison to other Gondwanan landmasses (e.g. South America) for characterizing faunal patterns and providing ample evidence to inform paleobiogeographical scenarios. Reflecting this uneven fossil record, titanosaurian sauropod dinosaurs—one of the most successful Cretaceous continental vertebrate groups—are underrepresented in the African fossil record with a handful of named and fragmentary forms known mostly from the middle Cretaceous (Aptian–Cenomanian). New research in sub-Saharan Africa is providing critical information regarding titanosaurian diversification within the middle and Late Cretaceous and for characterizing African faunas more generally. The re-evaluation of specimens from the Aptian Dinosaur Beds of Malawi reveals that material historically associated with *Malawisaurus dixeyi* represents at least two distinct morphs with affinities to coeval South American forms. Further, several new specimens from the geographically proximate middle Cretaceous Galula Formation of Tanzania are distinct from the Malawi forms, suggesting a much higher titanosaurian diversity for sub-Saharan Africa than previously appreciated. For example, a specimen from the lower Mtuka Member of the Galula Formation represents one of the most complete skeletons known from early in titanosaurian evolutionary history, whereas another specimen from the younger Namba Member has affinities with Late Cetaceous aeolosaurian titanosaurians known from South America. Finally, titanosaurian materials from the Maastrichtian Lapurr Sandstones of Kenya provide valuable insight for characterizing the largely unknown terminal Cretaceous African fauna. A new individual has close affinities with Late Cretaceous South American saltasaurian titanosaurians, and additional caudal vertebral specimens indicate the presence of several distinct and gigantic forms that may include a non-titanosaurian sauropod—a first for this time interval globally. The pattern of African titanosaurian evolutionary history broadly paralleled that in South America but with the development of a progressively isolated sub-Saharan region concurrent with the tectonics-driven separation of the two landmasses until the Late Cretaceous when the fauna included remanent early-branching lineages not present elsewhere worldwide.

Symposium II (Friday, October 28, 2016, 8:00 AM)

DEVELOPMENTAL CONSTRAINTS ON THE EVOLUTION OF THE MARSUPIAL CRANIUM

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Developmental constraints can significantly influence morphological change on macroevolutionary scales. Marsupials are born at an extremely altricial state, requiring an extended period of continuous suckling, during which most of their development occurs. Here, we use morphometric approaches to quantify cranial variation through ontogeny and across living and extinct marsupials and placentals to assess whether the marsupial reproductive strategy has constrained the evolution of their cranium. Using Principal Coordinates analysis and Phenotypic Trajectory analysis of 31 shape variables to quantify prenatal and early postnatal cranial ontogeny in 10 species of therian mammals, we demonstrate that ontogenetic trajectories of the early ossifying oral bones (premaxilla, maxilla, and dentary) show limited variation in marsupials, relative to placentals, but not those of the skull more generally. The few significant differences in full cranial ontogenetic trajectories were restricted to trajectory size of one placental (*Llama*) and one marsupial (*Macropus*). In contrast, there were 20 significant differences ($p < 0.01$) in trajectory size and shape of the oral apparatus, and all but one of these involved placentals. These results are consistent with the distribution of placentals and marsupials in Principal Coordinates analyses of oral-only and of whole skull variables and demonstrate that placentals are far more variable than marsupials in ontogenetic trajectories of oral bones, but not of the whole skull.

3D morphometric analyses of 32 landmarks from 125 diverse species of living and fossil marsupials and placentals demonstrate that marsupials are less disparate in adult cranial form than are placentals. However, this difference in disparity, as measured by delta variance ($\Delta\sigma 2$), is driven entirely by the early-ossifying bones of the oral apparatus ($\Delta\sigma^2 = .04$, $p < 0.01$), whereas the neurocranium is not significantly different in disparity between marsupials and placentals ($\Delta\sigma 2 = 0.008$, $p = 0.33$). Combined, these results suggest that the functional constraints of continuous and prolonged suckling have limited the ontogenetic and adult disparity of the marsupial oral apparatus, but not the skull more generally, throughout their evolutionary history. Surprisingly, analyses of 994 cranial semi-landmarks for 60 living and fossil marsupials and placentals suggest that these constraints do not extend to evolutionary rates, which are similar for the oral region of marsupials and placentals and are actually higher in marsupials for the neurocranium.

Grant Information
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Technical Session XI (Friday, October 28, 2016, 10:45 AM)

NEW RECORDS EXPAND THE DIVERSITY OF EOCENE FISHES FROM CANADA'S WESTERN ARCTIC GREENHOUSE

GOTTFRIED, Michael D., Michigan State Univ, East Lansing, MI, United States of America; EBERLE, Jaelyn J., University of Colorado Boulder, Boulder, CO, United States of America

Field research in the Canadian Arctic spanning several decades has led to the discovery of a diverse range of Eocene vertebrate taxa including sharks and bony fishes, turtles, crocodylians, birds, and mammals. These have provided strong evidence for relatively warm and ice-free conditions in the Arctic during the Eocene Greenhouse interval. Many of the fossils have come from Ellesmere and Axel Heiberg islands in Canada's eastern Arctic (Nunavut), which sample a primarily non-marine and terrestrial environment. Recent expeditions to Canada's westernmost Arctic island, Banks Island (NWT), have expanded the geographic scope of these investigations and recovered a more marine-influenced fauna, including relatively abundant sand-tiger sharks, smaller numbers of bony fishes (gars and teleosts), small turtle shell fragments, and a single crocodylian specimen, from Eocene strata (52–53 Ma) of the Cyclic Member of the Eureka Sound Formation. We report here on new additions to the Banks Island Eocene fish fauna that further expand our knowledge of Arctic Eocene diversity. These include diagnostic large scales of amiid fishes that conclusively confirm the presence of the group in the western Arctic. One well-preserved amiid [cf. *Amia* sp.] lateral line scale [Canadian Museum of Nature CMN 57523] measures 3.6 cm in length, corresponding to a fish that would have been well over one meter in total length and likely larger than the maximum size reached by extant *Amia calva*. We also recovered a sample of several dozen elongate, shallowly recurved, and conical to slightly laterally compressed teeth that range in size from a few mm to over 2 cm tall. Well-preserved specimens are lightly vertically striated and bear a small expanded translucent cap that has the appearance of a flattened arrowhead set onto the tip of the tooth. These closely match teeth from a range of lower latitude Old World Paleogene sites [including India, North Africa, and Europe] that have been assigned to the scombroid teleost genus *Eutrichurides*, interpreted as an ambush predator in shallow marine environments, which is consistent with the inferred paleoenvironment of the Cyclic Member. The presence of *Eutrichiurides* in the Arctic adds a distinctive new element to the Eocene Greenhouse fauna and raises potentially intriguing questions on the biogeography and dispersal capabilities of this taxon.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

CARNIVORE DAMAGE ON SEAL FOSSILS FROM LANGEBAANWEG, WEST COAST OF SOUTH AFRICA

GOVENDER, Romala, Iziko Museums of South Africa, Cape Town, South Africa; AVERY, Graham, Iziko Museums of South Africa, Cape Town, South Africa

Langebaanweg (West Coast Fossil Park) is about 120 km north of Cape Town. It includes Mio-Pliocene riverine and overbank facies that have produced numerous fossil remains of terrestrial and marine vertebrates and plants. In places, terrestrial and marine fossils occur in juxtaposition. More than 3000 phocid seal fossils have been collected and are housed in Iziko South African Museum. Previous taphonomic studies identified pathological changes to the seal bones while other damage was not studied in detail at the time. A recent re-evaluation of the damage on the bones has identified both terrestrial and marine carnivore damage to cranial and postcranial elements. Terrestrial carnivores are likely to include bears, hyaenas, wolverines, canids, felids, mustelids and viverrids, while marine carnivores are represented by sharks.

Here we describe preliminary results from the study of 571 fossil phocid seal humeri. Fractures represent 20% of the damage (115 bones), while terrestrial carnivore activity, including bites, gnawing, punctures and notches, represents 39% (224 bones) of the damage identified. Puncture marks indicating feeding as well as possibly moving of bones represent 48% of the tooth marks described. This evidence lends support to the proposition that the seals' carcasses were beached along the early Pliocene lagoon/estuary making them accessible to terrestrial scavengers. Only two bones (0.4%) showed signs of shark damage. Weathering (40%) has caused the most surface damage to the bones suggesting that the bones were exposed for a time prior to burial. Root traces were also present on many of the bones (36%).

Grant Information
The study is funded by NRF/AOP through Romala Govender's current project: Mio-Pliocene marine mammal palaeoecology and palaeoenvironment reconstruction.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

ASSESSING THE ECOLOGICAL AND EVOLUTIONARY DRIVERS OF ENDOTHERMY

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The selective pressures underlying the evolution and radiation of endotherms are poorly understood. During the Mesozoic, a diversity of thermoregulatory styles coexisted, with important implications for the distribution and competitive interactions of terrestrial vertebrates. Today, endotherms and ectotherms generally occupy distinct size-based niches on land, limiting our ability to infer the competitive implications of thermoregulation. In the ocean, however, similarly-sized endothermic, ectothermic, and mesothermic taxa co-occur and compete for similar resources. Here, I take a comparative biogeographic and metabolic approach to understanding the ecological significance of thermoregulatory strategies and energetics over space and time. I examine the distributions and foraging strategies of over 400 species of marine endotherms, ectotherms, and mesotherms, including cetaceans, pinnipeds, penguins, sharks, tuna, and other large teleosts. I also compile metabolic, locomotory, and visual processing rates as a function of ambient temperature and consider the foraging consequences of the observed metabolic asymmetry between endothermic predators and ectothermic prey. Further, abundance and ecosystem consumption rates of marine mammals are assessed globally and compared to predictions derived from metabolic foraging theory. All analyses are corrected for sea surface temperature, productivity, ocean depth, distance from land, and other environmental predictors. Finally, I derive general competitive principles for co-occurring animals that differ in their metabolic rates. I use theory and empirical observation of extant taxa to draw inferences into the physiology, ecology, and evolution of non-avian dinosaurs, pterosaurs, and other vertebrates of the Mesozoic.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

UNGULATE CRANIAL SHAPE AND THE TRANSITION FROM BROWSING COMMUNITIES TO GRAZING

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The late Paleogene and early Neogene were a time of extensive climate and environmental change in the great plains of North America. Early in this time interval, landscapes were primarily woodland environments and the ungulate fauna was dominated by browsers. By the Miocene, this had shifted as grasslands expanded, and the ungulate community was dominated by grazers. This difference in diet has been linked to some localized cranial shape differences, such as the shape of the snout, or changes to accommodate hypsodont dentition. This study used landmark based geometric morphometrics to analyze and compare the entire crania shape of ungulates from western Nebraska and surrounding areas in Wyoming and South Dakota from the Chadronian North American Land Mammal Age (NALMA) through the Clarendonian NALMA. Specimens were broken up into three groups based on stratigraphy: (1) specimens from the White River Group, spanning the Chadronian through the Whitneyan NALMAs and dominated by browsers; (2) specimens from the Arikaree Group, spanning the Arikareean NALMA; and (3) specimens from the Ogallala Group, spanning the Hemingfordian through Clarendonian NALMAs and dominated by grazers. Patterns in the Principal Component Analysis were dominated by the positions of camels, primarily from the Ogallala Group, to the extent that the rest of the specimens were relegated to an indiscernible clump. When camels were removed from the analysis, the first PC axis separated the specimens primarily based on taxa, with Equidae and Rhinocerotidae on either end, even though both of these groups contain both browsers and grazers. In morphospace, specimens from the White River and Arikareean Groups are not significantly different from each other, whereas the Ogallala Group is significantly different from both of them. When camels are removed from this analysis, the difference between the White River and Arikareean Groups becomes significant. The White River Group shows the least amount of morphologic disparity, while the Ogallala Group shows the most, but again, the differences between the White River Group and the Arikareean Group are not significant. When camels are removed from the calculation, all three disparities become virtually identical and are not significantly different. These results show that while there are differences between the three groups, they are likely driven more by taxonomic turnover rather than dietary shifts, and differences in overall cranial morphology patterns, especially disparity, are primarily an artifact of the bizarre cranial morphology of camels.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

HISTOLOGICAL DESCRIPTION OF AN INFECTIOUS PATHOLOGY IN THE VERTEBRAE OF *TYLOSAURUS* SP. (MOSASAURIDAE)

GREEN, Cyrus C., Fort Hays State University, Hays, KS, United States of America; WILSON, Laura E., Fort Hays State University, Hays, KS, United States of America

Though pathologies have been previously reported in the caudal vertebrae of mosasaurids, they are usually described from a morphological standpoint with little description of the bone microstructure. As a result, how different pathologies affect bone tissue is poorly understood. Here we compare the microstructure of three caudal pathological vertebrae of a *Tylosaurus* specimen (FHSM VP-17984) to a non-pathological caudal vertebra from the same specimen to better understand the changes in pathological bone microstructure.

The non-pathologic vertebra consists of trabecular bone in the centrum with thin vertebral walls consisting of compact bone, as is typical of juvenile hydropelvic mosasaurids. The bone matrix of the non-pathological vertebra is predominately parallel-fibered bone tissue in the cancellous centrum. In the pathological vertebrae, one vertebra was more affected by the pathology than the others. A large void space that once housed an abscess is present, as is an exostosis with a canal for pus drainage. The typical trabecular bone of the centrum is not observed. Instead, the abscess void is surrounded by cancellous bone with a parallel-fibered matrix and osteons that are still developing. The vertebra immediately posterior to the pathology displays a similar microstructure as the non-pathologic vertebra, except dorsally where the pathology formed a small exostosis of woven bone. These changes in bone microstructure reported here demonstrate how cells react to an infection. The many osteons inside the pathology indicate bone heavily supplied with blood and nutrients, both of which are needed to quickly build bone. An exostosis and pus drainage canal is how the body reacts to infection. Additionally, previous studies show that woven bone is first lain down in fractures to add strength to a weakened area, so the layer of woven bone on the vertebra directly posterior to the infection may be the reaction to a weakening in the affected vertebra. The information presented here not only gives new insight into pathological growth, but also into how bone reacts to infection. Future work should focus on modern analogues to see if vertebral infections are managed in the same way.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

VARIATION IN THE BROWSING DIET OF PLEISTOCENE *MAMMUT AMERICANUM* (MAMMALIA, PROBOSCIDEA) AS RECORDED BY DENTAL MICROWEAR TEXTURE ANALYSIS

GREEN, Jeremy L., Kent State University at Tuscarawas, New Philadelphia, OH, United States of America; DESANTIS, Larisa G., Vanderbilt University, Nashville, TN, United States of America; SMITH, Gregory J., Vanderbilt University, Nashville, TN, United States of America

Mammut americanum (Mammalia: Proboscidea) is noted for its wide distribution across North America through the Plio-Pleistocene and has been identified as a browser. However, regional populations of *M. americanum* were still exposed to different floral associations across the spatio-temporal distribution of the species. In the late Pleistocene, Florida mastodons were associated with cypress vegetation, whereas higher latitude populations tend to inhabit spruce-dominated forests. Dental microwear is influenced by the texture of ingested particles over a short temporal scale and is a useful tool to discern shifts in diet. We applied dental microwear texture analysis (DMTA) to the central enamel band on the metaloph/-id of 51 second and third molars (in wear stage 2–3) from six *M. americanum* populations across North America. Each population was classified into one of three habitat categories based on floral data: 1) Spruce-dominated boreal forest: Boney Spring, MO (n = 11); Hiscock Site, NY (n = 7); Indiana (n = 10); 2) Open-pine parkland: Jones Spring, MO (n = 8); Trolinger Spring, MO (n = 5); and 3) Cypress swamp: Aucilla River, FL (n = 10). Specifically, we tested the hypothesis that DMTA variables are significantly different among these populations. Kruskal Wallis tests revealed that complexity, textural fill volume, and heterogeneity were not significantly different among sampled loci. As anisotropy was normally distributed (Shapiro Wilk test: $p = 0.16$) with equal variance (Levene's test: $p = 0.69$), a one-way ANOVA showed significant differences for this variable ($p = 0.01$). Indiana ($p = 0.02$) and Aucilla ($p = 0.01$) mastodons had higher anisotropy than Jones Spring with Tukey HSD post-hoc tests. Likewise, LSD post-hoc tests found that both Indiana and Aucilla populations had higher anisotropy than Jones Spring (Indiana: $p < 0.01$; Aucilla: $p < 0.01$) and Trolinger Spring (Indiana: $p = 0.03$; Aucilla: $p = 0.02$). Anisotropy in the Aucilla population was also significantly higher than Boney Spring with LSD ($p = 0.04$). Our data reveal a pattern of significantly higher anisotropy in some mastodons from cypress and boreal habitats relative to those in open-pine parklands, suggesting individuals in the former regions were processing tougher food items with more constrained jaw motion. This difference highlights the power of microwear texture to detect subtle differences in browsing and expands our knowledge of the ability of *M. americanum* to adapt to different habitats.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

AN EXCEPTIONALLY PRESERVED AMPHIBIAN FROM THE PERMIAN SAAR-NAHE BASIN OF SOUTHWESTERN GERMANY: SOFT TISSUE PRESERVATION AND SKELETAL 3D IMAGING

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Sclerocephalus is a temnospondyl amphibian from the Carboniferous and Permian of Central Europe. The genus is known from numerous fossils collectively representing a virtually complete growth series, ranging from larval to senescent individuals. In addition, several specimens retain carbonized remains of soft tissues, including 'eye spots' and body outlines preserved as dark-colored halos surrounding the bones. Despite this, *Sclerocephalus* has hitherto received surprisingly little attention, not least from a preservational point of view.

Here, we describe a recently discovered larva from the Lower Permian of the Saar-Nahe Basin of southwestern Germany, tentatively referred to *Sclerocephalus*. The fossil is represented by the anterior half of a largely articulated skeleton and soft tissues in the form of dark-colored traces exposed on the bedding surface. Overall, the specimen is flattened, yet some bones are preserved in three dimensions, notably the braincase and jaws. Because the amphibian is embedded in a sedimentary concretion, computed tomography (CT) was employed to produce a virtual model of the fossil remains. Additionally, the micro- and ultrastructure of the presumed soft tissues were examined using scanning and transmission electron microscopy. These analyses revealed the presence of dense mats of sub-spherical to ovoid microbodies, measuring about 0.5 to 0.7 µm in length. Microstructures with similar dimensions and morphologies have previously been reported from orbital pigmentations and integumentary traces representing a wide range of fossil vertebrates, and have variously been interpreted as remnant melanosomes or microbes.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

THE EVOLUTION OF THE NEUROCRANIUM AND ITS EFFECTS ON BALANCE OF THE HEAD IN HOMINOIDS

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Efficient maintenance of head stability is vital to all mammals as the head houses vestibular and visual organs. Cervical vertebrae and their associated musculature are critical for head balance, particularly during locomotion, so vertebral morphology has been used to infer postural patterns in the primate fossil record. But, these skeletal elements are adapted to functions beyond those directly related to postural regime. Within the hominin lineage, the size and shape of the face and neurocranium, which are supported by cervical vertebrae and musculature, have undergone major morphological changes. Notably, the brain experienced not only an increase in overall size but also an expansion of the frontal, parietal, and cerebellar regions. These changes likely affected the way neurocranial mass is distributed around its center, thus affecting the manner in which head balance is maintained. We hypothesized that cervical vertebral morphology is adapted to maintain efficient balance of the head such that the shape of cervical vertebrae will change as neurocranial shape changes. Specifically, we predicted that a more anterior center of mass (COM) would result in longer, more inferiorly angled spinous processes in order to increase the moment arms of the nuchal musculature. Similarly, we predicted that a wider neurocranium would be associated with longer transverse processes in order to increase the mechanical advantage of lateral flexors of the neck.

To test this, we collected cervical morphological data from skeletal collections, calculated neurocranial COM and quantified brain shape by analyzing the location of COM relative to major cranial landmarks across nine extant and fossil hominoid taxa. The extent to which neurocranial morphology can predict cervical morphology was assessed using phylogenetic generalized least squares regressions. We found that more anterior COM is associated with longer spinous processes and a wider neurocranium is associated with longer transverse processes. These results suggest that shifts in neurocranial morphology observed in the fossil record are accompanied by concomitant changes in cervical morphology, emphasizing that both neurocranial shape and postural pattern should be considered when making adaptive inferences about vertebral morphology in fossil taxa.

Technical Session XV (Saturday, October 29, 2016, 12:00 PM)

ANOMOLOUSLY HIGH VARIATION IN ONTOGENY IS THE ANCESTRAL DINOSAURIAN GROWTH CONDITION

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Understanding growth patterns of extinct clades has been a persistent problem in vertebrate paleontology, especially for studies of dinosaurs and other archosaurs, which possess the widest range of body sizes of any group of terrestrial vertebrates. Understanding the ancestral dinosaurian growth condition is vital to interpreting the early evolution of this clade, because determining the ontogenetic stage of the rare specimens representing these early taxa is necessary for clarifying diversity and evolutionary trends; however, few non-destructive methods exist for determining skeletal maturity, and growth series of early dinosaurs are rare.

To tackle this issue, we analyzed 29 ontogenetically variable characters in the early theropod dinosaurs *Coelophysis bauri* and *Megapnosaurus rhodesiensis*. These taxa are temporally and phylogenetically close to the origin of dinosaurs and are known from the largest early dinosaurian growth series available from single populations. We used ontogenetic sequence analysis (OSA) to reconstruct growth pathways and quantify intraspecific variation, then used non-metric multidimensional scaling (NMDS) to test if these characters vary continuously. These data suggest a high level of intraspecific variation, with >50 developmental sequences found for these taxa. NMDS analysis returned a single cluster of individuals with no evidence of bimodality, suggestive that these characters are not sexually dimorphic. These results indicate that size is a poor predictor of skeletal maturity with the exception of the size extremes. In similar analyses of living birds (*Branta canadensis* and *Meleagris gallopavo*), <10 equally parsimonious developmental sequences were reconstructed, and NMDS analysis found that individuals of these taxa fall along a single path from the least to most mature individual, with size correlated with skeletal maturity.

Variation in growth patterns is widespread among early dinosaurs and other dinosauriforms, suggesting that this high level of variation is the ancestral dinosaurian condition. Given that variation in ontogenetic pathways is present in living crocodilians (but not nearly as high as early dinosaurs), but absent in more derived theropods (e.g., Tetanurae), this intraspecific variation was lost during the evolution to living birds. Based on these results, high variation can be assumed to be present in most early dinosaurs and may not indicate taxonomic diversity or sexual difference, though small sample sizes may obscure this variation.

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Technical Session XIX (Saturday, October 29, 2016, 2:15 PM)

INCREASED TRANSVERSE JAW MOVEMENT DURING MASTICATION WAS A CRITICAL EVOLUTIONARY CHANGE IN EARLY MAMMALS

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Cladotheria (i.e., tribosphenidans and “eupantotherians”) is an extremely diverse mammalian clade, comprising almost all living mammals and numerous extinct lineages. However, the clade was just one of many mammalian groups to diversify in the Jurassic, and it remains unclear as to why cladotherians survived and diversified while many non-cladotherian mammal groups went extinct. It has been suggested that early cladotherians benefitted from molar morphologies that allow for extended shearing or grinding, but less consideration has been given to concurrent jaw transformations. To examine this issue, I use fossil data to analyze the functional morphology of mandibles in early mammals. Morphometric analyses are used to establish macroevolutionary patterns, demonstrating the appearance of a prominent angular process and elevated jaw joint in early cladotherians. To examine the functional effects of these evolutionary changes, three-dimensional modeling is employed to calculate mechanical advantages for the muscle vectors of various musculoskeletal configurations. Results indicate that the posterior extension of the cladotherian angular process has little effect on mechanical advantage for rotation of the jaw around a mediolaterally oriented axis (i.e., pitch). However, molar morphologies of early cladotherians suggest that the chewing cycle includes significant transverse movement. When the jaw model is restricted to transverse movement produced by rotation around a dorsoventrally oriented axis (i.e., yaw), the presence of a posterior angular process results in muscle force vectors with considerably greater mechanical advantage. Evidence from modern mammals suggests that this yaw movement is produced by asynchronous but coordinated contractions of jaw adductor muscles. Thus, considerable changes to molars, jaws, and muscles likely evolved in concert in early cladotherians, permitting a more complex chewing cycle with significantly increased transverse movement. These transformations may have allowed a wider range of diets, assisting in the early survival and diversification of Cladotheria.

Technical Session III (Wednesday, October 26, 2016, 1:45 PM)

UP, UP AND AWAY: TERRESTRIAL LAUNCHING IN THEROPODS

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Many small non-avian theropods possessed well-developed feathered forelimbs, but questions remain of when powered flight evolved and whether it occured more than once within Maniraptora. Here, using a first principles modeling approach, we explore these questions and attempt to determine in which taxa takeoff and powered flight was possible. We constructed a dataset of 37 non-avian and early avian genera using 51 specimens representing various ontogenetic stages and whose wing length/area was either calculable directly from the fossils or reconstructed based on closely related taxa. We used two methods to estimate takeoff potential (wing loading and specific lift value) and estimated the minimum takeoff speed to determine if it was realistic given ballistic leaping or running models. Takeoff is here defined as a combination of both the hindlimb driving the ballistic launch phase, and the wing-based propulsion (climb out). High wing loading has been shown in living flying animals to impose a limit on flight such that no volant bird has values higher than 2.5 g/cm^2. The specific lift value combines multiple factors (wing length, body mass, muscle power output) to predict if an organism can produce lift forces sufficient to overcome gravity (9.8 N/kg). Both of these parameters have been shown to be reliable predictors in extant avians. Combining the results of wing loading and specific lift capacity indicated that only 18 specimens representing 4 non-avian and 5 avian genera would have been capable of take off. Of these, *Microraptor*, *Rahonavis,* and all avian specimens generated sufficient velocity during leaping or running for takeoff. We re-ran our analysis factoring in life history changes that can alter the flight capability in extant avians, such as egg retention and molting, to examine how these would influence take off capacity. Of the two, molting shows the most significant effects. Reducing the wing area via molting would make take-off in *Microraptor* difficult, though not impossible. Our data suggests that due to their high level of wing development, some non-avian and all basal avians had sufficient lift potential to achieve powered takeoff directly from the ground, even with pectoral muscle mass fractions as low as 10% of body mass. When these results are coupled with work detailing the lack of arboreal features among non-avian maniraptorans and early birds, they support the hypothesis that birds achieved flight without a gliding intermediary step, something perhaps unique among volant tetrapod clades.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

OVERALL BODY SIZE AS AN INDICATOR OF ONTOGENETIC STAGE IN SAUROPOD DINOSAURS

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Numerous bones from what, to date, appears to be an individual juvenile sauropod dinosaur have been recovered since 2006 from the 2 Sisters Quarry, in the Morrison Formation of the Bighorn Basin of Wyoming. These fossils are part of the collections of the Virginia Museum of Natural History (Martinsville, VA). The small size of the bones is responsible for the designation as a juvenile. However, the possibility that this specimen was a taxonomically novel individual was equally valid. The Morrison Fm. continues to produce numerous sauropod taxa, and a number of specimens have been identified as juvenile. A compilation of juvenile characters was made from the literature and then compared against the VMNH specimens to test the conclusion that the 2 Sisters Quarry sauropod is a juvenile.

Many of the juvenile characteristics in the literature were related to the skull. No skull material has been found from the 2 Sisters Quarry, so only postcranial characteristics could be used. The most common characteristics were overall small size compared to recognized taxa, incomplete fusion of vertebral elements, increase in percentage of vertebral pneumaticity with ontogeny, and the degree of fusion of the growth plates of long bones. We tested the hypothesis that our specimen was a juvenile by examining the prepared bones from the 2 Sisters Quarry for the above four characteristics. We also attempted to taxonomically identify the individual using the morphological characteristics of adult genera known from the Morrison Fm.

Three anterior caudal vertebrae (VMNH 120750) allowed for the examination of many of the noted characteristics. While the elements of the vertebrae were completely fused, there was little to no pneumaticity observed. The overall dorsal-ventral length of the vertebrae were much smaller than an adult sauropod dinosaur of any genus known from the formation, but larger than most that had been identified as juvenile. The distal end of the left femur (in prep) does not have a growth plate, indicating it was not completely fused before fossilization. The morphology of the caudal vertebrae very closely matches that of *Apatosaurus*, which is a very common sauropod from the Morrison Formation, though all of the elements are much smaller in size than adults of that genus. We concluded this individual is a near-adult *Apatosaurus*, rather than a fully-grown *Apatosaurus*, very juvenile *Apatosaurus*, or adult of a new genus of sauropod. We will be able to test this conclusion with the continued excavation and preparation of the material from the quarry.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

POSSIBLE EVIDENCE FOR CANNIBALISM IN THE GIANT ARTHRODIRE *DUNKLEOSTEUS*, THE APEX PREDATOR OF THE CLEVELAND SHALE MEMBER (FAMMENIAN) OF THE OHIO SHALE

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The Late Devonian (Fammenian) Cleveland Shale Member of the Ohio Shale in northeast Ohio is a noted vertebrate Konservat-Lagerstätten that has produced multiple specimens of the giant predatory arthrodire *Dunkleosteus terrelli*, including several complete cranial skeletons and isolated cranial plates. CMNH 5302 is a left suborbital from *D. terrelli* that preserves a series of impact traces (gouges) on its lateral surface. The largest of these traces terminates posteriorly at a hemispherical break. The position and sizes of the traces and the morphology of the break suggest that they are not taphonomic in origin, but are consistent with the inferred actions associated with a puncture made by the anterior bite margin of an arthrodire infragnathal. The only arthrodire known from the fauna that fits the trace profiles is the apex predator, *Dunkleosteus*. The suborbital surficial gouges are aligned in two sets of orientations, suggesting that they were applied to the bone during at least two distinct biting events. The traces show no sign of healing, thus indicating that they are evidence for an intraspecific behavioral interaction that led to the death of the individual represented by CMNH 5302. Based on modern analogs, possible scenarios for the interaction could have included disputes over resources (e.g., mates, food), or active predation (cannibalism).

Technical Session V (Wednesday, October 26, 2016, 3:30 PM)

PHYLOGENETIC DATING METHOD CRITICALLY AFFECTS INTERPRETATION OF CONTINUOUS TRAIT EVOLUTION

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Reconstruction of trait evolution on phylogenies is essential for understanding how organisms evolve, but modelling the evolution of those traits requires accurately dated phylogenies. Multiple methods exist for dating phylogenies, but there has been little study of the effects of changes in divergence dates on downstream analyses such as reconstructing continuous trait evolution.

Here, we investigate the effect of different dating methods on interpreting mammal body size evolution through the Cretaceous and Cenozoic. While the fossil record documents a sudden increase in body mass at the Cretaceous–Paleogene (KPg) boundary, several studies have found no shift in rate of body size evolution during this interval. We dated a comprehensive phylogeny of Cretaceous to modern placental mammals sampling over 60% of Cretaceous and Paleogene families using four methods—minimum-age dating, branch-sharing, the stochastic cal3 method, and a Bayesian tip dating approach.

We fitted multiple models of evolution onto each phylogeny, including models with shifts in evolutionary parameters at the KPg boundary, comparing relative likelihoods with the Akaike Information Criterion. We further allowed the shift point to vary to test whether the KPg boundary was the best supported shift time for the parameters and compared our results with a previous study of mostly Cretaceous and extant taxa.

Different dating methods consistently favour different models of body size evolution for the same phylogeny. Minimum-age dating favours Ornstein-Uhlenbeck (OU) models, branch-sharing favours an increase in rate at the KPg mass extinction or a release-radiate model. Bayesian tip-dating supports a trend of increasing body mass, while stochastic cal3 dating supports a tenfold increase in rate of evolution at the KPg boundary, consistent with most interpretations of the fossil record.

When allowing the shift point to vary, models were best supported with shifts prior to the KPg boundary, at approximately 70 million years ago, depending on the model. In those analyses, shifts were roughly contemporaneous with the reconstructed dates of origin for Placentalia. Compared with a previous study excluding extinct Cenozoic taxa, the reconstructed timing of shifts in evolutionary parameters is more precise; more even sampling through time improves model resolution. These results demonstrate that choice of dating method is critical for interpreting continuous trait evolution, and that care must be taken to consider these effects when interpreting macroevolutionary models.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

SKULL VARIABILITY WITHIN A POPULATION OF THE LARGE OREODONT *MEGOREODON GRANDIS* FROM A SINGLE LOCALITY IN WEST CENTRAL MONTANA—A PRELIMINARY ASSESSMENT

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Eleven partial to complete skulls of *Megoreodon grandis*, some with associated jaws and postcranial elements, were recovered from a single locality (Museum of the Rockies locality MV-026) within the White Earth local fauna of the Six Mile Creek Formation (early Arikareean, middle Oligocene). This provides a unique opportunity to assess individual variation within a sample from a restricted location and time interval. One specimen is a partial skull of a juvenile bearing an unerupted M3 and deciduous premolars. The other skulls represent adult individuals with fully erupted permanent dentitions; some indicating advanced age. Measurements show that skull lengths in this sample can vary by as much as 22% among adult individuals. Morphological differences are minor and appear to be primarily scaled to size, age, or individual variation, and would indicate that only one species is represented in this sample. Bullar shape is variable and appears to be independent of either age or skull size. The shape and character of the zygomatic arches seem to show the most variation. A cross-section near the dorsal apex of the arch shows a sub-rounded dorsal margin in three specimens, whereas the other specimens exhibit a sharp ridge, inclined slightly medially, at the dorsal margin. The posterior rami of the zygomatic arches on the three largest specimens appear at a near 90° angle to the skull midline, whereas the other three skulls having complete arches are closer to a 70° angle. The two largest specimens and one intermediate specimen exhibit less tooth wear than the other adult skulls, suggesting size is independent of age. Whether any of these characters, singly or in combination, indicate sexual dimorphism is unclear, as the suites of characters differ between skulls. In the older individuals, some bone remodeling and rugosities appear around the orbits, the maxillae, and the preorbital fossae. Pebbly exostoses are present on the zygoma and basicranial areas in some older individuals as well.

In addition to *Megoreodon grandis*, this locality has also produced four other oreodont species—*Leptauchenia major, Mesoreodon chelonyx, Merycoides pariogonus,* and *?Merycoides longiceps*. This is an unusually high number of oreodont taxa from one locality. Many of the specimens of the two largest species (*Megoreodon grandis* and *?Merycoides longiceps*) show advanced tooth wear, with several examples of cheek teeth worn down to or below the gum line, suggesting advanced age or consumption of abrasive food sources.

Technical Session III (Wednesday, October 26, 2016, 3:15 PM)

RECONSTRUCTING THE SKULL OF *HESPERORNIS REGALIS*: THE FIRST THREE-DIMENSIONAL MODEL OF A CRETACEOUS STEM BIRD WITH INSIGHTS INTO EARLY AVIAN FUNCTIONAL MORPHOLOGY, PLESIOMORPHY, AND CONVERGENCE

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The giant, aquatic, toothed bird *Hesperornis regalis* from the Late Cretaceous of Kansas represents the closest taxon to crown Aves known from nearly complete and undistorted cranial material. It is thus key for understanding the functional anatomy in the lineage leading to modern birds. Previous studies of the skull of *Hesperornis* were conducted when it was thought to belong to a lineage of modern aquatic birds, and concluded that the structure of the adductor chamber, palate, and rostrum were more similar to neognathous rather than palaeognathous birds. This hypothesis implies that the joints and articulations of the neognathous palate were plesiomorphic for modern birds, and the palaeognathous palate, which resembles the ancestral diapsid condition, was an evolutionary reversal. More recent phylogenetic analyses demonstrate that Palaeognathae (the extant ratites and tinamous) are the earliest-diverging lineage of birds, and that *Hesperornis* nests outside the crown, making it a particularly important taxon for polarizing cranial characters ancestral for crown Aves, in turn necessitating an extensive morphological reevaluation. We μCT scanned and digitally prepared disarticulated skull elements of *Hesperornis* from the Yale Peabody Museum and University of Kansas to construct a 3D model for comparative anatomical and functional studies. To aid the reconstruction of the functional morphology of the *Hesperornis* cranial kinetic system, we reconstructed the adductor musculature using comparative data from a crocodilian (*Alligator mississippiensis*), palaeognathous bird (*Nothoprocta pentlandii*), and neognathous bird (*Gallus gallus*). We show that the anatomical characteristics of *Hesperornis* palate and rostrum compare favorably with a palaeognathous and rhynchokinetic structure, where the palate lacks synovial joints and during movement, the bill shifts upwards due to deformation of the nasal process of the premaxilla, as opposed to a neognathous and prokinetic structure with interpterygoid joints and a frontal-premaxillary hinge. We also show *Hesperornis* has a suite of characters in the adductor chamber of the skull to accommodate enlarged musculature similar to that seen in several disparate lineages of modern aquatic birds such as cormorants, loons, and kingfishers.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

CARBON ISOTOPE COMPOSITIONS OF *KRYPTOBAATAR* ENAMEL AND ECOLOGICALLY WIDESPREAD ^{13}C ENRICHMENT IN UPPER CRETACEOUS MONGOLIA

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Dinosaurian eggshell and tooth enamel from the Upper Cretaceous Djadokhta and Nemegt Formations, Mongolia, have produced carbon isotope values averaging ca. -5‰ (PDB). These values are significantly higher than expected values (ca. -8‰ maximum) for terrestrial food chains based on C3 plants. Explanations for this carbon isotope enrichment include diagenetic alteration of the original isotopic composition, trophic level and methanogenic effects whereby carnivores and gut-fermenting herbivores are enriched in ^{13}C relative to non-fermenting herbivores, and the presence of plants with carbon-concentrating photosynthesis some 40 Myr prior to the known Neogene radiation of C4 plants. The Djadochtatheriid multituberculate *Kryptobaatar* is an atypically abundant and well-represented mammal from early Campanian sediments of southern Mongolia. The non-vagile nature of this taxon and estimated body mass below the threshold for efficient fermentation makes it an attractive target for further investigation of the enigmatic carbon isotope signal. Although *Kryptobaatar* is a small animal (mouse-sized), the enamel lining their procumbent incisors is suitable for carbon isotope analysis using in situ laser ablation, a minimally destructive technique.

As in the dinosaur material, we observe high ^{13}C enrichments in *Kryptobaatar* (average -7.4‰ PDB). This suggests that fermentation effects and trophic level effects (assuming *Kryptobaatar* was not highly carnivorous) are not viable explanations for the observed ecologically-pervasive ^{13}C enrichments. We also present triple-oxygen measurements from dinosaur eggshell from the Ukhaa Tolgod locality, which produced the *Kryptobaatar* specimens used here. These show highly negative ^{17}O anomalies relative to meteoric water, which are a vital effect owing to consumption of evaporated waters and metabolism using atmospheric O_2 as the oxidant, and would not persist in 100% diagenetically altered material. Thus triple oxygen isotope analysis of these eggshells, which are also enriched in ^{13}C, suggests that diagenesis is not the sole explanation for the enriched ^{13}C values. Taken together, these results suggest the possibility of an early appearance of plants with carbon-concentrating mechanisms predating the radiation of modern CAM and C4 plants by tens of millions of years. The case is made here for further minimally-destructive isotopic sampling of small mammalian specimens from the Gobi Basin to characterize the spatial, temporal, and ecological extent of the unique carbon signal in this region.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

TWO CHIMAERID (CHONDRICHTHYES, HOLOCEPHALI) EGG CASES FROM THE UPPER CRETACEOUS CLIFF HOUSE SANDSTONE OF THE MESAVERDE GROUP AT MESA VERDE NATIONAL PARK (MEVE): WITH COMMENTS ON THE CLASSIFICATION OF EGGS

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During an internship at Mesa Verde National Park (MEVE), Colorado, the senior author recovered two chimaera egg cases preserved as external molds from the coastal facies of the middle Campanian Cliff House Sandstone at the top of the Mesaverde Group in the park. The most complete specimen was 20 cm in length and 7.5 cm at its widest point. The ribbed fusiform flange and pronounced central capsule place it within the fossil egg case oogenus *Chimaerotheca*. The flange is far wider than the capsule. The capsule is also fusiform with a wider snout posteriorly and a slender tail portion anteriorly. Both specimens are most similar to a specimen collected over 100 years ago from the lower sandstone (Eagle Sandstone, lower Campanian) of the Mesaverde Group in Wyoming. This specimen was listed as *Elasmodus* (?) *gilli* in 1929 and was formally described as *Chimaerotheca wyomingana* in 1946 (genotype for *Chimaerotheca*). Current convention has been to assign chimaerid fossil egg cases to the modern genus producing the most similar morphology such that the Wyoming example is referred to as *Rhinochimaera gilli*. Since the MEVE specimens exhibit a fusiform central capsule (rather than subcylindrical) and capsule and adult morphology is closely related in living chimaeras, the MEVE specimens are interpreted to represent a new species.

Given that a description of this new species is warranted, a reappraisal of the taxonomic protocols for chimaera egg cases is justified. Fossil eggs are considered to be trace fossils and, as such, a parataxonomic system with distinct oogenera and oospecies are erected to classify them. For example, although an embryonic oviraptorosaur has been

found in the egg oogenus *Elongatoolithus*, the oogenus was not changed. The modern long-nosed chimaerid genus *Rhinochimaera* does not extend back to the Cretaceous and only rhinochimaerid taxon known from the Cretaceous Western Interior Seaway is *Elasmodus*. We would suggest *R. gilli* should be moved back to *Chimaerotheca* and propose *Chimaerotheca* n. sp. for the MEVE specimens.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

MECHANISTIC PHYSIOLOGICAL MODELLING PREDICTS GEOGRAPHIC DISTRIBUTION OF LATE TRIASSIC TETRAPODS

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Climatic conditions are thought to have been a primary driver of the distributions of vertebrate clades in the Late Triassic. Climates in the Late Triassic were characterized by high mean annual temperature and strong seasonal aridity. We used the physiological modelling program, Niche Mapper, to quantify climatic tolerances of several terrestrial vertebrate clades.

Niche Mapper requires parameterization using organismal and environmental data to calculate the solution to a heat-balance equation on an hourly over the course of a year. Physical parameters of taxa are from published dimensions of specimens, while physiological parameters were estimated from histological data and nearest living relatives. Mean annual temperature and precipitation are from published multiple proxy records. Cloud cover and wind speed are from modern analogue environments.

We find that small, mesothermic carnivorous dinosaurs and large semi-aquatic crurotarsans should have experienced minimal heat stress in low-latitude portions of North American. Large, mesothermic herbivorous dinosaurs exhibited heat stress at the lowest plausible temperatures. This heat stress can explain the "prosauropod gap" in the body fossil record of low-latitude environments in the Late Triassic. Large dicynodonts are especially sensitive to water availability, because amphibious behavior mediates heat stress. Our results support climate as a plausible driver of geographic distributions and extinction vulnerability in Late Triassic terrestrial ecosystem.

Technical Sesssion X (Friday, October 28, 2016, 9:45 AM)

CLADISTIC AND BIOGEOGRAPHIC ANALYSES OF A NEARLY COMPLETE SKELETON OF *HYPOSAURUS ROGERSII* (CROCODYLIFORMES, DYROSAURIDAE) INDICATE MULTIPLE CROCODYLIFORM DISPERSALS ACROSS THE EARLY ATLANTIC OCEAN

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Only a few lineages of crocodyliforms managed to survive the K–Pg extinction event. One of these was the family Dyrosauridae. Unequivocal remains of the dyrosaurid *Hyposaurus rogersii* have been recovered from just above the K–Pg boundary through mid-Danian (early Paleocene) strata in New Jersey (USA). This taxon is known from partial skulls and some postcrania. The recent discovery of a nearly complete skeleton of *H. rogersii*, NJSM 23368, now allows for a more complete scoring of the taxon for cladistic analysis, increasing from 63.3% to 92.5% for a 120 character matrix. These states were then cross-referenced with nearly all other known *H. rogersii* specimens.

A cladistic analysis of 37 taxa was conducted for the 120 characters, including 15 dyrosaurids, nine pholidosaurids (thought to be sister to Dyrosauridae), and 13 basal crocodylomorphs. The resulting consensus of 2,701 equally most parsimonious cladograms revealed a close relationship between *H. rogersii* and a clade uniting African and South American dyrosaurids. A biogeographic analysis of vicariance and dispersal was conducted using the S-DIVA (Statistical-Dispersal Vicariance Analysis) function within the program RASP (Reconstruct Ancestral State in Phylogenies). The analyses indicated an African origin for Dyrosauridae and no less than two independent dispersals from Africa to South America, possibly three. Additionally, the analyses indicated no less than two pholidosaurid dispersals from the Old World to the New World. The analysis also recovered a higher than expected probability (52.7%) that dyrosaurids dispersed back to Africa from South America, giving rise to the radiation of six derived African dyrosaurid species. In all, the results may indicate frequent dispersals back and forth across the early Atlantic.

Dispersal from Africa to South America would have followed Atlantic circulation currents and dispersal would have likely continued up the Atlantic coast into North America during the Maastrichtian, supported by a Late Cretaceous dyrosaurid in Mexico. However, the potential for a dispersal in the opposite direction, from South America to Africa, not only counters the general direction of Atlantic currents, but indicates a direct ancestry for the majority of African dyrosaurids from South American taxa, despite the family having originated in Africa. This potential for oceanic dispersal may help explain the ability of dyrosaurids to survive the end Cretaceous extinction and spread throughout the world in the early Cenozoic.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

HOMOLOGIES OF PEDAL MUSCLES BETWEEN AVIAN AND NON-AVIAN REPTILES AS A BASIS FOR THEIR RECONSTRUCTION IN FOSSIL ARCHOSAURS

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The evolutionary history of archosaurs displays a trend toward increasing bipedalism. The hindlimb anatomy, particularly the myology, is crucial for understanding their locomotor modes. Despite numerous attempts of reconstructing the hindlimb musculature in fossil archosaurs, muscles in the most distal portion, the pes, have often been neglected. Accordingly, detailed reconstruction of the pedal musculature in extinct archosaurs will provide an additional line of morphological evidence for clearer understanding of their locomotion.

As the essential basis for reconstruction and inference on evolutionary changes of the pedal muscles in archosaurs, homologies of the pedal muscles among extant reptiles including birds were established based on first-hand dissections and literature reviews, resulting in several new hypotheses. For example, the homologies of an ankle flexor and a digital extensor muscles between avian and non-avian reptiles were reversed from the classical interpretations, i.e., reptilian m. tibialis anterior and m. extensor digitorum longus correspond to avian m. extensor digitorum longus and m. tibialis cranialis, respectively. The new hypothesis is preferred because the relative positions of the putatively homologous muscles were more conserved with fewer differences in the attachment sites between non-avian and avian reptiles compared to the classical hypothesis. All the changes that are supposed have occurred between basal archosaurs to extant birds according to the new hypothesis were the fusion of m. extensor digitorum brevis and longus and the acquisition of an additional origin of m. tibialis anterior, both of which were also necessary based on the classical hypothesis.

Although the homology hypotheses newly proposed here are based on adult morphology and thus still need to be tested by ontogenetic data as well as anatomical studies on more taxa, they serve as a fundamental basis for discussion on the comparison of the pedal muscle morphology and functions among extant Lepidosauria, Testudines, Crocodilia, and Aves. In addition, many precise positions of the muscle attachments in the pes throughout major clades of extant reptiles including birds were newly revealed, enabling the pedal muscle reconstructions in extinct archosaurian taxa.

Grant Information
Grant-in-Aid for JSPS Fellows

Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

DIETARY PREFERENCES OF THE SHASTA GROUND SLOTH (*NOTHROTHERIOPS SHASTENSIS*) INFERRED FROM STABLE ISOTOPE ANALYSIS OF COPROLITES

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Cave deposits containing well-preserved ground sloths and associated dung are known from several localities. The exceptional preservation of these coprolites allows for dietary analyses including identification of plants, palynological analysis, and molecular coproscopy, as well as secondary use by insects. This level of paleodietary analysis only applies to coprolites, making dietary comparisons to other ground sloth taxa with no known coprolites difficult. There are, however, well-preserved ground sloths that allow for stable isotope analysis of bone collagen that is potentially comparable to coprolites. Previously, there were no isotopic studies of sloth coprolites and no published isotope values for any sloth in the Nothrotheriidae family. Here, we performed stable isotope analysis ($\delta^{13}C$, $\delta^{15}N$) of *Nothrotheriops shastensis* coprolites from Gypsum Cave, Nevada, to assess the comparability of these values to those from bone collagen of other sloth families. The bulk fraction from nine complete coprolites and 13 fragments yielded mean $\delta^{13}C$ and $\delta^{15}N$ values of -19.1 ± 2.1‰ and 12.4 ± 2.5‰, respectively. The $\delta^{13}C$ values likely represent matrix-embedded undigested plant pieces indicative of diet, whereas the high $\delta^{15}N$ values suggest alteration via bacterial degradation. Published $\delta^{13}C$ (n = 29) and $\delta^{15}N$ (n = 24) values from three sloth families (7 genera) show mean $\delta^{13}C$ and $\delta^{15}N$ values of -20.3‰ and 8.1‰. Assuming standard carbon fractionations between diet and collagen of 5‰ and between diet and dung of -0.9‰, we converted the mean collagen and coprolite $\delta^{13}C$ values to -25.3‰ and -18.2‰. The difference between these values was statistically significant ($p << 0.001$) and suggests that unlike all previously sampled sloths, the diet of *N. shastensis* included much more C_4 and CAM plants. Alternatively, it could be that differences in metabolism, physiology, and thermoregulation in sloths results in a different discrimination factor between diet and feces relative to other mammals. However, our analysis supports findings that show their diet included saltbush (C_4), yucca, and cactus (CAM). Our results establish this method as a viable means of comparing dietary information for *N. shastensis* quantitatively to that of sloths with no known coprolites. To better test these preliminary comparisons, we should next analyze the bone collagen $\delta^{13}C$ and $\delta^{15}N$ from *N. shastensis* directly. Those data would allow us to see if sloth bone collagen and feces discriminations differ significantly from other mammals and help us better interpret existing and future sloth stable isotope data.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

MATURATION AND GROWTH PATTERN OF *KEICHOUSAURUS HUI* (REPTILIA, SAUROPTERYGIA) REVEALED BY LONG BONE HISTOLOGY AND GROWTH CURVE

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Keichousaurus hui is a small pachypleurosaur from Middle Triassic of China. Though their skeleton anatomy and sexual dimorphism seem to be well studied, information about their life history including maturation and growth is hardly known. In both extinct dinosaurs and extant lizards, such information has already been derived from the histological growth record preserved in the mid-shaft cortex of long bones. Here, based on histological and mathematical analysis, one individual specimen of *Keichousaurus* was studied to reveal its growth rate, age at sexual maturity, and age at when the individual is fully-grown, reaching its asymptotic body size.

All the skeleton measurements of this well-preserved male *Keichousaurus* indicate that the individual is an adult: the snout-vent-length is 176.16 mm, the femur length is 22.05 mm, and the humerus length is 26.50 mm. Eight growth lines in total are recognized in the mid-shaft section of its humerus. Based on the sigmoid growth models (von Bertalanffy model, the Gompertz model, and the logistic model), generalized estimates of the traits above are established for this individual. According to residual analysis, the Gompertz model is the best one to describe the life history of *Keichousaurus*.

The inflection point in the gradient of growth rate indicating the sharpest decrease of individual growth rate is used to represent sexual maturity, because unambiguous signals of maturity in Sauropterygia are lacking. The model shows that the growth pattern of

Keichousaurus is similar to living lizards: both species reach sexual maturity before being fully-grown, and the gradient of growth rate reaches the lowest point at the onset of reproduction. Growth rate of the humerus width of this individual is 0.43, lower than of an average mammal. This *Keichousaurus* reached its full size within ten years, similar to scaled-up modern lizard, and the age at maturation was about three to four years. However, the variation among individuals cannot be excluded here due to the limitation of sample size.

Symposium II (Friday, October 28, 2016, 11:15 AM)

ROCKS BEAT *HOX*: FOSSIL AND EXTANT ANATOMICAL TESTS OF CONSERVATION IN REGULATORY GENE FUNCTION IN THE EVOLUTION OF NEW VERTEBRATE BODY FORMS

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Conservation of function is central to hypotheses of the roles of regulatory genes as fundamental mechanisms driving the evolution of new body forms. Among vertebrates, the most precisely examined *Hox* gene function is that of *Hox10* paralogs, which supress the development of dorsal ribs within the lumbar region of the vertebral column in model taxa by blocking expression of *Myf5*. Loss of *Hox10* function has been invoked to explain the apparent loss of ribless lumbar regions in the evolution of snakes and snake-like body forms within Squamata; however, the evolutionary polarity of "lumbarization" within the squamate axial skeleton has not previously been examined.

To test the hypothesis that conserved *Hox10* function has been lost in the evolution of snake-like body forms, we mapped presacral vertebral morphologies of 140 fossil and extant taxa onto comprehensive molecular and morphological phylogenies of Lepidosauria, and used Maximum Likelihood and Maximum Parsimony analyses to reconstruct ancestral values for Squamata and constituent clades, including snakes. Lumbar regions occur in multiple clades; however, ancestral state reconstructions do not support a hypothesis of secondary loss of a ribless lumbar region in the evolution of snake-like body forms, regardless of tree topology or reconstruction method. Instead, Squamata basally lacks a ribless region and snakes are nested deeply within clades that lack a lumbar region regardless of body form. We additionally examined the distribution of lumbar regions within the mammal total clade and found that a ribless region is homoplastically derived as well. Our results indicate that presence of a ribless lumbar region is not plesiomorphic for Squamata, Mammalia, or crown Amniota, despite expression of *Hox10* within all of these clades. This disjunct between gene expression and morphology indicates that that the initial role of *Hox10* in amniotes was not suppression of ribs and that its role in lumbar development in model taxa does not represent evolutionary conservation of function, highlighting the need to place gene function experiments in a broad, extensively sampled comparative phylogenetic framework.

Grant Information
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Preparator's Session (Thursday, October 27, 2016, 9:00 AM)

POLYESTER OR EPOXY: ASSESSING PRODUCT EFFICACY IN PALEOHISTOLOGICAL METHODS

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Histological examination of bone microstructure provides insight into the physiology of modern and extinct vertebrates. The field of paleohistology has grown immensely because of the wealth of data contained in the microstructure of fossil bone and sampling of modern bone allows for direct comparisons along evolutionary lineages of fossil taxa. Specimens sampled for histological examination are first embedded in a plastic resin which is then cut into thin sections, mounted on slides, and polished for viewing. Standard embedding procedure of fossil material involves embedding specimens in relatively inexpensive polyester resin. Conversely, small fossil material and modern tissue is embedded in a higher priced epoxy resin. Modern tissue and small fossil material often require thin sections near or below 100 µm thick. Anecdotal evidence suggests polyester resin thinner than 100 µm causes increased likelihood of sample peeling, material loss, and is unsuitable for modern tissue and small fossil material embedding. To test this assumption, three fossil bones and two modern bones were embedded in Epothin™, an epoxy resin, while five fossil bones and four modern bones were embedded in Silmar S-41, a polyester resin. Embedded specimens were sectioned and mounted following standard protocol. A total of 35 slides (26 from Silmar S-41 embedding and nine from Epothin™) were produced, then ground on a lapidary wheel using decreasing grit sizes until bone microstructure was completely discernable. Additionally, two slides, one with a polyester resin embedded specimen and one with an epoxy resin embedded specimen, were continuously ground on 600 grit paper until peeling occurred. Slide thickness at the point of peeling was measured for direct comparison of resin types and timing of specimen loss. Finished slide thickness ranged from 23–230 micrometers. We found no appreciable difference in bone microstructure visibility between Silmar S-41 embedded material and Epothin™ embedded material, and none of the 35 finished slides exhibited signs of peeling. There also was no observable difference in the timing of the occurrence of peeling. The specimen that was embedded in epoxy resin began peeling at 77 microns while the specimen in polyester resin peeled at 55 microns. Counter to previous assumptions, our results suggest that expensive epoxy resins can be replaced by polyester resins in histological preparation of modern bone tissue and small fossil material.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

A NEW, SHORT-FACED ARCHOSAURIFORM (?CROCODYLOMORPHA) FROM THE UPPER TRIASSIC *PLACERIAS*/DOWNS' QUARRY COMPLEX, EAST-CENTRAL ARIZONA

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With its rich assemblage and a collection history dating to the 1920s (including both macro- and microvertebrate techniques), the *Placerias*-Downs' Quarry complex is the most diverse Upper Triassic vertebrate locality known. Recent excavations at the Downs' quarry have yielded fossils of a new short-faced archosauriform (SFA) that further expands that diversity with a morphology that is unique among archosauriforms. The SFA is represented by parts of four different mandibles (two each left and right) representing 2–4 individuals, as well as a possibly referable braincase. The most distinctive feature of the SFA is its short, robust lower jaw (length ~2.5x height; ~175 mm:70 mm) with as few as 6 and a maximum of 8 tooth positions, including 3–4 smaller, anterior teeth that may be strongly procumbent, a large caniniform alveolus (~12 mm diameter), and 0–3 "postcanine" alveoli. Denticulated thecodont teeth and an external mandibular fenestra constrain the SFA to at least within Archosauriformes. Although the preserved jaws lack erupted teeth, the size and shape of the alveoli and the preserved tips of replacement teeth preclude assignment of the SFA to any taxon known only from teeth (e.g., *Uatchitodon*, *Crosbysaurus*, *Kraterokheirodon, Krzyzanowskisaurus*). Autapomorphies of the SFA include an interdigitating suture of the surangular with the dentary, fine ornamentation on the splenial, and a splenial ridge that completes a 90° arc. The external surfaces of the mandible bear numerous shallow, densely packed, irregular, fine pits and narrow, arcuate grooves lacking a clear pattern that become more rugose posteriorly, especially over the posterior portion of the surangular ridge. The highly ossified braincase bears a number of character states shared with, but not exclusive to, early crocodylomorphs (e.g., large metotic strut, large exit of cranial nerve V, narrow parabasisphenoid, sagittal crest formed from the parietals). Therefore, if the mandibular elements and the braincase belong to one species, the SFA may pertain to an aberrant, short-faced crocodylomorph with features previously not sampled. Given the *Placerias'* Quarry's maximum depositional age of ~220 Ma, the cranial structure of potential crocodylomorphs is highly divergent from other members of the clade (e.g., "sphenosuchians") early in the history of the group. Furthermore, in spite of more than a century of collecting Upper Triassic vertebrates, even the most well-known sites may preserve surprising new diversity.

Technical Session I (Wednesday, October 26, 2016, 8:45 AM)

CLARIFYING CAUSAL AGENTS OF DENTAL MICROWEAR FORMATION AS REVEALED BY KOALAS

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Dental microwear textures are capable of recording observed dietary behavior in a diversity of extant and extinct animals. However, recent work has questioned the utility of dental microwear at clarifying dietary behavior, instead suggesting that dental microwear surface textures are reflective of grit consumed and not the dietary properties of ingested food. Some suggest that dental microwear cannot reflect the textural properties of vegetation consumed because phytoliths are too soft to form microwear. Koalas (*Phasolarctos cinereus*) are model organisms for examining dental microwear formation because they consume a specialized diet consisting almost exclusively of eucalyptus leaves, which notably lack phytoliths. Here, we assess if dental microwear textures of the koala records a diet consistent with the consumption of tough leaves—despite the absence of phytoliths in their primary food source. Dental microwear texture data of koalas are consistent with tough folivorous diets, with high anisotropy values indistinguishable from folivorous primates and grazing bovids. However, koalas have significantly higher complexity (indicative of hard object feeding) than the folivorous primate *Alouatta palliata* and are indistinguishable in this variable from mixed feeding and browsing bovids with roughly similar teeth. While higher complexity values in koalas may result from increased dust and/or grit on the landscape, in comparison to folivores that occur in wetter environments, it may also result from the mastication of woody browse. We also determined that complexity and textural fill volume (Tfv) are not significantly greater in drier environments—as one would predict if grit is overprinting dental microwear features. Instead, complexity and Tfv are positively correlated with higher amounts of rainfall during the driest month in our study region (September). Koalas may be selecting softer, younger leaves in drier regions where water is limited. We conclude that microwear associated with tough object feeding can be formed in the absence of phytoliths, particularly if mastication is a dominant agent in microwear production. Further, grit may interact with food to form microwear reflective of diet, as opposed to overprinting dietary signals. While experimental work is needed to assess the relative role of grit and food material properties in microwear formation, the analysis of koalas helps demonstrate that this debate may be more nuanced and both grit and food materials may interact to form dental microwear textures indicative of diet.

Grant Information
NSF 1053839 and 1455198

Symposium I (Wednesday, October 26, 2016, 11:45 AM)

PALEOGENOMICS RESOLVES THE TAXONOMY AND SYSTEMATICS OF LATE PLEISTOCENE STILT-LEGGED EQUIDS FROM NORTH AMERICA

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States of America; STILLER, Mathias, German Consortium for Translational Cancer Research, Essen, Germany; SCOTT, Eric, Dr. John D. Cooper Archaeological and Paleontological Center, Santa Ana, CA, United States of America; MACPHEE, Ross D., American Museum of Natural History, New York, NY, United States of America; SHAPIRO, Beth, University of California Santa Cruz, Santa Cruz, CA, United States of America

Our understanding of the evolution of equids is a classic example of macroevolution inferred from the fossil record. Although the taxonomy of, and relationships among, living equids (*Equus*) are well understood, morphology and genetics give conflicting signals; consequently, there is substantial disagreement regarding the placement and systematics of their Pleistocene kin. Here, we apply a paleogenomic approach to address these problems with regard to an extinct group of poorly understood equids, the New World stilt-legged horses. Based on whole mitochondrial and partial nuclear genome data, we demonstrate that stilt-legged horses are sister to all living equids and thus warrant distinct generic status. Sampled genomic diversity within the new genus is low, and all relevant fossil material is referred to a single species, *E. francisci* Hay 1915, based on anatomical comparisons and nomenclatural priority. We were able to partially reconstruct the skeleton of this taxon, including complete limbs and the cranium, as well as determine its probable geographic range. This approach, which combines paleogenomic, geographic, and fossil evidence, could be used to resolve the systematics of other Pleistocene groups, especially those that are taxonomically over-split, thereby enabling a greater understanding of their diversity and evolution.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

POSTCANINE MICROSTRUCTURE IN *CRICODON METABOLUS*, A MIDDLE TRIASSIC GOMPHODONT CYNODONT FROM SOUTHEASTERN AFRICA

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Cricodon metabolus is a trirachodontid cynodont from the Anisian (Middle Triassic) of eastern and southern Africa whose dentition includes labiolingually expanded (gomphodont) postcanines but also a sectorial tooth in the last postcanine locus. The crown microstructure of isolated sectorial and gomphodont postcanines belonging to the holotype specimen of this taxon was examined for the first time using scanning electron microscopy. The enamel of both teeth is prismless and composed of discontinuous columnar divergent units, confirming the consistent presence of synapsid columnar enamel in cynognathians. Abundant odontoblast tubules and numerous irregularly spaced incremental lines are also visible in the enamel and dentine layers in each tooth. This study reveals that the enamel thickness varies along the tooth row in *Cricodon* as the enamel layer of the gomphodont postcanines is 7.5 times thicker than that of the sectorial crown. This difference likely reflects occlusal stresses and fewer replacements in gomphodont postcanines relative to sectorial teeth. Approximately one hundred interdental growth lines of von Ebner are present in the dentine layer, indicating that the odontoblast deposition of the dentine occurred for four months before the animal's death.

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Technical Session XX (Saturday, October 29, 2016, 4:00 PM)

***EORUBETA NEVADENSIS* REVEALED: NEW SPECIMENS OF THIS ENIGMATIC ANURAN FROM THE LATE CRETACEOUS–MIDDLE EOCENE SHEEP PASS FORMATION OF EASTERN NEVADA SHED LIGHT ON ITS PHYLOGENETIC POSITION**

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The North American record of anurans from the earliest Paleogene is sparse, and many of the taxa have indeterminate affinities. One of these taxa, *Eorubeta nevadensis*, is based on a single specimen discovered in a well core obtained from the Sheep Pass Formation of eastern Nevada. Hecht theorized that *Eorubeta* could be related to leptodactylids, but its relationship to other anurans is now considered to be indeterminate. In the past decade over 100 specimens of *E. nevadensis* have been collected from outcrops of the Sheep Pass Formation. Six members (A–F) comprise this formation, and the new collections were made from the lower and middle portion of Member B and several horizons near the top of Member C. The age of the Sheep Pass Formation ranges from Late Cretaceous–middle Eocene, though the ages of the contained members is not well constrained. Previously published U–Pb detrital zircon ages indicate that Member A is late Cretaceous. The base of Member B is potentially Late Cretaceous in age based on a U–Pb microbial carbonate date of 66.1 +/- 5.4 Ma and published studies on pollen and invertebrate biostratigraphy that further indicate a Paleocene age for upper portions of Members B and C. Given the uncertainties inherent in the absolute age control and previous biostratigraphic age assignments, the position of the K–Pg boundary relative to the anuran fossils is still in question.

The new anuran specimens range from disarticulated bones to nearly complete skeletons. The more complete specimens are in tight to loose articulation, and their overall preservation ranges from poor to good. Most bones of the skeleton are preserved. A growth series of post-metamorphic individuals is represented. Some variation is exhibited in the morphology of the individual elements, due to changes with growth or the result of the specimens being split into part and counterpart by weathering or collecting techniques. As such, bones can vary in shape depending on where the bone was split into part and counterpart (e.g., near the surface of the element, near the mid-plane, etc.).

The holotype is incomplete and not well preserved, but enough is present to determine that the new specimens are indeed *E. nevadensis*; they share a similarly shaped frontoparietal, scapula, vertebrae, and ilium. A phylogenetic analysis was conducted that included 29 taxa representing major anuran clades and 92 osteological characters. The analysis produced one most parsimonious tree that placed *E. nevadensis* as the sister taxon to Acosmanura and retrieved most major anuran clades.

Technical Session II (Wednesday, October 26, 2016, 10:15 AM)

PHYLOGENETICALLY INFORMED DISCRIMINANT FUNCTION ANALYSIS AIDS FOSSIL IDENTIFICATION

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A lack of diagnostic apomorphies can hinder fossil identification. However, if there is even subtle variation in shape, there is now a way to treat those subtle variations as apomorphies with the help of the discriminant function and a phylogenetic tree. Using a set of *a priori* groups, the discriminant function creates a combination of variables that tries to minimize within-group variation while maximizing between-group variation. Normally, researchers would have to create as many *a priori* groups as taxa that they want to consider, irrespective of the potential phylogenetic structure of shape variation. As such, variation that differentiates sister taxa counts as much in the discriminant function as variation that differentiates more distantly related clades. We are presenting a new algorithm that uses a phylogenetic tree to automatically divide a training data set into a pair of sister groups, then uses the discriminant function on morphometric data to determine to which of the two groups an unidentified fossil belongs. Once the fossil is identified as belonging to one of the two sister groups, the chosen group is subdivided into its constituent sister groups and the process is repeated. At each level of identification, a different combination of variables can be used to separate the groups, effectively allowing different commonalities of shape variation to serve as the apomorphic characters at each level of identification. At each stage of identification, the algorithm also saves the probability of membership in each group, so that one can say exactly how confident they are in their identification of the fossil. To test this new technique, we placed landmarks on disarticulated dentaries from small species of *Uta, Urosaurus*, and *Sceloporus*. Phylogenetically-informed discriminant function analysis was significantly better at identifying the dentaries to the species level than regular discriminant function analysis. Furthermore, the ease of placing landmarks and then using the phylogenetically-informed discriminant function analysisx allowed a novice to accurately identify unknown samples to species without any training in lizard systematics or comparative morphology, which opens up tremendous potential for crowdsourcing the idenfication of fossils.

Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

ECOMETRIC INDICATORS DEMONSTRATE SEASONALLY WARM AND ARID ENVIRONMENTS IN THE EARLY PLEISTOCENE OF NORTHERN EAST ASIA

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Paleoenvironmental conditions in the interior of eastern Asia in the early Pleistocene are debated, especially with regard to their suitability for year-round occupation by *Homo erectus*. The Nihewan Basin offers important evidence for conditions at the boundary of the known northern range of *H. erectus* in northeast China, and archaeological evidence indicates a hominin presence in this area for hundreds of thousands of years. We examined functional traits in the vertebrate fauna at two sites, Feiliang (1.2 Ma) and Donggutuo (1.1 Ma), to assess local paleoenvironments. Hypsodonty indices for the mammalian herbivores (6 hypsodont, 2 brachydont) indicate a dry climate with estimated annual precipitation of 200.9 mm, wettest quarter precipitation of 97.16 mm, and driest quarter precipitation of 14.98 mm. These Nihewan faunas and their precipitation estimates were compared to six key semi-contemporaneous sites from across the geographic range of *H. erectus*: Olduvai Gorge, Site BK (Tanzania); Middle Awash, Daka Member (Ethiopia); Dmanisi (Republic of Georgia); Trinil (Indonesia); Xiaochangliang (China); and Zhoukoudian, Locality 1 (China). All three precipitation estimates for Feiliang and Donggutuo are the same as those from Xiaochangliang, which is also located in the Nihewan Basin. Although the driest quarter estimates are equivalent across all sites (14.98 mm) except Trinil (50.98 mm), the Nihewan Basin sites appear to be drier throughout the rest of the year compared to all other hominin sites in the present analysis. Olduvai Gorge is estimated to have had a similar total annual precipitation as the Nihewan basin, but its wettest quarter estimate is 542.6 mm compared to 97.16 mm. All other sites produced annual and wettest quarter precipitation estimates higher than that for the Nihewan Basin sites. Notably, the presence of a crocodilian at Donggutuo provides evidence that this aridity in the Nihewan region was not accompanied by cold conditions. The seasonally wet climates found in other parts of *H. erectus*' range appear to be lacking in northern China, where it was more consistently dry but warm. This evidence suggests that *H. erectus* was able to cope with this dry local environment at the northeast edge of its range in any season, perhaps utilizing strategies like those used in the dry periods of the year in their native Africa.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

MORPHOMETRIC ANALYSIS OF A MASS ASSEMBLAGE OF *TRIMERORHACHIS* (AMPHIBIA, TEMNOSPONDYLI) FROM THE ARROYO FORMATION, LOWER CLEAR FORK

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A mass burial of of *Trimerorhachis,* a dvinosaurian temnospondyl from the early Permian, was encountered on the Craddock Ranch of the Texas Red Beds of Baylor County, Arroyo Formation (the lower member of the Clear Fork Group) in 2009. *Trimerorhachis* is quite common on the Craddock, and while most previously published analyses have been conducted on specimens found individually, our study of the large number of specimens in this bone bed adds a considerable amount of data that indicates several issues relative to past clade determinations and species formational occurrences. Computer-aided measurement techniques and geometric morphometrics, verified by conventional measurements using calipers, were used to analyze the dorsal roof morphology of 14 skulls from Site JDY, prepared in situ, to determine relationships of the encountered specimens to named species within Trimerorhachidae.

Historically, investigations have primarily concentrated on dermal bone geometry defined by dorsal surface suture positions and gross skull size and shape. Our analysis follows more recent methodology that aims more towards functional morphology. Orbit spacing and skull table shape were measured and compared to established species. Orbit spacing is an indication of orbit size in relation to inter-orbital width. Larger values indicate larger orbits relative to their spacing (~3 for *T. greggi)* while smaller values (~2 for *T. mesops*) indicate more "beady-eyed" specimens. Our sample values range 2.3–2.7, distinct from established taxa present in the Arroyo Formation (*T. mesops, T. greggi*). *T. rogersi,* however, known from only two specimens from the Vale Formation (Middle Clear Fork Group), brackets values for our sample. Skull table shape is defined as the ratio between skull length and width measured using tabular sutures. Although skull table shapes show much variation within individual species, indications are that our sample, ranging from 0.9 to 1.1, may characteristically fall outside *T. mesops* and *T. greggi*'s range of 1.0 to 1.4, and away from the single data point of *T. rogersi* at nearly 1.2.

Analyses place our sample as a possible new Arroyo species with orbit spacing and skull shape as defining characters that are different from established species. Similarity with *T. rogersi* is suggestive either of a separate morph within the same species, extending our sample later into the Vale, or the extension of *T. rogersi* earlier into the Arroyo.

Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

EXPLORING MACROEVOLUTION OF MESOZOIC LEPIDOSAURS

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Lepidosauria is an ancient group of reptiles that had its origin in the Triassic. This clade is currently divided into two orders, the Squamata and the Rhynchocephalia. The Squamata is today represented by over 9000 species with a cosmopolitan distribution, while the Rhynchocephalia has a single living species, the “Tuatara”, from the islands off New Zealand. However, in the Mesozoic this ratio was quite different; the fossil record shows that rhynchocephalians had an early radiation in the Triassic and a big diversity and disparity in the Jurassic. On the opposite side, there are no reliable records of Triassic squamates and its record for the Jurassic is modest. Nevertheless, in the Cretaceous, squamates showed a big radiation while rhynchocephalians decreased dramatically. For many years, it has been suggested that the radiation of Cretaceous squamates could have been the cause of the decline of rhynchocephalians, but to date no empirical evidence has been provided. In order to study the macroevolutionary patters of Mesozoic lepidosaurs, we compiled a database of 2D images of lower jaws to perform a geometric morphometrics analysis in R using the package Geomorph. We found that Jurassic rhynchocephalians occupied a wide morphospace while squamates formed a tight cluster, but without overlapping between both groups, suggesting distinct feeding functions. On the other hand, Cretaceous rhynchocephalians showed a considerable decrease in morphospace while squamates had a huge expansion that overlaps more than 80% of the rhynchocephalian morphospace. Our work is novel by providing for first time some quantifiable evidence to support the radiation of Cretaceous squamates as the possible cause of the rhynchocephalian decline in the late Mesozoic.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

A RE-EVALUATION OF THE CROCODYLIFORM *BATRACHOMIMUS PASTOSBONENSIS* FROM THE LATE JURASSIC OF BRAZIL: IMPLICATIONS FOR NEOSUCHIAN PHYLOGENY, BIOGEOGRAPHY, AND DIVERGENCE TIMING

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Batrachomimus pastosbonensis, a crocodyliform based on a skull and jaws from the Late Jurassic of Maranhão State, Brazil, was initially described as a paralligatorid neosuchian. Paralligatorids are otherwise known only from the Cretaceous of Laurasia. Along with other groups thought to represent derived Gondwanan neosuchians (e.g., susisuchids), *Batrachomimus* suggested that Eusuchia, and possibly Crocodylia itself, arose in Gondwana during the Jurassic and not, as long believed, in Laurasia during the Cretaceous.

Based on examination of the type specimen, we reinterpreted several character state codings for *Batrachomimus* in the data matrix used in the original description. We also added it to a matrix with expanded taxon (both ingroup and outgroup) and character sampling. In both cases, maximum parsimony and Bayesian analyses recovered *Batrachomimus* as a basal notosuchian. The external naris is divided by tall ascending rami of the premaxillae similar to those of many notosuchians. *Batrachomimus* shares with all notosuchians a reduced and sculpted lateral margin of the squamosal and a sinusoidal snout contour in dorsal view. It shares with notosuchians more derived than *Anatosuchus* caudal tips of the nasal that converge at the sagittal plane, a sinusoidal ventral edge of the maxilla in lateral view, and a surangular that does not reach the posterior end of the retroarticular process. *Batrachomimus* and notosuchians to the exclusion of *Anatosuchus* and peirosaurids share a choana with an anterior edge situated anteriorly between the suborbital fenestra and a dentary symphysis that tapers to an acute angle anteriorly. Absence of an external mandibular fenestra originally linked *Batrachomimus* to paralligatorids, but we interpret the smooth, modestly concave dorsal margin of the angular as the ventral margin of a mandibular fenestra. Constraining *Batrachomimus* to be a paralligatorid results in trees that are 13 steps longer.

Although arguably not a paralligatorid neosuchian, *Batrachomimus* is central to understanding early mesoeucrocodylian radiations. Its anteroposteriorly long internal choana resembles that of several protosuchian-grade crocodyliforms, suggesting more complex evolutionary history of the mesoeucrocodylian secondary palate than previously expected. It also helps fill a substantial gap in the notosuchian record and bears on optimizations of notosuchian adaptations as terrestrial predators.

Grant Information
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Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

MOLAR RELIEF INDEX OF EXTANT AND FOSSIL BATS WITH APPLICATION TO DIETARY HABITS

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For many fossil mammals, dentitions and isolated teeth are the only means to reconstruct their ecology. The size-independent relief-index is a tool for investigating dietary preferences. It determines the complexity of tooth crown shape by a quotient of its 3D surface area and 2D base area. In this study, relief index values of all three upper and lower molars of bats, if present, are compared to test the hypotheses that despite morphological differences molar complexity does not vary much throughout the tooth row and relief index values of all molar positions can be used to determine the diet of bats.

3D models of mostly unworn molars of 30 extant bat species were analyzed. Bats are a highly diverse group that developed a variety of different feeding strategies and dentitions, among them insectivory, carnivory, omnivory, frugivory and nectarivory. The range of values remains roughly the same throughout the molar row in frugivores, while the values of omnivores, carnivores and insectivores are generally lower in the upper dentition. In all molar positions with the exception of m3, there is a clear separation of nectarivorous/frugivorous and insectivorous bats. The gap between these dietary habits is most distinct in the m2 and smaller in the other molar positions. There is no clear separation of omnivorous and carnivorous bats from frugivorous or insectivorous bats. The values of omnivorous bats overlap with the values of both frugivores and insectivores or occupy the gap between them in the m1–m3 and M3 positions. For M1 and M2, they are considerably lower and within the range of frugivorous bats. The values of carnivorous bats are similar to those of insectivorous bats in m1 and m2. In m3 and M1–M3, they are within the lower range of insectivorous values with some falling within the frugivorous range.

Molars of several fossil bats from the late Oligocene fissure fillings of Herrlingen, Germany, were studied for comparison. Most molars are isolated m1s and show a tribosphenic pattern, indicating an insectivorous diet. The majority of the relief index values of the fossils falls within the lower range of the extant insectivorous bats or below it, supporting an insectivorous adaptation. In the case of *Myotis minor* and *M. horaceki* from Herrlingen, the values range from 3.6 to 3.8. Compared to the extant *M. myotis*, which has values ranging from 4.2 to 4.5, the fossil bats have distinctly lower values which may indicate an increase of tooth crown complexity over time.

Grant Information
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Poster Symposium I (Wednesday–Thursday, October 26–27, 2016, 4:15–6:15 PM)

COLOR AND CHEMISTRY AS PROXIES FOR ENVIRONMENTAL CHANGE DURING THE UINTAN NORTH AMERICAN LAND MAMMAL 'AGE' (NALMA) AND AT THE BOUNDARY BETWEEN THE UINTAN AND DUCHESNEAN NALMAS

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The middle Eocene of the Uinta Basin in north-central Utah is recorded in the Uinta Formation and the overlying Duchesne River Formation, namesakes for the Uintan and Duchesnean North American Land Mammal 'Ages.' Abundant fossils therein document trends in environmental change over this time span. Here, we utilize geochemistry and color analysis to further examine environmental trends and help us understand what environmental changes occurred at the transition from the Uintan to the Duchesnean Land Mammal 'Ages.' Isotopic analyses of brontothere teeth show a trend toward more negative values in carbon over time (from -2‰ to -10‰), which could be representative of a change in environmental structure and plant availability or a change in dietary habits. Our interpretation is the latter due to the fact that *Hyracodon* teeth occurring low in the section show delta values around -9‰. Oxygen values show no clear trend over time, suggesting little to no change in climate, or if there are changes, they offset themselves isotopically. Ongoing serial analysis (multiple samples per tooth) will help clarify this. While the Uinta Formation and the Duchesne River Formation are distinct lithologically, the boundary between them is gradational. The contact lies somewhere in an approximately 10 meter section between mudstones and vertebrate localities that are definitively in the Uinta Formation and large sandstone bodies that are definitely Duchesne River Formation. Isotopic analysis of sedimentary carbonate coupled with analysis of color of the sediments are being used to distinguish between the two formations. A trend toward larger L* values (from 40 to 60) from the Uinta Formation into the Duchesne River Formation is apparent, but its origin is unclear. Isotopic analyses are ongoing, but so far there is no clear pattern of isotopic change across the boundary. Further research is necessary, utilizing teeth of known Duchesnean 'Age' for further isotopic analysis and more detailed work on color and isotopic analysis of sediments across the boundary between the Uinta Formation and the Duchesne River Formation.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

ONTOGENETIC ENDPOINTS AND TAXONOMIC IDENTITIES OF ANKYLOSAURID DINOSAURS FROM THE DJADOKHTA FORMATION OF SOUTHERN MONGOLIA

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The ankylosaur *Pinacosaurus grangeri* is known from dozens of specimens, nearly all representing juvenile or subadult individuals. Several specimens from the Late Cretaceous of southern Mongolia provide new information about the anatomy and sequence of ontogenetic changes in this species and offer context for interpreting growth and development in Ankylosauria.

The first specimen includes a nearly complete skeleton with a vertebral series lacking only the distal caudal vertebrae and tail club. Posterior dorsal vertebrae preserve a previously unrecognized morphology with accessory zygapophyseal articulations. All elements of the synsacrum are preserved in articulation or close association, but unfused to one another. This facilitates description of the individual components of the synsacrum and aids in understanding the fused morphology of the pelvis in other ankylosaurs.

The four sacral vertebrae have unfused neurocentral sutures, ribs, and spinous processes. The sacroiliac articulations, also unfused, shift abruptly from nearly vertical at rib 2 to horizontal at rib 3. Numerous ossified tendons are preserved in association with spinous processes of dorsal vertebrae indicating that these were ossified even in very young individuals, well before the coossification of vertebral elements and elaboration of osteoderms. Most appendicular elements are also preserved, including articulated hands and feet. The ends of long bones are roughened, suggesting the presence of substantial cartilaginous end caps. Despite the close association and articulation of the specimen, no postcervical osteoderms were recovered, suggesting that these had not formed yet.

A second specimen includes a skull that likely represents an adult *Pinacosaurus*. It shares numerous characters with the holotype adult and referred juvenile specimens, including a lacrimal incisure, accessory apertures in the narial region, paired internarial and parietal osteoderms, long mandibular osteoderms, and peaked prefrontal caputegulae. Additional cranial specimens preserve a pedicle-like outgrowth of the squamosal bone, with the squamosal horn preserved as a separate ossification. Several specimens preserve hyobranchial elements consistent with interpretations of a muscular tongue in *P. grangeri*.

Together, these specimens expand the scope of morphologic and ontogenetic variability in *P. grangeri*, provide impetus for taxonomic revision, and may also expand the stratigraphic range of this increasingly understood and abundant dinosaur species.

Symposium II (Friday, October 28, 2016, 10:45 AM)

EVOLUTIONARY ORIGIN OF THE DIAPHRAGM

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The diaphragm, a skeletal muscle settled deep in the thorax, represents an evolutionary novelty in the mammalian lineage. How this de novo origination of a functionally significant muscle occurred is a good example of evolutionary studies, but had remained unclear. We have been working on this question through analyses on both embryonic developments and fossils. In amniotes, limb and tongue muscles develop from the migratory muscle precursor (MMP) cells that are derived from somites with a specific set of gene expressions, whereas body wall muscles do not. In mammalian embryos, the diaphragm develops also from MMP cells from the cervical somites. Therefore, from the developmental perspective, the diaphragm likely evolved from limb or tongue muscles (MMP-derived muscles). According to the fossil record, basal synapsids possessed five cervical vertebrae, and their MMP cells of the forelimb muscles were produced from more rostral somites than those in mammals—that is, the MMP cells of the diaphragm in mammals correspond to those of the forelimb in basal synapsids. Detailed comparison of spinal nerve patterns among amniotes suggests that the diaphragm is comparable specifically to the subscapular muscle of ancestors. Indeed, the subscapular muscle is located medial to the scapular girdle at around the thoracic aperture, and its evolutionary transition to a muscle intervening between the heart and liver is possible. In addition, we demonstrated through experiment of chicken embryos that the deep part of the lateral body wall at cervical levels is moved concomitant with the caudal transposition of the heart during embryonic development. This cellular infolding of the cervical lateral body wall into the thorax brings about the caudad shift of the diaphragm primordium in mammalian embryos. Collectively, the diaphragm probably evolved from the subscapular muscle, and the caudal shift of the forelimb—namely the increase of cervical vertebrae in the synapsid evolution resulted in diversification of the ancestral forelimb MMP cells into the forelimb and diaphragm subpopulations. In other words, a partial duplication of the MMP cell population may be involved in the de novo origination of the diaphragm. Our recent analyses of genes including *Hox* genes in mouse, chicken and axolotl embryos have shown differences in expression pattern at the neck-shoulder region between mammalian and non-mammalian tetrapods, which potentially reflect the partial duplication of the MMP cell population at the evolutionary origin of the diaphragm.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

IS *EUNOTOSAURUS AFRICANUS* REALLY ANCESTRAL TO TURTLES?

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Eunotosaurus africanus has been often hypothesized as an ancestral form for turtles, as they share the wider dorsal ribs and highly reduced number of axial skeletons of body portion. Recent research points out further synapomorphies such as the T-shaped cross-section of dorsal ribs shared with Triassic stem turtles such as *Pappochelys*, *Odontochelys,* and *Proganochelys*. Nonetheless, this theory has a serious weak point—in *E. africanus*, the gastralia were absent, or very poorly developed as reported in just a few specimens, if any. Ontogenetic studies of extant turtles strongly suggest that the chelonian shell was formed as a result of association of both carapacial (dorsal vertebrae and ribs) and plastral (pectoral girdle and gastralia) elements, with reduction of distal portion of dorsal ribs. This scenario seems to be supported by the body plan of Triassic stem turtles. *E. africanus*, however, has uniquely developed distal part of dorsal ribs. Dorsal vertebrae of *E. africanus* indicate a horizontal movement of the body and the presence of intercostal muscles. *E. africanus* has a unique overlapping of dorsal ribs, unknown in any stem turtles. A T-shaped cross-section of dorsal ribs is observed in several tetrapods such as ankylosaurs (Ornithisuchia), armadillos, and anteaters (Xenarthra), not unique to *E. africanus* and stem turtles. In conclusion, *E. africanus* has its own uniquely derived defensive body structure, exclusively depending on dorsal ribs, not probable as an ancestral form to the turtle body plan.

Technical Session VII (Thursday, October 27, 2016, 2:30 PM)

ANAGENESIS AND CRANIOFACIAL ONTOGENY OF *CORYTHOSAURUS*

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The cranial osteology of *Corythosaurus* is well known due to the high sample size from Late Cretaceous North America. Two stratigraphically separate species are known: *C. casuarius* (older) and *C. intermedius* (younger), which have been hypothesized as sexual dimorphs and ontogenetic morphs, but represent an anagenetic lineage. They provide the opportunity for studying anagenesis through ontogeny. The sample of both species includes juveniles, sub adults, and adults. Previous ontogenetic work on *Corythosaurus* is primarily size-based; however, size is variable, where it does not always represent relative maturity. Therefore, the primary goal of this project was to test the hypothesis of the congruence between size and maturity through a numerical cladistic analysis of ontogenetic characters. Using a cladistic approach, ontograms were obtained for the two *Corythosaurus* species. They were then combined into a single matrix to view anagenesis in this context, where all *C. intermedius* specimens were recovered as a polytomy of sub adults. This result sets the baseline of how anagenesis can be diagramed, and falsifies the hypothesis of sexual dimorphism. These results provide ontogenetic changes that can be used as potentially informative characters in cladistic analyses. With the acquisition of ontograms, the hypothesis that growth stages can be assessed via percent maximum skull length was tested using a Spearman Rank Correlation Test. For both species, it was found that relative maturity is not strictly congruent with size. This work provides the foundation for investigating the acquisition of phylogenetic changes in growth series.

Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

A SMALL CTENACANTHIFORM SHARK FROM THE LATEST MISSISSIPPIAN (SERPUKHOVIAN) BEAR GULCH LIMESTONE OF MONTANA

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The group of chondrichthyans referred to as “ctenacanths” remain an enigmatic collection of Paleozoic sharks as their fossil record is dominated by isolated spines, teeth, and occasional endoskeletal elements. Controversy continues as to whether ctenacanths represent a monophyletic group or not and where these forms fit into the origin and radiation of Paleozoic chondrichthyans. Partial skeleton remains of a few ctenacanthiforms, indicate sharks with blunt heads and terminal mouths, cladodont-style teeth, two dorsal fins with ornamented spines, bodies with tri-basal pectoral fin articulation, and a high angle symmetrical forked tail with a ventral lobe supported by few but well developed proximal and distal radials. Here we present data, including a nearly complete and partially articulated male fossil shark from the 323 million year old (Upper Mississippian) Bear Gulch Limestone of Montana that contributes to discussion of “what is a ctenacanth?” The Bear Gulch specimen presents as a new genus and species of Paleozoic elasmobranch that exhibits some features considered typical of ctenacanths. The dentition is similar to the tooth taxa *Saivodus striatus*, *Neosaivodus flagstaffensis*, and to *“Tamiobatis vetustus”* in having tall median cusps, shorten lateral cusps, and two to three intermediate cusps. The presence of a dorsal square shaped, anteriorly directed flange on the otic process of the palatoquadrate is present in this taxon as well as *Ctenacanthus*, *Heslerodus*, “*Tamiobatis*”, and an undescribed but articulated specimen from the Pennsylvanian of New Mexico. This flange articulates just posterior of the postorbital process of the neurocranium, as demonstrated by articulated crania of *Ctenacanthus,* and may be unique to ctenacanths. The Bear Gulch taxon shares with “*Tamiobatis*” an additional dorsal, rectangular-shaped facet on the otic process of the palatoquadrate. The Bear Gulch form differs from other recognized ctenacanth species in features of the upper and lower jaws, dorsal spines with a unique combination of rounded denticles on the lower lateral margin of the spine body that grade into long smooth ridges running towards the tip of the spine, and proportionately smaller pectoral fins. If ultimately confirmed as a valid ctenacanth taxon, it would the smallest adult ctenacanthiform identified to date.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

X-RAY COMPUTED TOMOGRAPHIC RECONSTRUCTION OF THE AETOSAUR *COAHOMASUCHUS* (ARCHOSAURIA, STAGONLEPIDIDAE) AND RE-ANALYSIS OF ITS PHYLOGENETIC RELATIONSHIPS

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Aetosaurs are a clade of armored, quadrupedal herbivorous to faunivorous archosaurs that were widespread across Pangea during the Late Triassic. As one of the few Triassic lineages to have evolved herbivory, the skeletal anatomy of aetosaurs is important for understanding pseudosuchian ecomorphology. However, as armored

animals with osseous dorsal, ventral, and appendicular osteoderms, the internal skeletal anatomy of many species is poorly understood. The best preserved aetosaur specimens are articulated and osteoderms obscure much of the appendicular and axial skeleton.

Multiple specimens of the aetosaur *Coahomasuchus* sp. have been recovered from the Upper Triassic Pekin Formation of North Carolina shedding new light on the anatomy of this taxon. Computed tomographic reconstruction of an incomplete, but largely articulated presacral skeleton (NCSM 23618) provides the first glimpse into the structure of the internal skeleton of *Coahomasuchus* revealing the morphology of elements not otherwise visible including axial and appendicular elements. At least three other specimens representing portions of the postcranial skeleton are known. These specimens are mostly osteoderms (29 dorsal paramedian, 13 lateral) yet also include dorsal vertebrae, a tibia, fibula, and other elements. Aetosaur materials from the Pekin Formation of North Carolina represent the second documented occurrence of *Coahomasuchus* and the only record outside of the American Southwest. Due to the abundance of well-preserved specimens, including skull material, additional characters can be scored for this taxon. Results of a new phylogenetic analysis with updated character scorings for *Coahomasuchus*, *Lucasuchus*, *Longosuchus*, and the recently named *Gorgetosuchus*, recovers *Coahomasuchus* as a basal member of the Typothoracinae, in contrast with a recent analysis that recovers this taxon as highly labile. Additionally, we found *Lucasuchus* to be a wild card taxon, creating a polytomy within Desmatosuchinae. Our results are more congruent with another recent study using a larger character set, which also recovered *Coahomasuchus* as a basal member of Typothoracinae. Furthermore, with a width:length ratio of homologous dorsal paramedian osteoderms of ≥ 3.5:1, the Pekin Formation *Coahomasuchus* is one of the stratigraphically oldest occurrences of a wide bodied aetosaur. If *Coahomasuchus* is a typothoracine, then it is the stratigraphically oldest one, and provides further evidence of an initial diversification of aetosaurs prior to the early Late Triassic.

Technical Session VIII (Thursday, October 27, 2016, 2:45 PM)

RECONSTRUCTING THE BEHAVIOR AND ECOLOGY OF THE ANCESTRAL PRIMATE AND FOSSIL TAXA USING COMPARATIVE PHYLOGENETIC TECHNIQUES

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Although morphology alone can suggest certain forms of behavior, a phylogenetic framework based on the behavior of extant species is necessary to make rigorous behavioral inferences for fossil taxa. With a rich fossil record as well as a rich behavioral literature, primates offer an ideal system for inferring the behavior and ecology of extinct species. We aimed 1) to reconstruct a set of morphological, behavioral, and ecological character states at the base of Primates and at other key nodes on the primate phylogeny, 2) to identify the behavioral and ecological traits that separate crown primates from the rest of Euarchonta, and 3) to infer behavioral and ecological traits of fossil taxa both inside and outside the crown clade by incorporating fossil taxa into a combined morphological and molecular tree. Using data collected from wild populations and published in the primary literature, we assembled a dataset of morphological, behavioral, and ecological characters sampled in 178 species spanning the extant diversity of primates; in addition, we included outgroup representatives from 12 families of Dermoptera, Scandentia, and Glires. We performed ancestral-state reconstructions using both Bayesian and maximum-likelihood techniques, so that we could compare the reconstructions obtained by each method and thereby test the robustness of our results. With strong support, we reconstructed the ancestral primate as nocturnal, arboreal, frugivorous-insectivorous, and sexually monomorphic in body size. We found that frugivory and insectivory were also present at the euarchontan node, dated to ~92 Ma, a finding with implications for several adaptive hypotheses for primate origins. Similarly, we found that reduced litter size—with the suggestion of a general slowdown in reproductive strategy—first appeared at the euarchontan node rather than the primate node. Stem primates (including *Purgatorius*, *Plesiadapis*, and *Carpolestes*) and fossil taxa within the crown (including *Notharctus*, *Darwinius*, and *Rooneyia*) were inferred to show a mixture of haplorhine and strepsirrhine-like, general primate-like, and general euarchontan dietary and locomotor behaviors. These results call into question adaptive and functional inferences for fossil primates that are based exclusively on morphology and fail to take into account the phylogenetic patterning of behavioral traits.

Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

THE FIRST POSTCRANIAL REMAINS OF A GONDWANATHERIAN MAMMAL

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Until recently, the fossil record of Gondwanatheria was chronicled almost exclusively on the basis of isolated teeth and fragmentary jaws. The first cranium of a gondwanatherian, belonging to *Vintana sertichi* from the Upper Cretaceous (Maastrichtian) Maevarano Formation of northwestern Madagascar, was described only in 2014. Here we present the first complete skeleton of a gondwanatherian, also from the Maevarano Formation. The specimen belongs to a new genus and species and provides the first postcranial evidence for Gondwanatheria. It also represents only the fourth taxon known from articulated postcranial material for any Mesozoic mammaliaform from the Southern Hemisphere (the others belong to the morganucodontans *Megazostrodon* and *Erythrotherium*, and the stem therian *Vincelestes*).

The preservation of the postcranial skeleton of the new Malagasy mammal is exceptional; even the costal cartilages and manual and pedal sesamoid bones are preserved. The specimen exhibits a mosaic of derived and basal traits, probably reflective of a long evolutionary history in geographic isolation on Madagascar. Among the bizarre and unique features are a mediolaterally compressed and anteroposteriorly bowed tibia, a double trochlea on the astragalus, a fully developed humeral trochlea, and an unusually high number of trunk vertebrae. The new taxon has at least 19 rib-bearing (thoracic) and 11 non-rib-bearing (lumbar) vertebrae. Aside from these derived features, the Malagasy mammal is evolutionarily intermediate in its pectoral girdle morphology: the procoracoid is lost, the coracoid is extremely well developed (into an enlarged process that contributes to half of the glenoid fossa), the interclavicle is small, and the sternoclavicular joint appears mobile. A ventrally facing glenoid and the well-developed humeral trochlea suggest a relatively parasagittal posture for the forelimbs. Remarkable features of the hind limb and pelvic girdle include a large obturator foramen similar in size to that of therians, a large parafibula, and the presence of an epipubic bone. The new postcranial material provides the first opportunity to test the phylogenetic position of Gondwanatheria within Allotheria (Gondwanatheria, Multituberculata, Euharamyida) based on more than just cranial and dental evidence, the subject of ongoing study.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

A SKULL OF *ARCTOCYON FEROX* (MAMMALIA, ARCTOCYONIDAE) FROM THE PALEOCENE OF WYOMING

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An excellent skull of *Arctocyon ferox* represents the most complete specimen preserving the cranial osteology of North American *Arctocyon*. The specimen comes from Paleocene sediments of the Polecat Bench Formation in Wyoming. It is missing the most anterior portions of the rostrum, including the premaxillae, and the most posterior portions of the occiput, but it is otherwise nearly complete and preserves a number of details of the orbit and ear region. The specimen is almost indistinguishable from the skull of *Arctocyon primaevus* from the Paleocene of France and further supports the inclusion of the North American and European species in the same genus. The Wyoming specimen preserves some details that are not as clear in European material of *Arctocyon*, including the presence of an alisphenoid canal. *Arctocyon* is often scored in phylogenetic studies as lacking this canal, and the absence of the alisphenoid canal is sometimes used as evidence of a close relationship between arctocyonids and artiodactyls. The clear presence of this canal in the Wyoming specimen indicates that absence of the canal is not a shared feature of these taxa. Phylogenetic analyses including information from this skull do not support a close relationship between *Arctocyon* and artiodactyls.

Grant Information
This study is supported by an award from the U.S. National Science Foundation (DEB-1456826).

Technical Session XII (Friday, October 28, 2016, 2:45 PM)

THE SOFT TISSUES OF THE DORSOTEMPORAL FENESTRA OF ARCHOSAURS AND ITS SIGNIFICANCE FOR DINOSAUR BIOLOGY

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The dorsotemporal fenestra has long been viewed as a largely muscular osteological correlate of tetrapods, where it allows for the attachment and bulging of temporal muscles during feeding. This long established but largely untested idea imparts numerous biases in our understanding of systematics, cranial biomechanics, and physiology of extinct and extant archosaurs. We used multiple lines of evidence, including dissection, vascular injection and radiographic imaging of extant alligators, several bird species, and iguanas, assessment of osteological correlates in extinct vertebrates, 3D muscle reconstruction and biomechanical modeling, thermography of living alligators, and phylogenetic comparative approaches to test hypotheses of soft tissue homology and biomechanical significance. We present findings that indicate: 1) in archosaurs, the rostral portion of the dorsotemporal fenestra (the frontoparietal fossa) is not a jaw muscle attachment as has been previously hypothesized; 2) the frontoparietal fossa and periphery of the fenestra are instead excavated by temporoorbital vasculature; and 3) using these vessels, minimally crocodyliforms and perhaps other archosaurs may have evolved a physiological device within the dorsotemporal fenestra that, at least on an anatomical basis, may be capable of influencing cephalic tissue temperatures independent of body core temperatures. The frontoparietal fossa remains conspicuous among primitive dinosaur groups, but later varies considerably among more derived clades of dinosaurs, such as ceratopsians and coelurosaurs. Although the bony feature is ultimately lost during avian evolution, homologous vasculature and sometimes carunculate skin remain. The frontoparietal fossa reached enormous proportions in large theropod taxa such as *Tyrannosaurus*, suggesting that theropod dinosaurs may have emphasized the temporoorbital vessels for a physiological role, potentially cephalic thermoregulation, and/or to support soft tissue ornamentation or display structures on their skull roofs. These new anatomical findings demonstrate the complicated interaction of muscular, vascular, and skeletal systems in a key cephalic region and will impact future hypotheses of dinosaur cranial biomechanics, behavior, and physiology.

Grant Information
Funding: NSF IOS-1457319 to CMH; NSF IOS-1050154 and IOS-1456503 to LMW.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

INSIDE DINOSAURS: A BROADER IMPACTS PROGRAM FOR RESEARCH, TEACHING AND PUBLIC EDUCATION THROUGH DINOSAUR BIOLOGY, PHYSICS AND EVOLUTION.

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States of America; WITMER, Lawrence M., Ohio Univ, Athens, OH, United States of America; MIDDLETON, Kevin, University of Missouri School of Medicine, Columbia, MO, United States of America

Inside Dinosaurs is a NSF-funded, multi-pronged broader impacts program that immerses undergraduate research interns, secondary-school science teachers, and the public in evolution, biomechanics and avian origins through a series of parallel and complementary activities. It incorporates STEM disciplines and offers opportunities for graduate and undergraduate lab members to interact with the local public and grade 6-12 teachers through science communication and outreach activities. Besides annual REU lines for University of Missouri undergraduates, we host two undergraduates from other institutions each summer to learn new experimental, modeling and anatomical techniques. Additionally, we recruit a local teacher each summer who, while embedded in the lab, conducts research and helps translate our discoveries into secondary school-level learning activities that fit within the Next Generation Science Standards. Together, the PIs, students, and teachers are developing and testing new classroom activities that are disseminated to interested Missouri teachers through a series of workshops. Besides these intense, lab-based interactions, Inside Dinosaurs sponsors the Dinosaurs and Cavemen Science Expo, a pop-up natural history museum exhibit that hosts two dozen activities put on by over thirty faculty and students and experiences crowds from 500-1000 people each year. These synergistic activities among faculty, teachers and visiting students help design and develop more specific learning activities to help bring paleontology, biomechanics, and anatomy to Central Missouri and the rest of the country.

Grant Information
NSF IOS 1457319

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

PHYTOSAURIAN CRANIAL EVOLUTION: INSIGHTS FROM GEOMETRIC MORPHOMETRICS

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Phytosauria was a clade of reptiles that included the largest, most common non-marine predators during the Late Triassic, until their end-Triassic extinction. As such, understanding the evolution of phytosaurs is crucial for understanding the evolution of the entire Late Triassic trophic system. To date, no quantitative comparative anatomical or functional morphological study of phytosaurs has been conducted, leaving assumptions about their ecology and role in the trophic system largely untested. Phytosaurs are characterized by a number of cranial apomorphies, including a unique morphology of the temporal region of the cranium. Temporal morphology is intimately linked to the organization of jaw musculature and, thus, to feeding mechanics and behavior. The unique temporal morphology of phytosaurs appears to have evolved via directional selection, though this apparent trend has not been explicitly examined. Here, geometric morphometrics was used to characterize and quantify the morphological disparity of phytosaurian crania, with an emphasis on the temporal region. Thirty-six unilateral landmarks, as well as semilandmarks, were used to characterize the 2D cranial morphology of 15 phytosaurian taxa, in dorsal view. Landmark data were analyzed using PCA in order to plot taxa within morphospace based on temporal region morphology. Results from these analyses recovered distinct clusters of taxa in cranial morphospace that are generally consistent with the gross topology of recent phylogenetic analyses. Early branching taxa formed one cluster (cluster 1), and successively later branching taxa clustered along a gradient between cluster 1 and another cluster comprising the latest branching taxa. The morphological differences that distinguish these clusters include: (1) caudal elongation of the squamosal; (2) widening of the postorbito-squamosal bar such that the supratemporal fenestra is reduced and displaced to the posterior margin of the cranium; and (3) slight expansion of the infratemporal fenestra toward the lateral margin of the cranium. These traits are here hypothesized to be related to functional differences between the crania of the taxa representing each cluster and the result of directionally selected niche and feeding behavior specializations that evolved within Phytosauria. These data on the evolution of phytosaur cranial morphology are the foundation of an ongoing effort to investigate the functional morphology of phytosaur skulls and test long-standing assumptions about phytosaur feeding behavior and ecology.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

SEDIMENTOLOGY AND TAPHONOMY OF THE *ABYDOSAURUS MCINTOSHI* QUARRY, (CEDAR MOUNTAIN FORMATION, MUSSENTUCHIT MEMBER; EARLY CRETACEOUS, LATEST ALBIAN), DINOSAUR NATIONAL MONUMENT, UTAH.

HOLMES, Aaron D., Brigham Young University, Provo, UT, United States of America; BRITT, Brooks B., Brigham Young Univ, Provo, UT, United States of America; CHURE, Daniel J., Dinosaur National Monument, Jensen, UT, United States of America; WILSON, Jeffrey A., University of Michigan, Ann Arbor, MI, United States of America; SCHEETZ, Rodney D., Brigham Young Univ, Provo, UT, United States of America

The type locality (DNM-16) of the brachiosaurid titanosauriform *Abydosaurus mcintoshi* is at the base of the Mussentuchit Member of the Cedar Mountain Formation. The site is bounded by smectitic clays/paleosols above and below. Detrital zircons from the underlying clay date to 104 Ma. The smectitic clays and the channel's incision into the Ruby Ranch Mbr indicate the quarry is within the Mussentuchit Mbr, the base of which is latest Albian.

The bones are preserved at and near the base of a heterolithic, trough-cross-stratified, clay-rich, sandstone channel. The channel represents the lowest fill of a paleovalley ~500 m wide and ~6 m-deep. The valley formed following a base level drop, and the bones were buried following a rise in base level during the initial fill of the incised valley. The trough-cross-bedded sandstones mark a time of rapid flow though the paleovalley and, based on bones whose upper surfaces were eroded off before final burial, likely represent intermittent flows of a braided stream.

The site has yielded ~200 specimens, all of which pertain to *Abydosaurus* except for several small theropod teeth. About one-third of the bones occur in close association or articulation, including: three skulls (one articulated with the first five cervical vertebrae) and three limbs, several with meso- and metapodials, and three short strings of caudal vertebrae. Preburial breakage is minimal, and there are no undoubted scratch marks. There is no evidence of preburial weathering. The articular ends of >8 bones have deep excavations instead of articular surfaces and irregular pits occur on the shafts of >20% of the bones. The irregular pits match the morphology of termite foraging traces, and the missing epiphysial ends indicate extensive mining by these insects. The distribution of insect traces ranges from a single side to all sides of the infested bones. Braincase count indicates there are at least four individuals of *Abydosaurus* and postcranial elements show two or three ontogenetic stages are present. Recovered femora range from 92 – 140 cm, and the longest cervical vertebra are 30 – 70 cm. The type of *Abydosaurus* is a 38 cm skull with five cervicals (longest = 30 cm) pertaining to a ~40%-grown juvenile.

Together, these observations indicate: 1) animals died in a paleovalley; 2) carcass degradation allowed separation of necks and limbs from the bodies when fluvially entrained; 3) the bones, some with intact soft tissues, were minimally transported in an ephemeral flow of a braided stream; 4) termite infestation occurred prior to fluvial entrainment or after burial.

Poster Symposium I (Wednesday–Thursday, October 26–27, 2016, 4:15–6:15 PM)

***PROTOREODON* AND THE DIVERSIFICATION OF BASAL RUMINANTS**

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The middle Eocene was a time of significant diversification among artiodactyls with the appearance of basal ruminants (deer and sheep), suids (pigs and peccaries), tylopods (camels and llamas), and whales. The phylogeny of the initial splits among these clades is still poorly resolved, particularly when Eocene taxa are included. This lack of resolution stems in part from a lack of data for the postcranial skeleton and an underappreciation of the range of postcranial morphology exhibited by Paleogene artiodactyls. We fill some of this gap in our knowledge by focusing on the potentially polyphyletic complex of middle Eocene species of *Protoreodon* from the southwestern United States. *Protoreodon* has been considered either an agriochoerid oreodont or one of several Eocene taxa near the base of Ruminantia.

Our work focuses on both restudy of the type material and detailed description and analyses of new collections from the Uinta Formation of eastern Utah that include the first associated skeleton of the type species *Protoreodon parvus* and other *Protoreodon* spp. partial skeletal associations. The postcrania of *P. parvus* shows many morphological differences from slightly younger and larger species that have been previously described. Notable differences are in the tarsal complex, ankle, and elbow in features associated with both smaller body mass and a more cursorial gait.

This variation among *Protoreodon* species suggests differences in locomotor behavior even among species currently thought to belong to this genus, as well as in comparison to other small Eocene artiodactyls. This finding suggests that previously published scorings in phylogenetic matrices based on species composites are not likely to be representative for the genus. Therefore, for each available species, we scored the new data available for the dentition and postcrania into two recent phylogenetic matrices and examined alternative interpretations of character polarities and reconstruction of ancestral locomotor modes for ruminants in light of alternative placements of *Protoreodon* spp. relative to one another and also to other early Paleogene artiodactyls. Although we cannot yet resolve the pattern of middle Eocene diversification of North American artiodactyls, our findings clearly highlight the utility of comprehensive restudy of basal artiodactyls to capture the full range of morphological diversity.

Grant Information
This work has been supported by Midwestern University and University of California Museum of Paleontology with permission from the Bureau of Land Management.

Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

RELATIVE ABUNDANCE IN THE MAMMALIAN FAUNA OF FOSSIL LAKE, OREGON, WITH IMPLICATIONS FOR UNDERSTANDING COMMUNITY COMPOSITION IN THE REGION

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The sediments of Fossil Lake preserve a large and diverse assemblage of Pleistocene vertebrates from south-central Oregon. These remains from an ancient playa provide an invaluable record in a region with a notable paucity of Pleistocene vertebrate localities. Fossil vertebrate materials have been collected from this site since 1877. The University of California Museum of Paleontology (UCMP) houses some of the earliest of these collections, including materials from the 1901 expedition by Annie Alexander and the 1923–1924 excavations by Stock and Furlong. These early collections provide an important window into the community composition of the vertebrate fauna.

Our work focused on identifying specimens and calculating relative abundance of the taxa present. We re-examined the 1073 mammal specimens from Fossil Lake in the UCMP collection and identified each to exact element, taxon, and side of body where applicable. For each taxon, we tabulated the number of identified specimens (NISP) and used the most common individual element to determine the minimum number of individuals (MNI). A comprehensive revision of the mammalian faunal list from this site has not been published since 1934. Here, we also present an updated faunal list, including more precise identifications that address synonyms and remove nomina dubia.

Equus, represented by two taxa of disparate body size, were the dominant faunal members with an MNI of 31 based on the number of left naviculi. Together, these comprised 72% of the total mammalian MNI for the site and 85% of our total NISP for Fossil Lake. Analysis of community composition showed camelids to be the second most common contributor at 14% of total MNI. *Mammuthus columbi* is represented by only two individuals, an adult and an adolescent. Predators and other large mammals such as *Paramylodon harlani* are present but are equally rare. The taxa found are indicative of a xeric grassland environment. The preponderance of horse specimens may suggest a herd

social structure, as is the case for present-day wild horses. We found a notable difference from typical attritional death assemblages, which are dominated by comparatively young and comparatively old individuals. The age-structure for *Equus* found in the Fossil Lake collection includes no young juvenile specimens and suggests that horses utilized the lake primarily during late summer through winter and foaled elsewhere.

Technical Session XVIII (Saturday, October 29, 2016, 3:15 PM)

EVOLUTION OF POTENTIAL CURSORIAL ADAPTATIONS IN MESOZOIC THEROPODA: PHYLOGENETIC, GEOCHRONOLOGIC, AND BIOGEOGRAPHIC DISTRIBUTIONS

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Assessing cursoriality (adaptation towards increased terrestrial locomotor performance at less energetic cost) in extinct organisms remains difficult. In particular, the actual performance values involved in the locomotion of extinct animals (e.g., maximum speed; maximum acceleration; average speed; duration of bouts of movement; size of home range; etc.) are currently beyond our ability to estimate with accuracy. Nevertheless, osteological attributes associated with cursoriality can be assessed and their distribution examined to trace the potential evolutionary history of the phenomenon within clades.

The present study is a phylogenetic comparative analysis of the distribution of these traits within Mesozoic non-volant theropod dinosaurs. The locomotory apparatus remains largely similar despite a nearly four order of magnitude size range. Work of the last several decades has studied many aspects of the functional anatomy and biomechanics of the theropod hindlimb, and our knowledge of the phylogeny and anatomical diversity of this clade has similarly greatly improved.

A new time-calibrated species-level supertree of theropod dinosaurs and their outgroups is assembled. BayesTraits was used for ancestral state reconstruction for potential cursorial characters including: proportional increases in the pre- and postacetabular portions of the ilium; elongation of the distal limb elements (tibia and metatarsus); alternative morphologies interlocking and reducing the mediolateral width of the metatarsus; size and position of the lesser and fourth trochanters; and length along caudal series of transverse processes. Nodes where statistical significant deviation from the main distribution (tested as residuals from allometric regressions of these traits) were identified.

Nodes of significant variation from the ancestral status were not randomly distributed across the phylogeny. Instead, significant evolution of cursorial adaptation was restricted to a small number of clades: those in which these are strongly expressed are the Jurassic "elaphrosaurs" and Cretaceous Noasauridae within Ceratosauria; variably in particular nodes within Oviraptorosauria and Troodontidae; and especially well-developed in Tyrannosauridae, Ornithomimidae, and Parvicursorinae. Similarly, these cursorial nodes are most strongly present in clades restricted to the Late Cretaceous Asiamerican landmass.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

SAUROPODOMORPH DIVERSITY IN THE EUROPEAN TRIASSIC: A NEW SAUROPODIFORM FROM THE NORIAN–RHAETIAN OF SWITZERLAND

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Sauropods, the large, long-necked dinosaurs that are well-represented in the vertebrate faunas throughout the Mesozoic era, most probably originated from small bipedal/quadrupedal basal sauropodomorphs. However, their origin and early evolution are not well understood. Depending on the definition of Sauropoda adopted, phylogenetic studies indicate that this transition must have taken place between the Late Triassic (Norian/Rhaetian) and the late Early Jurassic. Well-preserved material of derived, non-sauropodan sauropodomorphs from this time is known from Argentina and South-Africa. Although the Triassic of Europe has yielded a wealth of sauropodomorph material, all Triassic taxa recorded so far are quite basal, non-sauropodiform taxa, representing plateosaurids or more basal forms, with the exception of the enigmatic *Camelotia*. Apart from named taxa, which include *Thecodontosaurus*, *Pantydraco*, *Efraasia*, *Plateosaurus*, *Camelotia* and *Gresslyosaurus*, there is material that has not yet received much attention. The museum of Zurich University holds fragmentary sauropodomorph material found at Schleitheim in the Kanton of Schaffhausen, Switzerland, tentatively dated to be latest Norian to Rhaetian in age. The material had previously been assigned to *Plateosaurus*, but was found to differ from this taxon in a recent re-examination. The material consists of several presacral and caudal vertebrae, a partial humerus, ilium, partial femur, and other fragmentary appendicular elements, which are most probably derived from one individual. The material differs from all other known basal sauropodomorphs in the development of the postacetabular blade and the brevis shelf of the ilium and the crista tibiofibularis of the femur, and thus represents a new taxon. An extensive phylogenetic analysis combining two recent matrices with additional new characters, retrieves this specimen as a derived sauropodiform or even a basal sauropod, depending on which definition of Sauropoda is used. It is more derived than *Antetonitrus*, but more basal than *Isanosaurus*, *Pulanesaura*, and *Vulcanodon*, placing it within the phylogenetic nexus of the sauropodomorph-sauropod transition. This not only confirms the presence of derived non-sauropodan sauropodiforms in the Late Triassic of Europe, but also proves a greater diversity of sauropodomorphs in the Late Triassic of Europe than previously assumed.

Grant Information
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Technical Session XVI (Saturday, October 29, 2016, 8:00 AM)

APPLICATION OF QUANTITATIVE BIOSTRATIGRAPHIC METHODS TO THE RECORD OF TERRESTRIAL VERTEBRATES: CAN WE GAIN NEW INSIGHTS?

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Biostratigraphy is key to finding the age of most fossil faunas because absolute dating is frequently impractical or even impossible. While rigorous quantitative methods for reconciling biostratigraphic data across sections or cores have been developed over the last few decades for assemblages of marine invertebrates and microfossils, terrestrial vertebrate assemblages make the application of such methods challenging. The lack of continuous, productive sections with vertically stacked assemblages makes it difficult to reconcile order of occurrence of fossil faunas. Appearance Event Ordination (AEO) offered one of the first efforts to apply quantitative methods to the terrestrial vertebrate record, demonstrating that the North American record of Cenozoic mammals offered a rich dataset for quantitative analysis. However, the North American mammal biostratigraphy is still organized around a small number of key stratotype faunal assemblages. We compare this biostratigraphy to that obtained from another promising method, Unitary Associations (UA), developed for the marine fossil record. Analysis of a pilot data set drawn from the MIOMAP database reveals that UA obtains a result resembling the framework long-established from study of these faunas in stratigraphic and geologic context as well as that from AEO. In addition, the UA method allows us to infer that while assemblages of as few as two species can be confidently assigned biostratigraphic ages, obtaining a sample of ten species from an assemblage allows assignment within +/- 2 million years in all studied faunas. This method also recovers some of the biogeographic structure in the North American faunal assemblages (for example finding distinct associations for some groups of Great Plains, Rocky Mountain, and Northwest assemblages during the Arikareean), emphasizing the importance of accounting for geographic differences in the species pool from which assemblages were drawn. As the North American faunal record has improved in tandem with improving methods, increased absolute dating precision, and increased computing power, it is increasingly useful to apply quantitative methods to improving and assessing the quality and robustness of our biostratigraphic reconstructions.

Poster Symposium II (Friday–Saturday, October 28–29, 2016, 4:16 PM)

PALYNOLOGY OF THE LATE JURASSIC MORRISON FORMATION: NEW INSIGHTS INTO FLORISTICS, PALEOCLIMATE, PHYTOGEOGRAPHY, AND TETRAPOD HERBIVORY

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The poor plant fossil record of the Late Jurassic Morrison Formation is in stark contrast to its rich metazoan faunas: high levels of oxidation and alkalinity throughout the formation conspire to limit preservation of plant fossils. Although subject to some of the same taphonomic limitations, and with lower taxonomic resolution, pollen and spores are a valuable proxy for plant megafossils, are far more abundant and display higher species diversity. Data from over 50 samples collected from 35 localities in five states (Arizona, New Mexico, Utah, Colorado, and Wyoming) from all stratigraphic levels of the Morrison have yielded new understanding of floristic composition, paleoclimate and phytogeography, with important implications for faunal interactions. Morrison palynofloras are almost always dominated by conifers (primarily Araucariaceae, Pinaceae, and the extinct family Cheirolepidaceae) with spore-bearing bryophytes, clubmoss relatives and horsetails subdominant. Ginkgophytes, cycads and cycadeoids, and gnetophytes are present but rare (although phenology and distribution might underestimate their actual abundance on the landscape). Vegetation structure cannot be inferred from palynology but was probably open; the immense tetrapod fauna probably helped maintain an open structure even if a more closed canopy could have otherwise been supported. Palynology supports sedimentological evidence of seasonally dry conditions throughout the Morrison, based on the relatively low abundance and diversity of spores (produced by plants that usually require wetter and less open habitats). Basins in New Mexico appear to have been particularly arid, judging from the notably higher abundance of the xerophytic Cheirolepidaceous conifers. Fossil pollen and spores were preserved in ephemeral or rare perennial bodies of water and so are somewhat skewed toward wetter habitats; nevertheless, these were attractive habitats for tetrapods (and aquatic fauna, of course) and so yield valuable information about available browse for herbivores. Some of the important dinosaur quarries, such as Mygatt-Moore in Colorado, apparently represented 'watering holes' and are dominated by plants characteristic of modern aquatic habitats such as *Isoetes*, *Equisetum*, and ferns. Conifers most likely comprised the primary food source for large herbivores, as they contain the greatest biomass, although ferns and related herbaceous pteridophytes were probably a secondary source of browse.

Technical Session XIII (Friday, October 28, 2016, 1:45 PM)

THE EARLY PALEOGENE RISE OF PLACENTALS AND DECLINE OF MULTITUBERCULATES: INSIGHTS FROM ANALYSIS OF DENTAL DISPARITY, MORPHOSPACE OCCUPATION, AND BODY SIZE OF EARLIEST TORREJONIAN (TO1) MAMMALS FROM NORTHEASTERN MONTANA, USA

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The rise of placental mammals in the aftermath of the Cretaceous–Paleogene (K–Pg) mass extinction event is well documented. However, the timing and pattern of the changeover from more ancient lineages to the lineages leading to extant placental orders remains poorly resolved. The Tullock Formation in northeastern Montana provides an excellent window into a key time interval to address this gap. It preserves fossils from the first 1.2 million years after the K–Pg (66.04–64.87 Ma), spanning the Puercan (Pu1 and Pu3) and earliest Torrejonian (To1) North American Land Mammal 'ages.' Over 8,000 mammalian specimens have been recovered from earliest Paleogene localities in this study area, including more than 200 from the To1 localities. Analyses of earliest Paleogene local faunal dynamics have shown that from Pu3 to To1 multituberculates sharply declined in both taxonomic richness and relative abundances, while placentals, most notably plesiadapiform primates and 'archaic ungulates,' came to predominate. What changes in dental disparity, morphospace occupation, and body size accompanied this transition? And what do they indicate about changes in the ecological structure of these mammalian faunas?

Here, we report on patterns of dental disparity, morphospace occupation, and body size in the To1 mammalian fauna from northeastern Montana. We applied landmark- and semi-landmark-based geometric morphometrics to a sample of seven p4s from four multituberculate species and 41 M2/m2s from nine eutherian species. We estimated body mass of these taxa using taxon- and morphology-appropriate regression formulae. Our results indicate that relative to the corresponding aspect of the Pu1 mammalian fauna, (i) To1 multituberculates had similar levels of dental disparity, occupied regions of the morphospace corresponding to mostly animal-based diets, and were on average similar in body mass; whereas, (ii) To1 eutherians had greater dental disparity, occupied a greater amount of the morphospace corresponding to plant-based diets, and were on average larger in body mass. This increased dental disparity and morphospace occupation are primarily attributed to plesiadapiform primates and 'archaic ungulates,' both of which evolved quadrate upper molars and lower molars with broad talonid basins for crushing and grinding foods. Taken together, our results suggest that taxonomic and ecological diversification of placental mammals was underway less than 1 Ma after the K–Pg boundary and was characterized by an expansion in feeding ecologies toward herbivory.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

THE DISCOVERIES IN GEOSCIENCES (DIG) FIELD SCHOOL: HELPING TEACHERS INSPIRE STUDENTS WITH REAL SCIENCE IN THE CLASSROOM

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The Discoveries in Geosciences (DIG) Field School is a unique, non-profit education program for K–12 teachers created by University of Washington Burke Museum paleontologists. The DIG provides teachers with a hands-on, immersive learning experience through a four-day program at an active field research site in the Hell Creek badlands of northeastern Montana. The program began in 2010 with seven local Montana teachers, and has since served 110 teachers from 14 states and reached over 7,000 students.

The mission of the DIG is to connect K–12 STEM (Science, Technology, Engineering, and Math) teachers with scientific research and scientists through ongoing professional development and teaching curricula that extends well beyond the time spent in the field. Fossils spark student (and teacher!) interest and provide a fun and exciting way to engage with science-related subjects including Earth history, life sciences, critical thinking, and examining evidence. The DIG provides unique hands-on experience and professional training for teachers, who then bring real science into their classrooms. This "real world" professional development is a critical component of increasing teacher effectiveness and student engagement. Although most teachers are only with us for four days, we foster a continuing relationship with our participants by providing them ongoing educational support throughout the school year. We do this through a variety of methods including specialized curriculum development and education tools (e.g., our traveling "museum in a box"), online lesson plans that implement the current Next Generation Science Standards (NGSS), and classroom and museum visits.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

A RECONSTRUCTION OF THE SKULL OF *SAPEORNIS* AND CRANIAL EVOLUTION IN EARLY BIRDS

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Here we describe in detail the cranial anatomy of *Sapeornis chaoyangensis*, the largest Early Cretaceous basal pygostylian, and provide an accurate reconstruction of the skull of this taxon. This study is based on a survey of more than 60 specimens in the Shandong Tianyu Museum of Nature together with data from previously reported specimens preserving skull material. New specimens reveal the morphology of the dentary teeth and suggest their absence in previously reported specimens of *Sapeornis* is taphonomic. One specimen preserves the cranial bones in disarticulation, making it possible to observe the independent morphology of each element. This specimen provides the first information on the palate and preserves a complete jugal bar, both of which retain primitive morphologies similar to *Archaeopteryx* and nonavian theropods. This study indicates that *Sapeornis* and other Early Cretaceous basal birds were incapable of significant cranial kinesis. However, the widespread presence of dental reduction among Early Cretaceous basal birds, with such trends being largely absent in sympatric lineages of the more derived enantiornithines, suggests that cranial morphology has a greater phylogenetic signal, whereas dental morphology is more strongly influenced by diet.

Grant Information

National Basic Research Program of China 973 Program (2012CB821906), National Natural Science Foundation of China (41372014, 41402017 and 91514302)

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

A NEW NANHSIUNGCHELYID TURTLE FROM THE LATE CRETACEOUS OF JIANGXI, CHINA

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A large turtle specimen from the Late Cretaceous of Jiangxi Province (China) is stored at the Anhui Geological Museum (Hefei, China). This specimen is represented by a shell associated with a skull. The carapace is almost complete, although damaged, whereas condition of the plastron is unknown. No limb bones are exposed. The maximum length of the carapace is about 120 cm as preserved. The shell surface is ornamented with deep pits. Scute sulci are wide and deep. These features are characteristic for members of the family Nanhsiungchelyidae. A very deep nuchal notch of the carapace between a pair of long anterior processes ("horns") is similar to those of *Anomalochelys angulata* from the Cenomanian of Japan and specimen from the Late Cretaceous of Nanxiong (Guandong Province, China) stored at the Shanghai Science & Technology Museum (Shanghai specimen). However, unlike *A. angulata* and the Shanghai specimen, whose "horns" are formed by the nuchal, the "horns" of the Hefei specimen are formed by peripherals 1, more similar to *Nanhsiungchelys wuchingensis* from the Late Cretaceous of Nanxiong. In addition, the carapace of the Hefei specimen is characterized by wide anterior neurals (similar to *A. angulata* and the Shanghai specimen), unique neural formula of anterior neurals 6>6>4<8>4 and alternatively wedge-shaped costals 3 to 5 (similar to the Shanghai specimen); the pattern of scute sulci is unclear. The skull of the Hefei specimen is about 25 cm long as exposed. Similarly to *N. wuchingensis*, the nasal portion is constricted, being notably narrower than in *N. wuchingensis*. The skull roof is complete, suggesting that the upper temporal emarginations were either small or absent, and covered with the decoration of pits, like in *N. wuchingensis* and the Shanghai specimen. Inclusion of the Hefei and Shanghai specimens into the phylogenetic analysis of Adocusia (Adocidae + Nanhsiungchelyidae) revealed their position in one clade, which forms a polytomy with *A. angulata* and *N. wuchingensis*. This clade is supported by the formula of anterior neurals and alternatively wedge-shaped anterior costals. These data demonstrate that morphological and, probably, also taxonomic diversity of *Nanhsiungchelys*-like nanhsiungchelyids is higher than previously considered. Additional preparation of the Hefei specimen is needed to reveal new details of its morphology.

Grant Information

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Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

GEOLOGY, PALEOECOLOGY, AND TAPHONOMY OF A NEW LATE MIOCENE (HEMPHILLIAN) LOCALITY FROM NORTH-CENTRAL FLORIDA

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In 2015, sand mining near the former town of Montbrook, Levy County, Florida exposed a richly fossiliferous deposit about 4 m below the surface. Its lateral extent exceeds 250 m^2 and its thickness over 2 m. The deposit consists of an upper facies of massively bedded, sandy clay and a lower facies of interbedded layers of alternating sand/gravel and clay. Most of the sand layers consist of well-sorted, fine quartz grains, but others are poorly sorted with rounded grains of phosphate up to 3 cm in diameter. Rounded, rip-up clasts of clay are present in both facies. Fossils of freshwater vertebrates predominate in both facies, consisting mostly of isolated elements of boney fishes, turtles, and *Alligator*. Taxa indicating marine environments in Neogene Florida sites (cetaceans, dugongs, the crocodylian *Thecachampsa americana*) are notably absent, although small numbers of shark and myliobatid ray teeth are present (possibly reworked). Associated or articulated skeletons are rare in the sandy clay facies, but common in the sand layers. Over 50 articulated shells of turtles have been collected, almost all belonging to a species of *Trachemys* near *T. inflata*. Multiple articulated shells of *Macrochelys* and *Apalone* are also present. Articulated turtle shells lack directly associated limb bones, vertebrae, or crania, although such items are found isolated within the same strata. Fossil mammals are more common in the interbedded sand/clay facies. At least 14 taxa of mammals are present, including an early record of a river otter, the canid *Borophagus* cf. *B. hilli*, the equid *Nannippus aztecus*, the rhino *Teleoceras*, a small camelid, and the gomphothere *Gomphotherium*. The latter is the most common mammal; portions of seven skeletons ranging in age from very young juvenile to subadult were found along with isolated, adult-sized postcranial bones and an upper tusk. *Teleoceras* is represented by a very crushed but complete, adult male skull and mandible along with

much of an associated post-cranial skeleton. Fossil birds are rare, but one notable find is three associated bones from a swan (*Cygnus*). Most fossils show a complete absence of pre-burial taphonomic modifications (weathering, rounding, bite marks, etc.), and skeletal members of all three Voorhies groups are present in numbers approximating their relative proportions in the original skeleton. Preliminary biochronologic analysis of the turtles and mammals place the site in the late Hemphillian, but recovery and identification of additional taxa to the species level is needed for a more precise age determination.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

FIRST REPORT OF THE GIANT ICHTHYODECTID *XIPHACTINUS AUDAX* FROM THE MANCOS SHALE (CAMPANIAN) OF WESTERN COLORADO

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A partial skull collected in the Mancos Shale northwest of Grand Junction, Mesa County, Colorado, represents the first specimen of the ichthyodectid fish *Xiphactinus audax* reported from the formation in western Colorado. The Museum of Western Colorado specimen is from the Smoky Hill Member of the Mancos and is likely Coniacian or Santonian in age. The specimen is well preserved and consists of both premaxillae, the left maxilla, a fragment of the right maxilla, both dentaries, a ceratohyal, another indeterminate skull bone, two vertebrae, several fragments of pectoral fin spines, numerous rib and vertebral spine fragments, and nearly 400 scales. The only other *Xiphactinus* specimens from the Mancos Shale are a partial skeleton from near Snowmass, Colorado, at the Denver Museum of Nature and Science and very fragmentary field evidence from near Green River, Utah. All three occurrences of *Xiphactinus* in the Mancos Shale in Colorado and Utah (plus recent reports from the Tropic Shale of Utah) are unreported in previous summaries of the genus but push the distribution of *Xiphactinus* farther west in its southern distribution.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

RESPECT AND PROTECT: PALEONTOLOGICAL EDUCATION AND OUTREACH IN BLM CANYON COUNTRY DISTRICT, SOUTHEASTERN UTAH

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In 2009, the Paleontological Resources Preservation Act was enacted, instructing the Secretary to manage and protect paleontological resources on Federal land using scientific principles and expertise, and to develop plans to increase public awareness about the significance of paleontological resources. Many rural communities throughout the country, including southeastern Utah, remain underserved due to lack of resources to support physical fossil site visits. In response, lesson plans, activities, and videos targeted at K-12 students have been developed, which are used in both the classroom and to support exploratory, place-based learning experiences at Bureau of Land Management (BLM) fossil sites. These public lands fossil sites are used as outside laboratories, where stewardship, monitoring, and site-based science are taught.

The Natural History Museum of Utah and Museum of Moab have worked with the BLM to develop a suite of short educational videos that emphasize the site stewardship and the scientific process through featuring public fossil sites. The materials developed promote the importance of stewardship toward the natural world by discussing the benefits of preservation, both for future generations building scientific understanding of our ancient past, and informing current scientific understanding. These videos provide the audience with: 1) a brief historical overview of the area; 2) observations about the sites made by scientists and participants; 3) to foster curiosity about the sites and paleontology by asking relevant questions; and 4) to learn how to respect and protect our public fossil sites. The program concludes by administering evaluations to teachers and students to gather feedback on the effectiveness of the media and curricula used in their classrooms.

This project meets two of the President's initiatives: "America's Great Outdoors", supporting programs and projects that educate and engage Americans in our history, culture, and natural bounty; and "Every Kid in a Park", to get all children to visit and enjoy America's unparalleled outdoors through youth outings and existing educational programs, such as Hands on the Land sites. Integrating new technology, such as educational videos and curricula, that work in conjunction with traditional interpretive efforts to convey information helps to reach a variety of audiences and ability levels. This is in line with Secretary Jewel's efforts to engage the next generation in conservation and stewardship while building skills relevant to today's outdoor work-force.

Grant Information

This work was supported in part by a National Environmental Education Foundation Hands on the Land Mini-Grant, along with 2016 "Respect and Protect" BLM Project Funding.

Poster Symposium I (Wednesday–Thursday, October 26–27, 2016, 4:15–6:15 PM)

CARETTOCHELYINES FROM THE MIDDLE EOCENE OF COASTAL TEXAS: COSMOPOLITAN DISPERSERS IN A TIME OF GLOBAL WARMTH

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Carettochelyidae (pig-nosed turtles) today are restricted to New Guinea and northern Australia, but in the Eocene were widely distributed on northern continents. Anosteirines (carettochelyids retaining scales) were distributed in North America and East Asia. Carettochelyinae (carettochelyids lacking scales) are known principally from Europe and south and eastern Asia. North American carettochelyines have been reported from Virginia and Texas, but those identifications have been discounted by some workers. Here we report a sample of more than 120 isolated, identifiable specimens representing most of the shell of a large carettochelyine turtle from the Lake Casa Blanca fauna of the middle Eocene Laredo Formation, Webb County, Texas, that clearly demonstrate the presence of this clade in North America.

The Texas material is referred to the Carettochelyinae on the basis of the extension of the hypoplastral buttress onto P3, presence of vertebral pedicles on the nuchal, and the absence of epidermal scales. It is referred to *Allaeochelys* and differs from *Carettochelys* in having a complete neural series, narrower hypo- and xiphiplastron, and better developed central carina. It differs from Asian Paleogene carettochelyines in smaller size and weaker sculpturing on the visceral surface of the peripherals. It differs from European *Allaeochelys* in larger size, better developed dorsal carina, and possibly in the relative narrowness of the hypoplastron.

The presence of carettochelyines in eastern and southern North America that are related to European *Allaeochelys* further highlight the distinctiveness of the faunas of Texas in comparison with those of the western Interior in the middle Eocene. Additionally, this discovery requires a novel set of biogeographic scenarios. Carettochelyids are aquatic and would have required freshwater to disperse. Although an Asian origin cannot be excluded, a dispersal from Europe seems more likely but is in strong contrast to inferred dispersal routes for other Eocene herpetofauna. One possibility is that Paleogene carettochelyids may have been able to disperse via brackish or stratified estuarine waterways like those that have been reconstructed for many settings along the Paleogene Atlantic and Gulf coasts, just as living *Carettochelys* has been anecdotally reported in estuarine waters.

Grant Information

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Technical Session XIX (Saturday, October 29, 2016, 3:00 PM)

A LATE-SURVIVING STEM MAMMAL FROM THE CRETACEOUS OF UTAH

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Haramiyidans are an extinct clade of ecologically diverse stem mammals with a fossil record spanning the Late Triassic through Jurassic, but their Cretaceous records have been controversial. Although relatively abundant in the Middle-Late Jurassic of Asia, their fossils are depauperate elsewhere in the world. Here we report on the discovery of a mammaliaform from the Cretaceous of North America in the upper Yellow Cat Member of the Cedar Mountain Formation (~124 Ma) in eastern Utah. The specimen was recovered from a multispecies bone bed that has yielded the type of the basal iguanodont *Hippodraco*, a hypsilophodont, a dromaeosaurid theropod, and an undescribed crocodylomorph. The new mammaliaform is represented by a large and nearly complete cranium with in situ ultimate molars, and with an amalgam of plesiomorphic mammaliaform features and crown mammalian apomorphies. A phylogenetic analysis of 123 mammal and non-mammalian cynodont taxa comprising 531 characters places the new taxon amongst haramiyidans on the mammal stem and recovers the group as the sister taxon to crown Mammalia. The results corroborate haramiyidans as stem mammals and provide novel insight into the evolution of mammaliaform cranial features. The new taxon shows very distinctive dental characters, such as a mortar-pestle morphology and single root (or confluence of multi-roots) of the molars. Aspects of this dentition are diagnostic of several isolated teeth of uncertain "multituberculate" affinities from the Jurassic of Portugal or were previously assigned to the Hahnodontidae from the Cretaceous of Morocco. Based on the distinctive dental similarities of the new Cedar Mountain haramiyidan and hahnodontids, we hypothesize that the Iberian and Moroccan teeth of hahnodontids and uncertain "multituberculate" affinities more likely belong to haramiyidans, adding to a growing list of stem mammals from the late Mesozoic. We offer new evidence in favor of the haramiyidan affinities of hahnodontid teeth and discuss their previously unrecognized occurrences at important microvertebrate sites of Europe and Morocco. This discovery has significantly extended the stratigraphic range and broadened the cosmopolitan distribution of haramiyidan mammaliaforms across Pangea during the Jurassic–Cretaceous transition.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

REPORT ON A FOSSIL BIRD FROM THE LOWER CRETACEOUS KITADANI FORMATION, TETORI GROUP, FUKUI, JAPAN

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Our understanding about the evolution of the Early Cretaceous birds has dramatically improved due to recent numerous discoveries of the well-preserved fossil birds from the northeastern and northwestern China. However, the Early Cretaceous fossil birds are poorly known from other regions of Asia, making the fossil record heavily biased. Here, we report the first three-dimensionally preserved, nearly complete fossil bird from Japan, outside of the Lower Cretaceous of China in Asia. The specimen comes from the Kitadani Formation, the Tetori Group, Fukui, Japan. The Kitadani Formation is composed of the late Barremian to the early Aptian fluvial deposits, and has yielded diverse vertebrate remains including non-avian dinosaurs. The specimen was collected from the pale-green siltstone which likely represents a floodplain deposit. The skeleton is

disarticulated and preserves most of the parts of the body three-dimensionally; such state of preservation is uncommon for the Early Cretaceous bird fossils. The skull is present but severely fragmented. The pygostyle is slender and has a rectangular shape. The coracoid has semi-circular articulation surface. The furcula is robust and boomerang-shaped. Its round, inflated area at the both ends of the clavicular rami and lack of the hypocleidium resemble the furcula of *Confuciusornis sanctus*. The humerus measures 8.8 cm long and is similar to that of *Jeholornis prima* in having a convex humeral head and a prominent deltopectral crest, whose length approaches about 40% of the length of the humerus. The humerus bears a unique depression at the proximal end of the deltopectral crest. Ulna/femur length ratio is 1.33, indicating the specimen has relatively long forelimbs, but not to the degree seen in other Early Cretaceous basal birds such as *J. prima* (1.45) and *Sapeornis chaoyangensis* (1.66). The metacarpal III is long and slender. The femur, which measures 6.1 cm long, is slender compared to other basal Early Cretaceous birds. Such osteological characters as simple and robust furcula, and long and slender metacarpal III may indicate that the specimen is more basal than Ornithothoraces within Avialae. While the specimen shares some features with *C. sanctus* and *J. prima*, it exhibits a combination of characters that is not seen in other Early Cretaceous basal birds. The specimen probably represents the early stage of the evolution toward powered flight. A study utilizing the micro-computed-tomography on the specimen is undertaken to better understand its morphology and taxonomic position.

Technical Session XI (Friday, October 28, 2016, 9:45 AM)

INFERENCES ON FUNCTIONAL MORPHOLOGY OF *EDESTUS HEINRICHI* FROM TOOTH MACROWEAR

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Edestus is a Middle Pennsylvanian chondrichthyan possessing symphyseal tooth whorls in both the upper and lower jaws. How the tooth whorls functioned is unclear, since their convex curvature allows only a few of the most posterior (lingual) of the pointed, serrated crowns to occlude. According to a recently published hypothesis, the teeth were used to slash prey with vertical motions of the head, not to cut objects located between the two whorls. Such a function has been compared to that of the Hawaiian shark-tooth-lined weapon, called the leiomano. Observations of wear might provide clues as to how *Edestus* teeth functioned. *Edestus* tooth wear has been reported only rarely. A single tooth of *Edestus minor* with a truncated, smoothly worn apex has been reported. Teeth of *Edestus heinrichi* showing macrowear have not been reported previously. Here, the anterior (labial) end of a tooth whorl of *Edestus heinrichi* is reported in which the apices of the two anteriormost crowns are worn, so that the crown heights are reduced by about one third. The specimen comes from a coal mine in Randolph County, Illinois, where it was was found in a shale bed above the Herrin number 6 Coal, Carbondale Formation (late Desmoinesian). The form of wear supports the "leiomano" hypothesis. The most apical serrations on both the lingual and the labial edges of the two crowns are worn. This indicates that slashing was carried out with motion of the tooth whorl in both directions tangential to the long axis of the whorl. A postmortem source of the wear observed to the apices and serrated edges of the crowns is ruled out by the fact that no wear is observed to the lateral faces of the crowns or to the bases. The fact that wear is rarely observed in *Edestus* teeth suggests an unusual life history for these particular teeth. The crown apices might have been broken, perhaps by striking a hard object, exposing the softer, interior dentine, and then abraded by repeated acts of predation on large fish having skin covered with denticles or scales. The present observations of tooth wear provide the first physical evidence for the leiomano hypothesis for the function of the tooth whorls of *Edestus heinrichi*.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

THE FIRST EARLY CLARENDONIAN (MIOCENE) SNAKE ASSEMBLAGE FROM THE PENNY CREEK LOCAL FAUNA, WEBSTER COUNTY, NEBRASKA.

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Fossil Cenozoic herpetofauna are potential tools for environmental reconstruction and understanding the effects of climate change, as the physiologies of extant reptiles and amphibians correlate strongly with habitat. The Neogene beds of Nebraska include a long, well-preserved record of fossil snakes that illuminates the history of richness, turnover, and modernization of snakes from the Central Great Plains. Despite the excellent state of Nebraska's fossil snake record and an apparent peak of richness in the late Barstovian (Ba2), a paucity of fossil material has resulted in a distinct scarcity of data on snake assemblages from the early Clarendonian (Cl1). This temporal gap is present throughout most of North America and illuminates a glaring lack of knowledge about the scale of snake turnover and modernization immediately following the late Barstovian of Nebraska.

The Penny Creek Local Fauna of southern Webster County, Nebraska represents the first known early Clarendonian snake assemblage from the state, and therefore, the first opportunity to explore the differences between Nebraska's late Barstovian and early Clarendonian herpetofaunas. Mammal biostratigraphy suggests that the deposits are coeval to the Cap Rock Member of the lower Ash Hollow Formation (early Clarendonian), and the mammalian assemblage consists of grazers and browsers, indicating a mixed forest and grassland environment. The deposit's alternating coarse sands and gravels, abundant with feldspar and granite fragments, clay clasts, reworked Niobrara chalk, and bone scraps, suggest a more arid climate than the region's Late Barstovian deposits, while large scale tabular cross beds indicate a braided stream. The fossil snakes support this interpretation of the Penny Creek beds as a braided stream, as they include a high richness of natricines, which prefer nearby permanent water bodies, and the genus *Heterodon*, which prefers loose, sandy substrates, as well as other colubroid taxa. Additionally, Penny Creek lacks the richness of booids or colubroids that prefer warmer, more humid environments (e.g. *Micrurus*), such as those found in the nearby late Barstovian Myers Farm Local Fauna. Overall, evidence from the fossil snakes and mammals, combined with the geology of the deposit, lend credence to a hypothesis of increasing aridity and cooling associated with the opening of environments in the Central Great Plains of North America following the taxonomically rich Barstovian.

Grant Information
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Poster Symposium I (Wednesday–Thursday, October 26–27, 2016, 4:15–6:15 PM)

3D EPIPLASTRAL, GEOGRAPHIC, AND BODY SIZE VARIATION IN *ECHMATEMYS*, A GEOEMYDID TURTLE FROM THE UINTA FORMATION, UINTA BASIN, UTAH, U.S.A.

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Numerous fossil geoemydid turtle specimens from the genus *Echmatemys* have been recovered from the Uinta Formation, Uinta Basin. Specimens of this abundant genus are often highly weathered and fragmentary; however, relevant information on taxonomy, geographic distribution, and body size can still be obtained. We tested the hypothesis that congeneric, sympatric species *E. callopyge* and *E. uintensis* can be reliably differentiated based on morphology of the epiplastral gular scale, and whether their geographic distributions overlapped substantially. We also evaluated whether body size changed significantly in *Echmatemys* from Uinta B to Uinta C.

Isolated shell elements of Uintan *Echmatemys* specimens specifically 40 neurals and 27 epiplastra were scanned using a NextEngine laser scanner or photographed. Morphological differences in the curve of the gular sulcus on the epiplastron were collected in Landmark 3.6, and analyzed using geometric morphometric techniques in MorphoJ and IMP3D. The shape of the dorsal gular scale was significantly different between species in a Procrustes ANOVA ($p < 0.001$) and permutated Procrustes distances ($p = 0.004$), as was centroid size ($p < 0.001$). While permutated Procrustes distances for ventral scale morphology only approached significance ($p = 0.06$), the rates of correct Discriminant Function Analysis (DFA) classification were still quite high (74%). These findings suggest that these two congeneric species can be differentiated with reasonable reliability using the shape of the gular scale, especially its dorsal surface, and that the use of geometric morphometrics will be able to improve identification of fragmentary specimens.

ArcGIS was used to compare spatial and temporal distributions of *E. callopyge* and *E. uintensis* specimens. ArcGIS revealed overlapping geographic ranges for these species, and an Analysis of Variance (ANOVA) found no significant differences in stratigraphic distribution of species within the section. This confirmation of geotemporal overlap between Uintan *Echmatemys* species highlights the need for accurate taxonomic identification, such as the gular scale morphology validated here. Neural length and width were also measured in ImageJ and used to calculate maximum plastron length for each specimen. An ANOVA indicated that body size was significantly larger ($p = 0.012$) in specimens collected from Uinta B compared with those from Uinta C, indicating that *Echmatemys* decreased in overall body size between earlier and later localities.

Technical Session XIX (Saturday, October 29, 2016, 2:30 PM)

3D ANALYSIS OF THE CHEWING CYCLE AND DENTAL OCCLUSION OF *MORGANUCODON WATSONI*

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The occlusion of basal mammaliaforms is of interest due to its relevance for mammalian dental evolution. Previous studies on *Morganucodon* relied on the abundance of isolated teeth and fragmentary jaws from the Early Jurassic Welsh fissure fills (UK). Here we present an analysis of a well-preserved snout of *Morganucodon watsoni*, with matching upper and lower dentition, that was scanned with x-ray computed tomography. Existing hypotheses on the occlusion were tested virtually on 3D models with the Occlusal Fingerprint Analyzer (OFA) software. Additionally, isolated molars of *Morganucodon* from the same locality were examined with Scanning Electron Microscopy in order to determine the relative jaw movement based on micro-striations.

Results from the microwear show *Morganucodon* had a predominantly orthal occlusion, although several specimens have micro-striations indicating moderate mesio-distal movement of the lower jaw during mastication. OFA analysis confirmed the earlier hypothesis that the main cusp a of the lower molar occluded between cusps B and A of the upper antagonist. There was though a more significant contact between cusp a and the next anterior upper molar than previously assumed, similar to the two-on-one pattern described for *Megazostrodon*. This is most apparent for the enlarged m2 occluding between M1 and M2. The significantly larger main cusp a of m2 fits into a pit in the maxilla and influences the arrangement of the upper molars. The more posterior upper molars beginning with M2 are arranged at an angle, relative to the anterior upper teeth, in order to accommodate cusp a of m2. This tooth arrangement has been observed on multiple specimens. With differing tooth orientation and cusp size, wear facets have distinct patterns depending on molar locus. However, the facets are congruent on both sides, left and right, for each molar position. The m2 and m3 exhibit a higher degree of wear than m1.

OFA analysis confirms that the molars of *Morganucodon* were well adapted for puncturing and subsequent shearing along the flanks. While the triconodont dentition of *Morganucodon* allows a higher variability in terms of interlocking angle and direction of movement than more derived molar types, the exact angular orientation of teeth around the m2 and the expression of distinct facets according to tooth position both suggest a more precise mode of occlusion than previously assumed.

Grant Information
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Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

CORRELATION BETWEEN CALCANEAL MORPHOLOGY AND LOCOMOTION IN CARNIVOROUS MAMMALS: INFERENCE OF LOCOMOTOR DIVERSITY WITHIN NIMRAVIDAE

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Locomotion is intimately linked to the ecology of an animal, and so understanding the relationship between form and function in the calcanea of extant Carnivora permits comparative analyses with extinct Carnivora and other carnivorous mammals to better understand their paleoecology. The calcaneal heel is the point of attachment of the gastrocnemius tendon, while the calcaneal head is involved in the mid-tarsal joint: thus, calcaneal morphology both reflects the lever arm for powering foot retraction as well as the degree of motion within the tarsus. Additionally, the calcaneum is a robust bone, and hence frequently preserved, making it an excellent bone for analysis.

Our dataset comprises 164 calcanea from 87 extant Carnivora, 38 extinct Carnivora, and nine Creodonta. The extant taxa were classified into one of the following locomotor modes: cursorial, terrestrial, scansorial, arboreal, semi-fossorial and semi-aquatic. We explore calcaneal morphology using linear measurements and 2D landmarking, employing principle components analysis (PCA) and linear discriminant analysis (LDA). The relationship between morphology and locomotor grade was tested by ANOVA/NPMANOVA, and the role of phylogeny explored through maximum likelihood model testing and phylomorphospaces. Our results show that calcaneal morphology alone is a good indicator of locomotor mode in extant taxa, and can thus be used to infer the locomotor behaviour of extinct Carnivora and Creodonta. Carnivorans of different locomotor modes occupy distinct areas of the morphospace, particularly arboreal and semi-fossorial taxa (distinguished mainly by a broad calcaneal head with large articulatory facets for the astragalus) versus terrestrial and cursorial taxa (distinguished mainly by a long calcaneal heel). There is some phylogenetic influence—especially a distinct clustering of the Ursidae—but this does not hinder our interpretations, as analyses were performed both with and without ursids.

Among the extinct carnivorans studied, the Nimravidae ('false sabertoooths'), which are usually considered to have been arboreal, clustered in different areas of the morphospace. *Dinictis* species cluster with more arboreal taxa, while those of *Hoplophoneus* cluster with more scansorial or terrestrial taxa. Surprisingly, *Nimravus brachyops* clusters with the more cursorial felids, with the implication that this late-surviving (late Oligocene) taxon may have been more of a pursuit predator than its early Oligocene relatives.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

THEROPODS (DINOSAURIA: THEROPODA) FROM THE SAN JUAN BASIN, NEW MEXICO, AND IMPLICATIONS FOR LATE CRETACEOUS THEROPOD FAUNAS OF LARAMIDIA

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Theropod dinosaurs from the Upper Cretaceous (Campanian–Maastrichtian) sediments of the San Juan Basin (SJB) in New Mexico have been known for over 125 years. Early records were fragmentary, consisting of isolated, large coelurosaurian teeth and tooth fragments. Recent work has shown the theropod faunas from this region to be more taxonomically diverse at the genus and species levels. Three new theropod taxa have been named in the last 6 years, including a tyrannosaurid, a caenagnathid, and a dromaeosaurid. Additionally, there is evidence several other theropod taxa from the SJB are also distinct, with preliminary data suggesting generic differences. Dinosaur faunas from the Upper Cretaceous formations of the Western Interior Basin of North America show a similar theropod familial fauna regardless of their geographic location, including members of the Caenagnathidae, Dromaeosauridae, Ornithomimidae, Troodontidae, and Tyrannosauridae. This consistency in the family (and superfamily) level groups of Laramidian theropods is also seen in the SJB theropods. However, taxonomic differences are present in most faunas at both the genus and species level throughout most of Laramidia, including the SJB. Within the SJB, current data do not suggest the existence of multiple taxa within individual families living together temporally. Some groups persist throughout the Campanian and Maastrichtian in the SJB, including dromaeosaurids, tyrannosaurids, and potentially ornithomimids. Current data also suggest a later arrival for troodontids and caenagnathids, with the former preceding the latter. Both groups may have migrated south through Laramidia after migrating from Asia prior to the Campanian. A new dromaeosaurid from the Maastrichtian of New Mexico shows this group survived until the end of the Cretaceous in both “northern” and “southern” Laramidia, and lived with large tyrannosaurids throughout the Campanian and Maastrichtian. As several of these theropod groups, including caenagnathids, ornithomimids, and troodontids, have been previously suggested to represent either herbivorous or omnivorous groups, the main hypercarnivorous theropods (e.g., dromaeosaurids and tyrannosaurids) remain consistent throughout the Late Cretaceous in the SJB. Although much of the theropod fossil material from the SJB is fragmentary and/or isolated, it is still able to show generic and specific differences from other Laramidian faunas and provide further information regarding this group during the Late Cretaceous.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

A SYNOPSIS OF THE QUATERNARY PROBOSCIDEAN RECORD FROM ALBERTA, CANADA

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Quaternary proboscideans are known from nearly all of North America and are a major focus of research related to Pleistocene biotas and extinction. However, proboscidean fossils are understudied in some geographic regions of the continent (e.g., Alberta). Records from Alberta consist of unassociated specimens, typically isolated teeth or incomplete post-cranial elements, possibly explaining why they have received sparse attention in the published literature.

Quaternary sand and gravel deposits are the primary source of fossils of Ice Age proboscideans in Alberta, and most records were collected in conjunction with industry aggregate extraction. The largest sample of proboscidean remains is largely unpublished, comes from sand and gravel pits located near Edmonton in central Alberta, and includes a large number of teeth (n = 65). Other major source areas for proboscidean remains include regions in the northwest (Peace River region) and south (Bow River, South Saskatchewan River) of Alberta.

Recent re-evaluation of all proboscidean specimens housed at the Royal Alberta Museum (n = ~400) resulted in identification of *Mammuthus* cf. *M. primigenius*, *Mammuthus* cf. *M. columbi*, *Mammuthus* sp., *Mammut americanum* and Proboscidea indeterminate. Tentative identification of species of mammoth reflects both our own uncertainty in morphological separation between the two species and the results of recent molecular studies focused on species boundaries within North American *Mammuthus*. Post-cranial remains are typically incomplete and are identified at higher taxonomic levels (*Mammuthus* sp., Proboscidea indeterminate). No definitive post-cranial remains of mastodon are presently known from Alberta, limiting the record to a single mandible and several isolated teeth.

A direct radiocarbon dataset of published and unpublished ages provides a chronologic framework for proboscideans from the late Pleistocene in Alberta. Although limited (n = 3), radiocarbon data for mastodons are restricted to > 40,700 yr BP, whereas records of mammoth include the timeframe leading up to the Last Glacial Maximum (~22,000 yr BP) and a restricted, subsequent period prior to extinction (~12,000 yr BP to ~10,000 yr BP).

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

PHYLOGENETIC POSITION OF *PALACRODON:* AN ENIGMATIC EARLY TRIASSIC LEPIDOSAUR FROM SOUTHERN GONDWANA

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Palacrodon browni is an Early Triassic reptile found on both the South African and Antarctic continents. The taxon has been classified as a diapsid, rhynchocephalian, and procolophonid in descriptions dating from 1906 to 1999, and consensus has not been reached regarding its phylogentic relationship within Lepidosauria. A refined phylogenetic placement of this reptile would push back stem dates of Lepidosauria from the Middle to the Early Triassic. It is possible *Palacrodon* is part of the faunal assemblage that experienced a decrease in body size as a result of the Lilliput effect noted in several Early Triassic lineages. There is also a noted range shift which occurred within the first 20 million years of the Triassic. The change in size and range suggest *Palacrodon* was strongly affected by the Permian mass extinction. Using high-resolution computed tomography, two dentaries were scanned and digitally segmented using AMIRA 6.2 to examine tooth implantation type (i.e., acrodont or thecodont) and reveal characters for better resolving the phylogenetic position of *Palacrodon*. Thirteen additional tooth-bearing elements, made available by the Evolutionary Institute at the University of Witwatersrand in Johannesburg, were also assessed for externally visible characters. Characters were scored against known Rhynchocephalia and procolophonid specimens using MacClade 4.08 and using an apomorphy-based approach specific to characters relating to dentition and tooth-bearing bones. Preliminary data suggest rhynchocephalian association due to acrodont dentition implantation in combination with possible prototthecodont dentition in posterior teeth, and additional posterior dentition typical of sphenodontians. Initial survey also exhibits extreme wear on the occlusal surface of the teeth, a pattern typical of acrodont vertebrates and certainly rhynchocephalians. Phylogenetic analysis reveals *Palacrodon's* familial association to be within Lepidosauria and its close relationship to crown Rhynchocephalia. A better understanding of the taxa that survived the Permian extinction may be beneficial to understanding and predicting the survival patterns of the current extinction, which shares any similarities to the Permian event. Change in body size and range behavior may be examples of these patterns which can be assessed in *Palacrodon*.

Symposium II (Friday, October 28, 2016, 9:00 AM)

CONSERVATION OF THE FINE-TUNING OF MAMMALIAN TOOTH SHAPE

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Hybridization is well known to occur between living taxa. In mammals, hybridization has attracted renewed interest due to paleogenomic evidence that has implicated interbreeding among human taxa. We have investigated whether hybridization between morphologically disparate taxa can produce developmentally stable, intermediate morphologies. We analyzed teeth of two species of pinnipeds, Grey seal (*Halichoerus grypus*) and Ringed seal (*Pusa hispida*), together with a unique hybrid specimen between these two species. Grey seal post-canine tooth morphology is characterized by a prominent central cusp and small or missing accessory cusps. In contrast, the post-canine morphology of ringed seals consists of multiple relatively slender cusps. A computational model simulating tooth development was used to explore the developmental and genetic nature of the hybrid morphology. The results show that the hybrid specimen is phenotypically intermediate between the species. Furthermore, co-dominance of the alleles influencing the patterning cascade mode of cusp development is the likely explanation for the intermediate phenotype. These results highlight the potential for the conservation of developmental regulatory systems, and that intermediate fossils between taxa may indeed be intermediate because of being hybrids.

Technical Session XVII (Saturday, October 29, 2016, 8:30 AM)

A LARGE EARLY TRIASSIC ICHTHYOSAURIFORM FROM CHAOHU OF SOUTH CHINA AND FAST RADIATION OF MARINE REPTILES IN THE WAKE OF THE END-PERMIAN EXTINCTION

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It is widely held that early Mesozoic marine reptiles evolved slowly in the Early Triassic, and that the biotic recovery from the end-Permian extinction was delayed due to excessively hot climate, redox fluctuations, sea level changes and volcanism. However, recent discoveries of Early Triassic marine reptiles from southern China challenge this traditional view. Here we present an aberrant basal ichthyosauriform with an hitherto unknown body design. The new species is larger than coeval marine reptiles and has an extremely small head, and a long tail without a fluke. Its heavy-set body bears flattened and overlapping gastral elements reminiscent of hupehsuchians. A phylogenetic analysis places the new species at the base of ichthyosauriforms, as the sister taxon of *Cartorhynchus*, with which it shares a short snout with rostrally extended nasals. It now appears that at least 26 marine reptile species occurred in the Middle-Late Spathian (in just 2 myr), amongst which 15 come from the South China Block. These include five hupehsuchians, two basal ichthyosauriforms, four basal ichthyopterygians, and four sauropterygians. This demonstrates that marine reptiles underwent a fast radiation before the end of Early Triassic, earlier than previously believed. These diverse marine reptiles and fishes such as*Saurichthys*, occupied the apex level as predators and are associated with abundant invertebrates such as bivalves, cephalopods and arthropods in the Early Triassic marine ecosystem. This shows the first glimpse of a recovering biotic structure reaching a high trophic level.

The high-resolution record of carbonate carbon isotope documents eccentricity modulation of carbon cycling through the Spathian and shows a strong obliquity signal. Based on this data, the age of the lowest stratigraphic level of marine reptile fossil found at Chaohu is 248.81 Ma, about 3.35 myr after the end-Permian mass extinction, and 1.35 myr after the large Smithian-Spathian event. It appears that the first occurrence of marine reptiles corresponds to a change in the response of the oceanic carbon reservoir to astronomical forcing, indicating the recovery of the ocean circulation that may have triggered the onset of a complex marine ecosystem.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

PHYLOGENETIC RELATIONSHIPS OF TYLOSAURINE MOSASAURS (SQUAMATA, MOSASAUROIDEA) AND THEIR BIOGEOGRAPHIC PATTERNS OF DISTRIBUTION

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Mosasaurs were a successful group of marine reptiles, diverse and widespread during the Upper Cretaceous. Tylosaurine mosasaurs have been found on all continents, from the Turonian to the Maastrichtian. In order to assess tylosaurine relationships, an existing data matrix was modified by the inclusion of all currently recognized terminal taxa assigned to both *Tylosaurus* and *Taniwhasaurus*. The traditional search (heuristic search algorithm) was performed in TNT 1.1, with 1000 replicates. The phylogenetic analysis supports the existence of two major groups of Tylosaurinae: *Tylosaurus* and *Taniwhasaurus*. In the clade *Tylosaurus,* the upper Coniacian-lower Santonian *T. nepaeolicus* appears as the basal taxon, suggesting a *Tylosaurus* origin in the Southern Western Interior Seaway, North America. *Tylosaurus proriger* (upper Santonian-mid Campanian) and *T. bernardi* (lower Maastrichtian) are the more derived taxa. In the clade *Taniwhasaurus*, the Campanian *Ta. oweni* appears as sister group of the Campanian *Ta. antarcticus*, and the Santonian *Ta. capensis* as sister group of the upper Santonian-lower Campanian *T. mikasaensis*. The distribution of clades allows identification of biogeographic and temporal patterns of distribution during the Late Cretaceous, where the clade *Tylosaurus* occupied the North Atlantic Circle Basin during the Upper Turonian-mid Campanian, while the clade *Taniwhasaurus* was restricted to the Santonian-Maastrichtian of the Circum Pacific Basin and Antarctica. These patterns are relevant to understanding the evolution of tylosaurine mosasaurs, and the evolution of mosasauroids on a global scale.

Technical Session XI (Friday, October 28, 2016, 8:15 AM)

DIVERSITY OF SKIN DENTICLES IN FOSSIL AND EXTANT RAYS AND THE ORIGINS OF VERTEBRATE DENTITIONS

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Sharks and rays have been studied extensively to address the origin and evolution of teeth in jawed vertebrates. They possess an external dermal skeleton where odontodes form isolated placoid scales with patterns distinct from teeth organized into functional dentitions along the jaws. Enlarged and tooth-like placoid scales occur on the extended cartilaginous rostra in sharks and rays, including sawsharks, sawfish, and the fossil Sclerorhynchoidea. These enlarged denticles are also present on the midline of the chondrocranium, synarcual, and more posterior neural arches, and the pectoral girdle in a number of different batoids. Using X-ray microtomography, we recorded the development of the structural pattern of these denticles to compare them with oral dentition patterning. Current hypotheses of the evolutionary relationship between skin denticles and teeth were tested, which propose that teeth evolved from external dermal skin denticles such that teeth and skin denticles should share substantial developmental and patterning mechanisms, including addition and replacement.

In sawsharks and fossil Sclerorhynchoidea, the rostrum tip represents a growth center where new saw-denticles are added. Patterned skin denticles at the anterior chondrocranial margin in extant rays suggest a comparable organizing centre is present, although an extended rostrum saw is not formed. In sawsharks, saw-denticles are replaced only when in situ loss occurs, and in a size-specific manner. After loss, new saw-denticles develop lying flat in the vacant space and rotate into functional position. This developmental mechanism also applies to the enlarged denticles on the batoid chondrocranium, neural arches, and pectoral girdle. Saw-teeth in fossil sclerorhyncoids, especially *Schizorhiza,* also rotate into position, but as small crowns, in an unusual two-step manner. Although regulated, all these denticles differ from oral teeth in chondrichthyans and osteichthyans, where both functional and replacing teeth are present as part of a successional series linked by tooth-producing tissues (e.g., dental lamina). In batoids, replacement is more comparable to that of regular placoid scales, providing no evidence to support current hypotheses of tooth evolution.

Grant Information
Natural Environment Research Council

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

THE LATE CRETACEOUS CHIMAEROID FISH, *ISCHYODUS BIFURCATUS*, FROM SOUTHERN CALIFORNIA, USA, AND ITS PALEOBIOGEOGRAPHICAL SIGNIFICANCE

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Ischyodus is a genus of extinct chimaeroid (‘ratfish’) (Chondrichthyes, Holocephali) found nearly worldwide (North America, Europe, Australia, and New Zealand) from marine deposits that chronostratigraphically span from the Middle Jurassic to the Neogene. *Ischyodus bifurcatus* is a Cretaceous species known primarily from Santonian–Maastrichtian strata of eastern North America, but materials referable to the species have also been reported from the Albian of Poland as well as from the Campanian of Belgium and Russia. The species is known only from its tooth plates, and previously described North American specimens come from the East Coast as well as from the Gulf Coastal and the Western Interior. Here we report the occurrence of a complete right mandibular tooth plate of *I. bifurcatus* (SDNHM 25417) collected from the Point Loma Formation of the Upper Cretaceous Rosario Group in San Diego County, California, USA. The tooth plate measures 47 mm in length, 20 mm in width, and 9 mm in thickness, and preserves five tritors, including a bifurcate median tritor. The fossil was recovered from massive siltstones containing a well-preserved benthic molluscan assemblage that lived at outer shelf to upper slope water depths. SDNHM 25417 is paleobiogeographically important not only because it documents the presence of *I. bifurcatus* in California during the Campanian, but also because it constitutes the first and only known record of Mesozoic *Ischyodus* from the eastern North Pacific region.

Symposium I (Wednesday, October 26, 2016, 12:00 PM)

PUSHING NEW PERSPECTIVES: LESSONS LEARNED FROM THE HISTORY OF MOLECULAR PALEONTOLOGY

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Molecular paleontology is the study of biomolecules in fossils (lipids, amino acids, proteins, nucleic acids). New methods applied to old biomolecules have uncovered previously unknown processes of vertebrate evolution. This invites excitement but overenthusiasm, resulting in overconfidence in new methods. It is an emerging sub-discipline; its prospects and perimeters are not understood. Here, I place molecular paleontology within the discipline of vertebrate paleontology and ask: “How has molecular paleontology evolved, what is its present state, and what are implications of its applications to vertebrate paleontology?”

First, I present novel research from the history of ancient DNA research, a field first catalyzed by the polymerase chain reaction, but that also coincided with and was accelerated by popular interest in Jurassic Park. In the 1990s, series of studies claimed DNA from dinosaurs and fossils hundreds of millions of years old. The field was enthusiastically entertained, but problems of authenticity and reproducibility marked a dramatic drop in confidence in its utility. This case demonstrates the tension between excitement and unchecked enthusiasm.

Second, I address the present state of molecular paleontology as signified in this symposium. Methods from diverse disciplines like molecular biology, chemistry, and physics have changed the study of fossils. Synchrotron technology applied to vertebrate fossils has identified trace elements of biomolecules to determine that physiological processes of bone repair are consistent in ancient and extant organisms. Research also reveals properties of biomolecules and differing preservation potential. Combinations of methods have confirmed the cross-linking of proteins in ancient and extant samples as a contributing cause to their longevity over time. Proteins, more stable than DNA, are more useful in testing phylogenetic hypotheses, convergence, and reversal to ancestral states. This symposium shows that molecular methods have changed vertebrate paleontology.

Our field is in the midst of technological and methodological changes; changes that present challenges. Paleontologists must understand the underlying science of molecular methods and importance of their application in combination with morphological methods. We must also understand potential problems (false positives, authentication, replication). Reflection on the past and present is necessary if molecular paleontology is to be an established sub-discipline of vertebrate paleontology in the future.

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Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

USING THREE DIMENSIONAL GEOMETRIC MORPHOMETRICS FOR THE IDENTIFICATION OF A *CANIS* SPP. AT A HISTORIC SITE IN WESTERN TEXAS

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Ongoing fieldwork at Whisky Flats, a mid-18th century archaeological site on the Llano Estacado (western Texas), has produced a vertebrate assemblage that includes extant taxa native to the region, as well as domesticated horse. Within the recovered vertebrate sample is a set of remains typical of coyote (*Canis latrans*). The identity of a second set of larger canid remains is more ambiguous. The latter material represents at least one individual that is between *C. latrans* and *C. lupus* (gray wolf) in size. This larger canid is represented by a small, non-diagnostic sample (n = 5) of post-cranial elements and an isolated cheek tooth. The taxonomic identity of the large canid material is challenged by ambiguity in size, lack of morphologically diagnostic elements, and the temporal context. *Canis latrans* is common regionally, both in the modern fauna and within late Quaternary samples. Absent from western Texas today, *Canis lupus* is present historically and appears to have been extirpated as recently as the early 20th century. Further, Comanche (known occupants of the site) and Apache (potential occupants) were accompanied by both domestic dog and domestic horse. The size and morphology of 18th century domestic dogs likely is variable and could potentially resemble either native species. The ability to distinguish between incomplete skeletal remains of such genetically closely related and physically similar forms is a significant challenge in late Quaternary faunal studies. Making such distinctions, however, is important for documenting faunal changes during any time period. Statistical methods provide a means to search for distinctions between such taxa that may be practical in terms of diagnosis. Exploratory principal component analysis (PCA) and analysis of variance (ANOVA) are applied to post-cranial elements from modern comparative samples of *C. latrans* and *C. lupus* in an attempt to characterize quantitative variation. These results illustrate the differential potential among post-cranial elements to distinguish between these species in the absence of diagnostic craniodental measurements. Three-dimensional, landmark-based morphometric analysis and associated discriminant function analysis are used to delineate further the boundaries between the overall form and quantitative metrics of comparative *C. latrans*, *C. lupus*, and the unknown large canid. The methodology applied has been useful in exploring the range of variation of *C. latrans* and *C. lupus*, and in making a species determination of the specimens in question.

Poster Symposium II (Friday–Saturday, October 28–29, 2016, 4:19 PM)

NEUTRON COMPUTED TOMOGRAPHY SUCCEEDS WHERE X-RAY COMPUTED TOMOGRAPHY FAILS: ENAMEL THICKNESS IN THE HERBIVOROUS RHYNCHOCEPHALIAN *EILENODON* FROM THE LATE JURASSIC MORRISON FORMATION OF USA

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Over the past decade X-ray Computed Tomography (CT) has become a familiar approach for imaging and analysing fossil specimens whereas neutron CT has rarely been used. Nevertheless, X-rays are not always informative and neutrons can provide alternative results: X-rays tend to measure differences in atomic number (~density) whereas neutron attenuation coefficients do not show direct correlation with atomic number. We describe a case study where neutrons revealed the internal details of a specimen but X-rays could not. The specimen used was an unworn tooth referred to *Eilenodon* sp. (Lepidosauria: Rhynchocephalia) from Green Acres, Garden Park, USA (Late Jurassic Morrison Formation). The exterior shape of the tooth is relatively large (4.5 mm wide) and complex for a lepidosaur: distinct bulbous shape, pinched apex, large anterolingual shoulder, and apicobasal ridges. Worn teeth from the same assemblage show that the enamel was relatively thick and that when exposed in section it probably served as a cutting edge. This form of 'functional wear' is a common feature amongst mammalian herbivores such as rodents and suggests that *Eilenodon* orally processed herbaceous material. However, the enamel thickness has never been quantified or systematically compared to other rhynchocephalians. The tooth was subjected to both X-ray scanning (6.5 micron resolution) and neutron CT scanning (25 micron resolution). Despite the lower resolution, neutrons were able to distinguish between the enamel and dentine whereas X-rays could not. Using the neutron data and sophisticated segmentation software, we created three dimensional computer models of the dentine, enamel, and pulp cavity, so that they could be examined and measured in detail. The enamel thickness is about 0.2 mm thick with some regional variation (0.15-0.35 mm) which is considerably greater than that of many other rhynchocephalians such as the modern carnivorous relative *Sphenodon* (0.050-0.10 mm). Most of the apicobasal ridges of the tooth represent enamel thickening. However, some of the external complexity is reflected at the enamel-dentine junction so that the dentine component resembles a pyramid with four rounded faces. There is also a ridge on the distal face. To our knowledge, this study is the first comparison of the enamel-dentine junction in a lepidosaur and adds to our appreciation of anatomical diversity exhibited by extinct rhynchocephalian reptiles. More importantly, we show that neutron CT is superior to X-ray CT for understanding the internal structure of some fossil specimens.

Grant Information

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Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

A PRIMITIVE FOSSIL BAT FROM THE LATE MIDDLE EOCENE OF NORTHERN ANATOLIA

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Fossil bats (Chiroptera) first occur in the early Eocene, represented by such archaic taxa as *Onychonycteris* and *Icaronycteris*. By the middle Eocene, bats are present nearly worldwide, including modern families such as Rhinolophidae and Emballonuridae. Here, we report the discovery of an Eocene bat from the Uzunçarsidere Formation (UCF) in northern Anatolia, based on an isolated lower second molar and a lower fourth premolar and jaw fragment. The UCF bat shows similarities to archaic taxa like *Palaeochiropteryx* and *Honrovits*. The molar possesses a low hypoconulid positioned strongly posteriorly and somewhat lingually to the entoconid, and a nearly straight preentocristid connecting the entoconid and the metaconid. The premolar is anteroposteriorly broad with a relatively low protoconid and possesses a small paraconid and a distinct metaconid. The UCF bat is similar in molar morphology to *Palaeochiropteryx tupaiodon* with a similarly sized and positioned hypoconulid and straight preentocristid, but differs in having a less vertically projecting entoconid and hypoconid, and a preentocristid that is lower in relief. In premolar morphology the UCF bat resembles *Honrovits tsuwape* with a low-crowned protoconid and presence of possible paraconid, but differs in possessing a distinct metaconid and more lingual postprotocristid. The UCF bat differs from most other Eocene taxa in lacking a tall and anteroposteriorly narrow p4 and oblique preentocristed. The primitive characters of this specimen are notable, as it represents a relatively late occurrence of an archaic bat species during the late middle Eocene of Turkey.

Grant Information

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Technical Session XVI (Saturday, October 29, 2016, 10:45 AM)

TURNOVER OF LARGE HERBIVOROUS MAMMALS IN THE INDIAN SUBCONTINENT DURING THE PLIO-PLEISTOCENE

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The Plio-Pleistocene mammal faunas of the Indian Subcontinent are best known from the Siwaliks. This fauna can be divided into two faunal zones: Tatrot, which extends from the upper Pliocene to the Neogene–Quaternary boundary, and Pinjor, which spans most of the early Pleistocene. While fossils from these sediments have been collected since the mid 1800s, it is only recently that many of the localities have been dated magnetostratigraphically. These advances now allow us to analyze patterns of faunal change in this region.

Here, using the Sørensen-Dice dissimilarity index and its compositional difference and nestedness components, I characterized the species-level turnover of artiodactyls, perissodactyls, and proboscideans found in the Siwaliks of India and Pakistan. Species lists were collected from the published literature from the Potwar Plateau, Pabbi Hills, Mangla-Samwal anticline, Jammu, and Chandigarh region, and correlated with the paleomagnetic time scale. Taxa were binned into five time periods (3.6 Ma–3.1 Ma, 3.1 Ma–2.58 Ma, 2.58 Ma–1.77 Ma, 1.77 Ma–1.07 Ma, and 1.07 Ma–0.78 Ma). Changes in raw species richness for the different families were also assessed. Results show peaks of turnover after 3.1 Ma and after 2.58 Ma, largely driven by changes in species composition. A smaller peak after 1.77 Ma is also present but might be caused by sampling effects. Analyses of raw species richness of the individual families showed a gradual decline in suids with an accompanying increase in the number of bovid species and the appearance of cervids after 3.1 Ma. Hipparionine horses are replaced by *Equus* after 2.58 Ma. This replacement is also coincident with the reappearance of rhinocerotids in the Siwaliks. Stegodontids and elephantids persist through the time period, but gomphotheres disappear after 3.1 Ma. The peaks of turnover at 3.1 Ma and 2.58 Ma, coincident with an increase in the diversity of bovids, the appearance of the more hypsodont *Equus*, and the disappearance of browsing gomphotheres, suggests a change in the environment reflecting the global trends of cooling and aridification after the initiation of the Northern Hemisphere glaciations. Further investigations of the functional change of the Siwalik herbivores will help determine whether the patterns of turnover seen are consistent with the expectations of climatically induced habitat change.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

NEW INFORMATION ON THE CAPTORHINID REPTILE *CAPTORHINIKOS CHOZAENSIS* FROM THE LOWER PERMIAN OF TEXAS

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The reptilian family Captorhinidae is the most basal member of the Eureptilia and as such it is important to our understanding of the radiation and relationships of the entire reptilian clade. '*Captorhinkos*' *chozaensis* is a poorly known captorhinid reptile with multiple tooth rows. The species holotype is from Foard County, North-central Texas in what was originally characterised as the Lower Permian Choza Formation of the Clear Fork Group, but is now considered the upper part of the Clear Fork Group undivided. Recent studies in the Captorhinidae have accentuated the need for a more thorough examination of some members of the group, prompting this study of '*Captorhinikos*' *chozaensis*. The species holotype, specimen FMNH UR 97, is a partial lower and upper jaw with associated fragmentary tooth plates. The maxilla is fragmented, and no teeth from the anterior, single rowed region are present. However the maxilla clearly carries five rows of teeth in the multiple tooth row region, with the labial-most row extending posteriorly only about half the length of the remaining tooth rows. Contrary to the original illustration, the lower jaw exhibits clear suture lines between the dentary, coronoid, angular, surangular, and the prearticular elements. The dentary carries large but broken teeth anteriorly, and posteriorly four distinct rows of smaller teeth, the lingual-

most of which extends posteriorly only about half the length of the remaining tooth rows. Preliminary reassessment of the dentition of FMNH UR 97 suggests it conforms neither with the original generic diagnosis, which specifies the lingual-most and labial-most rows of teeth on the dentary never overlap, nor more recent redefinitions of the genus *Captorhinikos*. Further examination and phylogenetic analysis will be required to properly assign this specimen to either an existing or (possibly) a new taxon. Any new information on taxa originally designated as '*Captorhinikos*' has the potential to provide greater resolution to our understanding of the phylogenetic relationships of basal members of the captorhinid subfamily Moradisaurinae.

Technical Session XIV (Friday, October 28, 2016, 2:30 PM)

A NEW JURASSIC TRITHELEDONTID CYNODONT AND ITS IMPLICATIONS FOR SYNAPSID SURVIVORSHIP ACROSS THE TRIASSIC–JURASSIC BOUNDARY

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Tritheledontidae is a clade of small-bodied non-mammalian cynodonts lying extremely close to the origin of mammals. Few tritheledontid taxa are currently known, and most species are represented solely by fragmentary craniodental material. Here we present a new taxon of tritheledontid from the Lower Jurassic Upper Elliot Formation of Lesotho. The new taxon is based on a complete skull, lower jaws, both forelimbs, and anterior axial column, making it one of the most complete tritheledontids ever discovered. This specimen can be identified as a tritheledontid by the combination of upper postcanine morphology and presence of a hypertrophied lower incisor separated from the rest of the tooth row by a diastema. The new taxon can be distinguished from known tritheledontids by its extremely elongate, recurved, 'talon'-like main cusp on the lower postcanines and enlarged maxillary canines. This specimen is also remarkable for its relatively large size for a tritheledontid (7.0 cm dorsal skull length). The ulna of the new taxon lacks an olecranon process (as in *Diarthrognathus*, the only other tritheledontid for which there are extensive postcranial remains), suggesting limited burrowing ability compared to members of the other Jurassic non-mammalian cynodont clade, Tritylodontidae. Inclusion of the new taxon in a recent phylogenetic analysis of tritheledontids recovers it as a member of the otherwise-Triassic subfamily Chaliminiinae, with which it shares an increased maxillary tooth count (12 in the new taxon, 13 in the other chaliminiines). This indicates that all subfamilies of tritheledontids crossed the Triassic–Jurassic (Tr–J) boundary. Factoring in ghost lineages for tritylodontids and sinoconodontids and the universal survivorship of Triassic mammal clades into the Jurassic (even to the genus level in taxa such as *Morganucodon* and *Kuehneotherium*), we conclude that synapsids were largely unaffected by the Tr–J extinction event: the extinctions of Triassic synapsid groups like dicynodonts and gomphodonts significantly antedate the Tr–J boundary and were likely unrelated to the mass extinction.

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Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

MORPHOMETRIC ANALYSIS OF *URSUS ARCTOS* AND *U. AMERICANUS* MOLARS AS A DIAGNOSTIC TOOL

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Late Pleistocene American black bears (*Ursus americanus*) often overlap in size with brown bears (*U. arctos*). Thus, fossils of these ursids are occasionally difficult to diagnose to species level, especially when only partial remains are found. Large *U. americanus* have previously been distinguished from *U. arctos* by the length of the upper second molar (M2). However, large fossil *U. americanus* sometimes have teeth overlapping in size with those of small *U. arctos*. As such, there is need for a more accurate tool to distinguish the two species. Due to the high degree of variability in bear teeth, most simple features, such as presence or absence of accessory cusps, have proven to be non-diagnostic. Here we apply geometric morphometrics to the M2 and further assess the utility of this tooth for distinguishing modern *U. americanus* and *U. arctos* specimens. Preliminary results show a strong statistical separation between these bears, with the greatest difference concentrated around dimensions of the paracone and metacone. These results suggest that this tool is more reliable than using linear measurements, and that the inclusion of fossil specimens could lead to a better understanding of when brown bears spread across North America.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

PLACING NATURALIS' *TYRANNOSAURUS REX* SPECIMEN IN A TAPHONOMIC, PALEOENVIRONMENTAL AND INTEGRATED STRATIGRAPHIC FRAMEWORK: HELL CREEK FORMATION, EASTERN MONTANA

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From 2018 onwards, the National History Museum of the Netherlands, Naturalis Biodiversity Center in Leiden, will host a new exhibition dedicated to dinosaur paleontology. A relatively complete and extraordinarily well-preserved specimen of *Tyrannosaurus rex* will form the centerpiece of this gallery. Well over 50% of the skeleton has been recovered, including an articulated skull, left scapula and coracoid, furcula, much of the vertebral column and rib cage, pelvis, right leg and a large part of the tail.

The specimen was excavated in 2013 from a fluvial sandstone deposit of the Upper Maastrichtian Hell Creek Formation, c. 50 km southwest of Jordan, eastern Montana, USA. In September 2014, a geological field campaign was conducted to study three aspects of this fossil locality: the taphonomy and sedimentary context (1), the paleoenvironmental conditions (2) and the geological age of the site (3).

The unique three-dimensional preservation of this *Tyrannosaurus rex* specimen can be explained by a very rapid burial shortly after its death, as suggested by the presence of rip-up clasts and climbing ripples at the dig site. Additional grain-size and thermogravimetric analysis show that the skeleton was entombed in a 3.20 m thick body of fine, poorly consolidated, well-sorted sand with a high dolomite content. Furthermore, the sandstone was not compacted, thereby preventing bone deformation. Lastly, the high carbonate content protected the skeleton against subsequent leaching.

A paleoenvironmental reconstruction, based on field evidence and pollen analysis, shows that the ecosystem of this *Tyrannosaurus rex* was characterized by meandering rivers surrounded by densely vegetated floodplains and shallow lakes. The various palynomorph taxa indicate the presence of a high biodiversity, subtropical forest dominated by angiosperms of the *Wodehouseia spinata* Assemblage Zone.

The age of the fossil locality was determined using an integrated stratigraphic approach combining litho-, magneto-, bio- and cyclostratigraphy. Paleomagnetic measurements of the different sections all show a normal polarity that coincides with chron C30N and thereby excludes a stratigraphic position in the upper part of the Hell Creek Formation. Combined with the presence of the palynostratigraphic marker species *Aquilapollenites collaris*, an age range between c. 66.7 and 67.2 Ma can be established.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

THE YOUNGEST NORTH AMERICAN OCCURRENCE OF A BASAL CHORISTODERE (REPTILIA, CHORISTODERA) FROM THE UPPER CRETACEOUS (MAASTRICHTIAN) HELL CREEK FORMATION, NORTHEASTERN MONTANA, USA

KATSURA, Yoshihiro, Ishikawa Museum of Natural History, Kanazawa, Ishikawa, Japan; DEMAR, David G., University of Washington, Seattle, WA, United States of America; WILSON, Gregory P., University of Washington, Seattle, WA, United States of America

Choristodera is an order of extinct semi-aquatic diapsid reptiles commonly found in Upper Cretaceous and Paleocene non-marine deposits of North America, including the well-known gavial-like neochoristodere, *Champsosaurus*. Previously, the only post-Jurassic record of a lizard-like or non-neochoristodere (e.g., *Cteniogenys*) was from the Campanian-age Oldman and Dinosaur Park formations in southern Alberta, Canada. Here we note the youngest North American occurrence of a non-neochoristodere on the basis of a fragmentary left maxilla (UCMP 556734) from the lower portion of the Maastrichtian-age Hell Creek Formation, northeastern Montana, USA. Only the middle third of the bone remains, including the region of the palatine facet and opening of the superior alveolar canal. UCMP 556734 shares several morphological features in common with the Oldman and Dinosaur Park taxon (formerly identified as *Cteniogenys* sp., cf. *C. antiquus*) and the type species of *Cteniogenys* (*C. antiquus*) from the Middle-Late Jurassic of Euramerica, including subthecodont, short conical teeth that are heavily cemented at their bases and have large, rounded resorption pits, but lack the basal plicidentine infolding. Furthermore, a tiny developing tooth is visible in UCMP 556734 at the base and within the shell of a broken tooth, a feature also present in *Cteniogenys*. However, UCMP 556734 differs from the other taxa in lacking the numerous foramina with long grooves on the lateral surface of the maxilla and striated tooth crowns (faint in the Oldman and Dinosaur Park taxon). In contrast, the lateral surface of UCMP 556734 is smooth and perforated by three moderate-sized foramina and has unstriated tooth crowns with weakly developed mesial and distal carinae. These morphological differences suggest that two distinct non-neochoristoderes were present in North America during the Late Cretaceous and currently represents the only time when both basal lizard-like and derived gavial-like choristoderes co-inhabited the fluvial environments of North America.

Symposium II (Friday, October 28, 2016, 11:30 AM)

SHARED DEVELOPMENTAL RULES PREDICT PATTERNS OF SIZE EVOLUTION IN VERTEBRATE SEGMENTED STRUCTURES

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Phenotypic diversity is not uniformly distributed, but how biased patterns of evolutionary variation are generated and whether common developmental mechanisms are responsible remains debatable. High-level "rules" of self-organization and assembly are increasingly used to model organismal development, even when the underlying cellular or molecular players are unknown. One such rule, the inhibitory cascade, predicts that proportions of segmental series derive from the relative strengths of activating and inhibitory interactions acting on both local and global scales. Using skeletons of a large range of vertebrate fossil and extant taxa, we demonstrate that this developmental design rule explains population-level variation in segment proportions and macroevolutionary diversity in limbs, digits and somites. We also find that in populations of birds (pigeons), the response to artificial selection follows expectations of the model. Furthermore, in chick embryos, experimental blockade of putative signals results in a shift of proportions in the expected direction. Together with evidence from teeth, all these results indicate that segmentation across independent developmental modules shares a common regulatory "logic", which has a predictable impact on both the short- and long-term evolvability. Such biased variational patterns can help paleontologists interpret evolution of segments and modules in vertebrates.

Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

EVOLUTION OF MINERALIZED DENTAL TISSUE MATERIAL PROPERTIES IN GNATHOSTOMATA

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During their 425 million year diversification, gnathostomes came to exploit an unprecedented variety of trophic niches. Modifications to dental form and mineralized tissue constituents (enamel, dentines and cementum) facilitated their exploitation of novel prey and/or plant matter. In general it has been assumed that the tissue-level biomechanics of these constituents had little bearing on whole-tooth functionality, aside from mammals with dental occlusion. These animals possess teeth that self-wear to functionality and show a diversity of derived dental tissues (e.g., prismatic enamel types, coronal cementum)—some which have been shown to possess unique biomechanical attributes. Here we test the hypothesis that the biomechanical material properties of non-mammalian gnathostome dental tissues were uniform. We then explore how those properties may have changed with the cladogenesis of Mammalia and how changes in diets and dental morphology correlate with tissue-level biomechanics throughout the gnathostome radiation. The mineralized tissues of teeth from representatives of major taxonomic clades spanning the non-mammalian and mammalian radiation were tested using microindentation techniques. Young's modulus (pertinent to whole tooth structural biomechanics), hardness (a proxy for wear resistance), and crack channeling (a measure of tissue fracture resistance) were determined. These data were mapped onto a robust comprehensive phylogeny for Gnathostomata and analyzed in evolutionary and ecological contexts. The results show that the mechanical properties of non-mammalian gnathostomes exhibit substantial intercladal variation. For instance enamel/enameloid Young's modulus and hardness values are low in squamates and neopterygii, and very high in chondrichthyans, archosaurs and therian mammals. The enamels of non-eutherians exhibit isotropic fracture patterning and are prone to catastrophic failure. This stands in contrasts to eutherian enamel (with the exception of cetaceans) where crack channeling in association with enamel prism fabrics serves to localize damage. Orthodentine hardness and modulus values largely mimic the patterns seen in the enamels, but show greater variability within sub-clades. The results of our study show that mineralized tissue material property variation in non-mammalian gnathostomes, like mammals is considerable, and suggests that natural selection acted at the tissue-level to convey differences in whole tooth functionality throughout the radiation of gnathostomes.

Technical Session XII (Friday, October 28, 2016, 3:45 PM)

NOTHING BUT SKIN AND BONES: *ANCHIORNIS* BODY OUTLINE REVEALED BY LASER FLUORESCENCE

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The outline of an animal is a fundamental expression of its biology, reflecting its gross anatomy and size. Fossilised body outlines provide invaluable constraints for reconstructing aspects from biomechanics to physiology, but are extremely rare to find. Even with exceptional soft tissue preserving fossils, prior studies have been hesitant to quantify body outlines because of imperfections arising from taphonomic processes.

Using a new technique called laser-stimulated fluorescence imaging, high-definition soft tissues that are mostly invisible under white light conditions are revealed, greatly increasing the data available for body outline reconstructions. In this study, 229 specimens of the iconic Jurassic-aged 'five-winged' dinosaur *Anchiornis huxleyi* (Theropoda: Paraves) are surveyed and are shown to preserve exceptional details of the skin, patagial folds and footpads. In a first amongst dinosaurs, these data are used to reconstruct a quantitative high-detail body outline that confirms that the tail and legs were functionally decoupled and that the wing had close modern bird affinities, and reveals the body outline around the pubis for the first time. The imaging technique promises to reveal similar insights in other lagerstatten fossils and is facilitated by its low operational cost, rapid results and non-destructive nature.

Grant Information

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Technical Session XVII (Saturday, October 29, 2016, 9:15 AM)

BEYOND THE *SHONISAURUS* DEATH CULT: NEW INSIGHTS INTO THE ECOLOGY AND LIFE HISTORY OF THE EARLIEST GIGANTIC MARINE TETRAPOD

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Ranging up to 15 m in length, the Triassic ichthyosaur *Shonisaurus popularis* was the first marine tetrapod to attain truly gigantic proportions. *Shonisaurus* is famous both for its size and for exceptional fossil concentrations found in the Upper Triassic (Carnian–Norian) Luning Formation in central Nevada. An assemblage of 6–9 skeletons concentrated on a single 250 m^2 bedding plane is preserved as an *in-situ* public display at Berlin-Ichthyosaur State Park. Additional multi-individual accumulations of *Shonisaurus* occur at other sites in the area, but other marine tetrapods are conspicuously absent.

Although the apparent mass mortality preserved in the display quarry has garnered much attention, the paleobiology of *S. popularis* remains enigmatic despite a rich fossil record. As part of a detailed reappraisal of the site, we produced high-resolution digital models of the fossils in the display quarry and conducted extensive field surveys. Ichthyosaur fossils remain locally abundant and we discovered new material, notably the well-preserved partial jaws and skull of an individual much smaller than those in the display quarry. We also re-evaluated type material and additional specimens, including fossils from other Nevada ranges pointing to a broad distribution of *Shonisaurus* within the region.

The gigantic size of *Shonisaurus* suggests a novel ecology relative to contemporaries. Previously, the apparent absence of teeth associated with adult *Shonisaurus* skeletons inspired comparison to both baleen and deep-diving toothed whales and suggestions of filter or suction feeding. We located multiple dentigerous *S. popularis* jaws and isolated teeth, in the field and existing collections, including a jaw in the display quarry. These fossils confirm the presence of teeth in all ontogenetic stages. These robust, occasionally carinate teeth, set in individual sockets, likely played a role in prey capture or processing and indicate a macropredatory niche rather than filter or suction-feeding.

Our new data span a wide ontogenetic series, including the jaw of a small individual, probably an embryo or neonate. These indicate *Shonisaurus* occupied the area at multiple stages in its life history. Though the mechanisms behind the mass death assemblage remain a topic of investigation, our improved understanding of the paleobiology of *S. popularis* helps to constrain possible scenarios and is potentially consistent with previous suggestions of reproductive aggregations in a partially restricted environment devoid of other marine reptiles.

Grant Information

Smithsonian Small Grants Fund

Technical Session II (Wednesday, October 26, 2016, 9:00 AM)

OUT WITH THE OLD AND IN WITH THE NEW: A NEW SET OF BODY SIZE ESTIMATION EQUATIONS FOR *ANOLIS* AND THEIR IMPLICATIONS FOR MACROEVOLUTION

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Estimating the body size of fossil organisms is an essential part of many paleontological studies, and allows us to describe macroevolutionary trends in diversification and extinction for a multitude of taxonomic groups. But, paradoxically, few studies publish the methods used to produce the body size estimates that they report. This is especially true for squamates, where paleontological data suggests patterns of Holocene dwarfism and size-biased extinction throughout the Quaternary. We use modern comparative specimens to develop a set of body size estimation equations for the Neotropical lizard genus *Anolis*. We evaluate how different skeletal elements and suites of comparative specimens impact the accuracy of each equation in predicting the known body size of modern comparative specimens. We then compare our results with previously published body size estimates for fossils of *Anolis* lizards. We found that there is significant variation in the accuracy of different skeletal elements in estimating body size. Further, our new equations suggest that what has been described as Holocene dwarfism for some *Anolis* taxa is likely to reflect a methodological bias, and fossil representatives of these species likely had a similar size to modern individuals. Our study highlights the importance of method transparency and method standardization in reporting body size estimates for paleontological material, so as to further comparative studies and articulate macroevolutionary patterns.

Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

COMPOSITIONAL PROFILES OF TYMPANIC BULLAE OF MODERN BALAENOPTERIDS AND BALAENIDS (CETACEA, MYSTICETI): IMPLICATIONS FOR FOSSILIZATION AND CETACEAN PALEOECOLOGY

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Cetaceans (whales, dolphins, and porpoises) are united by the presence of a highly dense medial wall (the pachyosteosclerotic involucrum) of the middle ear bone (tympanic bulla), which is an adaptation for underwater hearing. The unique composition of this structure (low porosity and organic content, high mineral density) is more akin to that of enamel than other bone and may heighten its resistance to diagenetic alteration after burial. If so, tympanic bullae may provide a new resource for paleoecological study through geochemical analysis, an especially appealing outcome for those cetacean taxa for which tooth enamel is not available (i.e., mysticetes). Here, we assessed the preservation potential of the cetacean tympanics by generating high resolution records of compositional changes across these structures from extant species of mysticetes and then comparing these records to those generated from fossil ear bones. Our objective was to see if patterns identified in ear bones from living species are preserved in fossilized ear bones and, if so, to what degree are they retained. Thick sections were made from three tympanic bullae from extant mysticetes (*Megaptera novaeangliae, Balaenoptera physalus, Eubalaena glacialis*) and two tympanic bullae from fossil mysticetes (Miocene cetotheriids). A total of 78 samples were collected along dorsoventral transects running across each thick section. Samples were subsequently analyzed using loss-on-ignition (LOI) analysis. LOI is carried out by weighing samples before and after roasting them in a muffle furnace at progressively higher temperatures (100, 500, 1000°C) in order to assess the percent water, organic and mineral composition of the sample. For all tympanics from modern species, we found a clear increase in organic content from the dense, crystalline interior (~14 ± 2.7 wt%) of the tympanic outward (~34 ± 14 wt%), as well as a distinct decrease in mineral content (~86 ± 2.7 wt% to 66 ± 14 wt%). In the fossil specimens, we anticipated retention of a similar trend, but instead observed a steady mineral signal across the transect (~95 ± 0.5 wt%), which suggests degradation of some organic material (as expected) and ultimately mineral replacement. These results question the reliability of tympanics as a preservational proxy for teeth in fossil specimens, but do not rule out application of this material for paleocological analysis. Future studies will assess the tympanic's value as an archive of ecological information in a greater number of fossil and modern specimens.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

THE SMALLEST KNOWN DIDACTYL DINOSAUR FOOTPRINTS FROM THE EARLY CRETACEOUS JINJU FORMATION, JINJU, KOREA

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The trackways of dromaeosaurids such as *Dromaeosauripus jinjuensis* and *D. hamanensis* are known from the Cretaceous Jinju and Haman formations of the Gyeongsang Supergroup, Korea, respectively. Together with other deinonychosaurian tracksites from the Cretaceous of Asia, North America, and Europe, a total of at least 16 sites are known. Recently, diminutive didactyl dinosaur tracks were discovered from the upper part of the Jinju Formation at the large building site works of Gyeongnam Innovation City (usually called Jinju Innovation City) of Jinju City, Gyeongsangnam-do, Korea. The tiny didactyl dinosaur tracks are preserved on top of a fine-grained sandstone bed with a mud drape on the uppermost surface. A total of 16 recognizable didactyl tracks have been identified, including two trackways with 7 and 3 consecutive tracks, and an additional 6 isolated tracks. The length and width of the tracks range from 0.64 - 1.72 cm (average 1.05 cm) and 0.23 - 0.56 cm (average 0.39 cm), respectively. The step, stride, and pace angulation of the trackway 1 are 3.00 - 6.11 cm, 8.41 - 13.01 cm, and 182.2° - 196.7°, respectively. In trackway 2, the step, stride, and pace angulation are 25.2 - 31.3 cm, 55.6 cm, and 168.0°. The widths of digits III and IV, which are almost parallel, but clearly separated, average 1.62 mm. These are by far the smallest didactyl tracks ever found, and are at least an order of magnitude smaller than the smallest *Dromaeosauripus*.

The morphological characteristics of the didactyl tracks are similar to *Dromaeosauripus jinjuensis* from the middle part of the Jinju Formation, in which the proximal traces of the digits are separated. However, the sizes of the tracks are extremely small in comparison with *D. jinjuensis*. Therefore, they likely represent juvenile individuals, possibly of the *D. jinjuensis* trackmaker. Assuming a foot-length/hip height ratio of 1:5, the hip height would have been between 3.2 and 8.6 cm. Likewise, using a hip height:body length ratio of about 1:2.6, these diminutive trackmakers would have had body lengths on the order of only 8.3 to 22.4 cm. It is notable that the Haman Formation has also yielded very small theropod tracks (length ~1.0 cm) assigned to the ichnogenus *Minisauripus*. Thus two diminutive theropod track morphotypes are now known from the Cretaceous of Korea.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

ISOTOPIC DIETARY RESPONSE TO INTERSPECIFIC COMPETITION BETWEEN MURINE AND CRICETID RODENTS IN THE EARLY MIOCENE OF PAKISTAN

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Abiotic forces, including climate change, continental drift, and geographic barriers, have been viewed as dominant drivers of macroevolutionary change in organisms through various approaches of empirical research including ecological, phylogenetic, and paleontological studies, which operate on different time scales. On the other hand, influenced by van Valen's Red Queen hypothesis, biotic interactions such as interspecific competition for food, predator-prey interactions, sexual selection, and density-dependent natural selection have been recognized as limited factors of shaping macroevolutionary patterns. In vertebrates, possible morphological diversification and/or constraints due to the presence of competitors is rarely documented in the long-term scale. To examine dietary evolution of competitively vulnerable animals against superiors, we investigated a paleontological turnover in which hamster-like cricetid rodents of the Pakistan Siwaliks were completely replaced by murine rodents (mice) within 5 million years of the first appearance of basal murines.

We conducted laser-ablation carbon isotope analysis on tooth enamel of 80 specimens of cricetid rodents, ranging from 15 to 6.5 Ma, and compared values with murine data, previously obtained at the same laboratory, to test two preliminary hypotheses bearing on interspecific competition. The first hypothesis is that carbon isotope values can reveal dietary competition between mice and hamsters even in a C_3 plant-dominated region, and that temporal change of dietary niche breath can be observed as variance of the isotope values. The second hypothesis is that isotopic dietary behaviors reflect phylogeny more strongly than body size similarity in interspecific competition. Our dataset suggests that the dietary competition among these fossil rodents can be detected even in the C_3 plant-dominated region, but that change in dietary niche breath could not be observed by variance. Although the power of the statistics is still weak due to the small number of the samples, phylogeny is suggested to be a more important factor than body size. Mice have isotope values and variance similar to phylogenetically closer taxa, regardless of size, rather than distant taxa of similar size.

Grant Information
KAKEN 15H06884

Technical Session III (Wednesday, October 26, 2016, 2:30 PM)

SEMICIRCULAR CANAL SHAPE WITHIN AVES AND NON-AVIAN THEROPODA: UTILIZING GEOMETRIC MORPHOMETRICS TO CORRELATE LIFE HISTORY WITH CANAL CROSS-SECTIONAL SHAPE

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The semicircular canals of the endosseous labyrinth are one of the keystone features of the vestibular system in vertebrates due to their ability to detect angular acceleration and deceleration of the head. While the semicircular canal function in modern vertebrates is well understood, the cross-sectional shapes in theropods have not been studied. This exploratory project outlined and analyzed the interior shapes of 14 semicircular canals from non-avian theropods (tyrannosaurids, therizinosaurids, allosaurids, and ornithomimids), an extinct bird (phorusrhacid), and extant birds (ratites). To test how canal shapes changed through time, ImageJ was used to create two-dimensional shape outlines of rostral semicircular canals, caudal semicircular canals, and lateral semicircular canals from pre-rendered three-dimensional endosseous labyrinths. A Principal Components Analysis was performed on the outlines of the canals to observe how specimens grouped by shape change. The rostral semicircular canals exhibited groupings based on diet as the canal shape changed from a subtriangular (in carnivores) shape to circular (in herbivores). However, the caudal semicircular canals and lateral semicircular canals showed groupings that could not be interpreted as a behavior, diet, or the phylogenetic placement of a specimen. The caudal semicircular canals and lateral semicircular canals morphologies show little to no qualitative shape change in any of the taxa analyzed. Additionally, theropod semicircular canals exhibited the most significant shape change along their Y-axis ($p=0.03$) than the X-axis ($p=0.11$). This shows that theropod canals elongated or shortened dorsoventrally as they changed within each specimen rather than widening or narrowing. A grouping focused around diet in the rostral semicircular canals and a statistically significant shape change along the Y-axis potentially shows the importance of the rostral canal as an endocranial identifier of trophic level as well as indicate how labyrinth morphology changes within a lineage based on the dietary preferences of any given theropod. However, low sample sizes and constraining test parameters keep this hypothesis from being applied to all dinosaurian and avian taxa. Moreover, a more diverse sample set from additional modern analogs would help to address how changes in canal shapes affect the vestibular system of birds. Further scanning and modeling of bird and dinosaurian skulls would need to be carried out in order to apply this method to Ornithischians or flight capable birds.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

MICROVERTEBRATES OF THE LANCE CREEK FORMATION IN EASTERN WYOMING: A COMPREHENSIVE HISTORY OF THE LAST 70 YEARS

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Fossil vertebrate remains have been found in the Lance Creek Formation for over one hundred thirty years. This ranges from the early work by Hatcher to that done by Dorf and Hibbard and the ground breaking work done by Savage, Clemens, McKenna, Estes and Breithaupt. There are two main methods that were used in collecting. The first was surface collection, in which weathered specimens were picked from the surface. This method commonly involves the selection and collection of larger and more easily identifiable specimens. The second method used in these studies was minor quarrying, which required and still requires excavation, collection, and total screen rinsing of a large volume of material; this method was utilized in order to recover all fossils present.

The Lance Creek area is dominated by non-marine, coastal floodplain sandstones, mudstones, and marls, with marginal marine sandstones and shales in the lower part of the formation, which have yielded over forty thousand vertebrate remains that represent at least seventy-five species, with a minimum of twelve new species and ten genera that have been recovered. The results of these two common collection methods demonstrate how each one influences fossil recovery according to shape and size by skewing the characteristics of collected fossil assemblages and the taphonomic interpretations of microvertebrate accumulations.

The microvertebrate fossils and dinosaurs represent important components of the latest Mesozoic vertebrate assemblages. The dinosaurs are represented mostly by incomplete skeletal material, but the majority of the fossils tend to be disarticulated to fragmentary limb bones, vertebrae, fish scales, osteoderms, jaw and cranial elements, and loose teeth belonging to crocodilians, guitarfish other assorted fish including gars, turtles, lizards, and mammals. The microvertebrates in this area are prolific and the fossils tend to be relatively diagnostic, recording a greater diversity of taxa (at higher taxonomic levels) than do the more frequently collected large dinosaur elements.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

HOW GOOD IS THE TARSOMETATARSUS FOR AVIAN SPECIES IDENTIFICATION? 3D GEOMETRIC MORPHOMETRICS IN THE HESPERORNITHIFORMES (AVES, ORNITHURAE)

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Hesperornithiformes were flightless foot-propelled diving birds that lived during the Late Cretaceous and have an excellent fossil record compared to most Mesozoic birds. Extinct bird taxa are often identified from fragmentary or isolated specimens, and several species of within the Hesperornithiformes have been named on the basis of the tarsometatarsus alone. Size has often been the main criterion for taxonomic differentiation, but little has been done to examine intraspecific factors (ontogenetic stage, sex, etc.) that determine the form of this bone. To test for intraspecific and interspecific variation in the tarsometatarsus of hesperornithiforms, I examined variation in extant members of the foot-propelled diving Gaviidae (loons) and Podicipedidae (grebes). Loons and grebes are morphologically similar to extinct hesperornithiforms, making them appropriate analogues, even if we cannot assume homologous levels of variability in the two groups. Only adult female specimens were chosen for analysis to reduce the possibility of sexual dimorphism or ontogenetic differences. I used landmark-based Geometric Morphometrics to analyze 3D scans of specimens from three species per family, totaling 22 extant specimens, plus an additional thirteen individuals from five named species of *Hesperornis* and two individuals of *Parahesperornis alexi*. Separate analyses were performed on the shape of the full bone, the shape of the distal end, and the shape of the proximal end for each clade (Gaviidae, Podicipedidae, and Hesperornithidae). In nearly every Principal Component Analysis of extant and extinct groups, individuals did not group by species, and any "taxonomic" grouping recovered was poorly defined. Neither geometric analyses nor autapomorphic traits were able to recover the published species-level taxonomy of *Hesperornis*. In contrast, the tarsometatarsi of *Hesperornis* and the closely related *Parahesperornis* are distinct in both respects. These results indicate that intraspecific variation swamps interspecific variation

in foot-propelled divers, and so the tarsometatarsus alone is not a reliable taxonomic guide. Because there is no evidence that the tarsometatarsi of the much more poorly sampled hesperornithiforms bear species-specific synapomorphies, taxonomic schemes of named hesperornithiform species based solely or mainly on tarsometatarsi should not be used in studies of diversity, because they may artificially inflate species counts.

Grant Information
Received a Graduate Research Grant from the Geological Society of America

Poster Symposium I (Wednesday–Thursday, October 26–27, 2016, 4:15–6:15 PM)

A NEW PRIMATE PARTIAL CRANIAL SPECIMEN FROM THE LATE MIDDLE EOCENE OF THE TORNILLO BASIN, TEXAS

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Paleontological research in the Tornillo Basin of Texas since 2005 has yielded a large sample of late middle Eocene vertebrate fossils, including dento-gnathic material of at least five primate genera. Here we describe a new primate partial cranial specimen collected in March of 2015 from the middle member of the Devil's Graveyard Formation. Although the absolute age of the specimen has not yet been determined, it was recovered from a stratigraphic horizon located between the late Uintan (Ui3) localities of the Serendipity Local Fauna (approx. 41–43 Ma) and the Duchesnean localities of the Skyline Local Fauna (approx. 38–40 Ma). The new primate specimen consists of undistorted left and right frontal bones. Lack of an associated dentition precludes attribution of the specimen to a known genus. Nevertheless, the new specimen shares a suite of derived characteristics with *Rooneyia viejaensis*—a Duchesnean species known only from a cranium recovered in the Sierra Vieja, Texas, in 1964. Probable synapomorphies of the two Texas specimens include (1) partial fusion of the metopic suture, (2) orbital fossae that are deeply recessed under the anterior cranial fossa, (3) the presence of a small postorbital flange on the ventral surface of the lateral process of the frontal, and (4) the presence of a large foramen on the posterosuperior aspect of the postorbital flange. This combination of features is unique to the two Texas specimens among North American Eocene primates that are known from cranial material. Despite these similarities, the new Devil's Graveyard frontal differs from *Rooneyia* in exhibiting (1) slightly larger absolute size, (2) rounded and everted orbital margins, (3) more pronounced temporal lines, (4) a slightly larger olfactory bulb endocast, and (5) a frontal lobe endocast that is less dorsally expanded. The new Devil's Graveyard frontal is, therefore, probably not *Rooneyia* but may represent a closely related taxon. Furthermore, neither *Rooneyia* nor the new Devil's Graveyard frontal has contact between the alisphenoid and the postorbital flange. In this respect, the two Texas specimens differ from tarsiers and anthropoids, which exhibit more extensive postorbital septae comprised of flanges from the frontal, zygomatic, and alisphenoid. This lack of alisphenoid expansion, combined with the persistently primitive morphology of the middle ear and nasal cavity in *Rooneyia*, suggests that neither Texas specimen belongs to the haplorhine crown group.

Poster Symposium II (Friday–Saturday, October 28–29, 2016, 4:26 PM)

THE MORRISON FORMATION'S ANKYLOSAURS

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After nearly 150 years of dinosaur discoveries, the Morrison Formation's first ankylosaur, *Mymoorapelta maysi* (Mm), was described from western Colorado in 1994 and was soon followed by *Gargoyleosaurus parkpinorum* (Gp) from Wyoming in 1998. Subsequently, there are now 12 sites in the Morrison that have yielded ankylosaur remains. Both taxa are closely related (sister taxa), assignable as basal Polacanthidae. Although both preserve extensive skeletal material, there are few overlapping elements in the type specimens. Based purely on the type specimens, Mm and Gp are diagnosed on differences in proximal caudal vertebrae with expanded neural spines in Mm and not Gp; proximal caudal ribs flexed ventrally in Mm and not in Gp; the development of a wider, more massive basicranium in Mm and not Gp; the fusion of cervical half rings in Gp and not Mm; and in longer, more tapered proximal caudal plates in Mm and not Gp. Interestingly, it has been comparison of the armor between the types and newly discovered specimens that has done the most to emphasize the many additional skeletal differences between these two taxa. The presence of the cervical ring in a specimen from northern Wyoming permitted the assignment of a well-preserved pelvis to *Gargoyleosaurus*. A partial pelvis is known for *Mymoorapelta*, with a comparison of caudal plates in life position identifying another western Colorado skeleton to *Mymoorapelta*. From these, it is noted that *Mymoorapelta* has a dorsal groove on the ventral side of the sacrum and did not have a fused dorsal synsacral rod; apparently utilizing, widened, ossified dorsal tendons, instead of fusing the dorsal vertebrae to stiffen its back. The pelvis of *Gargoyleosaurus* has a typical ankylosaurian synsacral rod, and a keel on the ventral side of the sacrum. A well-preserved sacrum from southwest Utah is identifiable as that of *Mymoorapelta*. The caudal plates from the Dry Mesa Quarry, western Colorado, suggest *Gargoyleosaurus* was present in Colorado. Caudal plates in a specimen from near the base the Morrison Formation in southern Wyoming suggest a possible third taxon.

Technical Session II (Wednesday, October 26, 2016, 8:00 AM)

EARLIEST STEM-SQUAMATE (LEPIDOSAURIA) FROM THE LATE TRIASSIC OF ARIZONA

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Crown group lepidosaurs are highly diverse: they comprise more than 7,000 globally distributed extant species of lizards and snakes (Squamata), plus the single rhynchocephalian genus *Sphenodon*. The earliest known lepidosaurs are rhynchocephalians from the Late Triassic of Europe, and this group quickly diversified and achieved a global distribution by the end of the Triassic. In contrast, early squamates have a sparse fossil record; their first representatives are found in the Early-Middle Jurassic of Laurasia. Although Rhynchocephalia and Squamata diverged in the Middle Triassic, a 40-50 million years ghost lineage exists for Squamata. Jurassic squamates are already considerably derived, and have already diversified into their extant groups, which testifies to a substantial gap in the known fossil record.

Here we report on a new lepidosaur from a Norian microvertebrate site in Petrified Forest National Park, Arizona. This fossiliferous locality is from the Upper Blue Mesa Member of the Chinle Formation, and is dated to 221 mya. The depositional environment is a shallow anoxic lake, where skeletal elements preserved are disarticulated and often fragmentary. The site has yielded a diverse small vertebrate fauna, including the new lepidosaurs and several undescribed rhynchocephalians. Skeletal elements are represented by numerous small, delicate pleurodont maxilla and dentaries. We integrated the material of the new lepidosaurs into phylogenetic analyses of Permo-Triassic Diapsida and Mesozoic Lepidosauromorpha, using maximum parsimony, maximum likelihood, and Bayesian analysis. All analyses support the new taxon as the sister taxon to all other Squamata, substantially reducing the ghost lineage of Squamata. This discovery indicates that the absence of squamate fossils in their early evolutionary history could be caused in part by collection bias towards larger, more robust specimens.

This taxon provides a look into the early evolutionary history of squamates. It also adds direct evidence of yet another major lineage of extant terrestrial vertebrates to originate in the Triassic.

Grant Information
A grant was given to the primary author to travel and present at the SVP 2015 meeting; the grant was given by the University of California Museum of Paleontology for $845 dollars.

Preparator's Session (Thursday, October 27, 2016, 8:30 AM)

PALEONTOLOGY LABORATORY EQUIPMENT, MATERIAL, AND METHODS FOR UTILIZING ULTRAVIOLET LIGHT IN FOSSIL PREPARATION

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In an effort to facilitate and broaden the use of ultraviolet (UV) lighting techniques in preparation of fossils, several experiments were conducted utilizing various lighting methods and wavelengths from both visible and non-visible light. This research was primarily performed on a nearly complete *Stylemys nebrascensis* tortoise recovered in 1994 and donated to the Heard Natural Science Museum in 2013 for preparation and display. The specimen was collected from the White River Group bentonite sediments of the Brule Formation.

The bentonite matrix was a uniform gray color and the fossils contained within were of a similar neutral gray coloration; any contrast between bone and matrix was difficult to discern under visible light. Ultraviolet (UV) light in the high range (UVA, 395 nanometers [nm]) was found to be most effective and would greatly enhance the quality of fossil preparation. The source of the light was critical when using UV as light emitting diodes (LEDs) produced a focused beam on the specimen that excited the electrons of the matrix and bone in different ways. Incandescent or fluorescent light sources had a minimal effect and were inferior compared to LED illumination. When viewed through amber UV filter glasses, the matrix absorbed the UV light turning the uniform gray color to a dark brown while the bone reflected the light resulting in a pale blue, nearly white shade. The remarkable contrast in hues gave the laboratory volunteers a valuable resource to use and provided the confidence needed to remove deposits without incurring damage to the fossil. In addition to the initial research on the White River specimens, further experiments have concluded that the benefits of UV light during preparation also extends to other specimens within clay composition deposits. During the experiments, specific safety protocols were developed and utilized by the volunteers. Any exposure to additional UV light can be harmful and although the work is completed with UVA at very low wattage (3 watts) and a limit of four hours for UV sessions is established, each preparator is required to wear gloves and UV filter glasses to protect the skin and eyes from potentially harmful radiation. A typical lab station would include a desk lamp equipped with a three watt, 395 nm UV LED bulb(s), and UV filter glasses.

Symposium III (Saturday, October 29, 2016, 8:15 AM)

BLOOD FLOW INDEX OF BASAL EUPELYCOSAURIA SUGGESTS ELEVATED METABOLIC RATES SINCE THE CARBONIFEROUS

KNAUS, Philipp L., University of Bonn, Bonn, Germany; SANDER, P. Martin, University of Bonn, Bonn, Germany; VAN HETEREN, Anneke H., Zoologische Staatssammlung, München, Germany; LUNGMUS, Jacqueline K., University of Chicago, Chicago, IL, United States of America

Recent endotherms (mammals and birds) show at least a twofold increase in mass-specific maximum metabolic rate (MMR) over ectothermic reptiles. MMR is linked to basal metabolic rate, and as such MMR in the mammal and bird range indicates endothermy. The cross-sectional area of the midshaft nutrient canal (or canals) relative to femur length is an index of blood flow into the bone interior (Qi) and correlates with MMR in recent amniotes. This correlation is likely caused by the need for increased blood flow into the bone during and after exercise for dynamic bone remodeling. Mass-specific Qi has been used to infer the MMR of extinct animals, suggesting endothermy in dinosaurs. In synapsids, endothermy must have evolved at least before crown-group mammals but its origin is difficult to trace in the fossil record in the lines leading from the basal-most synapsids to the diverse non-mammalian therapsid groups. Here we show that mass-specific Qi is elevated in non-therapsid eupelycosaurs relative to non-varanid reptiles. The midshaft region of over 20 femora was scanned with a General Electric

Vtomex micro-CT scanner and nutrient canal cross-sectional area was measured in virtual sections generated with Avizo software. Mass of the individuals represented by the scanned femora was estimated based on equations relating femoral length and circumference to body mass in *Alligator mississippiensis*. Ophiacodontidae (*Ophiacodon retroversus* and *Varanosaurus acutirostris*) show a particularly high mass-specific Qi, in the mammalian and varanid lizard range, consistent with the elevated metabolic rates suggested by the fast-growing fibrolamellar bone tissue observed in *Ophiacodon*. Values for Sphenacodontidae (five species of *Dimetrodon*) and Edaphosauridae (*Edaphosaurus* boanerges) plot in the higher non-varanid reptile and mammalian range. Our findings suggest that MMRs elevated over those of non-varanid reptiles evolved at the beginning of the first major radiation of Synapsida during the late Carboniferous. Elevated MMRs could help to explain the ecological dominance of synapsids from the late Paleozoic to the early Mesozoic until the appearance of archosauriform sauropsids with similarly increased metabolic rates.

Grant Information
Funding for Micro-CT scanning was provided by the University of Bonn and AHvH was supported as a postdoctoral fellow through the Humboldt Foundation.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

A FALL DINOSAUR EXCAVATION: INSIGHTS ON COLD WEATHER JACKETING

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SWCA was contracted to monitor fall construction of two well pads in remote grasslands along the eastern edge of the Powder River Basin to fulfill Bureau of Land Management requirements for mitigation of paleontological resources. Lance Formation bedrock was immediately exposed at both locations, and fossils were uncovered. Due to their close proximity to the surface, many of the bones are fragile, having been exposed to freeze-thaw actions, rooting, and burrowing. This complicated each evaluation, and, when applicable, subsequent collection. Further complicating collection were widely ranging temperatures (5–70 degrees Fahrenheit [F]) and wind gusts exceeding 55 miles per hour. As additional fossils emerged, including ceratopsid, ornithomimid, and hadrosaur elements, SWCA explored methods that allowed timely well pad construction and fossil preservation and collection despite conditions. Total excavation depth at each location was minimal, not exceeding 3 and 10 feet, respectively. Due to the project's remote location, various supplies were not readily available. SWCA used pre-soaked plaster bandages for smaller bones and applied burlap and Plaster of Paris to larger elements. Low temperatures necessitated understanding the chemical reactions associated with Plaster of Paris to ensure jacket integrity. Crews learned to carefully consider a number of variables, including water temperature, plaster mix (e.g., ratio of water weight to plaster weight), soak time, stir time, jacket surface temperature before each application, and additives to ensure quick setting before freezing. Stirring time, for example, is not critical at optimal environmental temperatures, but in cold weather, extending stirring time aids in plaster setting. However, water temperatures impact stir time: Both cold (35–40° F) water and hot (100–105° F) water create ideal plaster consistency after six minutes in cold weather, but plaster stirred into room-temperature water (65–70° F) under the same conditions will set at that point. Formal measuring of plaster, unnecessary in warmer weather, becomes critical to consistency in colder weather, which slows the material's absorption of water. To improve plastering conditions, SWCA set up a canvas tent and used propane heaters to warm the tent; these efforts improved crew comfort but created other issues. The heaters required proper ventilation and the use of CO_2 monitors, and maintaining the heat was difficult. In addition, extreme winds threatened tent integrity during the most critical points of the excavations.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

PALEONEUROLOGY OF THE SPANISH IGUANODONT *PROA VALDEARINNOENSIS*

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Proa valdearinnoensis is an iguanodont ornithopod from the Early Cretaceous (Albian) of Spain (Teruel Province), which may be closely related to *Jinzhousaurus yangi*, *Bolong yixianensis*, *Iguanodon bernissartensis*, *Mantellisaurus atherfieldensis*, and possibly other taxa from the Early Cretaceous of Eurasia. Digital endocast reconstructions were previously attempted for specimens of *I. bernissartensis* and *M. atherfieldensis* from Bernissart. However, issues pertaining to the quality of the datasets and/or the reconstruction process itself prevented a detailed characterization of the paleoneurology. Thus, our knowledge of the brain of basal iguanodont dinosaurs rests so far mainly upon a natural endocast identified as *Barilium* sp. and an artificial one of *Mantellisaurus* sp. In this study, digital reconstructions of the endocranial and labyrinthine cavities of *Proa* were produced from CT scans of the holotype braincase and a referred specimen. The endocast of *Proa* shows extremely weak cerebral and pontine flexures. This feature gives it a primitive appearance, which is counterbalanced by inflation of the forebrain caudal to the relatively elongate olfactory lobes. Owing to imperfect preservation of the specimens, the oculomotor (III) nerve could not be reconstructed and neither could the abducens (VI), possibly due to scan resolution. A slender segment running rostrolaterally from the ventral side of the forebrain in one specimen may be interpreted as the trochlear nerve (IV). The optic nerve (II) is stout and short. The trigeminal nerve, which is by far the largest of the cranial nerves, bifurcates into an ophthalmic branch (V_1) that extends rostrally along the base of the capitate process, and a lateral, maxillomandibular ramus ($V_{2–3}$). The facial nerve (VII) emerges close to the vestibulocochlear nerve and extends lateroventrally. Information on both the vestibular and cochlear rami of the vestibulocochlear nerve (VIII) was collected. The glossopharyngeal and vagoaccesory nerves (IX-XI) constitute a remarkably slender metotic group. Indeed, it is not thicker than the two hypoglossal roots (XII) that protrude from the endocast caudoventrally to it. The labyrinth is well developed with strongly arched semicircular canals. As for the discernible endocranial vasculature, the cerebral carotid arteries penetrate the cranial cavity at the ventral tip of the pituitary. Our results contribute to knowledge of the brain and inner ear gross anatomy of basal iguanodonts, a major component of early Cretaceous terrestrial ecosystems worldwide.

Grant Information
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Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

THE REDISCOVERY OF *LEPTOLEPIS NATHORSTI*: A JURASSIC TELEOST FROM THE AGARDHFJELLET FM, SPITSBERGEN, SVALBARD

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In 1900, A.S. Woodward described several isolated cranial and postcranial elements from a Jurassic teleost found at Svenskøya, Kong Karls Land, Svalbard. The locality is today recognized as early Kimmeridgian, Kongsøya Formation. This teleost was named *Leptolepis nathorsti* in honour of the Swedish scientist Alfred Gabriel Nathorst. No further remains of this species have been recognized in other locations in the Arctic, such as Greenland, Siberia, or Alaska.

The Agardhfjellet Formation (Middle Jurassic to lowermost Cretaceous) of Svalbard (Norwegian Arctic) is well known for its abundant and unique vertebrate fauna, among which are multiple specimens of ichthyosaurs and plesiosaurs. In an attempt to reconstruct the paleoecology and palaeoenvironment of the Agardhfjellet Fm, a study on the invertebrate fauna, geochemistry, and stratigraphy was conducted. The study revolves around two drill-cores obtained as part of the CO_2 project on Svalbard to investigate CO_2 storage in the Triassic sandstones. The Agardhfjellet Fm in these cores correlates perfectly with the outcrop material and is unexpectedly abundant in fossil material. During this study numerous small vertebrate fossils were collected and after closer examination ascribed to an early teleost species. This is the first discovery of teleost remains in the Agardhfjellet Fm of Central Spitsbergen.

The Kongsøya Formation is equivalent to the Agardhfjellet Fm. After more than a century, more remains of *L. nathorsti* have now been found in the lower Kimmeridgian of the Agardhfjellet Fm of Central Spitsbergen. These new remains might shed light on this enigmatic species and will provide more information on the paleoecology of the Jurassic of Central Spitsbergen. It certainly augments our understanding of the Jurassic ichthyosaur and plesiosaur diet, where stomach content now will be carefully studied for similar remains.

Technical Session II (Wednesday, October 26, 2016, 11:00 AM)

NON-LETHAL FACE BITING BETWEEN MOSASAURS (SQUAMATA: MOSASAURIDAE): THE FIRST UNEQUIVOCAL EVIDENCE FROM AN EXCEPTIONAL SKELETON OF *MOSASAURUS* SP. FROM SOUTHERN ALBERTA, CANADA

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In 2012, the ammolite mining operation by Korite International in southern Alberta, Canada resulted in the discovery of a fully articulated, 6.5-meter-long skeleton of *Mosasaurus* sp., cf. *M. missouriensis* from the upper Campanian (c. 75 Ma) Bearpaw Formation. The specimen (TMP 2012.010.0001), now fully prepared and revealing an exquisite nature of preservation typical of the material from the vicinity, preserves at least three legions across the left mandible that were inflicted by a bite from another, similar-sized mosasaur, whose marginal tooth was left embedded in one of the legions. All the three legions show varying degrees of active bone remodeling, suggesting that TMP 2012.010.0001 survived through and beyond the incident, which therefore must not have been lethal. Unexpectedly, the other side of the skull does not show obvious bite marks, which indicates either that: (1) different degrees of impact affected different skull regions of the mosasaur that was bitten; or (2) the bite was asymmetrical with respect to the mid-sagittal axis of the skull, primarily affecting the left side of the lower jaw. Intraspecific combat including biting is known in certain squamates living today, such as *Heloderma suspectum*, the Gila monster. In the case of *H. suspectum*, the winning male in the male-male combat would bite its opponent's throat region from underneath, thus preventing the other from biting back. It is possible that a similar tactic was employed by the mosasaur individual that left its tooth in TMP 2012.010.0001, where the bite was from one (the left) side of the jaw and from underneath, forceful enough to subdue the opponent but not to kill it. At present, no other bite marks are discernible in the rest of the skeleton including appendages, save the unprepared right side. Subjecting the skull to the CT scanning will likely have revealed the generic identity of the embedded mosasaur tooth, while gross morphology level analysis indicates strongly its *Mosasaurus* affinity.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

NEW MATERIAL OF THE DIDELPHID MARSUPIAL (MAMMALIA) *HERPETOTHERIUM MERRIAMI* FROM THE JOHN DAY FORMATION (LATE OLIGOCENE: ARIKAREEAN: CHATTIAN), OREGON, USA

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Recently found specimens of the marsupial *Herpetotherium merriami* were collected from the John Day Formation, Oregon. The species was previously known only from a single (type) specimen. These additional specimens have allowed for more data to be collected on this rarely acquired species. *Herpetotherium merriami* is distinct from other species of the genus by its larger size, the consistent presence of stylar cusp E+ on M1–M3, and the enlargement and fusion of stylar cusps C and D on M1 and M2.

Herpetotherium merriami, known throughout the Arikareean (latest Oligocene), is one of the last occurring marsupials in North America before the immigration of Recent didelphids from South America in the Pleistocene. Within the genus *Herpetotherium,* there is a general reduction in size through time from the Chadronian (*H. marsupium* and *H. valens*) to the Orellan/early Arikareean (*H. fugax*) and finally to the smallest Miocene specimens. *Herpetotherium merriami* does not fit into this pattern and is similar in size to the larger, earlier Chadronian species. The unique nature of the size and morphology of the cheek teeth of *H. merriami*, separate from the trends in other species, may well be attributed to its relative geologic isolation from the other known species of the genus that are predominantly from the Rock Mountains, Great Plains, and Florida.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

A TRIGONOMETRY BASED METRIC TO DESCRIBE SAUROPOD DENTITIONS

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Recent research indicates greater sophistication in the dental anatomy of the megaherbivorous dinosaur clade Sauropoda than previously appreciated, including high tooth replacement rates that range from comparable with those of hadrosaurs to much higher rates (90 to 14 days). Diplodocoid and titanosaurian sauropods convergently acquired the highest tooth replacement rates among sauropods and slender elongated teeth, despite employing different feeding modes as evidenced by contrasting tooth wear patterns. Much work remains to be done on the evolution of tooth replacement strategies in herbivorous dinosaurs, including identifying ecological and anatomical constraints, convergences, and correlations within and among these clades. Here we present a novel approach to visualizing tooth formation times and a new metric to characterize dentitions based on previous studies that developed and applied empirical equations to calculate tooth formation times in sauropods.

The formation time of teeth within each of the following positions (e.g., functional teeth, first replacement teeth, second replacement teeth etc. ...) follows a wave that can be described by a trigonometic function such as the cosine. In the dentary and maxillary teeth, especially of taxa with several generations of replacement teeth for a single functional tooth (such as *Dicraeosaurus*), the formation time for the increasingly smaller distal teeth decreases and consequently the cosine function has a dip. The function can be further modified to represent the waveform of the formation time and be expressed as y=a-bx+c*cos(dx), where “a” is the place where a linear trendline of the plot passes the ordinate, “b” is the dip of the cosine wave (and of the trendline), “c” is the average amplitude of the cosine function away from the trendline, and “d” is the square root of the dip. The resulting functions for the tooth positions run subparallel to each other, their trend lines run parallel. Lines parallel to the trendline can be used to assign replacement teeth to developmental stages, although this method comes to a limit if there is rapid decrease in tooth size in the distal teeth. Trend lines of modified cosine functions provide a new, quantitative metric to describe trends in dental replacement within Dinosauria, particularly those clades evolving high tooth replacement rates and associated high numbers of replacement tooth generations, including variation in tooth replacement trends from mesial to distal tooth positions and can be used to define developmental stages of replacement teeth.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

PLESIOSAUR HUMERUS MUSCLE RECONSTRUCTIONS AND FINITE ELEMENT ANALYSES IN COMPARISON TO SEA TURTLES REVEALS OPTIMIZED BIOLOGICAL LIGHT-WEIGHT STRUCTURES

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Plesiosaurs were Mesozic diapsid reptiles adapted to open marine habitats around the world. As the only tetrapods ever, they evolved hydrofoil-shaped fore- and hind-flippers probably used in underwater flight. Over 135 Ma of evolution, this locomotor design experienced only minor structural changes. Although it had been consensus that long bones are loaded under bending stress, recent finite element (FE) analyses revealed loading under compression stress instead. Tension chords (ligaments, tendons, and muscles) arranged in a complex three-dimensional pattern are responsible for the establishment of compression. Lack of bending moments throughout the bone results in the conservation of bone material, in turn leading to an optimized biological light-weight structure. We applied the compression loading concept to the comparative analysis of the humeri of a specimen of the Middle Jurassic plesiosaur *Cryptocleidus eurymerus* from England on exhibit at the Goldfuß Museum (University of Bonn, Germany) and of a recent underwater flyer, *Caretta caretta* (Cheloniidae). Muscles inserting, originating, and spanning the humerus were reconstructed for the plesiosaur based on the extant phylogenetic bracket method. Taxa chosen for bracketing were Archosauria, Lepidosauria, and Testudines. Reconstructed soft tissues were assigned to osteologic correlates, if present. Likewise, locomotor muscles inserting, originating, and spanning the humerus of recent *Caretta caretta* were dissected at the Stazione Zoologica Anton Dohrn Napoli, Italy. Cross sectional areas of these muscles were measured and maximum muscle forces were approximated. For plesiosaur and sea turtle alike, pairs of agonistic and antagonistic muscles for the main phases of the limb cycle, i.e., upstroke and downstroke, were identified. Micro CT scans of the right humerus of *Cryptocleidus eurymerus* and another extant sea turtle, *Chelonia mydas*, provided the basis for FE models by reworking and meshing in Simpleware ScanIP 5.1. Next, data gained from muscle reconstructions and dissections on muscle orientation and forces were entered into these FE models in ANSYS 12.0. FE analyses of the humeri of *Chelonia mydas* and *Cryptocleidus eurymerus* display evenly distributed and physiological compression stresses in all cross sections which implies that they are structurally optimized light-weight constructions functioning in similar ways.

Grant Information
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Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

NEW UNDERGROUND FINDINGS OF PLEISTOCENE AND HOLOCENE MAMMALS IN EXTREME NORTHEASTERN BRAZIL: FROM EXTENSIVE CAVE DEPOSITS TO POTENTIAL PALEO-BURROWS

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Fossil remains of extinct megafauna have been found in surface deposits around the state of Rio Grande do Norte (RN) for decades. In contrast, very few cave deposits with fossils have been reported. Here, we report the first fossil findings of Quaternary megafauna in caves of Felipe Guerra municipality, the largest karst area of the Rio Grande do Norte. Since 2008, the Potiguar Speleological Society conducted five survey trips to the area and eight cave deposits were found. These discoveries include extralimital felids and peccaries, as well as extinct ground sloths and giant armadillos. The faunal remains record the paleoecology of an unknown region in the midst of dramatic climatic change, from relatively wet in the late Pleistocene to desert-like conditions in the Holocene. In addition to these cave deposits, we report a potential paleo-burrow near the capital of RN. Because of its location close to an old church, the people of this area believed it was dug by natives or priests who used the chamber as a hideout, or to escape from enemies. There is no evidence that the tunnel was formed by people or through geologic/hydrologic processes. Based on the general characteristics of the tunnel, we surmise that it was produced by a large mammal, such as an extinct xenarthran. Fossils of such animals have been found all over the state, but their burrows have not been identified in northeastern Brazil. This potential burrow is nearly horizontal and approximately 1–2 meters in diameter. Overall, the tunnel is similar to other burrow-like structures that have been attributed to extinct giant armadillos from other parts of South America.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

THE BIZARRE DENTAL MORPHOLOGY OF A NEW GONDWANATHERIAN MAMMAL FROM THE LATE CRETACEOUS OF MADAGASCAR

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The dentition in the only known specimen (composed of a nearly complete skull and skeleton) of a new gondwanatherian mammal from the Late Cretaceous of Madagascar is markedly disparate morphologically from that of any known mammal, extinct or extant. The new gondwanatherian has two large and procumbent upper incisors that are marginal in position and occupy the entire length of the premaxilla. They are open-rooted and have a restricted band of enamel. The single lower incisor is also large, procumbent, and open-rooted, and also bears a restricted band of enamel. A rudimentary upper canine was likely present, as indicated by shallow, elliptical alveoli on both sides at the premaxillary-maxillary suture. The upper cheek tooth dentition is composed of a small, peg-like tooth mesially and four large teeth distally. The latter are quadrangular in outline, each with four major cusps surrounding a central valley that is open buccally. There are four lower cheek teeth, also with four major cusps, which are arranged in a diamond pattern with the mesial cusp being the largest by far. The ultimate and penultimate lower cheek teeth each bear a basined pseudotalonid mesiobuccally. The cusps and crests of both the upper and lower cheek teeth cannot be homologized with those of other mammals. Small diastemata are present between the left and right mesial upper incisors, and between the distal upper incisors and the purported upper canines. Much larger diastemata are present in the upper dentition between the canines and cheek teeth and in the lower dentition between the incisors and cheek teeth.

The new gondwanatherian from Madagascar, like several gondwanatherians from the Late Cretaceous and Paleogene of Argentina (*Ferugliotherium*, *Gondwanatherium*, *Sudamerica*, *Greniodon*), retains relatively plesiomorphic enamel (i.e., single-layered schmelzmuster, radial enamel, non-decussating small prisms in which most of the interprismatic matrix anastomoses around prisms). This is less derived than the modified radial enamel found in other gondwanatherians from the Late Cretaceous of India and Madagascar (*Bharattherium*, *Lavanify*, *Vintana*, and an indeterminate sudamericid), which exhibit prominent interrow sheets of interprismatic matrix.

Grant Information
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Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

A NEW PARTIAL CRANIUM OF PLESIADAPIS TRICUSPIDENS AND INSIGHTS INTO PLESIADAPIFORM CRANIAL ANATOMY

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Plesiadapidae (plesiadapiform primates) are among the most commonly recovered Paleocene fossil mammals and some of the best studied plesiadapiforms. Whereas cranial anatomy has been studied in this group, especially the European species *Plesiadapis tricuspidens,* circulation and inner ear anatomy remains poorly studied. The cranial circulation in *P. tricuspidens* is heavily debated, and the bony semicircular canals and cochlea have never been comprehensively studied. Here, we present a new partial cranium of an individual of *P. tricuspidens* from Mont Berru, France (Thanetian ELMA) that represents the only largely undistorted cranium from this species. It preserves the posterior half of the cranium, including a significant portion of the right petrous bone that contains the promontory. The state of preservation of this specimen, along with minimal matrix, enabled hypotheses to be tested through microCT imaging. Based on previous

work, we hypothesized the presence of the promontory artery and absence of the stapedial artery. Furthermore, we hypothesized that measurements of the semicircular canals would indicate that the relatively large *P. tricuspidens* has low agility, on par with another plesiadapid, *P. cookei*. Isolating the petrous bone revealed a short canal for the internal carotid artery, which terminates on the lateral side of the promontory at the posterior edge of the oval window. There are no apparent further grooves or canals for either the promontory artery or the stapedial artery. Measurements of the semicircular canals indicate they are narrow and small in relation to other primates, where canal radius size is 1.81 mm, 1.35 mm, and 1.56 mm for the anterior, lateral, and posterior canals, respectively. Agility scores calculated from a primate regression of body mass and canal radius size were low: 2.8, 2.3, and 2.5 on a score of 1–6. Based on this specimen, we cannot confirm or refute previous hypotheses about the stapedial and promontory arteries; however, the presence of a canal for the proximal portion of the internal carotid confirms previous work on this taxon. Semicircular canal measurements suggest *P. tricuspidens* was likely less agile than other primates, perhaps related to a terrestrial habit.

Technical Session III (Wednesday, October 26, 2016, 3:30 PM)

NEW EVIDENCE FOR THE TIMING AND PATTERN OF PENGUIN EVOLUTION

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Penguins (Aves, Sphenisciformes) underwent a unique pattern of radiation and extinction. In contrast to nearly all other avian clades, there are more extinct species of penguins known from the fossil record than there are extant species. Thus, penguins present an attractive target for novel methods of combining morphological, molecular and temporal evidence.

Bayesian total evidence dating provides insight into the timing of the crown radiation of penguins. New analyses sampling all extant and reasonably complete fossil penguin species support a Miocene (~12Ma) origin of the crown clade, in stark contrast to results of divergence dating analyses sampling only extant taxa which have resulted in estimates two to four times older. In the case of penguins, the inclusion of stem taxa has a strong impact on the resultant dates. This demonstrates the importance of the fossil record in providing morphological and temporal data to inform phylogeny.

Newly reported fossil specimens re-enforce the impact of fossils on our understanding of body size, morphology, and biogeography. As more strata are surveyed, a strong signal has accumulated for markedly higher levels of species diversity and wider ranges of body size in penguin faunas from every continent inhabited by penguins today. Repeated waves of extinction and radiation appear to have occurred throughout the Cenozoic, with species exhibiting primitive morphologies including transitional levels of osteosclerosis vanishing by the end of the Paleogene. Given contemporary accounts of penguins re-establishing colonies on vacant landmasses and the support for Pleistocene divergences between most crown spices and their sister taxa, our modern penguin fauna may represent a recent recovery that failed to reach earlier Cenozoic levels of species diversity and morphological disparity.

Grant Information
NSF DEB-1556615

Technical Session I (Wednesday, October 26, 2016, 9:45 AM)

THE EVOLUTION OF MODIFIED RADIAL ENAMEL IN EQUIDS CONFERED DAMAGE TOLERANCE THROUGH CONTROLLED FRACTURE AND DAMAGE LOCALIZATION

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The morphological modifications that equid ungulates underwent in the face of Miocene climatic and floral changes represent a classic evolutionary story. During their radiation, they showed greater cursoriality, increases in body size, the development of hypsodonty, and increased occlusal enamel complexity for generating stresses to comminute plant matter. Changes in enamel microstructure accompanied the dental modifications. Browser-frugivore *Hyracotherium* displays the primitive condition: horizontal Hunter-Schreger bands (HSB). The cladogeneisis of *Parahippus*-grade mixed-feeding horses show derived modified radial enamel (MRE). This microstructure was retained in all lineages, including primarily browsing clades. The changes in diets led to greater ingestion of small, hard particulates (exogenous grit and phytoliths) in grazers and increases in body size (and hence bite forces) that promoted enamel wear and fracture with the potential to impair whole tooth functionality. We posit that MRE evolved to counter these wear and fracture promoting agents. Here we use instrumented Vicker's microindentation to determine hardness (a proxy for wear resistance) and promote controlled fracture to study crack channeling capacities throughout equid diversification. We sampled nine genera from the Equidae: *Hyracotherium, Mesohippus, Parahippus, Merychippus, Hypohippus, Hipparion, Pliohippus, Dinohippus*, and *Equus*. Hardness measurements show a consistent gradient across the enamel surface, with increasing hardness toward the outer enamel. However, there is no clear trend of increased hardness across taxa. On the other hand, we find evidence of increased crack channeling within the MRE. Perfuse indentation fracture follows interprismatic rows and travels perpendicular to the enamel-dentine junction. Fracture path in the HSB mid-enamel displays a bimodal distribution as cracks are channeled along prism boundaries. However, outer radial enamel exhibits a reduced degree of fracture control, with a more isotropic crack pattern. These results were further corroborated by neontologic data from other mammals showing the outgroup and derived enamel structuring of horses. MRE is a biomechanically sophisticated wear and fracture resistant microstructure that inhibits enamel crest damage by localizing damage and preventing microcrack coalescence. We suggest that it evolved in equids in response to dietary and loading changes. The development of paleontologically-inspired modern-age ceramics based on our findings may result.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

OSTEOHISTOLOGY OF *RAPETOSAURUS KRAUSEI* (SAUROPODA, TITANOSAURIA) FROM THE LATE CRETACEOUS OF MADAGASCAR

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Bone histology yields abundant data on dinosaur life history, and sauropods are among the most widely sampled dinosaur taxa, with significant sampling gaps only in basal forms and derived titanosaurs. Most sauropods exhibit highly vascularized fibrolamellar bone that signals rapid growth rates comparable to those of extant mammals, slower than birds, and faster than reptiles. That said, growth rates and final size are taxon specific, particularly among Titanosauria. This group includes several small-to-medium sized sauropods hypothesized to gain these more diminutive adult body sizes either through reduction of growth rates relative to other neosauropods and/or by shortening the active phase of rapid growth throughout ontogeny. In this study, we add to the titanosaur dataset with an ontogenetic, histologic analysis of the Late Cretaceous Malagasy titanosaur *Rapetosaurus krausei*. Our data allow a test of the hypothesis that Titanosauria exhibits a novel growth strategy when compared to other sauropod groups.

Our sample consisted of twenty-five forelimb, hindlimb, and girdle elements of *Rapetosaurus krausei* at different ontogenetic stages, including samples from the largest (femur length = 143 cm) and smallest (femur length = 19 cm) *Rapetosaurus* yet known. Maximum bone length allowed us to group our sample into four relative age classes (Early Juvenile – Adult). We compared bone tissue among specimens of similar relative size/age to garner an understanding of growth throughout the skeleton, and within single elements through ontogeny to decipher growth history throughout life in *Rapetosaurus*. Finally, we compared the bone growth patterns in *Rapetosaurus* to those known for other titanosaurs as well as other sauropods. Primary bone in *Rapetosaurus* exhibits highly vascularized, fibrolamellar tissue as in other sauropods and most sampled titanosaurs. However, some of the smallest juveniles in our sample exhibit extensive replacement of the primary cortex by secondary Haversian bone, extending into the mid-cortex. Remodeling is most pervasive in the hind limbs of younger *Rapetosaurus*, and becomes more evenly distributed between fore- and hind limbs in older individuals. In these key ways, *Rapetosaurus* growth aligns with that known in other titanosaurs. Early onset of bone remodeling may be shared by titanosaurs and could relate to functional specialization of the hind limb.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

NEW DROMAEOSAURID DINOSAUR FROM THE EARLY CRETACEOUS OF JIUQUAN AREA, GANSU PROVINCE, CHINA

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The Yujingzi Basin in Gansu Province, China is famous for producing a diverse Lower Cretaceous dinosaur fauna. In 2007, Excavation by the Fossil Research and Development Center (FRDC) found a new dromaeosaurid specimen from the Lower Cretaceous Zhonggou Formation (Aptian?-Albian). The Yujingzi Basin is an inland basin consisting of fluvial, lacustrine, and inter-montane alluvial fan depoists, when the climate was semi-arid and subtropical. It is considered that there was as abundant a vertebrate fauna in this place as the early Cretaceous Jehol biota.

The new dromaeosaurid dinosaur, FRDC-GJ(07)11-2 consist of a nearly complete left frontal, some vertebrae, nearly complete sacrum, right pelvic girdle, left pectoral girdle, and some pedal phalanges including digit II. The frontal is approximately twice as long antero-posteriorly as wide transversely behind the orbit. The articular surface of the pedal phalanx II-2 is bilaterally symmetrical in proximal view, and it lacks a proximo-ventral expansion of the flexor heel.

The phylogenetic place of this specimen is in the dromaeosaurid clade Eudromaeosauria (Velociraptorinae + Dromaeosaurine). Its clade and FRDC-GJ(07)11-2 share a long and lobate flexor heel, and the acromion process of the scapula does not project anteriorly. The phylogenetic data matrix that includes 118 OTUs is based on a previously published matrix.

Grant Information
Touka education faundation,
Cloud foundation,New Dromaeosaurid Dinosaur from the Gansu Province

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

A REVIEW OF THE LARGE NEOSUCHIAN *KANSAJSUCHUS* (CROCODYLIFORMES, NEOSUCHIA) FROM THE LATE CRETACEOUS OF ASIA

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Kansajsuchus is a monospecific genus of large neosuchian crocodyliforms from the Late Cretaceous (Santonian–early Campanian) Yalovach Formation, Tadzhikistan. The type and the only valid species of *Kansajsuchus—K. extensus*—is known from a fragmentary braincase and isolated cranial and postcranial bones. *Kansajsuchus* was originally considered as an aberrant member of the neosuchian family Goniopholididae and, later, this attribution was supported by phylogenetic analysis that placed *Kansajsuchus* among species of the Late Jurassic–Early Cretaceous goniopholidid *Sunosuchus*.

Our study revealed that *K. extensus* differs from goniopholidids by the presence of multiple rows of the dorsal keeled osteoderms lacking anterolateral processes (two rows of unkeeled osteoderms with anterolateral processes in goniopholidids). It shares with the Late Cretaceous Mongolian members of the advanced neosuchian family Paralligatoridae (*Paralligator* and *Shamosuchus*) such characters as the presence of the system of blunt transverse preorbital ridges with a continuous sulcus on their top, the presence of the sagittal ridge on the frontal and the horizontal ridge on the jugal, the absence of the ectopterygoid-postorbital contact in the postorbital bar, the presence of a prominent ridge

on the angular, multiple rows of dorsal osteoderms with posteriorly displaced keels. Based on this suite of features, *Kansajsuchus* can be referred to the Paralligatoridae. *Kansajsuchus* differs from other paralligatorids in the following features: the presence of a long contact between premaxillae posterior to the naris, the large subcircular supratemporal fenestrae, the prefrontals comprise most of the medial orbital margin, and the frontal forms posteromedial orbital corners.

Kansajsuchus extensus is the largest (up 8 m long) among all members of the family Paralligatoridae. The assignment of *Kansajsuchus* to the Paralligatoridae suggests that paralligatorids were widely distributed in the Late Cretaceous of Asia and they were common faunal elements of Asiatic vertebrate assemblages during that interval of time.

Grant Information
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Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

VERTICAL EXAGGERATION OF 3D SURFACE MODELS REVEALS ADDITIONAL DETAIL IN SAUROPOD TRACKWAYS

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Photogrammetry has become widespread in vertebrate paleontology as a nondestructive method for producing digital 3D surface models of a wide range of specimens. A number of studies have employed photogrammetry for accurate digitization of vertebrate skeletal fossils, soft tissue, and tracks. Due to their great size, distortion-free dinosaur trackway documentation was difficult before the advent of capture by photogrammetry. To improve the usability of photogrammetric models of tracks not only for documentation but also for interpretation, I present an enhanced visualization technique, vertical exaggeration. In vertical exaggeration, the scale of the vertical axis is increased relative to the horizontal axis, and 3D models were stretched along the z-axis to emphasize subtle features of the tracks and to make very shallow tracks recognizable at all.

Additional detail was elicited from seemingly poorly preserved sauropod trackways by the application of vertical exaggeration to photogrammetric 3D models from four tracksites: the Upper Jurassic Copper Ridge (Utah, USA), Pedreira do Avelino (Portugal), and Barkhausen (Germany) tracksites and the Lower Cretaceous Münchehagen tracksite (Germany). After capture using the commercial photogrammetry software Agisoft PhotoScan (version 1.2.4), vertical exaggeration was applied to the sauropod trackways. To visualize model elevation and to produce model exaggeration the software Paraview (version 4.2.0) was used. Since all the studied trackways show a wide range of preservation quality in terms of depth, detail, and post-imprint modification, a detailed comparison was made between the models for determining the best factor of vertical exaggeration for the purpose of re-interpreting the trackways.

Additional tracks that could not be recognized in the field were revealed by the application of vertical exaggeration in the 3D models of existing trackways which also confirmed the presence of questionable ones. The resulting footfall pattern was then used for the interpretation of locomotion. Vertical exaggeration by a factor of ten appears to be most effective, whereas greater exaggeration by, e.g., fifty times is counterproductive, since it causes distortions and artifacts.

Although vertical exaggeration is common in the visualization of geological cross sections, it is a novel approach in vertebrate ichnology. The technique is a powerful tool when it comes to the visualization of difficult tracks, trackways, and track surface and hence to their interpretation.

Technical Session II (Wednesday, October 26, 2016, 9:30 AM)

MULTIPLE ORIGINS OF MULTICUSPID TEETH IN SQUAMATE REPTILES

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Teeth represent excellent targets for evolutionary studies of vertebrate epithelial tissues, with both an extensive fossil record and substantial suitability for experimentation. Strong selective pressures affect dental characters, since these features determine possible diet ranges. This applies namely to tooth complexity, which varies mainly due to the number and disposition of positive reliefs on the tooth occlusal surface — the cusps. Through cusp addition events, mammals have achieved considerable variation in terms of complex tooth morphologies during their evolution. Experimental approaches applied to a few model species (mouse, zebrafish) revealed the mechanisms of odontogenesis, in particular the genetic pathways involved in cusp growth and patterning. However, little is known about the development and evolution of teeth in other non-classical vertebrate groups such as squamate reptiles (*i.e.* lizards and snakes). Here we present the first large-scale assessment of squamate tooth morphologies, comprising a dataset of over 450 extant and fossil species sampled in all major lineages and exposing a unique and widely overlooked diversity. Geometric morphometrics reveal that the mode of implantation explains most of the variation of complex tooth shapes in lizards. Importantly, complex tooth shapes also significantly correlate with diet, since highly complex teeth with a high cusp number correlate with increased plant consumption. Lizard groups including an important proportion of herbivorous species — Iguania (iguanas, chameleons, etc) and Lacertoidea (true lizards, worm lizards, etc) — notably show the broadest tooth shape variability. Based on the most recent phylogenetic data, ancestral character reconstructions specifically indicate that the last common ancestor to all squamates was an insectivore with unicuspid pleurodont teeth. Complex tooth shapes then evolved multiple times independently in different lineages, primarily during the Late Cretaceous. During this period classically associated to the rise of angiosperms, we find the Cretaceous radiation of modern squamates to comprise almost exclusively insectivorous taxa. Plant consumption evolved in current lizard groups only during the Cenozoic, substantially delayed from the initial increases in tooth complexity. Such results question the drivers of tooth phenotypic variation in lizards, hence calling for a better characterization of squamate tooth development and particularly of the genetic pathways responsible for producing complex tooth shapes.

Grant Information
Four-year research grant from the Integrative Life Science Doctoral Program, University of Helsinki; Academy of Finland funding.

Technical Session VI (Thursday, October 27, 2016, 12:00 PM)

AN OBJECTIVE METHOD FOR THE GENERATION OF FOOTPRINT OUTLINES

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Quantitative shape analysis of fossil footprints is hampered by the lack of widely applicable, objective means to define the footprint margins. Subjectivity equally affects interpretive outline drawings and measurements, and is especially problematic when footprint walls are fading gradually into the surrounding sediment and/or contain multiple edges. In recent years, the study of fossil footprints has greatly benefited from the rapid development of digitization techniques such as photogrammetry, which are able to capture footprint topographies with high accuracy. It is these techniques that now make the development of objective and repeatable methods for generating footprint outlines possible.

The presented objective approach is based on contour maps generated from three-dimensional data of individual footprints. Contour maps reduce the complex three-dimensional problem of defining outlines to an easier-to-handle two-dimensional one. In general, objective footprint outlines may either be defined based on a specific height, e.g., by selecting an individual contour line, or based on the inclination profile of the footprint wall, e.g., by tracing along the steepest points of the wall. A single contour line, however, is a poorer representation of the footprint wall than the steepest points, because it often does not depict the full footprint extent and is more strongly affected by extramorphological influences. The presented method, therefore, is based on the inclination profile, with coordinates of the steepest points being automatically traced along the footprint wall by a computer script. In order to level out abrupt jumps in the height of the tracing on the wall, elliptic Fourier transforms were applied to the tracing to produce an approximating, continuous outline. The presented method was tested by generating outlines of Lower Cretaceous tridactyl dinosaur footprints from Münchehagen, Germany. Geometric morphometric analysis of traditional interpretive outlines of these footprints revealed trackway-specific variation patterns of footprint shape. The objective outlines generated using the presented approach were able to reproduce these results.

Technical Session XV (Saturday, October 29, 2016, 10:30 AM)

ANATOMY, PHYLOGENY, AND PALEOBIOLOGY OF *SARMIENTOSAURUS MUSACCHIOI*, A TITANOSAURIAN SAUROPOD DINOSAUR FROM THE UPPER CRETACEOUS OF CENTRAL PATAGONIA, ARGENTINA

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Sarmientosaurus musacchioi is a recently-named titanosaurian sauropod dinosaur from the Upper Cretaceous (Cenomanian–Turonian) Bajo Barreal Formation of central Patagonia, Argentina. The holotype consists of an articulated, essentially complete skull and part of the cervical series. *Sarmientosaurus* exhibits multiple autapomorphies, such as an extraordinarily large orbit, a unique maxilla–lacrimal articulation, and an elongate ossified tendon ventrolateral to the cervical vertebrae and ribs. The cranial endocast of *Sarmientosaurus* preserves some of the most complete information yet obtained on sauropod brain and sensory systems. Phylogenetic analyses recover the new taxon as a basal member of the titanosaurian subclade Lithostrotia, occupying a position more derived than *Malawisaurus* but more basal than saltasaurids and taxa frequently regarded as nemegtosaurids. *Sarmientosaurus* is thus the basalmost known titanosaur to be represented by a well-preserved skull. The new taxon exhibits a previously-undocumented cranial form that amalgamates plesiomorphic titanosauriform features such as a proportionally broad snout with a large narial fossa with more derived morphologies such as an elongate rostral process of the prefrontal. Moreover, the presence of the comparatively derived lithostrotian *Tapuiasaurus* in Lower Cretaceous deposits indicates that *Sarmientosaurus* represents a 'ghost lineage' with a comparatively archaic craniodental form, the evolutionary history of which is missing for at least 13 million years of the Cretaceous. The cranial anatomy of *Sarmientosaurus* suggests that multiple titanosaurian species with disparate skull architectures coexisted in the mid-Cretaceous of southern South America. Furthermore, the new taxon possesses a number of distinctive morphologies—such as the ossified cervical tendon, extremely pneumatized cervical vertebrae, and (probably) a habitually downward-facing snout—that have rarely, if ever, been documented in other titanosaurs, thus broadening knowledge of the anatomical diversity of this sauropod group. The latter two features were convergently acquired by at least one penecontemporaneous diplodocoid, and may represent mutual specializations for consuming low-growing vegetation. In sum, *Sarmientosaurus* provides crucial new insights into the cranial anatomy of basal members of Titanosauria, which in turn enhances understanding of the evolutionary history and paleobiology of this exceptionally diverse and abundant herbivorous dinosaur clade.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

THE PHYLOGENETIC AFFINITIES OF THE SHOVEL-TUSKED GOMPHOTHERE *KONOBELODON* (MAMMALIA, PROBOSCIDEA): IS ITS SISTER GROUP *AMEBELODON* OR *PLATYBELODON*?

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Though the shovel-tusked gomphothere *Konobelodon* was initially created as a subgenus of *Amebelodon* due to strong resemblance in mandible, lower tusk, and dentition morphology, there is debate as to whether it is actually closely related to that genus, or whether it is instead more closely related to another group of allied shovel-

tusked gomphotheres including *Platybelodon* and *Torynobelodon*. The main basis for this debate lies in dispute over the homology of a single feature found in all three genera, namely internal dentinal rods in the lower tusks rather than the lamina found in typical gomphotheres. Those claiming a close relationship between *Konobelodon* and *Platybelodon*/*Torynobelodon* argue that this feature is homologous in these taxa, while conversely those supporting a sister group relationship between *Konobelodon* and *Amebelodon* argue that it is convergent.

A number of lines of evidence indicate that the dentinal rods in *Konobelodon* and *Platybelodon*/*Torynobelodon* are not homologous. First, detailed examination of the lower tusk dentinal rods in the taxa in question shows very clear differences both in their shape and distribution through the tusk, suggesting distinctly different mechanical functions despite a superficial similarity. Secondly, the lower tusk of one species of *Konobelodon*, *K. cyrenaicus*, has a medulla filled with *Konobelodon*-like dentinal rods but a laminated cortex resembling that seen in typical gomphotheres, suggesting that the *Konobelodon* condition evolved directly from the primitive gomphothere condition. Thirdly, biochronological evidence indicates that the *Platybelodon*/*Torynobelodon* condition is considerably older than that found in *Konobelodon*. Given these facts, the most plausible explanation for presence of dentinal rods in both *Konobelodon* and *Platybelodon*/*Torynobelodon* is convergence, with the implication that *Amebelodon* and *Konobelodon* are sister groups.

Technical Session IV (Wednesday, October 26, 2016, 2:45 PM)

LOST IN TRANSITION: DEVELOPMENTAL PATTERNS OF TOOTH FORMATION AND LOSS IN FETAL BALEEN WHALES AND IMPLICATIONS FOR MYSTICETE EVOLUTION

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The origin of baleen and bulk filter feeding in mysticetes occurred approximately 28–24 million years ago and represents a major macroevolutionary transition in cetacean morphology (teeth to baleen) and ecology (raptorial to filter feeding). We present new evidence of how this transition was made possible by radical changes in cranial ontogeny. We employed computed tomography (CT) scanning enhanced with a reversible staining iodine protocol to increase contrast in the CT data for six fetal specimens of humpback, blue, and sei whales. The presence of tooth buds was observed in all specimens with the largest individuals having the most complete dentitions (15–25 teeth per side in both upper and lower jaws). All major cranial bones are recognizable in scans, and the dentaries appear to ossify first, followed by ossification of the maxilla and premaxilla. In addition to the morphology described here, it was recently discovered that the tooth development gene C4orf26 is inactivated in mysticetes but conserved in toothed cetaceans (Odontoceti). The pseudogenic sequence, however, is not shared by all extant baleen whale lineages, suggesting that loss of the adult dentition was progressive. The presence of teeth during mysticete ontogeny can be explained by retention of functionality in similar genes with pleiotropic effects. Thus, both molecules and morphology support a toothed ancestry of Mysticeti.

Based on molecular and morphological data, we propose a hypothesis that reconstructs the dramatic ontogenetic shifts in mysticete skull development that include resorption of fetal dentition and origin and growth of baleen. We hypothesize that this macroevolutionary stepwise transition was driven by external selective pressure. Fossil evidence shows that two distinct lineages of Oligocene stem-mysticetes (Aetiocetidae and Eomysticetidae) preserve bony correlates (lateral palatal foramina and sulci) compatible with the occurrence of baleen. In addition, aetiocetid fossils preserve an adult dentition, while eomysticetid fossils preserve alveolar grooves and alveoli that may indicate the presence of a reduced adult dentition in the anterior portion of the mouth.

Comparison with odontocete development data suggests that acceleration in cranial growth and tooth formation during ontogeny in mysticetes could have allowed for the evolution of baleen, by permitting the teeth to be reabsorbed and the baleen plates to grow without dramatically increasing gestation time. This could have driven the gradual ecological shift to bulk filter feeding.

Grant Information
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Technical Session XVIII (Saturday, October 29, 2016, 4:00 PM)

SUB-MILLION YEAR EVOLUTIONARY PATTERNS IN SMALL THEROPOD DINOSAUR LINEAGES CORRESPOND TO PERIODS OF CLIMATIC CHANGE IN THE LATE CRETACEOUS

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The Horseshoe Canyon Formation is one of the few well-sampled and highly fossiliferous non-marine assemblages spanning the Campanian–Maastrichtian boundary and bridging the well-known Late Campanian and Late Maastrichtian assemblages of North America. Recent work revising the lithostratigraphy, chronostratigraphy, and palaeoenvrioments has resulted in a high-resolution framework for the study of dinosaur biostratigraphy sampled across ~7 Ma, and spanning multiple transgressive-regressive cycles, and climatic cycles characterized as warm/wet to cool/dry. Biostratigraphic analysis of the well-sampled dinosaur fossil record has revealed distinct biozones defined by the occurrence of ornithischian taxa, and correlated with the transition between warm/wet and cool/dry climates. Surprisingly, the theropod taxa span the almost entire formation without noted taxonomic turnover.

Due to their rarity and often fragmentary nature, skeletons of theropod dinosaurs are often not useful for testing hypotheses of evolutionary changes on short timescales. However, abundant isolated teeth from vertebrate microfossil assemblages with fine-scale stratigraphic data can be used to assess the evolutionary patterns of these taxa on a fine evolutionary scale. Here, we analyze a morphometric dataset of 287 isolated theropod teeth, representing four major lineages of maniraptoran dinosaurs (*Troodon*, *Richardoestesia*, *Atrociraptor*, and Dromaeosaurinae indet.), with precise stratigraphic data representing ~3.5 Ma interval spanning the Campanian–Maastrichtian boundary to test hypotheses of within-lineage evolutionary change. Specimens were binned by stratigraphic level, and evolutionary model fitting of directional, Brownian motion, and stasis models, as well as more complex models was performed for each lineage, and compared to periods of climatic change and ornithischian turnover.

Results suggest that none of the four theropod taxa are static through the interval, and strongly supported models often incorporate evolutionary shifts, with the initial shift corresponding to the onset of a cool and seasonally dry climate, rather than environmental or stage boundary-dependent ecosystem turnover. These morphological shifts also corresponds to a complete absence of *Atrociraptor* in the two early cool and seasonally dry timebins and with ornithischian turnover. The results of this study provide evidence for climatically induced eco-evolutionary change in the fossil record of individual species through these fine timescales.

Grant Information
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Symposium II (Friday, October 28, 2016, 12:00 PM)

DEVELOPMENTAL EVOLUTION OF DISCRETE TO CONTINUOUS TO COMPLEX MORPHOLOGIES: EXAMPLES FROM THE DINOSAUR–BIRD TRANSITION.

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Ontogeny recapitulates phylogeny, sometimes. Broad statements like this prove useful in guiding scientific ideas but may also simplify complex biological processes to subjective constructs. Although constructs are inevitable, attempts to explore beyond and challenge them may lead to novel insights to biological variation. Here we explore developmental mechanisms of discrete, continuous, and complex morphological variation, and their constraints that may limit disparity. Examples are drawn throughout the skeleton, from the skull, axial column, to limbs. Developmental mechanisms orchestrating these morphologies are equally varied and add a layer of complexity as to how we identify, qualify, and quantify anatomical variation. Evolutionary variation of the skull will be discussed from the standpoint of continuous variation of landmarks. However, the complexity of developmental mechanisms, including how cranial sinuses reshape original patterns, have severe limits to this simple measure. Axial variation is discussed as an example of discrete variation. However, we present a case where this may be re-patterned under genetic controls during pygostyle development. Finally, limb variation will be discussed from the aspect of discrete and continuous variation but shown to actually have a much more complex bases for initial patterning. Subtle changes to physical and molecular parameters can yield surprisingly different skeletal patterns. Moreover, many other epigenetic forces are at play and may contribute to the majority of characters used in evolutionary studies. Conclusions are drawn from this complex assortment of developmental mechanisms to propose a way forward.

Technical Session XI (Friday, October 28, 2016, 9:15 AM)

NEUROCRANIAL MORPHOLOGY OF A NEW LARGE LATE TRIASSIC NEOPTERYGIAN FISH AND DEEP-BODIED FISHES ON THE TELEOST STEM

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The diversification of neopterygians in the Late Triassic was tied with the advent of new morphologies in ray finned fish and resulted in the temporary success of deep bodied fishes such as pycnodonts and the genus *Dapedium* as well as set the stage for the future diversity in living teleosts. Uncertainty surrounds the precise phylogenetic position of the wholly extinct taxa from that radiation, partially due to inadequate preservation or lack of relevant fossils. Analysis of a large new actinopterygian neurocranium preserved in three dimensions from the Late Triassic of Schesaplana, Switzerland shows a unique set of characters relevant to the systematic position of stem teleosts and dapedids. High resolution computed tomography revealed endocranial morphology including well-developed posttemporal fossae which are confluent with the fossa bridgei and spiracle, and an unpaired posterior myodome is well separated from the notochord. The preserved portion of the skull is well ossified, the cranial fissures are closed, and all three semicircular canals are contained in bone, yet a large dorsal fontanelle resulted in the collapse of the median portion of the frontal during preservation. The specimen also has an internal carotid on the ascending process of the parasphenoid, and an efferent pseudobranchial foramen. Additionally, it has an insertion point for the longitudinal ligament and carotid ligament, two features seen in *Dapedium*, suggesting this large fish was probably also deep bodied. A large phylogenetic analysis combined from other published analysis plus new characters supports a single clade as sister to holosteans including the new specimen, dapedids, pycnodonts, and teleosts.

Grant Information
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Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

FUNCTIONAL NICHE PARTITIONING AND DIETARY SPECIALISATION IN THERIZINOSAUR DINOSAURS

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Therizinosauria is a group of Cretaceous, secondarily herbivorous theropod dinosaurs. Derived members of this group are characterised by small skulls with an edentulous premaxilla and a rostral rhamphotheca, an elongate neck, hypertrophied manual unguals and a broad, opisthopubic pelvis. Within the last two decades a number

of new fossil findings have further substantiated the phylogenetic position of Therizinosauria and the coeval occurrence of different taxa and morphotypes within the same locality indicates that different species might have occupied different ecological niches. Furthermore, skeletal morphology is very diverse across therizinosaurian species and most likely reflects different palaeoecological specialisations and dietary strategies among Therizinosauria. However, cranial remains are rare and only few skeletal elements are equally represented in all therizinosaurian taxa. Amongst them, the dentary is the most consistently preserved element known from at least six species with a high degree of morphological variation thought to be indicative of dietary specialisation patterns

A combined approach of actually preserved specimens and theoretical models has been applied here, to investigate the functional morphology of the mandibles of six therizinosaurian taxa. Using the complete and well-preserved mandibles of the derived therizinosaurid *Erlikosaurus andrewsi*, theoretical models were created incorporating morphological information provided by fossil specimens of further taxa, spanning the full phylogenetic and morphological range across Therizinosauria. Finite element analysis was applied to compare biomechanical performance and to assess the functional significance of specific anatomical features.

Results showed notable differences in the biomechanical behaviour of the mandibles of the studied taxa. A comparably long and dorsoventrally narrow mandibular morphology, such as present in *Falcarius utahensis*, *Jianchangosaurus yixianensis* and *Alxasaurus elesitaiensis,* recorded increased stress and strain in the postdentary elements. In comparison, the dorsoventrally broad postdentary region, as exhibited by *Erlikosaurus andrewsi* and *Beipiaosaurus inexpectus*, appeared to dissipate stresses. At the same time, taxa with down-turned dentaries recorded the lowest relative bite forces, suggesting functional disadvantages in transmitting muscle forces.

Technical Session XVII (Saturday, October 29, 2016, 9:30 AM)

WHAT MAKES AN *ICHTHYOSAURUS*? A MORPHOMETRIC AND PHYLOGENETIC ANALYSIS OF THE CLASSIC LOWER JURASSIC GENUS

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The type genus for Ichthyosauria, *Ichthyosaurus*, is associated with Lower Jurassic localities in Dorset and Somerset in southern England and is variable in several traits. This has led to great confusion regarding its taxonomy and phylogeny. *Ichthyosaurus* is represented by hundreds of specimens, but little work, phylogenetic or otherwise, had been done on the taxon until recently. Four species are recognized, of which the newest is *I. anningae*. Another, *I. conybeari*, is rare, poorly defined, and had not been studied in detail until this year. *I. breviceps*, recognized by its short snout and small size, is also rare and poorly known. *I. communis* exhibits the greatest amount of variation, and authors have tried to split it into more than one species, even proposing that subspecies or other variants can be recognized. In order to confirm and understand variation within *I. communis*, over 26 collections were visited and more than 200 specimens were examined.

I report the most comprehensive phylogenetic study of *Ichthyosaurus*; over 100 characters were coded for more than 200 specimens, over 50 of which represent mostly complete skeletons. The characters include those employed by previous authors in addition to newly devised characters. This character set provides previously recognized species with more comprehensive diagnoses and better characterizes diversity present within the genus. The application of morphometric techniques including log bivariate plots show that many previously used ratios like snout ratio, orbit ratio, and humerus to femur ratio are not as informative as historically thought. Newly analyzed specimens show both that there is a much wider range to these ratios than previously proposed as well as significant overlap between species. Accordingly, these ratios have been excluded from this study.

My results reveal that specimens previously thought to belong to the same taxon do not group together and that phylogenetic structure within *Ichthyosaurus* does not conform to conventional taxonomy. This discovery requires both that named *Ichthyosaurus* species warrant revised, more precise diagnoses and revised content as goes which specimens represent them, but also that new species need to be recognized within the genus. It is suspected that similar issues affect other parvipelvian taxa including *Leptonectes* and *Temnodontosaurus*, which would benefit from similar specimen-level analysis. Through ongoing work, new light is being shed on the diversity present within ichthyosaurs that Mary Anning discovered over 100 years ago.

Grant Information

University of Southampton and Graduate School at National Oceanography Centre, Jurassic Coast Trust, and Primary Science Teaching Trust.

Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

A FOSSIL EGG CLUTCH FROM THE STEM TURTLE *MEIOLANIA PLATYCEPS*: IMPLICATIONS FOR THE EVOLUTION OF TURTLE REPRODUCTIVE BIOLOGY

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A fossil egg clutch from the Pleistocene Neds Beach Formation on Lord Howe Island, Australia belongs to the stem turtle *Meiolania platyceps*. The 23 cm by 18 cm clutch (AM F82183) consists of a minimum of ten large (53.9 mm) spherical eggs that occur in at least two superimposed layers. The 800 µm thick eggshell exhibits barrel-shaped shell units with a height-to-width ratio of 1.2:1. Thin sections and scanning electron microscopy demonstrate that the eggshell consists of a single layer of shell units with radiating acicular aragonite crystals. Prior to now, this mineral composition was only known from crown clade Testudines and taxonomically unassignable Mesozoic and Cenozoic turtle eggs. Therefore, this discovery provided the first definitively identifiable aragonitic stem turtle eggs and pushes the origin of this unique eggshell composition back to the Early or Middle Jurassic. Additionally, this suggests that aragonite eggshell first evolved either before the split between Meiolaniformes and crown Testudines or prior to *Proterochersis robusta*, the earliest known stem turtle.

To assess the incubation strategy used by *Meiolania platyceps*, we calculated gas conductance (GH2O) for the first time on a fossil turtle egg and compared this value to that obtained from eggs of modern taxa. The fossil eggs exhibit a conductance of 170.27 mg H_2O day^{-1} $Torr^{-1}$, which is approximately 10.6 times higher than predicted for a bird egg of equal mass. This GH2O compares closely with calculated values for two extant tortoises eggs, *Kinixys erosa* and *Indotestudo elongata*, which have gas conductance values approximately 19.7 and 11.7 times higher, respectively, than bird eggs of equal mass. High gas conductance and the presence of at least two superimposed egg layers within the clutch indicate that *Meiolania platyceps* incubated its eggs in the high humidity environment of an excavated hole nest. This turtle nesting strategy likely evolved no later than Early to Middle Jurassic.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

FOSSIL ARTIODACTYLA (MAMMALIA) FROM MARKAYTOLI, A NEW MIDDLE PLEISTOCENE SITE IN THE LOWER AWASH VALLEY, ETHIOPIA

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Here we report on fossil remains of terrestrial artiodactyls (n = 271) from the Markaytoli drainage, a new site in the Ledi-Geraru Research Project area, Afar, Ethiopia. Artiodactyls represent 64.9% of the total fauna recovered. Remains of Bovidae dominate the assemblage (84.1%) and most are identifiable to the genus level. Horn core specimens and dental remains of small Reduncini suggest that the common bovid in the assemblage is *Redunca*, although larger dental remains referable to *Kobus* and a horn core of *Kobus ellipsiprymnus* are also present. A large *Aepyceros* comparable in size to the living form *A. melampus* is represented by a nearly complete horn core. Large Bovini teeth may be referable to *Syncerus*. Giraffids are rare (3.7%) but are represented by both craniodental and postcranial remains that suggest the presence of a species smaller than extant *Giraffa* and *Okapia*. Further identification of giraffids is difficult given the small sample size. Suidae are represented by two species and constitute 12% of the assemblage. Adult and juvenile dental remains are attributable to *Kolpochoerus majus* and a derived species of *Metridiochoerus* (possibly *M. modestus*) or an early species of *Phacochoerus*. A preliminary biochronological estimation based on the suid remains suggests an early middle Pleistocene age, probably roughly contemporaneous to the sites of Daka (Ethiopia) or Buia (Eritrea). The dominance of reduncin bovids (22% of all bovid remains) and remains of Bovini indicate the presence of edaphic grasses, while the rarer *Aepyceros* and Giraffidae imply some tree cover. Geologic observations of the fossil site indicate alternating beds of silts and clays with varying degrees of paleosol development and the presence of root casts suggesting a floodplain overbank depositional environment. The habitat inferred from the artiodactyls is consistent with other faunal groups and geological evidence, which collectively point to a riverine forest with woodland and wetlands that indicate a more mesic middle Pleistocene compared to the habitat of this region today.

Grant Information

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Technical Session XII (Friday, October 28, 2016, 3:00 PM)

SEPARATING TOOTH IMPLANTATION FROM TOOTH ATTACHMENT: A CASE STUDY USING DINOSAURS

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As close relatives of crocodilians, dinosaurs are ideal candidates for shedding light on dental evolution in archosaurs. The spectacular diversity of dinosaur dentitions also makes them well suited for understanding the functional and phylogenetic significance of tooth attachment and implantation. Tooth attachment distinguishes between teeth that are fused to the jaws and those that are suspended by ligament, whereas tooth implantation describes the geometry of this attachment. Among modern amniotes, only mammals and crocodilians are considered thecodont, because their teeth are suspended by ligament in deep, symmetrical sockets and are replaced subdentally. By comparison, dinosaurs exhibit a wide range of attachment, implantation, and replacement modes. Despite numerous studies of dinosaur dentition, no study has examined dinosaur tooth attachment, replacement, and implantation within a comparative framework or how these could be modified to suit particular functions in disparate lineages.

Here we provide a survey of tooth attachment, implantation, and replacement across a sample of theropod, hadrosaurid, and ceratopsid taxa. These comparisons show that, unlike crocodilians, the odontogenic organ (dental lamina) in dinosaurs was consistently retained along the lingual surface of the jaw rather than being deeply buried within an alveolus. Theropod teeth develop far lingual to their functional predecessors allowing some taxa to possess multiple generations of replacement teeth at each tooth position. Hadrosaurid and ceratopsid teeth develop subdentally, immediately resorbing significant portions of older teeth, but the dental lamina is still located outside of the jaw. As such, there is a fundamental asymmetry in tooth replacement and tooth implantation in dinosaurs. This condition bears striking resemblance to hatchling crocodilian dentitions, suggesting that a symmetrical, thecodont mode of implantation and subdental tooth replacement is an apomorphic condition restricted to mature crocodilians and convergently in mammals. Furthermore, despite variation in tooth implantation and replacement in dinosaurs, every taxon we examined possessed identical tooth attachment tissues (alveolar bone, periodontal ligament, and cementum) and were all ligamentously attached to the alveoli, which we identify as the ancestral condition for dinosaurs. These results reveal juxtaposition between evolutionary conservatism in tooth attachment, irrespective of diet, and plasticity in tooth replacement and implantation.

Symposium III (Saturday, October 29, 2016, 9:30 AM)

ENDOTHERMIC ARCHOSAURS? THE USE OF BONE HISTOLOGY IN PHYLOGENETIC RETRODICTIONS

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Archosaurs are a clade of vertebrates that includes birds, crocodiles, and numerous fossil groups. This clade has been a matter of debate among paleontologists for decades concerning the evolution of its thermometabolism. The classical hypothesis considers that only modern birds are truly endotherms (i.e., able to produce their own body heat), whereas all other archosaurs are ectotherms (i.e., relying on the external environment to maintain their body at a high temperature). Bone histology allows the study of several traits linked to thermometabolism, otherwise impossible to estimate on fossil specimens. However, no quantitative estimation of metabolic rate has ever been performed on fossils using bone histological features.

Here we performed statistical predictive modeling in a phylogenetic context using a sample of vertebrates and a set of bone histological features to estimate metabolic rates of fossil archosauromorphs. We used the recently published method called Phylogenetic Eigenvector Maps (PEM) to express phylogenetic relationships between species as independent variables in our models. This method allows to estimate the missing values of quantitative characters in a phylogenetic framework, and is thus a very powerful tool to perform phylogenetic retrodictions in paleontology.

Our results show that Mesozoic theropod dinosaurs exhibit metabolic rates very close to those of modern birds, and that most fossil archosaurs share an ancestral metabolic rate significantly higher than that of extant ectotherms. Ancestral state reconstructions for metabolic rate indicate that this derived metabolic rate was acquired at a more inclusive level of the phylogenetic tree, among non-archosaurian archosauromorphs. These preliminary results also highlight the difficulties of assigning a given heat production strategy (i.e., endothermy, ectothermy) to an estimated metabolic rate value, and confirm findings of previous studies that the definition of the endotherm/ectotherm dichotomy may be ambiguous.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

UTILIZING PROBOSCIDEAN CRANIAL METRICS FOR ANALYSIS OF REGIONAL VARIATION IN THE COLUMBIAN MAMMOTH *(MAMMUTHUS COLUMBI)*

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Apart from dentition, metrics of the proboscidean crania have been largely ignored in paleontological analysis. Thirty metrics, both utilizing identifiable cranial landmarks and extremal points of the cranium of the Columbian mammoth *(Mammuthus columbi)* were analyzed. Fifty-nine specimens from across the United States were studied. Each specimen had a varying degree of completeness, ranging from only the maxillary teeth being preserved in association to preserved full crania, complete with tusks. Of the thirty metrics, eight of these metrics failed to reject the null hypothesis of zero correlation (p value > 0.10). The remaining twenty-two metrics significantly rejected the null hypothesis of zero correlation (p value < 0.10) and were subsequently analyzed to look for regional variation across the contiguous United States. The largest population of crania studied was from the Mammoth Site of Hot Springs, South Dakota, Inc., a natural deathtrap that captured at least sixty-one mammoths while it was active. Twenty-three crania were studied from the Mammoth Site as well as an additional twenty-six crania from across the United States. Specimens preserved are dominantly from the central portion of the United States as there is an apparent preservational bias for that region. The limited specimens available for study from both the eastern and western portion of the United States limited the potential of robust, weighted, statistical tests, but principal component analysis (PCA) and multidimensional scaling (MDS) analyses were completed on smaller subsets of the data. The PCA tests did not demonstrate any separation of crania for regional differences and the MDS analyses, though having a high goodness-of-fit (GOF > 0.90) when projected in two-dimensional space, still did not indicate evidence of regional differences. Visual inspection of the plotted raw data, plus both the PCA and MDS results indicated that regional variation in Columbian mammoth crania is not exhibited across the United States. This could be due to evolutionarily similar adaptations across the United States, a low degree of separation between populations, or simply a function of there not being enough well-preserved crania to witness this degree of variation. Though regional variation was not evident, there appeared to be other significance to collecting data of this nature. When visually inspecting the raw data, it appeared that sexually dimorphic differences were evident amongst the Columbian mammoth crania.

Romer Prize Session (Thursday, October 27, 2016, 8:30 AM)

EVOLUTION OF A TERRESTRIAL-STYLE FEEDING SYSTEM IN WATER: *TIKTAALIK ROSEAE* AND *ATRACTOSTEUS SPATULA*

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In order to successfully colonize land, early tetrapods would have had to transition from an aquatic, suction-based feeding system to a terrestrial, biting-based one, but exactly when and how this shift occurred is poorly known. The elpistostegid, *Tiktaalik roseae*, provides insight into these issues due its phylogenetic proximity to early tetrapods and the well-preserved nature of its cranial material. I present a detailed reconstruction of the feeding mechanism of this important transitional taxon, made possible through computed tomography (CT) scans of 7 specimens with preserved cranial material. By reconstructing joint surfaces and sutures, a model of feeding kinematics in *Tiktaalik* is possible for the first time. Previous studies relied on the lower jaws to reconstruct feeding behavior in early tetrapods, but the greatest changes to feeding morphology in elpistostegids occurs in the cranium. The blunt-snouted alligator gar, *Atractosteus spatula*, is the best extant taxon for understanding elpistostegid feeding behavior, due to convergent evolution in rostral proportions, tooth anatomy, and joint morphology of the upper jaws. Initial comparisons of sutural morphology and cranial architecture suggest both taxa were capable of splanchnokinesis (i.e., independent motion of the palate relative to the braincase). To test the role of splanchnokinesis in prey capture, high-speed videos of juvenile *Atractosteus* specimens were filmed in lateral and dorsal aspect. Analyses of these videos document cranial kinesis in gar skulls that were previously thought to be akinetic. Differences in the palatobasal articulations in each group suggest slight differences in the way splanchnokinesis was achieved, but overall function appears to remain the same. These data demonstrate that, while suction remains important in the feeding mechanics of both gars and elpistostegids, the most significant morphological changes in the crania of both aquatic lineages are elaborations of a biting-based feeding mechanism. These findings support the hypothesis that biting-based feeding in tetrapodomorph fishes evolved in water and was subsequently exapted by early tetrapods for use on land.

Grant Information

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Technical Sesssion X (Friday, October 28, 2016, 9:15 AM)

CONSERVED SEMIAQUATIC MORPHOLOGIES BETWEEN EXTANT CROCODYLIANS AND PHYTOSAURIA

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Apparent selective advantage is observable in the convergence between various semiaquatic organisms over the past 200 million years. Extant crocodylians and extinct members of Phytosauria exhibit characteristics that suit their environments. We conducted comparative examinations across Late Triassic phytosaurs, specifically investigating endocranial morphology and nerve innervation in order to understand the conserved ecological and functional implications of a semiaquatic lifestyle. We utilized the most basal known phytosaur, *Wannia scurriensis*, and the more derived *Rutiodon carolinensis* and *Machaeroprosopus mccauleyi*. *W. scurriensis* is interpreted to preserve the basal endocranial anatomy of Phytosauria, which is similar to that of *Crocodylus johnstoni* in general shape, nerve location, and the presence of a large hypophyseal fossa, though with noticeable differences in the extent of the pineal region and medulla orientation. The antorbital cavity and posterior portion of the rostrum of *W. scurriensis* preserves the anterior extension of the antorbital cavity into the premaxilla and neurovasculature in the maxilla lateral to this cavity, similar to that of *Alligator mississippiensis*. *R. carolinensis* also preserves the antorbital cavity as well as the entire length of the rostrum. This provides a detailed view of the trigeminal nerve, which perforates the rostral and mandibular regions, also similar to *A. mississippiensis*. The paranasal sinus of *R. carolinensis* enters, but does not extend to, the anterior end of the premaxilla as previously described. *M. mccauleyi* preserves an endocranial morphology that is similar to *Wannia scurriensis* and *C. johnstoni* but differs in the absence of an apparent hypophyseal fossa. *M. mccauleyi* also exhibits a poorly preserved antorbital cavity marked by a dorsal expansion of the antorbital cavity anterior to the nares. Extensive trigeminal innervation in crocodylians assists in sensing stimuli. Therefore, we argue that the density of trigeminal branches and foramina in phytosaur maxillae, premaxillae, and dentaries indicates similar sensory abilities and ecologies of these animals. Conversely, though both crocodylians and phytosaurs have elongate rostra with anteriorly extending antorbital cavities, these morphologically comparable structures seem to differ functionally due to placement of the nares. The comparisons assist in further establishing phytosaur relationships based on endocranial morphology while also ecologically linking an extinct clade with its extant analogue.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

A RIGID PALM TREE OR A MIGHTY BRANCHING OAK? USING MUSKRATS TO STUDY EVOLUTIONARY MODE

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Patterns of evolution revealed by the fossil record are among the best physical evidence for exploring the mechanisms by which evolution occurs. In particular, mammal groups with extensive Quaternary fossil records represent excellent case studies for the mode of evolution. This is, perhaps, best exemplified with the fossil record of arvicoline rodents (modern lemmings, muskrats and voles), which are abundant in well-stratified and tightly correlated fossil localities from around the world, spanning the last five million years. The evolution of species within Arvicolinae has been the subject of intense investigation and has resulted in patterns of macroevolution that can represent multiple potential modes of evolution. Namely, these patterns could be explained by anagenetic evolution, cladogenetic evolution, or budding cladogenesis. The evolution of arvicolines has been conceptualized as occurring within all three of these modes. To identify whether anagenesis, cladogenesis, or budding cladogenesis is the dominant pattern, a combination of approaches must be taken to investigate mode of evolution. Here we present a study using a dataset of lower first molars (n = 243) from 12 of the 18 modern subspecies of *Ondatra zibethicus.* Ninety-three molars from fossil localities were also analyzed. Triangle number was found as the most discriminating trait of the muskrat molar, showing little intraspecific variation in modern samples. Based on the traits analyzed, we hypothesize an anagenetic evolution from *O. idahoensis* to *O. zibethicus* around 1.8 Ma. To assess if anagenesis is the dominant mode of evolution within *Ondatra*, we are expanding our sample to include a dataset made up of continuous multivariate data aimed at determining if characters of the lower first molar, which are not easily discretized, also appear to be evolving anagenetically.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

THE VARIATION OF THE VERTEBRAL CENTRA LENGTH AND EI IN SAUROPOD DINOSAUR—HOW TO BUILD A SAUROPOD

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Sauropod dinosaurs include the largest of all dinosaurs and in particular are characterized by long necks and long tails. The sauropod axial skeleton comprises 12 to 19 cervical vertebrae, 10 to 12 dorsal vertebrae, 4 to 6 sacral vertebrae and up to 82 caudal vertebrae. The goal of this study is to investigate the elongation trend of sauropod necks and derive some general principles of their construction using a dataset of 68 relatively well preserved sauropods.

A general empirical model was set up to visualize the elongation of the centra throughout the entire vertebral column. The study also focuses upon detailed variation within and between cervical, dorsal, sacral and caudal regions. The model documents marked differentiation in the cervical region but shows comparative uniformity in the remainder of the vertebral column. Incomplete preservation is a major taphonomic factor in the fossil record of sauropods and an accurate means of estimating the lengths of missing axial elements, and thus completed animals, is desirable. The model also helps pinpoint the positions of disarticulated vertebrae based on the relatively symmetric variations of the centrum length on both sides of the longest cervical vertebra (LCV). If the LCV is not preserved, significant correlation between the lengths of the femur and the length of LCV allows estimation of the lengths both of the LCV and overall neck length. Among selected vertebrae in the collected specimens in this study, the femur presents an allometric relationship with all the cervical vertebrae except the atlas and axis, and caudal vertebrae from 20-30th. However most dorsal and all sacral vertebrae and most of the caudal vertebrae have an isometric relationship with the femur.

The general model of vertebral length in the presacral region of sauropod is distinct from the patterns in the short necked alligator (*Alligator*) and long-necked giraffe (*Giraffa*). Interestingly, the swan (*Cygnus*), a particularly long-necked bird, has a similar cervicodorsal pattern to that of sauropods. An Elongation Index (EI) value is adopted to demonstrate graphically the significant elongation of the centra in the cervical and caudal regions of the vertebral column. These regions exhibit distinct biomechanical specializations.

Poster Symposium I (Wednesday–Thursday, October 26–27, 2016, 4:15–6:15 PM)

NEW RODENT ASSEMBLAGE FROM STRATA NEAR THE EOCENE–OLIGOCENE BOUNDARY IN ERDEN OBO SECTION (NEI MONGOL, CHINA)

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The boundary of Eocene/Oligocene is a critical transitional period in the evolutionary history of Cenozoic mammals and also witnessed one of the most severe climatic changes. The perissodactyl-dominant faunas of the Eocene were abruptly replaced by the rodent/lagomorph-dominant faunas of the Oligocene in the Mongolian Plateau. However, the rich rodent fossil records of the late Eocene and the earliest Oligocene of China are rarely reported.

Here we present the preliminary study of the rodent assemblage from the 'Upper Red' beds of the Erden Obo section in Nei Mongol, China. The assemblage of rodents contains the cricetid, the dipodoid, the ctenodactyloid, and the cylindrodontid and shows rich and highly diversified rodent faunas. We recognized at least nine species and two species indeterminata belonging to seven genera in the new fossils. Of these taxa, cricetid *Eucricetodon wangae* sp. nov. is more primitive than other known species of the genus from the lower Oligocene of Asia and Europe, and *Pappocricetodon siziwangqiensis* sp. nov. is more advanced than other species of the genus. The dipodoid includes *Sinosminthus*, *Allosminthus*, and *Heosminthus*, and *Gobiomys* dominated in the ctenodactyloid. The composition of the rodent assemblage shows that the 'Upper Red' of the Erden Obo section is younger than the Upper Eocene Houldjin and Caijiachong Formations, but older than the strata containing the Shandgolian faunas; the 'Upper Red' is most closely correlative to the Ergilian beds in age, and probably close to the Eocene/Oligocene boundary. The cricetid provides new evidence to support that the cricetid dispersal from Asia to Europe occurred prior to the Eocene–Oligocene boundary. The late Eocene rodents may have served as a stock for 'Mongolian Remodelling.'

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

***CHINLECHELYS:* A REEXAMINATION OF NORTH AMERICA'S OLDEST (TRIASSIC, REVULTIAN, NORIAN) TURTLE AND ITS IMPACT ON THEORIES OF TURTLE ORIGINS**

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The Late Triassic turtle *Chinlechelys* is known from a large number of associated shell fragments. It shows a stage in the development of the turtle shell intermediate between *Odontochelys* and *Proganochelys*. While the preserved portions of the plastron of *Chinlechelys* resemble those of *Odontochelys*, the carapace shows a more advanced state. It differs from all other turtles except *Dermochelys* in that the ribs and overlying osteoderms are not nearly parallel, and instead cross at a 45° angle. These ribs are separated from the overlying osteoderm by compact bone present in both the rib and on the costal sides of the suture. This means that the ribs and overlying osteoderms represent separate ossifications, indicating fusion of the ribs and osteoderms rather than the expansion of ribs alone. Further, the morphology of these costals suggests a terrestrial habit based on the occurrence of raised bosses perpendicular to the midline of the animal as well as the occurrence of near right angles in the costals, both of which would incur a significant hydrodynamic penalty. The carapace of *Chinlechelys* resembles that of *Dermochelys,* which has often been referred to as neonate in its morphology. This indicates some of the unique features of *Dermochelys* are reversals to the primitive state, following the notion that ontogeny mirrors phylogeny. Based on this comparison we speculate that the carapace may not have been absent in *Odontochelys* but rather made up of a great many separate osteoderms, and, as often occurs with modern *Dermochelys,* they were disarticulated following death. Thus, *Odontochelys* represents a side branch of turtle evolution--an early sea turtle as some have suggested--rather than the ancestor of later turtles. This is primarily based on the derived state of lacking a bony attachment between the pelvis and the vertebral column, unlike all other uncontroversial stem turtles, which have a bony attachment. *Pappochelys* is here disregarded as a stem turtle because the morphology linking it to turtles better indicates it is a basal placodont. Based on the presence of turtle footprints in the lower Middle Triassic, turtle-like animals must have evolved by that time. These are unlikely to have been made by *Odontochelys,* given its unique pelvis morphology. We conclude from this that *Chinlechelys* represents an earlier stage in the evolution of the turtle shell than *Proganochelys* and other Norian turtles, and this reinforces the conclusion that *Odontochelys* is not ancestral to other turtles.

Symposium I (Wednesday, October 26, 2016, 9:15 AM)

SKIN PRESERVATION AND TAPHONOMY ELUCIDATED BY INTEGRATED MOLECULAR, ULTRASTRUCTURAL, AND EXPERIMENTAL APPROACHES

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The fossil record is capable of exceptional preservation. Occasionally, normally labile and decay-prone tissues, such as skin, are preserved as organic residues and/or phosphatized remains with a high degree of morphological fidelity. These rare findings yield information on traits of ancient organisms not otherwise available to the scientific community, and are thus important for our understanding of the biology, ecology and evolutionary trends of extinct animals.

We examined an array of 'carbonized' fossils (including amniote skin and various controls, such as cephalopod ink, leaves, and wood) to investigate the preservation and taphonomy of vertebrate integument in marine environments. We used a suite of sensitive chemical, molecular, and ultrastructural techniques, including alkaline hydrogen peroxide oxidation, infrared (IR) microspectroscopy, field emission gun scanning electron microscopy (FEG-SEM), immunohistochemistry, transmission electron microscopy (TEM), and time-of-flight secondary ion mass spectrometry (ToF-SIMS). Additionally, as an extant analogue, we performed decay experiments on *Morelia* dermal tissues incubated in a seawater medium under oxic and anoxic conditions using various sediments and soils. Our integrated approach revealed that a complex series of taphonomic pathways, incorporating both organic and geochemical agents, probably contribute to the replacement of original tissues by authigenic minerals, as well as the retention of endogenous biomolecules in multimillion-year-old animal remains. Moreover, by combining multiple independent analytical techniques the precision of the data collected is greatly improved, which in turn augment the accuracy of the interpretations.

Grant Information
Swedish Research Council

Technical Session XI (Friday, October 28, 2016, 10:30 AM)

EOCENE FOSSIL RECORD OF CATOSTOMIDS (TELEOSTEI, CYPRINIFORMES) FROM NORTH AMERICA AND DISCOVERY OF THE FIRST LOACH-LIKE CATOSTOMID

LIU, Juan, University of Alberta, Edmonton, AB, Canada; WILSON, Mark V., University of Alberta, Edmonton, AB, Canada

Catostomid fishes (Ostariophysi, Cypriniformes, Catostomidae) are commonly known as suckers because of their ventrally directed mouth used in suction feeding. They occupy a wide variety of freshwater habitats and are widely distributed in North America, playing a critical role in freshwater ecosystems. Diversification of this clade began in both North America and Asia in the early Eocene. Eight nominal species have been recognized from Eocene deposits in North America, but until now all were assigned to the genus *Amyzon*. A large number of recently collected specimens allows us to recognize two types of Eocene North American catostomids: an *Amyzon*-type and a non-*Amyzon*-type. Whereas the former is carp-like, large-bodied, and includes the majority of Eocene catostomids, the latter is loach-like, small-bodied, and recognized so far only from the Allenby Fm., British Columbia, Canada. The Allenby specimens, which were initially described as *Amyzon brevipinne*, are distinguished from all species of *Amyzon* in having dramatically fewer pharyngeal teeth and dorsal fin rays and a shorter posteroventral process of the dentary. Among currently known catostomids, only the Allenby specimens possess a preopercular sensory canal well enclosed by the preopercle, a plesiomorphic character of cypriniforms. Phylogenetic analyses suggest that the Allenby specimens are the most basal clade within the Catostomidae; they are not members of the *Amyzon* clade and thus require a new generic name. The new group has a unique combination of loach-like frontal shape with a shallow and thin, gyrinocheilid-like (algae eater) infraorbital series, suggestive of a novel ecological niche previously unknown among catostomids. Catostomidae, Gyrinocheilidae, and the loach families comprise the superfamily Cobitoidea, yet this is the first known catostomid that resembles loaches both in general appearance and in osteological characters. These retained primitive traits highlight the complexity of character evolution early in the history of this important group of freshwater fishes.

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Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

THE TETRAPOD FAUNA OF THE UPPER PERMIAN NAOBAOGOU FORMATION OF DAQINGSHANG, INNER MONGOLIA, CHINA

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In China, late Permian tetrapods have been reported from four different regions. Two of these regions are dominated by dicynodonts, in congruence with the famous late Permian faunas of South Africa and Russia, whereas the other two regions are notably rich in pareiasaurs. Up to now, pareiasaurs and dicynodonts did not coexist in any of these localities. We recognize that this apparent exclusion may not represent the original faunal composition, as the number and the diversity of the collected and studied specimens are low.

In Daqingshang, Inner Mongolia, two species (dicynodont and captorhinid) have been formally reported from the Naobaogou Formation, but the region was apparently home to a much more diverse Permian fauna. After several years of fieldwork, we have now recorded 73 different fossil-bearing sites. Most of the specimens collected thus far can be identified as dicynodonts (more than 20 individuals), but there are also five therocephalian specimens and two parareptilian specimens. The specimens exhibit a stratrigraphic distribution that extends from nearly from the bottom to the top in all three members of the Naobaogou Formation.

One of the two parareptile specimens represents a new species of pareiasaur, whereas the other can be diagnosed as a new species of Lanthanosuchoidea. There are at least three new therocephalian species. The newly discovered specimens also support the conclusion that the holotype of *Daqingshanodon limbus* is likely a juvenile. Some specimens can be referred to Geikiinae or Dicynodontoidea, and represent a new species. In total, at least nine species from four groups were present here, and the pareiasaurs did coexist with the dicynodont. The new discoveries also help to clarify the origination of the late Permian tetrapods of Laos, and help to reconstruct the palaeogeographical reconstruction of this age.

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Technical Session II (Wednesday, October 26, 2016, 10:45 AM)

THE EVOLUTION AND VARIATION OF BASAL MOSASAURINAE BASED ON A SPECIMEN-LEVEL PHYLOGENY OF "*CLIDASTES*": IMPLICATIONS FOR MOSASAUR MACROEVOLUTION

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I examine the relationships among and variation within species of *Clidastes* to better understand the evolution of the Mosasaurinae, a clade of marine squamates that are known from Upper Cretaceous strata of the world. The oldest and most basal mosasaurine is from the Turonian of Texas. By the Maastrichtian, they were the most diverse and disparate clade of mosasaurs, and exhibited a global distribution. Despite the high diversity and an abundance of specimens, a number of phylogenetic and taxonomic issues within the clade are unresolved. One of those issues is the paraphyly of the genus *Clidastes*, a basal grade of mosasaurine with an abundant fossil record in North America and some referred specimens from Europe.

To better understand the evolution and systematics of *Clidastes*, I scored morphological characters of over 40 specimens of *Clidastes*, as well as other species of mosasaurines. I then performed specimen-level phylogenetic analyses, using both traditional character scorings from previous studies and character states that more precisely describe the anatomy present on a given specimen. Characters I found that vary intraspecifically within *Clidastes* include the length of the premaxilla-maxilla suture, the number of teeth in the maxilla and dentary, sculpturing of the frontal, and the dimensions of the quadrate stapedial pit. Paraphyly of "*Clidastes*" is supported by both of my analyses. The analysis using characters that more precisely capture variation decreases the resolution of the phylogenetic hypothesis, producing a basal polytomy within Mosasaurinae. This is likely because there are more characters that vary intraspecifically than there are apomorphic character states that unite each species. Depending on the preferred phylogenetic hypothesis, at least two interpretations can be drawn from these results. One possible conclusion is that there were at least three highly variable species of basal mosasaurine that cannot be united under a single monophyletic genus. Another possible conclusion is that there is a single, highly variable basal mosasaurine lineage in North America from which the fossil record is sampling. If this is the case, individual species within that lineage may be difficult to distinguish. The high level of variation within basal mosasaurines is not observed in other clades of mosasaurs. I hypothesize that the propensity to express such variation may represent an emergent property of the lineage, upon which selection acted to produce the high diversity and disparity observed in Maastrichtian mosasaurines.

Grant Information
Evolving Earth Foundation; Geological Society of America; Texas Academy of Science; Jackson School of Geosciences, The University of Texas at Austin

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

A PHYLOGENETIC ALTERNATIVE TO RICHNESS AS A BIODIVERSITY METRIC SUGGESTS A MID-CRETACEOUS PEAK FOR MESOZOIC DINOSAURS

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The fossil record constitutes the only empirical evidence for how biodiversity has changed over time. However, despite the existence of a broad array of biodiversity metrics, palaeontological studies have focused almost exclusively on taxonomic richness. One common biodiversity metric applied to extant species is Phylogenetic Diversity (PD), the sum of the branch lengths of a time-scaled tree that connects all the taxa present in a sample. PD thus captures information about the relatedness of taxa in a sample, and can vary even when richness is constant.

Here we explore how PD changed over time in Mesozoic dinosaurs using a 960-taxon meta-analytical phylogenetic hypothesis time-scaled using two separate probabilistic methods. 25 separate time-sliced trees (corresponding to stage boundaries) were generated and PD measured. Overall, dinosaur PD shows an exponential rise from the Norian to the Aptian, consistent with a model of net positive diversification (speciation greater than extinction). However, from the Aptian to the Maastrichtian, PD shows much greater volatility and an overall decline following an Albian peak. Separate examination of the three major subclades (Ornithischia, Sauropodomorpha, Theropoda) reveals more nuanced PD changes. Although theropods and ornithischians resemble the overall pattern – albeit with overall PD peaks in the Albian and Campanian, respectively – sauropodomoprhs are notably different, remaining essentially flat through the Middle Jurassic before a linear rise to an overall Albian peak followed by a steep decline towards the end-Cretaceous.

Although here PD is positively correlated with richness (R-squared = 0.89), a bivariate plot shows this is not a simple linear relationship. Relative persistence of the root (i.e., the most recent common ancestor of all taxa considered) appears to be a key factor in determining PD over time. For dinosaurs as a whole, the root (basal split between Ornithischia and Saurischia) remains identical until the end-Cretaceous extinction, when it is dramatically reset to the Palaeognathae-Neognathae split that remains today. Ornithischians and theropods also establish a root in the Triassic that persists until the end-Cretaceous, but sauropodomorphs continually change root until the Middle Jurassic. Overall, we show that PD can provide a new understanding of past biodiversity changes by capturing both the magnitude and phylogenetic selectivity of extinction.

Grant Information
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Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

SEXUAL DIMORPHISM IN PLIOCENE *GAZELLA* (MAMMALIA, ARTIODACTYLA) FROM MAKAPANSGAT LIMEWORKS CAVE, SOUTH AFRICA

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Makapansgat Limeworks is a fossiliferous cave site located in Limpopo Province, South Africa. The late Pliocene deposits of Makapansgat have yielded a diverse large mammalian fauna that includes primates, artiodactyls, perissodactyls, and carnivorans. Studies of the fossil Bovidae from this site have played a major role in the reconstruction of the local paleoenvironment and have provided insight into the evolution of late Neogene mammal communities in southern Africa. The taxonomy of some of the Makapansgat bovids, however, remains controversial. In particular, the number of *Gazella* species in the assemblage has been debated.

Here we use a large comparative sample of craniodental data from extant Antilopini to show that two of the *Gazella* species from Makapansgat, *Gazella vanhoepeni* and *G. gracilior*, actually represent male and female individuals of a single taxon. Qualitatively and quantitatively, the horn cores of *G. vanhoepeni* resemble extant antilopin males, whereas those of '*G. gracilior*' exhibit the reduced horn core dimensions and rounder cross-section typical of female antilopins. Differences in abundance of male and female specimens, previously interpreted as reflecting differences in species abundance on the paleolandscape, are likely the result of size-related taphonomic biases. The recognition of sexual dimorphism in fossil *Gazella* has implications for reconstruction of the fossil community, including paleoenvironmental reconstructions that incorporate bovid species diversity and abundance. Additionally, our results demonstrate that the pattern of horn core sexual dimorphism characteristic of extant Antilopini was already in place by at least the late Pliocene.

Grant Information
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Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

STASIS IN RANCHO LA BREA BLACK VULTURES (*CORAGYPS OCCIDENTALIS*) OVER THE LAST GLACIAL-INTERGLACIAL CYCLE

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In textbooks, bird evolution is often modeled on the example of the Galapago finches, which show rapid responses to climatic change. We studied the sample of Pleistocene relative of the Black Vulture (*Coragyps occidentalis*) from the Rancho La Brea to see if they showed size or shape changes in response to the climate changes of the last 35,000 years, including the last complete glacial-interglacial cycle. Even though living *Coragyps atratus* shows a strong Bergmann's rule effect, with larger body sizes in colder climates and smaller subspecies in the tropics, the Rancho La Brea Black Vultures showed no statistically significant change over this interval, with no meaningful changes in size or robustness. This was true even during the peak glacial interval at 18,000-20,000 years ago, when the region was covered by coniferous forests and snowy winters. These results are consistent with earlier studies on La Brea Condors, Golden Eagles, Bald Eagles, Turkeys, Great Horned Owls, Barn Owls, and Caracaras. In contrast to the Galapagos finches, Rancho La Brea birds do not respond rapidly to long-term changes in climate in a simple fashion. Instead, they are ecologically flexible and live in a wide range of habitats and climates without change in size or limb robustness.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

TEMPO AND MODE IN THE EVOLUTION OF CTENODACTYLINE RODENTS

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Ctenodactyline rodents (or gundis) are a subfamily of the Ctenodactylidae known from the late early Oligocene up to the present. Although low in diversity today (only five species distributed in four genera), the group experienced in the Miocene a significant diversification together with a wide distribution from Asia, their land of origin, to Africa. Gundis never returned from Africa and became extinct in Asia at the dawn of the Pliocene. Although ctenodactyline relationships are well known, the patterns and processes that have underpinned their evolution remain uncertain. Although they are today restricted to desert and semi-desert areas in North and East Africa, dental evolution in these rodents strongly suggests a shift in ecological requirements. We used a combination of disparity and evolutionary rates analyses to explore the tempo and mode of evolution in ctenodactylines. Results indicate accelerated evolutionary rates and greater disparity at 13.7, 8, and 2.5 Ma, which correlate with important environmental events. The first evolutionary rate acceleration may be related to the gradual global cooling that took place after the mid-Miocene climatic optimum. The second appears to be approximately coeval with the emergence of the Sahara. And the third acceleration in evolutionary rate is paralleled by a further cooling reflecting the onset of Northern Hemisphere glaciation. Overall, the evolutionary history of gundis seems to have been mainly triggered by abiotic phenomena. Their adaptation to increasingly arid environments from 8 Ma onwards exemplifies an evolutionary shift in response to environmental change. At that time, ctenodactylines became hypsodont, which can be interpreted as a way of dealing with the intensive dental wear that would result from the abrasive food that is found in open habitats.

Grant Information

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Technical Session VIII (Thursday, October 27, 2016, 2:00 PM)

DENTAL TOPOGRAPHIC ANALYSIS OF PAROMOMYID (PLESIADAPIFORMES, PRIMATES) CHEEK TEETH: MORE THAN 15 MILLION YEARS OF CHANGING SURFACES AND SHIFTING ECOLOGIES

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Plesiadapiforms represent the first adaptive radiation of Primates, appearing near the Cretaceous–Paleogene boundary. Eleven families of plesiadapiforms are recognized, including the Paromomyidae, which are known from North America, Europe, and Asia. While the investigation of the taxonomic diversity and evolution of paromomyids has a long history, studies quantifying the three-dimensional (3D) dental morphology of this group have never been published.

Dental topographic analyses generate quantitative data on the 3D morphology of teeth. We used three dental topographic metrics, Dirichlet normal energy (DNE), relief index (RFI), and 3D orientation patch count rotated (3D OPCR), to assess changes in the morphology of the most taxonomically diagnostic tooth for paromomyids, the lower fourth premolar (p4), and of the lower second molar (m2). The use of the m2 allows for comparison to data from previous dental topographic studies on living taxa of known diet.

Our results indicate that paromomyids, traditionally thought to be frugivores with some potential for including tree exudates in their diet, occupied a more diversified range of dietary categories than suspected. Although RFI values calculated for *Ignacius graybullianus* suggest that taxon was frugivorous, other species are reconstructed as mixed feeding omnivores, with *Phenacolemur willwoodensis* having values that are suggestive of a more insectivorous diet. The results from the DNE analysis are consistent with the inference that there was a broad range of dietary habits in the family.

Both RFI and DNE values also show clear taxonomic signals. For example, values of RFI reflect the previously hypothesized evolution of *P. praecox* into *P. fortior*, allowing for quantification of the shift from a higher to a lower-crowned morphology of p4. *Phenacolemur simonsi* and *P. willwoodensis* were similarly sized species that both lived during the early Eocene (Wasatchian North American Land Mammal Age) in the Bighorn Basin, Wyoming. Markedly different values in RFI with respect to the m2 and p4, and contrasting values for DNE in the m2, reflect subtle differences in dental morphology, suggesting that *P. willwoodensis* was ecologically distinct in being more insectivorous. These contrasts support the inference that they were in fact distinct species.

These results suggest that dental topographic metrics are informative to the study of paromomyids not only for dietary categorization and the understanding of ecological niche separation, but also to the distinction of species at a fine taxonomic level.

Grant Information

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Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

MORPHOMETRIC AND BIOSTRATIGRAPHIC ANALYSIS OF CRANIAL VARIATION IN *GRYPOSAURUS* (ORNITHISCHIA, HADROSAURIDAE) FROM THE DINOSAUR PARK FORMATION (CAMPANIAN)

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The Dinosaur Park Formation (Campanian) of Alberta contains one of the most diverse assemblages of hadrosaurid dinosaurs. Despite a decent fossil sample, the systematics of species within the genus *Gryposaurus* from this formation is unresolved. Historically, two *Gryposaurus* species have been recognized, *G. notabilis* and *G. incurvimanus,* which are differentiated primarily on the morphology of the nasal arch. In *G. incurvimanus*, the arch is less prominent and occurs more anteriorly than that in specimens historically assigned to *G. notabilis*. The two species have recently been suggested to either represent two valid taxa, intraspecific variation within *G. notabilis* (e.g., ontogeny), or anagenesis within an evolving *Gryposaurus* lineage. However, these alternative hypotheses have never been adequately tested via detailed morphological comparisons, morphometrics, and biostratigraphy.

A geometric morphometric analysis of hadrosaurine skulls from the Dinosaur Park Formation was performed to assess the influence of ontogeny (i.e., skull size) on skull morphology. Independent of size, *G. incurvimanus* skulls are found to be more similar to each other than to those of *G. notabilis*, with little overlap in a landmark-based morphospace. However, the differences in morphology can be explained by skull growth. This type of ontogenetic nasal retraction is commonly seen in other hadrosaurids, such as *Brachylophosaurus* and lambeosaurines. High-resolution stratigraphic data was then used to map this morphology through time, to evaluate the anagenesis hypothesis. The biostratigraphy of the two species shows considerable chronological overlap, and indicates that the sampled individuals lived over a relatively short period of time (< 0.5 mya). The anagenesis hypothesis is therefore rejected.

Based on these analyses, we do not reject the hypothesis that *G. incurvimanus* and *G. notabilis* represent different ontogenetic stages within a single species. This study contributes to the understanding of individual variation within a single *Gryposaurus* species, which will be important for assessing the validity of other named species in the genus.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

A NEW SPECIMEN OF TRIASSIC PISTOSAUROID *YUNGUISAURUS* FROM LADINIAN (LATE MIDDLE TRIASSIC) XINGYI FAUNA OF GUIZHOU, SOUTHWESTERN CHINA

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Triassic Pistosauroidea (Reptilia: Sauropterygia) is the sister taxon of the Jurassic-Cretaceous Plesiosauria, a group that achieved high diversity and cosmopolitan distribution during the Mesozoic. Nine pistosauroid genera have been reported, but only few of those were well known by its complete skeleton with relatively well preserved cranial material. *Yunguisaurus liae* Cheng et al., 2006 was the first Triassic pistosauroid found in southwestern China and east Tethys represented by quite a few almost complete skeletons. But the anatomic information of its skull, especially the lateral side, is still poorly described.

Recently, a new nearly complete and articulated skeleton of *Yunguisaurus* was discovered from the Middle Triassic Zhuganpo Member of Falang Formation at Nimaigu of Wusha Town, Guizhou, China, where abundant *Keichousaurus* specimens were excavated at the famous Xingyi Fauna site. The geological age of this Xingyi Fauna level, Ladinian of Middle Triassic or Carnian of Late Triassic, has been controversial for a long time. We collected a zircon samples for dating from the volcanic tuffs close to the fossil layer. Based on the LA-ICP-MS U-Pb analysis, an age of 240.8 ± 1.8 Ma (1σ, MSWD=0.043) for the Xingyi Fauna fossil level has been obtained. This result reconfirms that the Xingyi Fauna is of Ladinian in age.

The new specimen can be referred to *Yunguisaurus* Cheng et al., 2006 on the basis of the following characteristics: the elongate snout with slender teeth, at least six premaxillary teeth, a large pineal foramen located at the frontal/parietal suture, slender humerus and epipodials, hourglass-shaped ulna. The new specimen shows its unique preserved skull in lateral view, therefore, some unique characters were gleaned, such as premaxilla-maxilla suture, jugal-postorbital suture, the ventral edge of the prefrontal, and so on. It reveals the complete lateral morphology of the skull of *Yunguisaurus* for the first time.

Technical Session IX (Thursday, October 27, 2016, 3:00 PM)

THE FIRST STEM-SARCOPTERYGIAN FROM THE PRAGIAN OF SOUTH CHINA HIGHLIGHTS THE EARLY EVOLUTION OF SARCOPTERYGIANS

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Recent discoveries of stem sarcopterygians (e.g., *Guiyu*, *Psarolepis*, and *Achoania*) from the late Silurian (~419 million years ago) to Lochkovian (Early Devonian, ~415 million years ago) in South China have greatly increased our knowledge of the origin and early diversification of osteichthyans, and shed light on the early evolutionary history of lobe-finned fishes. However, poor preservation of available otoccipital units has prevented a detailed understanding of this half of the neurocranium. Here, we report the first stem sarcopterygian from the Posongchong Formation (Pragian, Early Devonian, ~409 million years ago), Zhaotong, Yunnan province of South China, which preserves a completely ossified otoccipital unit. The new form shares similar features of the skull roof with *Guiyu* and *Psarolepis*, most notably middle and posterior pit-lines lying close to the midline of the shield. The dermal skull roof shows vermiculate ridged ornamentation similar to that of *Guiyu*. The new form has an exceptionally large notochordal opening, occupying more than half of the height of the occipital region in posterior view, and paired hyomandibular facets on the lateral commissure. These facets do not straddle the jugular canal, but rather sit dorsal to it. CT scanning reveals that the semicircular canals of the new taxon are very narrow. The anterior semicircular canal is widely separated from the brain cavity, recalling the condition in some early chondrichthyans and 'placoderms'. The new Pragian stem sarcopterygian extends the stratigraphic range of stem sarcopterygians by six million years, and provides new details on their endocranial structure that might help to clarify aspects of early sarcopterygian evolution.

Grant Information

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Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

RECONSTRUCTING INTERNAL ANATOMY OF THE BONE LAYER IN THE MARE AUX SONGES DODO-LAGERSTÄTTE (MAURITIUS): 3D-BONE MAPPING USING GEOGRAPHIC INFORMATION SYSTEMS (GIS)

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We present a novel workflow for the analysis of bonebeds in 3D involving Geographic Information Systems (GIS), geometrical corrections and in situ sampling by means of a rotary scoop.

In order to assess and reconstruct death and post-mortem scenarios that gave rise to the bone layer of 4,200 yr old Mare aux Songes Dodo (*Raphus cucullatus*)-Lagerstätte in Mauritius, spatial bone distribution, 3D-orientation and completeness of vertebrate bones and tree stems were mapped, visualised and analysed by means of GIS and assessed geostatistically. In 2009, a dry excavation pit was realised in the marsh. The pit was located within the reconstructed paleo-centre of the lake, representing conditions of low-energy lacustrine accumulation. Bone and wood orientations were measured by compass and their 3D-positions were mapped. In 2010, the Dodo-polder flooded, but dry excavation and 3D-measurements were continued in 2011 by means of a specially designed rotational scoop, measuring 190 cm by 140 cm, the so-called "Floore-arc". During lifting of the Floore-arc the originally horizontally deposited layers were tilted and folded. In this current study the deformation and implemented structural geometric corrections were assessed in order to reconstruct original in situ compass orientation measurements. XYZ-Positions of 423 bone and wood elements were mapped and described during excavation. Objects were assigned centroids to generate a 3D-model in GIS. We found that all bones of all species are chaotically mixed, with no articulation and only one single case of poor association. Based on minimum number of individual (MNI)-estimates and total bone finds per species, skeleton incompleteness is estimated >90% for all species. Bones show no statistically preferred orientation and the mean dip of bones are generally significantly less than 20°. Lower limbs dip low-angle on average at 21°.

Based on these findings we conclude that high degree of post-mortem bioturbation and hydrotaphonomic processes are the dominant signature of the Mare aux Songes Dodo-Lagerstätte.?

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

DISCORDANCE BETWEEN MOLECULAR AND MORPHOLOGICAL PHYLOGENIES REQUIRES A REEXAMINATION OF CLADISTIC METHODOLOGY: TURTLES AS AN EXAMPLE

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Molecular and morphological phylogenies rarely agree in detail. For example, the matrices produced for testudinoid turtles assign the family level placement of taxa as do molecular phylogenies, but at lower taxonomic levels the results rapidly begin to conflict. For example, *Rhinoclemmys,* shown by all genetic studies to be very basal in the Geoemydidae, or even a testudinid, are non-monophyletic and highly derived in morphological matrices. This conflict begs the question of which is the correct phylogeny, and this is still of some debate, but the molecular data have generally been thought to be more accurate. The greater issue is that if morphological methods cannot give an accurate result using modern species with near perfect availability of morphological data (i.e., no taphonomic destruction of soft tissues and other information), should trust be placed in the same morphological framework applied to fossil taxa without the availability of a secondary molecular check? In particular, this is an issue when the results of these studies conflict with stratigraphic data. For example, recent phylogenies have placed *Baena arenosa* as the most basal eubaenid despite it having a significantly more recent first appearance than other turtles in the clade. We think this indicates convergence in the characters used. As has been suggested by others, the importance of carefully constructed homologies is paramount. In the end, all sound methods of phylogeny rely on choosing synapomorphies for taxonomic groups. Given the issues pointed out by Vermei and others, it may not be a simple matter of cleaning up matrices and removing "bad" characters. A fundamental new direction is needed that is consistent with the evolutionary process, instead of rectangular matrices that inherently tie the deeper parts of the tree to changes in the shallower parts of the tree that are evolutionarily irrelevant. For another example, recent phylogenies of the origin or turtles move the base of Testudines in and out of Diapsida based on analysis greatly influenced by the common habit of choosing characters to obtain a desired result rather than making an objective homology assessment and letting the chips fall where they may. This highlights the importance of care in assessing homology, the need for caution in the interpretation of the results computers produce, and the value of stratigraphic data to give potential insight into problematic phylogenies. Similar inconsistencies have been pointed out in the phylogenetic analysis of some squamates and some bats.

Poster Symposium I (Wednesday–Thursday, October 26–27, 2016, 4:15–6:15 PM)

REDUCTION OF THE OLFACTORY SYSTEM IN PRIMATES: NEW INSIGHTS FROM THE NASAL FOSSA OF THE DUCHESNEAN PRIMATE *ROONEYIA VIEJAENSIS*

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Among living primates, tarsiers and anthropoids exhibit reductions in the size and complexity of the nasal cavity. By comparison, the anatomy of the nasal cavity in lemurs, lorises, and bushbabies is suggested to be generally plesiomorphic for crown primates. However, direct observations of internal nasal structures in fossil primates have been limited by (1) the rarity of specimens that preserve the delicate bony structures within the nasal cavity and (2) insufficient resolution of older CT scans. Here we present a detailed comparative study of internal nasal anatomy in *Rooneyia viejaensis* based on new high-resolution CT scans. The holotype of *Rooneyia*, a Duchesnean primate from the Sierra Vieja of West Texas, is a well-preserved cranium that retains intact bony turbinals in the left nasal fossa. We confirm that *Rooneyia* has four anteroposteriorly-compressed bullar-shaped ethmoturbinals (ET). This condition is similar in number to strepsirrhines and similar in shape to galagids and indriids. In contrast, tarsiers have two or three bullar ETs and anthropoids have one or two scrolled or bullar ETs. *Rooneyia* further differs from living tarsiers and anthropoids in lacking mediolateral compression of the ETs. *Rooneyia* preserves a laminar nasoturbinal that is similar in shape and size to the nasoturbinals of cheirogaleid lemurs. All strepsirrhines and many small- to medium-sized platyrrhines have a nasoturbinal, but nasoturbinals are absent in large-bodied platyrrhines and catarrhines. Two frontoturbinals (FT) are present in extant scandentians and dermopterans, while living strepsirrhines only have one. The FT is entirely lost in tarsiers and anthropoids. *Rooneyia* preserves one well developed and one significantly reduced FT, suggesting that the primitive condition for primates may be the presence of two FTs as in living non-primate euarchontans. As in strepsirrhines and most non-primate mammals but in contrast to tarsiers and anthropoids, *Rooneyia* has a transverse lamina forming a relatively long olfactory recess. The retention of numerous plesiomorphic bony olfactory structures suggests that olfactory cues were important in the sensory ecology of *Rooneyia*. It is also clear that *Rooneyia* lacked the derived reduction of nasal cavity complexity shared by living haplorhines, providing further evidence that *Rooneyia* is not a crown haplorhine.

Technical Session XIV (Friday, October 28, 2016, 2:00 PM)

MORPHOMETRIC ANALYSIS OF PELYCOSAUR-GRADE SYNAPSID PECTORAL ELEMENTS REVEALS DECREASED DISPARITY APPROACHING THERAPSIDS

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Pelycosaur-grade synapsids represent the first major radiation of Synapsida. Arising in the Lower Pennsylvanian and persisting through the Early Permian, pelycosaurs were taxonomically diverse and evolutionarily successful. Due to the their status as early-diverging lineages, pelycosaur paleobiology has major implications for subsequent synapsid evolution. However, little work has been done to quantify specific aspects of pelycosaur paleobiology, such as the amount of morphological disparity represented within the postcranial elements of the clade. Morphological disparity, or the variance among forms of anatomical elements within a group, can reveal extrinsic and intrinsic forces argued to be of principle importance to clade evolution. The pelycosaur family Sphenacodontidae is hypothesized to be the sister taxon of Therapsida. Variation within Therapsida appears to be high, but it is unknown whether the characterization of increased variation is present in the closely related or ancestral groups of therapsids.

Here we present the first detailed analysis of shape variance in select pectoral elements of pelycosaur-grade synapsids. The study included material from all pelycosaurs families except Eothyrididae, and measurements were taken of humeri, scapulae, and the proximal end of available ulnae. Shape variance was analyzed with linear measurement-based morphometrics, using variables such as element length, width, and flaring. Geometric morphometric analysis was conducted on the ventral portion of scapulae, the proximal section of ulnae, and both proximal and distal sections of humeri. Clades were analyzed for statistically significant differences in morphology, and disparity was calculated both within and between groups. Results show strong shape similarity between major pelycosaur clades, and variance across the group seems limited. However, our results suggest higher disparity in more basal pelycosaurs, such as Ophiacodontidae and Caseidae, especially compared to the more derived Sphenacodontidae. The lower range of within-group variation observed in Sphenacodontidae is interesting when compared to the recognized disparity within members of Therapsida. Additionally, low morphological disparity in the pectoral elements of higher order pelycosaurs suggests the presence of unique functional constraints and potential specialization in the forelimbs.

Symposium II (Friday, October 28, 2016, 8:45 AM)

PHYLOGENETIC HOMOPLASY AND DEVELOPMENTAL MORPHOGENESIS OF MAMMALIAFORM INNER EAR COCHLEA

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Understanding the transformation of complex novelties is a major quest of evolutionary morphology and paleontology. The mammalian inner ear cochlea, with its sensory organ of Corti and lagenar macula, innervation and osteological structures, and the distinctively coiled morphology, is a complex evolutionary novelty with crucial hearing function and great evolutionary consequences. Evolution of key features of the cochlea is now shown to be homoplastic in Mesozoic mammaliaforms, as the ossified cochlear canal has become well documented in new fossils of diverse clades. Mesozoic mammaliaforms, including extinct clades of crown Mammalia, show that the ancestral cochlea of Mammalia has a simple, uncoiled cochlear canal, with a large cochlear nerve bundle passing into a single cochlear foramen, and with an intra-otic cochlear ganglion that lacked osteological support, all of which are ancestral characteristics of amniote vertebrates. The derived cribriform plate with multiple foramina for divided cochlear nerve fibers to innervate the cochlea evolved separately in extant monotremes, in therians, and in extinct gondwanatherians. The derived Rosenthal's canal, a bony enclosure of the cochlear ganglion, evolved separately in gondwanatherians and in the cladotherian clade (dryolestoids + Theria). The curved cochlear canals evolved several times in stem mammaliaform docodonts, in extant monotremes, and in gondwanatherians, and then in cladotherians. The development of the neural and osteological structures of the cochlea is also better understood by the increasingly precise mapping of the genetic network and ontogenetic morphogenesis by studies of extant mammalian model *Mus*. We argue that the convergent patterns in Mesozoic

mammaliaform fossils are the consequence of the labile chondrogenesis of the otic capsule relative to the cochlear nerve(s) and its cochlear ganglion, which also contributed to the varying degrees of the cochlear canal curvature and coiling among different mammalian clades. Both the evolutionary homoplasy and the labile development of osteological structures are deeply rooted in the complex cascade of genetic networks for cochlear development. However, the homoplastic patterns of the cochleas in Mesozoic mammaliaforms provide the historical evidence of how and where along the phylogenies the conserved morphogenetic mechanisms, although highly canalized in normal development of extant mammals, had occurred in much broader variation in the deep evolutionary history of mammaliaforms.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

MARTES AMERICANA IS SELECTIVE IN FOLLOWING THE RULES: A TEST OF BERGMANN'S AND ALLEN'S RULES

LYNCH, Leigha M., Oklahoma State University Center for Health Sciences, Tulsa, OK, United States of America

Martes americana is widely distributed across North America and is successful in many different climates. Wide geographic spread can often result in morphological variation between populations, including differences consistent with Bergmann's or Allen's rule. I tested for both rules in *M. americana* using skeletal measurements from 22 individuals from Alaska (n = 11), Maine (n = 5), Idaho (n = 2), and New York (n = 4).

Bergmann's rule states that individuals of a species living in colder climates will be larger than individuals found in warmer climates. I tested for Bergmann's rule using a Wilcoxon signed-rank analysis on the skull length, as a proxy for body size, of individuals from two groups: 1) Alaska and 2) Maine, Idaho, and New York. These groups are based on the minimum annual temperature of each region, of which Alaska is about 15°F colder. There was a significant difference in skull length between the two groups ($Z = -2.101$, $p = 0.035$), with Alaskan specimens averaging 5 mm larger ($\delta = 0.478$cm) or about 5% of the skull length. This is consistent with Bergmann's rule.

Allen's rule states that individuals living in colder climates will have proportionally shorter limbs than their warm climate counterparts. Because *M. americana* follows Bergmann's rule, I tested whether skull length and limb length were changing in conjunction using a Pearson's correlation. I measured forelimb length by combining the length of the humerus and ulna and hindlimb length by combining the femur and tibia. Both forelimb ($r = 0.704$, $p = 0.001$) and hind limb ($r = 0.746$, $p = 0.0001$) length had a strong and significant positive correlation to skull length. I then tested if this correlation differed between the previous two groups using a Wilcoxon signed-rank analysis for forelimb/skull length and hind limb/skull length. There was significant difference between groups in the forelimb ($Z = 2.445$, $p = 0.014$, $\delta = 0.122$) and hind limb ($Z = 2.781$, $p = 0.005$, $\delta = 0.104$). However, this difference is a result of individuals in Alaska having proportionally longer limbs than similarly sized individuals in warmer regions. For example, an individual from Alaska with a skull length of 8.74 cm has a forelimb and hind limb length about 1 cm longer than an individual with a similar skull length from Idaho. This is the reverse relationship to that proposed by Allen's rule.

The presence of size and limb proportional differences in populations of *M. americana* suggests it is skeletally adapted to a wide climatic range. Future geometric morphometric studies of *Martes* must take allometric effects of shape into account.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

ANATOMICAL COMPARISON OF THE POSTCRANIAL SKELETON OF THE EXTANT RED PANDA, _AILURUS FULGENS_, TO THE EXTINCT LATE MIOCENE AILURIDS _SIMOCYON BATALLERI_ AND _PRISTINAILURUS BRISTOLI_ (CARNIVORA, AILURIDAE)

LYON, Lauren M., East Tennessee State University, Johnson City, TN, United States of America; WALLACE, Steven C., East Tennessee State Univ, Johnson City, TN, United States of America; SALESA, Manuel J., Faculdade de Ciências da Universidade de Lisboa, Lisbon, Portugal; SILICEO, Gema, Universidad de Alcalá, Madrid, Spain; ANTON, Mauricio, Museo Nacional de Ciencias Naturales-CSIC, Madrid, Spain

Pristinailurus bristoli is only known from the late Hemphillian Gray Fossil Site (Washington County, TN). Since its description in 2004 based on an isolated M1, several specimens have been found, bringing the MNI up to seven. Among the new material are two nearly complete specimens: ETMNH 3596 (~98% complete) and ETMNH 15000 (~75% complete). Though being among the most complete known fossil ailurids, both skeletons have yet to be described in detail. Once a widespread and successful group across the northern hemisphere, ailurids are restricted to a single extant taxon (*Ailurus fulgens*) that inhabits the remote regions of the Himalayas. What adaptations did this family exhibit in the past that allowed it to be so successful compared to today? Postcranial fossils of ailurids are rare, so the new material of *P. bristoli*, considered an Ailurinae along with *A. fulgens*, allows direct morphological comparison to address this question. Hence, we compare both ailurines (*P. bristoli* and *A. fulgens*) to the basal ailurid *Simocyon batalleri* from the late Miocene site of Batallones-1 (Madrid, Spain). By including other extant musteloids, we hope to infer if *P. bristoli* was more terrestrial, yet adapted for explosive climbing, as is predicted for *S. batalleri*; more arboreal, like *A. fulgens*; or some ecomorph as yet to be recognized. Initial observations show that some elements of *P. bristoli* are more similar to those of *S. batalleri* in shape, whereas others resemble *A. fulgens*, suggesting that *P. bristoli* was intermediate in morphology, but in a mosaic fashion.

A notable example is the scapula of *S. batalleri*, which exhibits a large surface along the ventro-caudal edge for the teres major. This surface is caudally penetrated by a triangular-shaped wedge that anchors the subscapularis minor (homologous to the postscapular fossa of ursids and amphicyonids). Though incomplete, both scapulae of *P. bristoli* show these features; however, their size cannot be assessed. Such a structure indicates a strong subscapularis minor and teres major, the latter important for vertical movements during rapid climbing, suggesting relatively stronger shoulder muscles and a locomotor behavior different from *A. fulgens*. All of this suggests that there is no clear-cut ailurine or simocyonine postcranial pattern, and that basal ailurines such as *P. bristoli* shared many postcranial characters with simocyonines.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

KEY INNOVATIONS AND EVOLUTIONARY CONSTRAINTS DURING THE EVOLUTION OF AVIAN FLIGHT

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The evolution of powered flight happened three times independently in vertebrates (bats, pterosaurs, and birds). Among these, avian flight is unique in the inclusion of the tail into the forelimb locomotor module. In birds, the shortened tail is connected to a retroverted pubis through the internal and external pubocaudalis muscles. These muscles contribute to tail movements that stabilize the bird during take-off and help maneuvering during flight. Pubis retroversion was thus a crucial innovation during the evolution of avian flight, but it remains unclear how and why this change in orientation occurred at the first place. Retroverted pubes evolved five times convergently among dinosaurs: four times in Maniraptora and once in Ornithischia. Here, we perform Fisher's and Barnard's exact tests to check for statistically significant correlations with traits that possibly influenced the orientation of the pubis: accessory ventilation system, gait, feeding strategy. These tests showed a strong correlation between anteriorly projecting pubes and the presence of the so-called cuirassal ventilation. This accessory ventilation system is considered a plesiomorphic feature within Dinosauria. Cuirassal ventilation helped inflating the lungs through the expansion of the gastral basket by the ischiotruncus muscle, which connected the gastralia to the anteriorly projecting pubis. The correlation indicates that the presence of cuirassal ventilation has been an evolutionary constraint inhibiting pubic retroversion. Within Maniraptora, the evolution of avian ventilation aided by uncinate processes and powered by the external oblique and the appendicocostalis muscles released this constraint and led to the development of the typical avian bauplan necessary for active flight. The acquisition of the avian accessory ventilation was therefore the evolutionary key innovation that allowed a retroversion of the pubis and finally actively powered flight in birds.

Grant Information
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Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

THE EARLY PERMIAN (CISURALIAN) RICHARDS SPUR LOCALITY, OKLAHOMA, USA, AND THE EARLY EVOLUTION AND DIVERSITY OF PARAREPTILIA.

MACDOUGALL, Mark J., University of Toronto Mississauga, Mississauga, ON, Canada; REISZ, Robert R., University of Toronto Mississauga, Mississauga, ON, Canada

Parareptiles first appear in the fossil record in the Late Carboniferous, and the clade continued to diversify into the Permian, eventually obtaining a cosmopolitan distribution and becoming a common component of Middle and Late Permian terrestrial vertebrate faunas. In contrast to their diversity during the Middle and Late Permian, Early Permian parareptiles were historically rare and exhibited low taxonomic diversity, with eureptiles and synapsids being the more common amniote carnivores and herbivores. As a result of extensive studies of the vertebrate assemblage at the Early Permian (289 ma) Richards Spur locality of Oklahoma, several new parareptile species have been described from the locality since the description of *Colobomycter pholeter*, the first parareptile to be found at the locality. These new discoveries have drastically increased our knowledge of parareptile evolution during the Early Permian. Nearly a century of work at this locality has yielded an exceptionally diverse fauna of terrestrial amniotes. The locality represents a unique upland faunal assemblage in which numerous small to medium sized taxa are exceptionally preserved and in abundance.

Here we discuss the importance of the Richards Spur parareptile fauna and how it grants us previously unavailable knowledge of the Early Permian. Currently, eight of the 15 Early Permian described parareptile species are known from Richards Spur. Furthermore, the species present at Richards Spur represent some of the earliest members of most major Early Permian parareptilian clades, the sole exception being the aquatic, Gondwanan-restricted Mesosauridae. These factors indicate that Richards Spur was clearly an important locality for understanding early evolution and diversification of parareptiles. The species-level/taxonomic diversity of Early Permian parareptiles is now coming close to matching that of contemporaneous eureptiles, which is not surprising, given their relationship as sister taxa. The Richards Spur assemblage provides a rare glimpse into the initial diversification of Parareptilia and highlights the importance of this region of Laurasia as the potential center for the radiation of small, predatory parareptiles, as exemplified by the lanthanosuchoids.

Technical Session I (Wednesday, October 26, 2016, 10:30 AM)

HORSES IN THE CLOUD: BIG DATA EXPLORATION, MINING, AND INTEGRATION FOR _EQUUS_ (MAMMALIA, EQUIDAE)

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Large cloud-based specimen and related natural history databases are becoming more important to analyze biodiversity distributions. Here we report the results of a meta-research study using *Equus*. Extinct species of *Equus* are widely distributed and have an abundant fossil record. Likewise, extant species of the genus *Equus* have a widespread distribution today on all continents except Antarctica. In order to test the efficacy of six relevant big databases for (paleo)biogeographic analyses, location data records (latitude, longitude) for the genus *Equus* were explored and mined from iDigBio, the Paleobiology Database, VertNet, BISON, Neotoma, and GBIF. These were chosen from prior knowledge of where relevant data might be aggregated, and also because these databases have different objectives and data sources and, therefore, would provide a useful comparative study of a widespread taxon. Although they vary based on their objectives, each of the six big databases contain paleontological location data, whereas five contain modern location data as well.

The mining of data records for *Equus* from these six sources yielded 105 thousand location records, ranging from 32.3 thousand (GBIF) to 0.2 thousand (Neotoma). These data include individual points that are unique, in other words, only occurring in one of

these databases, as well as those that are duplicated in multiple databases. When the data were downloaded as csv files and then plotted, at least one of the databases produced spurious location records resulting from transpositions that did not occur in the correct latitude and longitude fields. Data screening and quality control are, therefore, essential before downloaded results are accepted. While some tools developed for neontological data may help, extra effort may be needed for paleontological spatiotaxonomic data quality assessment. Furthermore, some of the databases are biased towards North American location records. Perhaps due to their more global coverage, GBIF and PBDB provide the least geographically biased distribution data for the genus *Equus* in space and time. GBIF contains or duplicates more than 99% of all location records of *Equus* mined from other databases used here. While this result satisfies our original research objective for *Equus*, queries for other taxa that have both fossil and modern distributions might yield different results with regard to which big databases are optimal for these kinds of analyses.

Grant Information
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Technical Session IX (Thursday, October 27, 2016, 4:00 PM)

A DOUBLING OF EYE SIZE AND MASSIVE INCREASE IN VISUAL RANGE ENABLED COMPLEX VISUALLY-GUIDED BEHAVIORS IN EARLY DIGITED TETRAPODS

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Evolutionary transitions between aquatic and terrestrial habitats pose one of the most physically challenging events in the history of life. Vision in water and in air is fundamentally different, yet the evolutionary and ecological consequences of this for the emergence of tetrapods have seen little exploration. Through measurements of fossilized eye sockets in early tetrapods (N = 50 taxa), and computational modeling of their aquatic and terrestrial visual ecology, we show that the visual range of the first land vertebrates is likely to have increased by at least 100 times over their aquatic ancestors. This dramatic change was initiated by a dorsalization of orbits in aquatic tetrapods and fully unfolded with increased terrestrial activity, primarily due to the higher transparency of air over water. However, an additional increment in range occurred through a doubling of eye size. Modeling of trait evolution with time-calibrated phylogenies and reversible-jump Bayesian methods suggests that the observed pattern is best explained by a double-peak Ornstein-Uhlenbeck process, with a selective regime shift favoring large eyes occurring near the origin of digited tetrapods. This is a surprising development given the great increase in range that occurred simply from moving from water to air, and the metabolic costliness of eyes. We therefore suggest that the doubling of eye size is likely due to selection for higher acuity rather than an increase in visual range, but we cannot rule out that the eye size increase was driven by the benefits of higher light sensitivity to support a crepuscular or nocturnal lifestyle. Enhanced visual acuity and range provide several fitness benefits and can afford ethological complexity. We have shown in other work that the proportion of an animal's reaction time to the time to collision to an ethologically relevant stimulus is an important determinant of the complexity of the resulting behavior. When the proportion is near unity, ie., time to collision is similar to the reaction time (for example, when a predator is sensed only a few body lengths ahead due to turbid water), then only stereotyped rapid responses are possible. When reaction time is a small proportion of the time to collision, such as during gradual approaches from a distance, response variability increases. We propose that the great increase in range and acuity that aerial vision generated in the digited tetrapods afforded the evolution of more complex visually-guided behavior, since the time to collision to behaviorally relevant targets underwent a large increase.

Grant Information
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Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

BIOSTRATIGRAPHY OF THE HIGH-ELEVATION DRY UNION FORMATION (MIOCENE–PLIOCENE) OF SOUTH CENTRAL COLORADO

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The Dry Union Formation (Fm) crops out along the western margins of the Arkansas River valley in south central Colorado, though small outcrops are also present east of the Arkansas River. The unit is largely comprised of upward fining packages of friable, unstratified glacial till, capped by course sandstone or pebble-cobble conglomerate interbedded with thin lenses of ash. Though it represents a unique high-elevation (~7,000 ft) setting of mixed Miocene and Pliocene sediments, the Dry Union Fm has never been formally characterized and is currently under study by the U.S. Geological Survey (USGS). Geological mapping in the 1950–1960s, and subsequent surface collections of fossils, has recovered a variety of large and small vertebrate fossils thought to indicate a Miocene–Pliocene age (23.8–2.3 Ma). To date, recovered specimens represent a wide variety of artiodactyls (two species of camelid, two species of paleomerycid, a peccary), perrisodactyls (three species of horses, one rhinoceros), lagomorphs, gomphothere, and five species of rodents including three mylagaulids. Many of the taxa found in the Dry Union lend themselves to determining a more accurate relative age for the formation utilizing North American Land Mammal (NALMA) framework. In 2015, Denver Museum of Nature & Science (DMNS) paleontology crews began exploratory paleontological field work in the Arkansas River valley. Specimens recovered by DMNS, combined with an evaluation of historic USGS specimens, suggest the Dry Union Fm is more likely Barstovian (15.6–13.4 Ma) or Clarendonian (13.4–9 Ma) NALMA, with the possibility that some outcrops may be early Hemphillian (Hh1–Hh3). Though gomphotheres and *Prosthennops* (peccary) make their first appearance in Colorado by 14.4 Ma and are both found in the fauna of Dry Union Fm, it is the mylagaulids that lend themselves to a better estimate of age. The mylagaulids *Ceratogaulus* cf. *rhinoceros* and *Pterogaulus* preliminarily indicate a Barstovian age for the Dry Union Fm. Here, we describe the biostratigraphy of over two dozen historic USGS fossil localities and new DMNS localities and suggest a Barstovian–Clarendonian NALMA age for the Dry Union FM.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

SIZE AND SHAPE STASIS IN RANCHO LA BREA BARN OWLS OVER THE LAST GLACIAL-INTERGLACIAL CYCLE

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Conventional evolutionary biology highlights examples like the Galapagos finches, which show rapid responses to climatic change. We studied the sample of Barn Owls (*Tyto alba*) from Rancho La Brea to determine if they showed size or shape changes in response to the climate changes of the last 37,000 years. Even though living Barn Owls exhibit a weak Bergmann's rule effect, with larger body sizes in colder climates, the Rancho La Brea owls showed complete stasis over this interval, with almost no statistically significant changes in size or robustness even during the peak glacial interval at 18,000-20,000 years ago, when the climate at Rancho La Brea was dominated by coniferous forests and snowy winters. These results are consistent with earlier studies on La Brea Condors, Golden Eagles, Bald Eagles, Turkeys, Great Horned Owls, and Caracaras. Apparently, many birds do not respond to long-term changes in climate in a simple fashion, but are ecologically flexible and live in a wide range of habitats and climates without change in size or limb robustness.

Technical Session XX (Saturday, October 29, 2016, 1:45 PM)

AN EXQUISITELY PRESERVED, NEW EUCACOPINE DISSOROPHID (TEMNOSPONDYLI) FROM THE CARBONIFEROUS OF NOVA SCOTIA, CANADA

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The fossil record from the Carboniferous deposits of Nova Scotia, Canada, has produced key insights into the early evolution of each of the major tetrapod lineages (amphibians, synapsids, and reptiles). Despite this, fossil material is rare, and often highly fragmentary.

Here we report on a recently discovered, exquisitely preserved skull and articulated, partial post-cranial skeleton recovered from the cliffs along the shores of Nova Scotia, Canada, near the town of Brule. The specimen was found within the Malagash Formation, Cumberland Group, of Late Carboniferous (Late Westphalian C–D) age. The specimen bears obvious affinities to dissorophid temnospondyls through the presence of such traits as a box-like postorbital region of skull and large posterior temporal embayment, large interpterygoid vacuities on the palate, and dorsal armor.

This new taxon, described here for the first time, is distinctive in several regards, including a very high marginal tooth count (40+ in the maxilla in contrast to typical range of 18–30), absence of anterior internarial fontanelle, hyper-elongate neural spines in the dorsal region of the vertebral column, and relatively small dorsal armor that drapes over the distal tips of the neural spines. Phylogenetic analysis places the new specimen within eocacopine dissorophids, as the sister taxon to the clade containing *Cacops*, *Kamacops*, and *Zygosaurus*. The preserved dorsal armour is highly unusual in its somewhat delicate, drape-like appearance covering the tips of the neural spines. Interestingly, the preserved hyper-elongated neural spines show evidence of fusion between adjacent spines. The ribs are also unusually broad, significantly broader than in *Cacops,* with large overlapping flanges. The fusion of the spines, the drape-like dorsal armor, and the broad ribs would have certainly reduced or largely eliminated axial mobility, but is matched by elongated propodials, adding a fascinating perspective to the functional interpretations of locomotory mechanics in dissorophids.

The occurrence of the new species in the Late Carboniferous pushes the divergence of Eucacopinae from Dissorophinae well into the Carboniferous, and increases the known diversity of Carboniferous tetrapod assemblages at a time when amniotes started to show significant increase in diversity. Finally, as one of the largest known tetrapods from the Carboniferous of Canada, this eucacopine provides new insights into early terrestrial vertebrate ecosystem composition and evolution.

Grant Information
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Poster Symposium II (Friday–Saturday, October 28–29, 2016, 4:30 PM)

A CHRONOSTRATIGRAPHIC FRAMEWORK FOR THE MORRISON FORMATION, AND THE LATITUDINAL BIODIVERSITY GRADIENT IN MORRISON DINOSAURS

MAIDMENT, Susannah C., Imperial College London, London, United Kingdom; MUXWORTHY, Adrian, Imperial College London, London, United Kingdom

The Morrison Formation is an ideal candidate for examining biodiversity distributions and population ecology at a time in Earth's history when climatic conditions were significantly different to today. It crops out over 12 degrees of latitude, from Montana in the north to New Mexico in the south, making it possible to examine latitudinal biodiversity gradients at a time when temperature gradients between the equator and poles were significantly reduced. The Formation was deposited over about 10 million years, making it possible to examine high-resolution changes in alpha and beta diversity through time in terrestrial vertebrate communities. The intensive study of the formation since the discovery of the Morrison's diverse and well-preserved dinosaurian fauna in the latter part of the 19th century has generated a very large body of data that should allow diversity studies to be possible. However, attempts to use the Morrison for such studies are hampered by a lack of long-range correlation: the chronostratigraphy of the Formation is entirely unknown. Sedimentological logging and magnetostratigraphic sampling were carried out at 19 sites in order to use terrestrial sequence stratigraphy and magnetostratigraphy to produce a chronostratigraphic framework for the Formation.

Terrestrial sequence stratigraphic approaches were used to divide the Formation into three sequences, comprising six systems tracts. Magnetostratigraphic results were generally unsatisfactory due to magnetically weak samples with low intensities, the alteration of magnetic phases on heating, and poor sample coverage as a result of friable mudstones and unconsolidated sandstones. However, where magnetostratigraphic data has been recovered, it appears to support the chronostratigraphic framework based on sequence stratigraphy. Sample-standardized dinosaur biodiversity within systems tracts indicates that biodiversity did not increase with decreasing latitude, in contrast to the pattern seen across the area today. This finding suggests that latitudinal temperature gradients may be a principal driver of today's latitudinal biodiversity gradient, and significantly reduced latitudinal temperature gradients in the Upper Jurassic resulted in significantly different biodiversity distributions at that time.

Grant Information
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Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

BATHYMETRIC CONTROLS ON TAPHONOMIC REWORKING AND BIOEROSION OF CHONDRICHTHYAN TEETH: A COMPARATIVE STUDY FROM THE PUNGO RIVER AND YORKTOWN FORMATIONS, ONSLOW BAY, NORTH CAROLINA

MAISCH IV, Harry M., City University of New York Graduate Center, New York, NY, United States of America; BECKER, Martin A., William Paterson University, Wayne, NJ, United States of America; CHAMBERLAIN JR, John A., Brooklyn College, Brooklyn, NY, United States of America

The continental shelf of southwestern Onslow Bay, North Carolina, preserves submarine hardbottom outcrops belonging to the Miocene and Pliocene Pungo River and Yorktown Formations. Post-Pliocene sea level fluctuation and paleochanneling of the ancestral Cape Fear River have subsequently reworked and concentrated chondrichthyan teeth from these two formations into unconsolidated, gravel lag deposits that are exposed at two separate submarine localities. The two separate localities occur along a northeast-southwest trend of the submerged shelf and ancestral Cape Fear River valley and are approximately 32 Km (30 m deep) and 64 Km (35 m deep) from the present day shoreline. At the shallower shelf locality, Miocene chondrichthyan teeth belonging to *Carcharocles chubutensis*; *Isurus oxyrinchus*; *Hemipristis serra,* and *Physogaleus contortus* occur with Pliocene chondrichthyan teeth belonging to *Carcharocles megalodon*; *Parotodus benedini*; *Isurus hastalis*; *Carcharodon carcharias; Hemispristis serra,* and *Galeocerdo cuvier*. The deeper shelf locality contains only the Pliocene chondrichthyan assemblage. Additionally, chondrichthyan teeth from the shallower shelf locality display a greater degree of reworking, phosphatization, and bioerosion compared with those recovered from the deeper shelf locality. In particular, Pliocene chondrichthyan teeth from the shallower shelf locality contain extensive borings of the ichnospecies *Gastrochaenolites torpedo* attributed to the endolithic behavior of *Lithophaga* sp. Comparative taphonomy between these two distinct chondrichthyan tooth assemblages provides a unique opportunity to assess the dynamic interaction between sea level cyclicity, bathymetry and fluvial processes on recent lag deposit formation along the submerged southern North Carolina continental shelf.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

NEW SPECIMEN OF ALLOSAUROIDEA (DINOSAURIA, TETANURAE) FROM THE UPPER JURASSIC OF PORTUGAL

MALAFAIA, Elisabete, Instituto Dom Luiz, Faculdade de Ciências, Universidade de Lisboa / Sociedade de História Natural, Torres Vedras, Portugal; ORTEGA, Francisco, Grupo de Biología Evolutiva, Facultad de Ciencias, UNED, Madrid, Spain / Sociedade História Natural, Torres Vedras, Portugal; MOCHO, Pedro, Grupo de Biología Evolutiva, Facultad de Ciencias, UNED, Madrid, Spain / Sociedade História Natural, Torres Vedras, Portugal; ESCASO, Fernando, Grupo de Biología Evolutiva, Facultad de Ciencias, UNED, Madrid, Spain / Sociedade História Natural, Torres Vedras, Portugal

The Lusitanian Basin (Central-West Portugal) has yielded a diverse theropod fauna from the Late Jurassic that is composed by ceratosaurs, megalosaurids, allosauroids, tyrannosauroids, compsognathids, dromaeosaurids and troodontids.

A new small-sized juvenile allosauroid specimen (SHN.036) from the Praia da Amoreira-Porto Novo Formation (upper Kimmerdigian) at Praia de Valmitão is described. The new specimen preserves cervical, dorsal and caudal vertebrae, ribs, an almost complete right ilium, and both pubes and ischia. Most preserved cervical, dorsal and anterior caudal vertebrae bear open or partially fused neurocentral sutures. The neurocentral suture closure pattern in this specimen begins from both the most posterior caudal vertebrae and the most anterior cervical vertebrae.

A phylogenetic analysis recovered the new specimen as a basal Allosauroidea based on the strong constriction of the posterior dorsal centra, rounded morphology of the ischial peduncle of the ilium, presence of a fossa cuppedicus on the ilium, and the ischium length more than 80% the pubis length. The new specimen shows a combination of shared characters with the other two allosauroids known in the Portuguese Upper Jurassic record, *Allosaurus* and *Lourinhanosaurus*, but some differences can also be recognized.

SHN.036 can be distinguished from those taxa by the position of the parapophysis in the ventral surface of the axis, the absence of a ventral keel on anterior dorsal vertebrae, the presence of a pair of large recesses in the neural arch of anterior dorsal vertebrae, the presence of hyposphene-hypantrum articulation in anterior caudal vertebrae, spinoprezygapophyseal lamina projecting from the medial surface of the prezygapophyseal process, presence of well-developed lateral crests adjacent to the dorsal margin of the anterior articular facets in middle caudal vertebrae, and presence of an almost continuous additional lateral lamina – lateral spinopostzygapophyseal lamina in the middle and posterior caudal vertebrae. This combination of features might justify the description of a new theropod taxon for the Portuguese Late Jurassic. Nevertheless, the presence of three sympatric and almost synchronic closely related basal allosauroids requires further discussion on their intra- or interspecific variability.

Grant Information
This work was supported by SFRH/BD/84746/2012 PhD scholarship, financed by the "Fundação para a Ciência e Tecnologia" (Portugal).

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

A NEW PARTIAL SKELETON OF *LEPTOCERATOPS GRACILIS* FROM THE LANCE FORMATION OF WYOMING, U.S.A.

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Leptoceratops is a primitive ceratopsian dinosaur known only from the latest Cretaceous units of Montana, Wyoming, and Alberta, Canada. This genus includes only one species, *L. gracilis*, and is characterized by its small stature, diminutive frill, and lack of horns. *Leptoceratops* remains rare, as only eight confirmed specimens are currently reported, three of which lack postcranial material.

Here we describe NJSM 24228, a new partial skeleton of *L. gracilis* discovered within the Lance Formation in the northern Bighorn Basin in Park County, Wyoming. All recovered elements were closely associated and include facial and cranial material, the occipital condyle with a basipterygoid process, a partial predentary, fragmented rostrum, and costal elements. Additionally, a humerus, radius, and partially articulated manual and pedal elements are particularly complete and well-preserved. The specimen is identified as *L. gracilis* based on a diagnostic series of teeth with unbifurcated roots, as well as a deep, truncated rostrum and elongate predentary.

These well-preserved remains provide an important opportunity for insight into this rare neoceratopsian. In addition to helping us answer crucial questions regarding the anatomy and phylogenetic position of *L. gracilis* within the Ceratopsidae, NJSM 24228 has much more to tell us about the paleogeography and paleoecology of the genus. This is only the second specimen of *L. gracilis* reported from the Lance Formation and the first to be recovered from silty shale matrix indicative of overbank deposits.

Preparator's Session (Thursday, October 27, 2016, 10:15 AM)

"LIBERATION FROM THE BONE CELLAR"—LOW TECH, HIGH QUALITY—HOW TO CHEAPLY 3D DIGITIZE A COLLECTION OF VERTEBRATE MACROFOSSILS

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The Museum für Naturkunde Berlin's Bone Cellar holds a vast collection of fossils from the German Tendaguru Expedition. In our project "Liberation from the Bone Cellar—online access to the Tendaguru dinosaurs of the Museum für Naturkunde" we used photogrammetry to 3D digitize all longbones, all girdle elements, some vertebrae and some manus and pes bones, ranging in size from several centimeters to 2+ meters, at high accuracy (< 0.5% error compared to total bone size) and high resolution (better than 0.1 mm). The workflows we developed are applicable not only to dinosaur bone collections, but also to all other kinds of skeletal remains, and even on non-vertebrate specimens in the same size range.

Data capture was performed in the Bone Cellar with equipment costing less than $2000. The data capture time per specimen on average was three to eight minutes for photography, and two to six minutes for other tasks, e.g., moving the bones and placing scale bars. Model creation was immediately successful in more than 80% of cases. Manual addition of masks on the images and other post-capture improvements resulted in half of the remaining models giving good results, for a total success rate of over 90%.

For this project we developed a number of workflows that may be of high interest for the paleontological community, as they allow high-resolution data capture at a high success rate and comparatively low cost. These include details of how the specimens were placed on various backgrounds for data capture, how scale bars were used during data capture and model creation, how the specimens were lit, how the camera equipment was handled and how the individual images were best and most speedily acquired. Our methods are versatile and also suited for data capture on research visits. Our project can thus serve as a best-practice guide and as a model for calculating digitizing time and monetary costs, both for in-house digitizing initiatives and research visits.

Grant Information
This project was funded by the Service Center for Digitization Berlin (digiS) of the State of Berlin

Technical Session V (Wednesday, October 26, 2016, 2:15 PM)

TERRESTRIAL VERTEBRATE DIVERSITY IN LATE CRETACEOUS NORTH AMERICA

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The long-term response of terrestrial biodiversity to sea-level change is of growing interest in light of modern conservation concerns. The development of the Late Cretaceous Western Interior Seaway is presumed to have affected North American vertebrate diversity on land, but quantitative support this hypothesis is lacking. We examined the relationship between Late Cretaceous vertebrate diversity and sea-level change using a database of 3,220 fossil occurrences from throughout North America. Species-level rarefaction shows that richness was lowest prior to the incursion of the seaway, highest while the seaway was in place, and dropped slightly in the three to five million years following the final regression. Richness was significantly higher on the subcontinent of Laramidia than on Appalachia. This pattern remains true at higher taxonomic levels (i.e., genus, family, order). Beta diversity (community turnover in the spatial dimension) likewise increased on Laramidia following the incursion of the

seaway, but remained unchanged on Appalachia. Following the final regression of the seaway, beta diversity returned to initial levels, suggesting that environmental changes during transgression of the seaway enabled increased species packing. Our interpretation of patterns of beta diversity must be tempered in light of the fact that between-site similarity is generally correlated with site-level richness. However, a pattern of increasing beta diversity during seaway incursion was robust to an iterative subsampling approach. Overall, there is good evidence to suggest that the development of the Western Interior Seaway strongly influenced the adjacent terrestrial vertebrate assemblages in terms of both richness and beta diversity.

Technical Session XI (Friday, October 28, 2016, 9:30 AM)

FIN END OF THE WEDGE: CONSERVATISM OF THREE DIMENSIONAL STRUCTURE WITH DIVERSITY IN TWO DIMENSIONAL FORM REVEALED IN THE PACHYCORMID APPENDICULAR SKELETON

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Pachycormids occupy a key position within Actinopterygii, as part of the Holostei–Teleostei Transition, although their precise position in this hierarchy has been fought over for some years. The larger the adult size of a pachycormid taxon, the more reduced the amount of its skeleton that ossifies. This reduction in preservation potential for the axial skeleton means that, although known for over a century, large Middle Jurassic through Late Cretaceous pachycormids were primarily represented by incomplete fragmentary and often times disarticulated and distorted remains. Large isolated pectoral and caudal fins were most commonly collected, however little work was done with them besides installing them as striking museum showpieces.

Recent discoveries of new specimens and innovative preparation work have provided new insight into the three dimensional shape and arrangement of the pelvic and pectoral fins in both the tusked and toothless tribes of pachycormids. Pronounced streamer-like elongate pelvic fins are common to both of the ecomorphological extremes of pursuit predator and planktivore represented by these tribes. The unusually long pectoral fins appear to have developed in conjunction with otherwise reduced skeletal ossification to counteract buoyancy problems in a group apparently lacking a gas bladder. Closer analysis also reveals adaptations of a primitive morphology to suit a suite of lifestyles from swift and agile carnivore to slow-cruising suspension feeder. Although a diversity of pectoral fin morphs can be recognised within a group where the pectoral was once simplistically dismissed as 'scythe-like', there is a surprisingly high degree of staticity in fin placement and mechanics that can be observed across both the extremes of these diverse feeding strategies, as well as across 100 million years of geological time. Unsurprisingly, some of the observed pachycormid pectoral fin morphotypes mirror some of the most modern fuel-saving wingtip designs from today's aerodynamicists, converging on similar solutions to these enigmatic and fascinating fish. This new data allows us to apply these inferences to animals that, through a pronounced lack of skeletal ossification, would otherwise remain more mystery than organism.

Technical Session XII (Friday, October 28, 2016, 2:15 PM)

COULD PTEROSAURS ADOPT A BATLIKE WING POSE? IMPLICATIONS OF A FUNCTIONAL ANALYSIS OF THE AVIAN HIP LIGAMENTS FOR THE EVOLUTION OF ORNITHODIRAN STANCE AND GAIT

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Tetrapod stances and gaits largely depend on the motions possible at the coxofemoral (hip) joint. Hip mobility is determined in part by the osteological morphology of the acetabulum and femoral head. However, the joint capsule and its ligaments constrain motion to a smaller range than what seems possible from dry bones alone. The anatomy of the coxofemoral ligaments has been described for several groups, but their function in restricting joint excursion has not been reported for any non-mammalian taxon. As a result, paleontologists have tried to reconstruct the locomotion of extinct ornithodirans (bird-line archosaurs) without accounting for ligamentous constraints in the hips of their extant avian relatives.

We dissected the hip joint capsules of 30 free-range farmed specimens of the domestic chicken (*Gallus gallus*). For each specimen, maximum hip ranges of motion in the sagittal, frontal, and transverse planes were first determined from manipulation of carcasses. All soft tissues other than the hip joint capsule were then resected by hand, and the resultant increase in mobility was measured. The individual ligaments of the capsule were dissected out to determine their contributions to limiting excursion. These values were then compared to ranges of motion obtained from manipulating the femora and pelvic bones alone.

The coxofemoral ligaments restrain the hip joint of the domestic chicken in all three (orthogonal) planes of motion and in the spaces among them. Joints with an intact capsule could only be moved through approximately 63 ± 4% of flexion–extension, 44 ± 6% of adduction–abduction, and 41 ± 5% of long-axis rotation predicted from the skeleton alone. Cutting portions of the capsule to abduct, extend, and rotate the hindlimb into a horizontal plane compromised the stability of the hip and subjected it to possible dislocation.

In the light of archosaur soft tissue homologies, these data suggest that many inferences drawn from dry bones alone have overestimated ranges of hip motion and have proposed stances and gaits for ornithodirans that would have been made implausible or impossible by soft tissues. Specifically, our findings suggest that ligamentous constraints would have prevented batlike incorporation of the pterosaur hindlimb into a uropatagium. These data also have implications for other ornithodirans. For example, they suggest that the "4-wing gliding" model of basal maniraptoran flight (e.g., *Microraptor*) would have been difficult or impossible if it required bringing the hindlimbs into a strictly horizontal plane.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

INVESTIGATING THE DIAGENESIS OF TURTLE SHELL FRAGMENTS USING STABLE ISOTOPE, KAIPAROWITS FORMATION, SOUTHERN UTAH

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The Kaiparowits Formation in southern Utah contains the most complete fossil record of Late Cretaceous age, including elevated biodiversity and various endemic taxa. Understanding the paleoclimate helps deciphering paleoecology of such unique fauna. Stable isotope composition of fossils can be used for paleoclimatic and paleoecologic investigation; however, assessing the effect of the diagenetic alteration is necessary. Turtles are common in the fossil record of the Western Interior Basin of Cretaceous North America, hence turtle shell fragments are potentially useful as paleoclimatic and paleoecologic proxy. The goal of this study is to understand the effect of carbonate cementation on carbonate isotopic composition of turtle shell fragments. Typical analysis of turtle shell is via O-isotopic composition of the PO_4 component of turtle shell. However, few have analyzed the CO_3 component of turtle shell. The C and O-isotopic composition of turtle shell may reveal different habitats among the different turtle taxa in the Kaiparowits and may help explain differences in the calculated $\delta^{18}O_w$ from the $\delta^{18}O_p$ composition of turtles from different localities/species. By analyzing both the CO_3 and PO_4 component of turtle shell we can also address the diagenetic nature of the shell.

Fossil samples and UTM coordinates of fossil localities were provided by the Utah Natural History Museum, and rock samples were collected from fossil localities. Petrographic analyses were conducted to observe permineralization and mineralogy of the turtle shell apatite. Fossil and rock samples were analyzed using isotopic ratio mass spectrometer attached to Gas Bench II at the University of Arkansas Stable Isotope Laboratory.

Petrographic analyses indicate (1) histology is well preserved in fossilized turtle shells, and (2) pores in turtle shells are filled with sparry calcite. Preliminary isotope analyses indicate there is no correlation between isotopic compositions of turtle shell fragments and sandstone host rock (R^2=0.053 for $\delta^{13}C$ and R^2=0.047 for $\delta^{18}O$). Although the $\delta^{13}C$ and $\delta^{18}O$ values differ by 7.57‰ and 1.76‰ respectively, potential correlation was observed between isotopic compositions of turtle shell fragments and mudrock host rock (R^2=0.425 for $\delta^{13}C$ and R^2=0.642 for $\delta^{18}O$). Such result may indicate that isotopic compositions of turtle shell bone carbonate are at least partially altered through diagenesis. The relationship between host rock cement and turtle shell bone carbonate will be further investigated employing trace element analyses.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

A RE-DESCRIPTION OF *AMPHIBAMUS GRANDICEPS* (TEMNOSPONDYLI, DISSOROPHOIDEA) FROM THE FRANCIS CREEK SHALE, MAZON CREEK, ILLINOIS

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The Carboniferous temnospondyl *Amphibamus grandiceps* is one of the oldest known members of Amphibamidae, occurring in the Middle Pennsylvanian aged (309 Ma) Mazon Creek deposits in Grundy County, Illinois, USA. *Amphibamus* was once considered a pivotal taxon in the debate over the origins of modern amphibians. Several features, including the presence of small pedicellate bicuspid teeth, an abbreviated skull table, reduced ribs, a pectoral girdle incorporating a small interclavicle and bar like clavicles, link *Amphibamus* to modern amphibians. Taxonomic revision of *Amphibamus* in light of recent advances has been hindered by the loss of the original type specimen in a fire, and a lack of subsequent descriptive papers on significant specimens, including the near complete neotype YPM 794. In addition, other specimens from Mazon Creek have since been reassigned to *Amphibamus*, including specimens pertaining to *Micrerpeton caudatum*, *Miobatrachus romeri*, *Mazonerpeton longicaudatum*, and various larval specimens. Many of these specimens vary in their morphology and their ontogenetic stages have not been assessed. Additionally, anatomical features of *Amphibamus* including the shape of the skull and cranial elements, morphology of the terminal phalanges, length of the limbs, and number of caudal vertebrae remain unclear. Here we re-describe the neotype of *Amphibamus* and include a discussion of new anatomical and ontogenetic data from this and several reassigned specimens. A phylogenetic analysis including YPM 794 was performed for the first time where a heuristic search recovered a strict consensus tree yielding YPM 794 as the sister taxon to *Amphibamus*, thus supporting its assignment to the taxon. The specimens are united by the presence of two shared character states: an interorbital width/skull length that is broad with values markedly beyond 0.3 and ventral belly osteoderms/scutes that are spindle shaped. Further observation of the ventral scutes of YPM 794 reveals several undescribed features, including strong ornamentation and concentric rings. Additional analysis of amphibamid integumentary structures may provide valuable new taxonomically informative characters.

Technical Session XVI (Saturday, October 29, 2016, 9:00 AM)

THE PALEOECOLOGY OF THE PLIOCENE SITE OF KANAPOI, NORTHWESTERN KENYA

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Australopithecus anamensis is widely considered the earliest member of the clade containing *Australopithecus* and humans, and the locality of Kanapoi, Kenya, dated to 4.195–4.108 Ma, is one of the oldest australopith sites. Although fossils of *A. anamensis* have been found at Allia Bay in the Turkana Basin (Kenya), and at Galili, Fejej and Asa Issie in the Afar Depression (Ethiopia), the largest sample comes from Kanapoi, where *Australopithecus* was more abundant (over 8% of the fauna) than at other localities. *Australopithecus anamensis* appears to have been the first committed terrestrial hominin biped. It shows incipient adaptations for processing a tougher diet than earlier hominins, even though a substantial dietary shift to incorporate more C_4 foods, an elaboration of

masticatory robusticity, and related traits occurred only later in hominin evolution. Important research on the paleoecology of Kanapoi has been published, but until recently, key aspects of the ecology of Pliocene Kanapoi have remained poorly understood.

Fieldwork conducted by the West Turkana Paleo Project from 2003–2015 provides new information on the ecology and biology of Kanapoi, with a wide range of faunal data and other paleoenvironmental indicators. Isotopic data from fossil-bearing paleosols reveals a largely arid habitat with variable water sources. Previously published isotopic data indicates a primarily C_3 diet for *A. anamensis*, unlike the more generalized C_3-C_4 range characterizing later hominin taxa, but show that other taxa (bovidae, suidae, rodentia, cercopithecidae) may not all have followed a similar trend. Microwear analyses of bovid teeth indicate the prevalence of generalists; and additional microwear analyses indicate that nonhuman primates have similar microwear to the hominins, and that rodents are consistent with a grassland habitat. Species diversity and abundance of numerous taxa including birds, rodents and squamates support the presence of slow moving water sources in a mixed but open and arid environment. Data from 40 systematic paleontological surveys reveals that frequency of fossils preserved is consistent with relatively arid habitats near water sources. Overall, analyses of the fauna and other paleoecological indicators suggest that Kanapoi was relatively drier and more open than other sites in the Omo-Turkana Basin during the Pliocene. These results provide important new evidence for our understanding of the environments of the earliest *Australopithecus*.

Grant Information
Research supported by the National Science Foundation (BCS 1231749), Wenner Gren Foundation, and the University of Missouri Research Board.

Technical Session XIX (Saturday, October 29, 2016, 2:45 PM)

TOOTH ENAMEL MICROSTRUCTURES OF THREE JURASSIC EUHARAMIYIDANS AND IMPLICATIONS FOR PRISM EVOLUTION IN ALLOTHERIAN MAMMALS

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Here we report incisor enamel microstructures of three euharamyidans, *Shenshou lui*, *Xianshou linglong*, and *X. songae*, from the early Late Jurassic Yanliao Biota, Liaoning Province, China. The tooth enamel of the three species is prismless and consists of primarily irregular polygonal columnar units that are delimited by major convergent discontinuities. There is no distinct line or plane along the divergent axis within the unit. Of the three species, the enamel of *S. lui* is most primitive in having columnar enamel units that are perpendicular to the enamel dentine junction (EDJ). The enamel structures of *Xianshou* appear more derived than that of *S. lui* in having more irregular and complex crystallite units. In particular, the columnar units of *Xianshou* rise apically with an angle to the EDJ and some crystallites between two units are differentiated to form clusters that assemble incipient prisms with poorly defined seams and sheaths. This enamel type of *Xianshou* may represent a transitional stage between the prismless enamel and prismatic enamel. Mapping known enamel types from selected members of early mammaliaforms on a simplified phylogeny with focus on allotherians, we think that the columnar enamel present in *Thomasia*, *Shenshou* and some 'plagiaulacoid' multituberculates probably represents the plesiomorphic condition of allotherian enamel from which evolved the transitional enamel (as represented by *Xianshou* and the plagiaulacoid *Paulchoffatia*), the plesiomorphic prismatic enamel (in some post-plagiaulacoid multituberculates and gondwanatherians), and finally, and independently, the true prismatic enamel (in advanced multituberculates and gondwanatherians). Despite that the tooth enamels from the three euharamiyidan species revealed additional morphologies of the initial stage in prism evolution of allotherians, what the amelogenesis mechanism for development of incipient prisms and how the transitional enamel evolved into the prismatic enamel of mammaliaforms remain unclear.

Grant Information
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Technical Session I (Wednesday, October 26, 2016, 11:15 AM)

RATES AND PATTERNS OF LIMB EVOLUTION OF NORTH AMERICAN EQUIDAE

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The pattern of environmental change throughout the Cenozoic is characterized by a trend toward increasing ecological dominance of open habitats (e.g., grasslands) at the expense of closed habitats (e.g., forests). Numerous lines of evidence constrain the spatial and temporal pattern of this transition. Traditionally, the radiation of hypsodont horses in North America has been assumed to signal the spread of open, grass-dominated environments. However, grass phytoliths show a rise in the numerical abundance of open-habitat grasses at least 4 Myr earlier. A possible reason for this discrepancy is that dental evolution was slow to respond to the spread of grass-dominated environments. Limb evolution might show a more immediate response to the spread of open environments. Many studies of extant taxa demonstrate a link between morphology of the limb skeleton and habitat, which are corroborated by biomechanical studies of locomotion. Studies of fossil taxa have leveraged these relationships to establish patterns of limb evolution within clades of mammals in the context of Cenozoic environmental changes.

In this study, we analyze the evolution of the limbs in the family Equidae. We use both linear measurements and geometric morphometrics to quantify the morphology of six limb elements. We use a dated estimate of North American equid phylogeny to estimate rates between 55 and 5 Ma, spanning most of horse evolution in North America. Our results show a generally low rate of evolution between 35 and 25 Ma, followed by a rapid increase in evolutionary rate that persists across the Oligocene/Miocene boundary. This rapid increase is coincident with estimates of grassland expansion based on phytoliths and precedes the radiation of hypsodont horses. These results also corroborate previous studies of ungulate limb evolution and suggest that limb evolution might be more sensitive to environmental change than dental evolution.

Grant Information
NSF EAR 12-52123

Technical Session VIII (Thursday, October 27, 2016, 4:00 PM)

GETTING A HEAD IN HARD SOIL: CONVERGENT AND DIVERGENT CRANIAL ALLOMETRIC TRAJECTORIES REFLECT MOSAIC EVOLUTION IN THE HIGHLY MORPHOLOGICALLY DIVERSE RODENT GENUS *THOMOMYS*

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Allometry measures the change in shape as body size varies. The way shape changes with size can reflect developmental, adaptive, and phylogenetic impacts. High morphological diversity may occur when selection favors shapes with functional or developmental trade-offs. For example, in the highly fossorial rodent genus *Thomomys*, larger body sizes facilitate development of the procumbent (increased incisor angle) tooth-digging adaptation while also increasing the necessary tunnel diameter, an energetic cost. Using geometric morphometrics on two views of 415 crania with geo-referenced soil data, we show that for all three major *Thomomys* phylogenetic groups, the cranial morphospace corresponds with ecological differences, at times convergently: species with more procumbent incisors and robust skulls inhabiting harder soils separate from gracile species with acutely-angled incisors inhabiting softer soil. Furthermore, these morphological changes are not due to simple allometry across various body sizes. Indeed, Procrustes D-ANOVA post-hoc tests suggest the variation in allometric slopes relate to different underlying developmental patterns: 1) increased maturation, 2) retained juvenile characters, and 3) a combination of both, with the ventral cranial view showing more lability than the lateral. Craniodental re-positioning of the incisor root—a shape change independent of size variation—appears to increase the y-intercept of the lateral cranial allometric trajectories. Meanwhile, the largest taxa as well as the most procumbent taxa show a decreased allometric slope, suggesting a more complicated developmental process than the previously hypothesized mechanism of hypermorphosis (a constant slope across all body sizes) alone. At the level of regional subpopulations, cranial allometry also differed, including dramatic trajectory divergence in the two smallest subspecies of *Thomomys*. Thus, the genus *Thomomys* illustrates classic mosaic evolution, in other words, evolutionary change taking place in some body parts without simultaneous changes in other parts with different trajectories both within and between species. Overall, our findings reinforce previous work suggesting niche conservation at the genus level by demonstrating the high morphological flexibility likely to underlie patterns of stable ecological ranges through time. This supports the idea that limited conservation resource use on genera rather than species—at least for placental mammals—may better protect present biodiversity.

Grant Information
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Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

SUDDENLY CUTE! FINALLY, A GAME TO ENGAGE STUDENTS IN THE MODERN UNDERSTANDING OF EVOLUTIONARY DEVELOPMENT

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Science standards around the world now require students as young as 10 to understand how scientists use embryonic development as one line of evidence to infer evolutionary relationships. For example, Australia's Science Standard, ACSSU165, and the United States's Next Generation Science Standards, MS-LS4-3 and HS-LS4-1, use this language. To meet this need, I have created a card game called Suddenly Cute that communicates a modern understanding of evolutionary development accessible to kids aged 10 and up.

Suddenly Cute elaborates on the familiar rules from the game of SPOONS while the art leverages both the delightfully disgusting appearance of embryos and the broad appeal of baby animals. In Suddenly Cute, players must develop a baby animal from an ancestral vertebrate embryo by applying growth cards to different traits while also sabotaging the progress of other players. The first player to successfully develop a baby animal, wins. To play strategically, players must: (1) constantly compare their developing "hopeful monster" to the possible baby animals they have drawn and decide which is facilitated by the growth cards in their hand and; (2) assess their opponents' progress and avoid giving them helpful cards. The game teaches a fundamental evolutionary development insight: tiny tweaks in the genes that control growth create significant evolutionary changes. Playing the game organically engages players in comparing and contrasting vertebrate embryos using accurate information and visuals while avoiding teleology.

Currently, the vast majority of free online resources on evolutionary development rely on the beautifully rendered yet inaccurate depictions created by Ernst Haeckel in 1892. Suddenly Cute thus provides a more current and apolitical resource for teachers to better meet these standards. I will make this card game available for free online, along with standards alignment documentation, for science educators worldwide.

Technical Session XX (Saturday, October 29, 2016, 3:00 PM)

TEMNOSPONDYLS, LISSAMPHIBIANS, AND MIDDLE EARS

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The origin of the amphibian crown-group is most often sought among the temnospondyls. One character complex that is particularly often pointed to as evidence for such a relationship is the tympanic ear found in frogs, for which osteological

correlates have been proposed in many temnospondyls, particularly the amphibamid *Doleserpeton*.

A stapes in a tympanic ear is expected to be small and light; often just the base is ossified, while the long, thin tympanic process—much thinner than the paroccipital process or the basal plate of the parasphenoid—remains mostly cartilaginous. The distal end of this process is expected to lie in or close to the center of the tympanum for maximal response to its vibrations. The footplate either forms a hinge with the rim of the fenestra ovalis (as in frogs and crown-group diapsids) or acts as a piston within the fenestra (as in eucynodonts, including mammals).

Given these criteria, most temnospondyls did not have a tympanum, and the best candidate for having one is not *Doleserpeton*, but the dissorophid ?*Broiliellus reiszi*. Except in the latter, temnospondyl stapedes are remarkably well ossified, long (reaching the surface of the skull or nearly so), robust (comparable to clubs, handles, planks, or pillars, not "rodlike" as they are often called), and immobile (currently unknown in ?*B. reiszi*), even forming a deeply interdigitated suture with the parasphenoid in mature eryopiforms (*Mastodonsaurus*, *Stanocephalosaurus*, *Platyoposaurus*, ?*Eryops*) as well as in *Greererpeton*, far rootward of Temnospondyli. Their distal ends, with the same exception, participate in the caudal wall of the temporal embayment. In *Doleserpeton*, the paroccipital process bears paired ridges that have been interpreted as support for a froglike cartilage ring around the tympanum, but may have held the stapes instead.

Rather than bracing the tabular against the ventral braincase or contacting a tympanum, the distal end of the stapes (not the quadrate process) may have plesiomorphically anchored spiracle-opening/closing muscles as in *Polypterus*, an extant actinopterygian which breathes air through its spiracles. The bottom-dwelling dvinosaurids and plagiosaurids lost the dorsodistal process of the stapes along with the spiracle. The ability to hear high-frequency airborne sound was a late, rare innovation restricted to some (not all) forms with fully terrestrial adults—within Temnospondyli, within Amniota, and also within Lissamphibia, where no evidence of a formerly tympanic ear in salamanders, caecilians, or albanerpetids has been described so far.

Technical Session XVIII (Saturday, October 29, 2016, 2:00 PM)

AN ANATOMICAL AND PHYLOGENETIC REVISION OF *CHINDESAURUS BRYANSMALLI* FROM PETRIFIED FOREST NATIONAL PARK AND ITS IMPLICATION FOR THE LATE TRIASSIC DINOSAURIAN RECORD OF NORTH AMERICA

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Much of our understanding of early dinosaur evolution emanates from the Carnian and Norian of South America, however there are number of more fragmentary forms from the Norian of North America that help inform the first 20 million years of dinosaur evolution. The early dinosaur *Chindesaurus bryansmalli* was first thought to be a sauropodomorph from the Late Triassic Chinle Formation of Petrified Forest National Park (PEFO) and was later described and rediagnosed as a herrerasaurid. In some phylogenies, *Chindesaurus* joins the South American taxa *Herrerasaurus* and *Staurikosaurus* in a monophyletic Herrerasauridae near the base of Theropoda. Because the holotype specimen is highly fragmentary, many character states cannot be scored, and those that can be scored introduce ambiguity in character optimization in phylogenetic analyses centered on early dinosaur evolution. The holotype of *Chindesaurus* was recovered in the Petrified Forest Member of the Chinle Formation at PEFO and new fossils that are nearly identical to *Chindesaurus* were found from the same member, including a proximal femoral head and pair of sacral vertebrae. The proximal end of another femur was found in the Jim Camp Wash beds of the Sonsela Member at PEFO. This stratigraphic range extension now places *Chindesaurus* between 209 Ma and 217 Ma. No remains of *Chindesaurus* have been found below the Adamanian-Revueltian boundary at the park but a femoral head similar to that of *Chindesaurus* is known from the Otis Chalk of Texas. Newly recognized features of the holotype provide a more complete understanding of the anatomy of *Chindesaurus*, including a long cervical centrum that preserves bilateral anterior pneumatic fossae. Unlike neotheropods, *Chindesaurus* retains two sacral vertebrae as in *Herrerasaurus*. The left femur has been prepared since it was first figured and indicates that the distal lateral condyle and crista tibiofibularis were not well separated from one another. The right astragalus is broken along its lateral edge and its distinct "glutealiform" distal shape is divided more prominently than that of neotheropods. The reinterpreted holotype of *Chindesaurus* was scored into a recent phylogenetic dataset and a parsimony analysis recovered it not as a herrerasaurid but as the sister taxon to *Tawa hallae* closer to Neotheropoda. These results indicate that a clade of non-neotheropod theropods may be endemic to the western United States and remove the unambiguous presence of Herrerasauridae in the Late Triassic of North America.

Grant Information
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Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

A LATE NORIAN COELOPHYSID NEOTHEROPOD (DINOSAURIA, SAURISCHIA) FROM NORTHWESTERN ARGENTINA

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Coelophysoids are carnivore dinosaurs that lived around Pangaea during the Late Triassic–Early Jurassic and are considered the earliest radiation of neotheropods. Despite its abundant record, the only species known for South America is *Zupaysaurus rougieri* (Mid-Norian of Argentina), a putative coelophysoid of controversial phylogenetic relationship. We present here a new coelophysoid from the Quebrada del Barro Formation (Late Norian), Northwestern Argentina, preserving an articulated vertebral sequence from 3rd to 13th presacrals, sacrum composed of five co-ossified vertebrae articulated to the last dorsal and the first caudal, pelvis lacking distal end of pubis and ischium, and proximal end of left tibia. Phylogenetic analysis placed the new specimen well nested within a monophyletic Coelophysidae in a polytomy with *Coelophysis rhodesiensis* and *Camposaurus arizonensis*, and as the sister group of *Coelophysis bauri* and *Lepidus praecisio*. Deep pleurocoels on the centrodiapophyseal laminae of the posterior cervical vertebrae differentiates it from other neotheropods. This first record confirms the presence of coelophysoid neotheropods in South America, providing new information on the controversial early evolutionary history of Theropoda during the early Mesozoic of Pangaea.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

POSTCRANIAL PALEONEUROLOGY OF PTEROSAURS

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Paleoneurology of the postcranium in fossil reptiles is comparatively understudied, the handful of previous reports focusing on crocodyliforms and dinosaurs. No published postcranial paleoneurological data exists on pterosaurs. In vertebrates, it is typical for intervertebral foramina to house major nerves that emerge from the spinal cord and exit the neural canal to innervate the surrounding tissues and extremities. In the heavily fused (and often distorted or poorly preserved) pterosaurian sacrum, intervertebral foramina can be difficult to observe and hence have rarely been identified. The Lower Cretaceous azhdarchoid *Vectidraco* from southern England is known only from a partial pelvis and sacrum, and exhibits large, paired foramina on each sacral vertebra. These were originally identified as pneumatic foramina but computed tomography (CT) scanning reveals that they communicate with the neural canal and hence are spinal nerve foramina (SNF) for the major sacral nerve roots. The term 'SNF' is used here to distinguish nervous from non-nervous foramina as the foramina found in some pterosaurian sacral supraneural plates are often referred to as 'intervertebral foramina'. The sacral vertebrae of *Vectidraco* are fully fused, and SNF are present dorsolaterally on the centra, SNF can be identified in other three-dimensionally preserved pterosaur sacra, including those of *Anhanguera* and *Coloborhynchus*. We sought to determine the relative size of the sacral neural canal and link in with locomotor function as per previous studies on SNF. The relatively large sacral neural canal of *Vectidraco* implies a large sacral plexus of the spinal cord for innervation of the legs. When compared to that of *Anhanguera,* this supports previous hypotheses that azhdarchoids were more hindlimb-proficient than ornithocheiroids, an observation presumably linked to terrestrial ability. Study of the neural canal throughout the vertebral column of *Coloborhynchus* also supports the idea that ornithocheirids spent less time on the ground since a large brachial plexus and comparatively small sacral plexus indicates a greater amount of innervation in the pectoral region and wings than the sacrum and legs. As this is the first study to focus on postcranial paleoneurology in pterosaur, it is currently unknown how representative our data is of pterosaurs as a whole.

Grant Information
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Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

A NEW SILESAURID (DINOSAURIFORMES) ALLIED TO *DIODORUS* FROM THE CHINLE FORMATION OF NORTHERN COLORADO, AND ITS SIGNIFICANCE TO LATE TRIASSIC DINOSAUROMORPH PALEOBIOGEOGRAPHY

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The middle to late Norian 'red siltstone' member of the Chinle Formation in the Eagle Basin of Colorado contains the northernmost known Late Triassic dinosauromorph assemblage from North America. Silesaurids are the most abundant dinosauromorph component of the Eagle Basin Chinle vertebrate assemblage. Silesaurid specimens across a range of sizes share several autapomorphies distinguishing them from previously described silesaurid taxa. Autapomorphies of the Eagle Basin silesaurid are: a massive flange on the medial surface of the maxilla, a robust posterior process of the maxilla, a broad antorbital fossa, twelve maxillary teeth and fourteen dentary teeth, a greatly elongate and blade-like preacetabular process on the ilium, a subtriangular eminence along the brevis fossa of the ilium, and an extremely thin and sharp edged medial condyle on the femur that is much less robust than the lateral condyle and crista tibiofibularis. Our phylogenetic analysis identifies the Eagle Basin silesaurid as sister taxon to *Diodorus* from Morocco rather than the previously known North American taxa *Technosaurus, Eucoelophysis* or the Ghost Ranch silesaurid. This further illuminates the diversity and widespread distribution of derived Late Triassic silesaurids, and potentially identifies a silesaurid clade of predominantly tropical distribution that includes *Diodorus* and *Sacisaurus*. Additional dinosauromorph material from Eagle Basin includes the lagerpetid *Dromomeron romeri* and basal neotheropods that cannot be distinguished from *Coelophysis bauri*, demonstrating that the Triassic dinosauromorph fauna north of the Ancestral Rocky Mountains is broadly similar to those in the Colorado Plateau and Texas, and helping to characterize the Late Triassic vertebrate assemblage of western North America in relation to the rest of Pangaea.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

A DISCOVERY OF A NEW SKELETON OF THE MAMMOTH (*MAMMUTHUS* SP.) FROM THE SARTANIAN DEPOSITS IN EASTERN SIBERIA, RUSSIA

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The Megin Mammoth specimen represents the first and almost complete skeleton of a mammoth discovered in eastern Siberia. It was found in 2015 in the Suola River bank (Lena River Basin) deposits in the vicinity of Nizhniy Bestyakh, Yakutian Republic. The site deposits were accumulated during the Sartanian (~29,000–14,000 cal BP) glacial. Here, we characterize the morphological features of the Megin mammoth to explore its taxonomy, age, size and sex. We generate a radiocarbon date and extract ancient DNA from a small sample of tooth root to infer its relationship to other mammoths. The Megin mammoth is excellently preserved and nearly complete, allowing inference of its age and sex. The remaining last molars (M3) are preserved in all jaw quadrangles, show moderate wear and are positioned in closed alveoli. The mandibular foramina are also enclosed by grown-in bone. The tooth wear corresponds to that of a 58–62 year old Asian elephant, a very old age that is also supported by complete obliteration of fusion lines on all limb bones and vertebrae discs. The tusks are larger and heavier than those of the old male Lena Mammoth and fall near the upper limit of woolly mammoth tusk sizes, indicating that the Megin Mammoth was a male. This conclusion is supported by the large size of the other skeletal elements: the estimated height to the shoulders is 283–295 cm (taller than the Taymyr Mammoth but shorter than the Lena Mammoth), corresponding to a 304–308 cm tall animal. With respect to the taxonomic identification of the Megin mammoth, AMS radiocarbon dating provided an age of 17,820–17,330 cal BP, suggesting that it is probably a woolly mammoth, *M. primigenius*. In addition, we generated a high-coverage, complete mitochondrial genome, which placed the Megin mammoth within woolly mammoth clade I, the basal clade to the species. However, several morphological features appear to be too archaic to ascribe the specimen to *M. primigenius*. For example, the dental characteristics (relatively short M3, 14–15 plates on the upper M3 and 15–16 plates on the lower M3, relatively low plate frequencies [5.5–8.0], and high enamel thickness [2.9 mm]), the size and low torsion of the tusks, and the massive-sized limb bones are characteristic of the steppe mammoth, *M. trogontherii*. Because reconciliation of the morphological and mDNA data remains problematic, the specimen is temporarily identified as *Mammuthus* sp., as work continues to generate nuclear genomic data.

Technical Session XVII (Saturday, October 29, 2016, 9:45 AM)

THE RETURN OF *PROTOICHTHYOSAURUS*: A VALID SISTER TAXON OF *ICHTHYOSAURUS* (REPTILIA, ICHTHYOSAURIA)

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The genus *Protoichthyosaurus* was proposed in the late 1970s, but it was synonymized with the genus *Ichthyosaurus*, with which it shares several features including a wide forefin with at least five primary digits, an anterior digital bifurcation, a humerus that is slightly wider distally than proximally, and a coracoid with well-developed anterior and posterior notches. However, a closer examination has determined that the two genera are distinct, and can be distinguished on the basis of skull, forefin, and coracoid morphologies. The maxilla of *Protoichthyosaurus* is large, high, and triangular, separated from the external naris by a sliver of bone, if at all; whereas the maxilla of *Ichthyosaurus* is lower, and separated from the external naris by a fairly broad contact of the lacrimal and premaxilla. Differences also exist in the shapes and sizes of the postfrontal, prefrontal, lacrimal, and postorbital. In the forefin, the difference is most evident in the mesopodium, as was noted in the original diagnosis. *Protoichthyosaurus* has three elements in the distal carpal row rather than four as in *Ichthyosaurus*. Metacarpal 5 does not contact the ulnare in *Protoichthyosaurus*, as it does in *Ichthyosaurus*. Phylogenetic analysis confirms that *Protoichthyosaurus* is sufficiently different from *Ichthyosaurus* to be considered a valid genus. Thus there are two genera of wide-finned ichthyosaurs in the Lower Jurassic of the U.K. Recognized specimens of *Protoichthyosaurus* are in historic collections, and so the stratigraphic range is poorly known, although it is probably from the earliest Hettangian to early Sinemurian. The resurrection of this genus increases the diversity of ichthyosaurs in the lowest Jurassic and further supports the hypothesis of very rapid diversification of ichthyosaurs immediately after the Triassic extinction.

Poster Symposium II (Friday–Saturday, October 28–29, 2016, 4:32 PM)

LATE JURASSIC OF MORRISON FORMATION AND PORTUGAL TETRAPODS COMPARED: A MODEL TO EXPLAIN FAUNAL EXCHANGE AND SIMILARITY

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The precursor of the North Atlantic existed between the North American and Iberian blocks from the earliest Jurassic Hettangian and has been ever expanding since. By the Kimmeridgian and Tithonian, when much of the Morrison Fm rocks were deposited, the proto-Atlantic was more than 300 km wide at 27° paleolatitude between North America and Iberia. Macrovertebrate paleontology reveals a unique story to the isolation of Iberia and instead suggest a paleogeographic land connection between North American and Iberia. *Torvosaurus*, *Allosaurus*, *Ceratosaurus*, *Stegosaurus*, *Supersaurus* and others have a distribution restricted to Morrison Formation in North America and Lourinhã Formation in Portugal.

A novel paleogeographic model is here suggested: (1) around the Middle–Late Jurassic transition there is a major palaeoceanographic and palaeoclimatic reorganization, coincidental to a major eustatic sea-level drop and uplift associated with the Callovian–Oxfordian Atlantic Regressive Event; (2) creating an ephemeral land bridge presenting a temporary opportunity for terrestrial gateways likely across the Flemish Cap and Galician Bank land masses, allowing large dinosaurian taxa to cross the northern proto-Atlantic in both directions; (3) finally, a Callovian–Oxfordian faunal exchange around the 163 Ma, through latest Kimmeridgian at 152 Ma (the age of equivalent genera in both Morrison and Portugal), is was an interval that allowed speciation, but retaining generic similarity of vertebrates. This model is consistent with the chronology and taxonomy required for speciation of the Iberian and American forms, exemplified by the coeval sister-taxa pairs *Torvosaurus tanneri* and *T. gurneyi*, *Allosaurus fragilis* and *A. europaeus*, or *Supersaurus vivianae* and *S. lourinhanensis*.

While some of the smaller animals in the fauna show Morrison/Portugal affinities, most from Iberia have European or even Asian affinities. The larger-bodied fauna are more closely related to Morrison than to mainland Europe (except for dacentrurine stegosaurs). The body size differences and affinities of taxa across paleogeography is comparable to what is observed today across the Wallace Line.

Migration may have also occurred in both directions. The closest relative of *Torvosaurus* is likely the European Bathonian *Megalosaurus*, thus the presence of the genus in North America represents a European migration. On other hand, *Allosaurus* and *Supersaurus* origins are consistent with a North American origin, representing an west-to-east migration.

Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

RE-EXAMINATION OF DESMOSTYLIAN PHYLOGENETIC RELATIONSHIPS

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The order Desmostylia, belonging to Tethytheria or Perissodactyla, is an extinct clade of marine mammals of which remains are found from shallow marine strata of the uppermost Eocene to lowest upper Miocene in the North Pacific Rim. Traditionally, Desmostylia has been divided into two families, Desmostylidae and Paleoparadoxidae, on the basis of dental morphology. With recent establishment of two new genera, *Ounalashkastylus* and *Seuku*, Desmostylia now includes two families and 10 or 11 genera with 13 species, with the two genera *Seuku* and *Behemotops* with indeterminate familial affinities.

The phylogenetic relationships within Desmostylia have been debated. Two alternative hypotheses have been proposed on the relationship between the two families. Both Desmostylidae and Paleoparadoxidae are considered as monophyletic groups in one hypothesis, whereas Paleoparadoxidae is regarded as comprising paraphyletic, successive outgroups for monophyletic Desmostylidae in the other. One factor contributing to such different hypotheses has been the lack of well-preserved specimens that can be used as suitable outgroups for phylogenetic analyses. Another factor is the small size of data matrices used in previous studies unsuitable for analyses including all desmostylian taxa.

In this study, the desmostylian inter-relationship was assessed by rectifying the shortcomings of the previous studies. First, based on the recent description of a well-preserved skull of *Anthracobne*, this taxon was used as the outgroup. Second, previously published datasets were combined and revised to produce one large matrix including 13 species of Desmostylia based on both cranial and postcranial characters. Phylogenetic analyses were conducted with equally weighted parsimony using TNT v. 1.1. As a result, Paleoparadoxidae with the traditional taxonomic content was found as paraphyletic, successive outgroups for the monophyletic Desmostylidae. Furthermore, the systematic positions of new genera were resolved. *Seuku* was found to be a sister taxon of *Behemotops*, whereas *Neoparadoxia* was a sister taxon of the clade consisting of *Paleoparadoxia* and *Archaeoparadoxia*. *Ounalashastylus* was placed between *Desmostylus* and *Cornwalius*. This result provides a phylogenetic framework for discussing various aspects of Desmostylian evolution. In addition, it indicates that the classification of Desmostylia, especially at the family level, needs to be revised.

Poster Symposium I (Wednesday–Thursday, October 26–27, 2016, 4:15–6:15 PM)

A NEW CARPOLESTID FROM SOUTHWESTERN WYOMING AND ITS PHYLOGENETIC IMPLICATIONS

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Carpolestids are a family of plesiadapiform mammals that flourished during the Paleocene of western North America. They are particularly diagnostic in possessing a large plagiaulacoid lower fourth premolar, the size and shape of which serves as an important basis for determining evolutionary relationships within the clade. *Carpolestes,* with its hypertrophied and highly polycuspidate p4, is the youngest and most derived carpolestid genus. Older carpolestid species currently classified in either *Carpodaptes* or *Carpomegodon* retain a more primitive p4 morphology with fewer apical cusps, and these species are widely regarded as comprising a paraphyletic grade with respect to *Carpolestes*. However, identifying which of these earlier carpolestid species is most closely related to *Carpolestes* remains contentious. Fundamentally, this decision entails a longstanding debate over size versus shape in evolution, because p4 in species of *Carpodaptes* and *Carpomegodon* varies markedly with respect to these parameters. Here, we report the discovery of new late Tiffanian (Ti5) mammal fauna from the eastern flank of the Rock Springs Uplift in Sweetwater County, Wyoming. Carpolestid specimens from the new Twelvemile Bonanza local fauna document a new species of *Carpolestes* that illuminates the final stages in the transformation of carpolestid p4 blades. Morphometric analysis of the new *Carpolestes* from Twelvemile Bonanza shows that its p4 closely resembles that of *Carpodaptes hobackensis* in terms of shape, although the latter taxon differs significantly from species of *Carpolestes* and *Carpomegodon jepseni* in terms of size. A phylogenetic analysis based on dental characters that incorporates the new species of *Carpolestes* from Twelvemile Bonanza conflicts with previous interpretations of carpolestid phylogeny in reconstructing *Carpodaptes hobackensis* as the sister group of *Carpolestes*. Taken together, these results indicate that shape trumped size during the evolutionary transformation of the iconic p4 blade of carpolestids.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

HERE AND GONE: EXPLANATIONS FOR THE VARIABLE ABSENCE OF THE ENTEPICONDYLAR FORAMEN IN SLOTHS (MAMMALIA, PILOSA)

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The entepicondylar foramen of the humerus first appears in early tetrapods and persists throughout many later members of the group; albeit with much variability in its retention. In mammalian groups bearing the foramen, it is proximal to the medial epicondylar region and serves as a short passage for protection of the median nerve; the brachial artery irregularly traverses the foramen. The entepicondylar foramen is variable in both living (*Choloepus* = present, *Bradypus* = absent) and extinct sloths, and its overall presence is considered to be ancestral for all sloths. However, rationale for the variability of its occurrence has not been much considered. Examination of the literature and fossil sloth specimens with known humerii reveals additional variability in foramen retention, and there exist at least three trends to explain the loss of the foramen: medial epicondyle morphology, body size, and function of the anterior limb. A well-developed projection of the medial epicondyle places the origin of the forelimb pronators and flexors such that the orientation of the muscles prevents them from providing protection for the median nerve until it is distal to the elbow. This is exemplified by megalonychid sloths that all possess a developed medial epicondyle and an entepicondylar foramen, with the exception of *Parocnus* that lacks both. Mylodontids have a strong medial epicondyle but in a more proximal position that then provides more coverage and less need for an entepicondylar foramen; retention of the foramen in scelidotheres indicates morphology is not the only explanation. Loss of the foramen also appears to be associated with increasing body mass, as the larger mylodontids and megatherriids from the Pleistocene all lack the feature, and each group has different medial epicondyle morphologies. In the megatheriids, who lack a distinct medial epicondyle, the region is instead proximodistally elongated because of the greater size and thereby keeps the muscle origins slightly proximal and near to the shaft, so that their orientation covers the nerve just at, or proximal, to the elbow. For small-sized *Parocnus*, loss of the entepicondylar foramen could also be tied to changes in locomotion, wherein alternate positioning of the forelimb places the median nerve in a protected position that negates a need for the foramen; this has been hypothesized for other mammals. Shifts in manus position of terrestrial sloths (e.g., plantigrade vs. 'knuckle-walking') would also lead to distinct changes that would impact the level of protection required for the median nerve.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

ADDITIONS TO THE MAMMALIAN FAUNA AND THE FIRST DOCUMENTED NON-AVIAN REPTILE FROM THE LATEST EOCENE FLORISSANT FORMATION, FLORISSANT FOSSIL BEDS NATIONAL MONUMENT, COLORADO

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Renewed fieldwork targeting microvertebrate fossils from the latest Eocene (Chadronian) Florissant Formation in Florissant Fossil Beds National Monument, central Colorado, has increased the known diversity of the mammalian fauna to more than 20 species. Concentrated dry screening of fluvial sediments in the lower mudstone unit and sorting under a microscope, while low yield, reliably produces isolated teeth and postcranial elements. Most recently, a number of new occurrences of mammals were identified from a small sample of teeth collected using this method, including the eomyid rodents *Paradjidaumo* cf. *P. hansonorum* and *Namatomys lloydi*, the sciurid rodent cf. *Hesperopetes*, and some intriguing insectivoran teeth (study in progress). The occurrence of these taxa helps corroborate a Chadronian age for the Florissant fauna, and all represent southern range extensions. Notably, the occurrence of cf. *P. hansonorum* represents a significant range extension southward from North Dakota and Saskatchewan. The taxa reported here further support the hypothesis that the Florissant mammalian fauna shows much greater taxonomic affinity to more northern Chadronian faunas than to coeval faunas to the south, despite its central location. Significantly, we also document the first instance of a non-avian reptile (represented by a vertebra from a basal crown snake) from the Florissant Formation—a group whose absence from the fauna has long puzzled researchers. Its discovery, and the continued augmentation of the mammalian fauna by dry-screening methods employed at a single locality (University of Colorado Museum locality 92179), suggest that this small window into the latest Eocene terrestrial vertebrate fauna of Florissant has much more to reveal.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

A POSSIBLE LATE CAMPANIAN RECORD OF PTERANODONTIA FROM THE KAIPAROWITS FORMATION OF GRAND STAIRCASE-ESCALANTE NATIONAL MONUMENT, SOUTHERN UTAH

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Pterosaur remains are relatively common from the Upper Cretaceous of North America, consisting largely of marine or marginal marine occurrences near the Western Interior Seaway, and usually represented by ornithocheiroid pterosaurs. In contrast, records from continental settings during this interval are relatively rare, usually preserved in foreland settings along the eastern margin of Laramidia, and are typically fragmentary and taxonomically ambiguous. Historically, many of these remains were referred to Azhdarchidae, though their fragmentary or incomplete nature provided little morphological support for these assignments. Ongoing reassessments of these materials suggest previously unrecognized taxonomic diversity of Upper Cretaceous pterosaurs in continental settings. An isolated but three-dimensionally preserved first wing phalanx (digit IV) of a pterosaur was recovered from a channel lag deposit in the Upper Campanian (76.5–74.5 Ma) Kaiparowits Formation of Grand Staircase-Escalante National Monument, southern Utah. This represents the first definitive pterosaur remains from the unit and compares favorably with pteranodontid and nyctosaurid (Pteranodontia), rather than azhdarchid, pterosaurs. The proximal extensor tendon process of the specimen is similar in overall morphology to *Pteranodon* and *Nyctosaurus* on the basis of its sub-rectangular extensor tubercle, the position of its pneumatic foramena, the expanded curvature of the dorsal cotyle, and the posterior flare of the proximal articulation. Furthermore, the specimen differs morphologically from similar-aged azadarchoids, which typically possess a sub-triangular proximal extensor tubercle and weaker curvature in the dorsal cotyle. The presence of a pteranodontian in the Upper Campanian Kaiparowits Formation represents a relatively late occurrence for the clade and supports mounting evidence for greater taxonomic diversity in Upper Cretaceous continental settings of North America.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

TOOTH REPLACEMENT IN A DIPLODOCOID SAUROPOD FROM THE UPPER JURASSIC MYGATT-MOORE QUARRY (MORRISON FORMATION) IN RABBIT VALLEY, COLORADO

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Two tooth-bearing snout fragments (MWC 6002 and MWC 8430) of a diplodocoid sauropod are described from the grey mudstones of the Upper Jurassic Mygatt-Moore Quarry in Rabbit Valley, Colorado. Located in the upper Brushy Basin Member of the Morrison Formation, the Mygatt-Moore Quarry has produced thousands of vertebrate fossils from over thirty years of excavation. The sauropod *Apatosaurus* and the theropod *Allosaurus* dominate the assemblage, with other sauropod taxa including *Camarasaurus*, Sauropoda indet., as well as material identified as "cf. *Diplodocus* or *Barosaurus*". However, positively identified remains of *Diplodocus* have been found outside of the quarry in Rabbit Valley. Sauropod tooth replacement in Morrison Fm. taxa has been described in *Camarasaurus* and *Diplodocus*, but not in *Apatosaurus* or *Barosaurus*. Both specimens in this study preserve eight replacement teeth per alveolar position, as observed through broken surfaces at the gross anatomical level and also through computed tomography (CT) scans. This is inconsistent with an identification of these elements as belonging to *Diplodocus*, which has been previously shown to have only five positions per alveolus. Therefore, these two specimens are tentatively referred to the abundant genus *Apatosaurus*, as *Barosaurus* has not been positively identified from the vertebrate remains at the Mygatt-Moore Quarry. The presence of eight replacement teeth per alveolus has previously only been reported in the Cretaceous rebbachisaurid *Nigersaurus*, which is interpreted to have a similar feeding strategy to *Diplodocus* and *Apatosaurus*. This is the first report of this mode of tooth replacement in a diplodocoid sauropod from the Morrison Fm. The high number of replacement teeth, relative to the contemporaneous *Diplodocus*, provides further evidence for niche partitioning among the ground-height browsing *Diplodocus* and *Apatosaurus*. This indicates that the diet of *Apatosaurus* comprised tougher vegetation than *Diplodocus*, which would have in turn resulted in increased shed or broken teeth and the need to generate additional teeth at an increased rate relative to *Diplodocus*.

Grant Information
No grants were provided to fund this project.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

GEOMETRIC MORPHOMETRIC ANALYSIS OF THE PEDAL CLAW OF *CONFUCIUSORNIS SANCTUS* (AVES, CONFUCIUSORNITHIDAE) AND ITS IMPLICATIONS FOR MORPHOLOGICAL VARIATION BETWEEN BEHAVIORAL GROUPS

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Confuciusornis sanctus is an Early Cretaceous bird from the Liaoning Province of northeastern China. Much work has been published on this species, but some details of its habitat and behavior remain unclear. Geometric morphometric analyses allow for the separation of specimens based on morphological variables, however each analysis must be assessed to determine which variables are most informative for answering the question being asked. A geometric morphometric analysis of the ungual of the second pedal digit of *Confuciusornis sanctus* was performed to determine how its morphology compares to that of extant birds and which morphological variables best distinguish between behavioral groups. A total of 128 specimens was examined, comprising 104 extant bird species and *Confuciusornis sanctus*. Three fixed landmarks and 50 sliding semilandmarks were used to define shape. A principal component analysis gave two axes explaining over 73% of the variation in shape, with principal component one explaining 56%. Principal component one, which varies in the angle of claw curvature, clearly distinguishes terrestrial from predatory species, with arboreal species overlapping both. Centroid size separates arboreal from predatory species, with terrestrial species overlapping both. Principal component two, which varies in claw thickness, shows complete overlap of all behavioral groups. This indicates that claw curvature and claw size are the variables that are most correlated with differences in behavior, whereas claw thickness is not an informative morphological variable. *Confuciusornis sanctus* is similar to *Passer griseus* (northern grey-headed sparrow) in all three variables, indicating that *C. sanctus* may have spent most of its time in the trees and on the ground in temperature wooded areas, feeding on plant material and/or insects and other small invertebrates. The claw morphology of *Confuciusornis sanctus* is dissimilar to predatory birds, indicating that *C. sanctus* was unlikely to have been an active predator. Further studies need to be done to determine how overall body size and the ratio of claw size to body size affect patterns of variation between species and behavioral groups.

Technical Session XVI (Saturday, October 29, 2016, 11:15 AM)

TAPHONOMY OF NEWLY DISCOVERED NEOGENE MASS DEATH ASSEMBLAGES IN KOCHKOR BASIN, KYRGYZSTAN

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The Tien Shan Mountains of Kyrgyzstan give it the highest average elevation of any country, and today's fauna reflects this high steppe environment. Yet the evolutionary history of these faunas is unclear. Furthermore, recent finds in the Late Cenozoic record of Central Asia suggests their pivotal importance in the origins of the cold-adapted fauna of the Pleistocene and Holocene. We present newly discovered Neogene mammalian faunas, illuminating the roles of tectonics and climate in shaping the response of Central Asian faunas to uplift and climate change. While the Himalayas prevented the stronger

Southeast Asian Monsoon from reaching Central Asia prior to the Neogene, the weaker Indian Monsoon may have impacted the environment until the late Miocene. The majority of the Kochkor basin fossil deposits of Kyrgyzstan are mass death assemblages. Because these deposits date from a time coincident with the loss of West-Indian Monsoon activity, we hypothesize that they were caused by drought-related mass die offs. Additional evidence supporting this hypothesis includes disproportionate representation of juvenile animals in the assemblages, over-representation of the ungulate fauna compared to microfauna or carnivores, and grazing taxa (e.g., the three-toed horse *Hipparion*) with extreme browsing macrowear as well as browsers (e.g., the rhino *Chilotherium*) with asymmetrical wear, all patterns observed in modern African drought-killed death assemblages. The age of these deposits (9–5 Ma), dated using a combination of biostratigraphy and paleomagnetostratigraphy, coincides with carbonate nodule and speleothem data from Kazakhstan and China recording a climatic shift away from a monsoonal climate. Each bone bed records a single depositional event, as expected from emplacement from flood events. These bone beds seem to preserve carcasses from a flood plain environment that accumulated over months to years, suggested by the range of specimen completeness, from fragments to articulated skeletons. Additionally, the presence of primary gypsum and mud cracks in some sediments sets the scene for flood plain to low foothills environments near the rising Tien Shan. Together, the biological and geological evidence combine to suggest the reoccurrence of droughts in Kyrgyzstan as the physical environment changed from plateaued scrublands to the alpine steppe of today.

Grant Information
2015 Fulbright Student Research Grant to the Kyrgyz Republic

Poster Symposium II (Friday–Saturday, October 28–29, 2016, 4:31 PM)

CONTROLS ON THE STRATIGRAPHIC DISTRIBUTION OF NON-MARINE FOSSILS: A CASE STUDY IN THE JURASSIC MORRISON FORMATION, WESTERN USA

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Covariation between non-marine fossil occurrence and stratigraphic architecture has received minor attention despite numerous studies indicating that stratigraphy is a key control on fossil preservation in marine environments. Much of the vertebrate fossil record is found in terrestrial environments, making it an important system to understand to interpret the history of life. The non-marine Late Jurassic Morrison Formation in the western United States is renowned for its abundant vertebrates; therefore it is an ideal template for assessing the relative importance of rate of accommodation formation, sediment supply, and fluvial geomorphology in governing fossil preservation.

Fluvial architecture was compared with the distribution of fossils using the Paleobiology Database (PBDB), literature, and field data. Fifteen Morrison stratigraphic sections were measured at both vertebrate sites and prospected regions where no or few vertebrates were discovered. This study area includes different fluvial architectures from the Colorado Plateau and the Montana–Wyoming region that capture the range in quality and abundance of fossil preservation. The scale and completeness of this study was increased substantially by inclusion of data from the PBDB (paleobiodb.org), which houses a great record of Morrison vertebrates, including 300 collections of 1416 fossil occurrences.

The Morrison is spatially and temporally heterogeneous as fluvial systems prograde from the southwest and west of the depositional basin. Stratigraphic architecture has profound effects on the presence, abundance, and quality of fossil preservation and three general categories are identified relative to the source: proximal, medial, and distal. Proximal sites tend to preserve small collections in amalgamated channelforms (~31% of PBDB collections are channels) with rare dry floodplain collections (~8% PBDB collections). Distal sites tend to preserve diverse and relatively large collections in wet floodplain (~29% PBDB collections) to lacustrine settings (~18% PBDB collections) with some crevasse splay localities (~11% PBDB collections), and rare marginal marine sites (~3% PDBD collections). Typically, medial sites are the most fossil-rich regions and preserve fossils in a range of depositional environments including amalgamated to individual channels, floodplain, and crevasse splays. These results indicate that it is necessary to understand and work within a stratigraphic framework to accurately interpret the vertebrate record in terrestrial settings.

Grant Information
Geological Society of America
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Technical Session XV (Saturday, October 29, 2016, 10:15 AM)

A REVISED SAUROPODOMORPH-BASED BIOSTRATIGRAPHY OF THE ELLIOT FORMATION, LATE TRIASSIC–EARLY JURASSIC, SOUTH AFRICA

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South Africa's Upper Triassic–Lower Jurassic Elliot Formation is best known for its diverse assemblage of basal sauropodomorph dinosaurs. This assemblage provides the primary faunal basis for the biozonation of the formation, and is a major biostratigraphic correlative unit for similarly-aged continental strata globally. Traditionally, the Elliot Formation was divided into two sauropodomorph range zones: a lower zone thought to be dominated by the large-bodied taxon '*Euskelosaurus*'; and an upper zone named for the abundant (and seemingly exclusive) occurrence of the comparatively smaller, gracile *Massospondylus*. These range zones are largely coincident with the informal lithostratigraphic subdivision of the Elliot Formation into lower (LEF) and upper (UEF) members, and with a temporal division of Upper Triassic LEF deposits and Lower Jurassic UEF deposits. Dramatic shift in our understanding of the diversity and distribution of the sauropodomorphs of the Elliot Formation, along with the increasing primacy of recent litho- and magnetostratigraphic partitioning of the formation, brings into question the continued utility of this (primarily size-dependent) biostratigraphic subdivision.

We present an updated sauropodomorph-based biostratigraphy of the Elliot Formation, based on taxonomic revision and fieldwork aimed at establishing accurate provenance of key sauropodomorph taxa. The aims of this work are twofold: 1) to synthesize the findings of several years of palaeontological field research and taxonomic revision and, 2) to place the exemplar specimens within the refined stratigraphy of the formation. Our principal findings show that the problematic '*Melanorosaurus*' hypodigm crosses the LEF–UEF contact, and confirm that the type locality of *Antetonitrus* is located within the UEF and not the LEF. The resulting reduction in diversity of the LEF suggests a sauropodomorph assemblage of relatively conservative *bauplan*, with the exception of the unparalleled stockiness of *Blikanasaurus*. In contrast, the morphological and taxonomic diversity of the UEF is shown to be considerably greater than previously believed, including several grades of large-bodied browser – amongst them the earliest true sauropods. Although liable to refinement via ongoing fossil sampling, these new data have major implications for our understanding of sauropodomorph evolution across the global Triassic–Jurassic boundary.

Grant Information
BWM is supported by an NRF African Origins Platform grant-holder bursary to Bruce Rubidge and a DST/NRF Centre of Excellence for Palaeosciences post-graduate bursary.

Technical Session VI (Thursday, October 27, 2016, 9:30 AM)

A 30-YEAR CASE OF MISTAKEN IDENTITY: THE WOLVES FROM NATURAL TRAP CAVE, WYOMING

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Pleistocene wolf diversity was much higher than it is today, for example there were three known wolf morphotypes (dire, gray, Beringian) in Pleistocene North America versus one today (gray). Previous fossil evidence suggested that these three groups overlapped ecologically but split the landscape geographically. The Natural Trap Cave (NTC) fossil site in Wyoming, USA is an ideally placed late Pleistocene site to study the geographical movement of species from northern to middle North America before, during, and after the Last Glacial Maximum. Previous studies have posited that both gray wolves (*Canis lupus*) and dire wolves (*Canis dirus*) were present, but it is not clear which, if any, of these species is found at NTC. We used 2D geometric morphometrics on mandibles of three known wolf groups (*Canis dirus*, extant *Canis lupus* from North America, and Alaskan Beringian wolves) to determine which wolves were present at NTC and what this indicates about wolf diversity and migration in Pleistocene North America. Our analyses show NTC wolves group with Alaskan Beringian wolves. This provides the first morphological evidence for Beringian wolves in mid-continental North America. Their location at NTC and their radiocarbon ages suggest they followed a temporary channel through the Cordilleran and Laurentide ice sheets before the Last Glacial Maximum. Our results demonstrate a higher degree of geographical overlap and competition in Pleistocene North American wolves than was previously known. The presence of mid-continental Beringian morphotypes adds important data for untangling the history of migration and evolution of *Canis* in North America.

Grant Information
This work was funded by NSF EAR #1425059.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

CROCODILIAN CONTROVERSY: A RE-DESCRIPTION OF THE DEBATED TAXON *TERRESTRISUCHUS GRACILIS* AND ITS POSITION WITHIN BASAL CROCODYLOMORPHA

MEARS, Ellen M., University of Edinburgh, Edinburgh, United Kingdom; BRUSATTE, Stephen L., University of Edinburgh, Edinburgh, United Kingdom; FRASER, Nicholas C., National Museums Scotland, Edinburgh, United Kingdom

Basal (non-crocodyliform) crocodylomorphs were an important part of Late Triassic–Early Jurassic ecosystems, having evolved and flourished alongside other pseudosuchians and Avemetatarsalia during the Triassic. Basal crocodylomorphs later expanded to fill many niches, with evidence of apex predators and specialized herbivores, as well as cursorial faunivores. Phylogenetic relationships within basal Crocodylomorpha have been highly debated since the clade was first recognized. The largest phylogenetic analysis of Archosauria to date found basal Crocodylomorpha to be paraphyletic. *Terrestrisuchus gracilis* is the only described basal crocodylomorph from the UK, and has been found exclusively in Late Triassic fissure fills in southwest Britain. *T. gracilis* has itself been controversial, with uncertainty surrounding the validity of the taxon. Thus far, the diagnosis of the species has been based almost completely on paratype specimens rather than the holotype, despite significant variation within the specimens, and some not even appearing to represent archosaurian remains, let alone a single species of crocodylomorph. A series of as yet undescribed fossils from at least one UK fissure fill seem to represent a crocodylomorph species distinct from *T. gracilis*; if more than one species of crocodylomorph is present, a firm understanding of *T. gracilis* is required to allow for identification of other species. We examined the holotype of *T. gracilis*, re-described the specimen, and updated the species diagnosis. The altered diagnosis, the first since *T. gracilis* was originally named and described, has changed significantly to include new characters, the combination of which is unique within Crocodylomorpha. This provides the first strong evidence that *T. gracilis* is a valid taxon. We then used the holotype exclusively to re-score a dataset based on the largest published phylogenetic analysis of Archosauria, and an analysis was run to determine whether the position of *T. gracilis* within Crocodylomorpha changed. Several previous scores were altered, including scoring of previously unscored characters due to new interpretations of bones, and other characters becoming unscorable due to the exclusion of paratype specimens. This dataset provides a new insight into the phylogenetic affinities of *T. gracilis*. With a more complete understanding of *T. gracilis*, the examination of other crocodylomorphs

from the fissure fills will be possible, thereby expanding our understanding of the UK fissure fills and basal Crocodylomorpha.

Grant Information
Research grant provided by NERC E3 Doctoral Training Partnership with CASE funding

Technical Sesssion X (Friday, October 28, 2016, 9:30 AM)

MULTIPLE ORIGINS OF HERBIVORY IN MESOZOIC CROCODYLIFORMS SUGGEST NOVEL ECOLOGICAL DYNAMICS DURING THE MESOZOIC

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Extinct reptiles display a range of dental morphologies not present in extant representatives, making detailed paleoecological studies of these groups highly speculative. In particular, extinct Mesozoic crocodyliforms repeatedly evolve unusual "mammal-like" dental morphologies, suggesting novel ecological roles in their respective ecosystems. Recent descriptions of extinct crocodyliforms and their dentition posit an omnivorous and/or herbivorous diet in many taxa, but these hypotheses remains untested using quantitative methods. In order to elucidate the diet of these extinct crocodyliforms, we quantified dental complexity from high resolution microCT scans of 16 taxa using orientation patch count rotated (OPCR) and compared these results to a novel dataset of OPCR values from extant saurian reptiles. OPCR has been shown to be an effective proxy for diet in both mammals (extant and extinct) and saurians, with omnivores and herbivores generally having higher complexities than those of carnivores. Our data indicate that extinct Mesozoic crocodyliforms occupied a greater range of ecological roles than their extant relatives. In particular, crocodyliforms independently developed herbivory a minimum of three times, each with novel tooth morphologies: once in *Edentosuchus*-like early crocodyliforms, at least once in Notosuchia, and once in Hylaeochampsidae. Similar to multituberculate mammals and extant lizards, increases in cusp number and relative size of the distal portion of the dentition drove increased dental complexity. Many of these crocodyliform taxa lived alongside omnivorous or herbivorous synapsids, suggesting at least two disparate clades of amniote primary consumers characterized some environments throughout the Mesozoic, and that these crocodyliforms did not simply "occupy" mammalian niches in these ecosystems. This result indicates novel ecological interactions between Mesozoic mammals and crocodyliforms that do not occur in modern ecosystems.

Grant Information
Funding is provided by an NSF Graduate Research Fellowship.

Technical Session XX (Saturday, October 29, 2016, 3:45 PM)

ANURANS, CAUDATES, AND ALBANERPETONTIDS (LISSAMPHIBIA) REVEAL DIFFERENTIAL PATTERNS OF TURNOVER AND EXTINCTIONS DURING THE END-CRETACEOUS MASS EXTINCTION, NORTHEASTERN MONTANA, USA

MERCIER, Garrett K., University of Washington, Seattle, WA, United States of America; DEMAR, David G., University of Washington, Seattle, WA, United States of America; WILSON, Gregory P., University of Washington, Seattle, WA, United States of America

Although modern frogs and salamanders are considered highly vulnerable to environmental perturbations, the fossil record has shown unexpectedly high survivorship for lissamphibians during mass extinction events. Here, we analyzed the faunal dynamics of anurans, caudates, and the salamander-like albanerpetontids during the Cretaceous–Paleogene (K–Pg) mass extinction event. We studied 2,150 lissamphibian fossils from the Hell Creek and Tullock formations of Garfield County, Montana. These fossils were recovered via surface collection and underwater screenwashing of bulk sediment samples from localities that have been tied into a well-constrained chronostratigraphic framework. We compared taxonomic diversity and taxonomic composition of each lissamphibian group across four time bins leading up to and across the K–Pg boundary and spanning approximately 2.4 million years (Ma).

Our results show that caudates exhibited low levels of species turnover during the last ca. 2 million years of the Cretaceous and high survivorship (75%) across the K–Pg boundary. Among albanerpetontids, *Albanerpeton nexuosum*, and *A. galaktion* have largely non-overlapping biostratigraphic ranges with the former species occurring in the upper two Hell Creek time bins and the latter in the lower two bins. Albanerpetontids went locally extinct across the K–Pg boundary. We record up to 40 distinct maxillary morphotypes among anurans from the Hell Creek Formation. Anuran assemblages show higher taxonomic turnover leading up to the K-Pg boundary than do the caudates and low species survivorship across the boundary (25% of non-singleton morphotypes). Whereas caudates exhibit no clear pattern of extinction selectivity, there is a morphological shift within local anuran assemblages across the K–Pg boundary. Taxa with sculptured cranial ornamentation predominate in latest Cretaceous local assemblages; however, in early Paleocene local assemblages, these forms were rare (one out of six) as taxa with smooth or unornamented cranial bones predominate. This morphological shift across the K–Pg boundary might represent extinction selectivity due to differences in ecology, phylogenetics, or some other correlated variable. Overall, the observed differences in K–Pg survivorship among lissamphibians might relate to habitat preferences and extinction mechanisms: high survivorship of caudates relating to an aquatic lifestyle and habitat vs. low survivorship of albanerpetontids and anurans relating to inferred terrestrial and semi-aquatic lifestyles, respectively.

Grant Information
UCMP Doris O. and Samuel P. Welles Fund to DGD, UW Mary Gates UGRF to GKM.

Technical Session XVII (Saturday, October 29, 2016, 8:00 AM)

CRANIAL ANATOMY OF A NEW SPECIES OF THALATTOSAUR BASED ON THREE DIMENSIONAL MATERIAL FROM THE CARNIAN VESPER FORMATION OF CENTRAL OREGON

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Thalattosaurs are a poorly known clade of Triassic, secondarily aquatic tetrapods. In North America, five species of thalattosaur are known. However, our understanding of cranial anatomy in these taxa is rudimentary given that most are known from crushed and disarticulated skulls, and none preserve all of the cranial elements. In particular, the braincase morphology is essentially unknown for all thalattosaurs, which significantly hampers our ability to elucidate their phylogenetic relationships. In 2011, the remains of a new species of large thalattosaur were found in a single carbonate nodule in the Late Triassic (Carnian) Brisbois Member of the Vester Formation in central Oregon. The nodule preserves semi-articulated and three dimensionally preserved remains of multiple individuals, including abundant cranial material. CT data of the new material is incorporated into a comparative and phylogenetic analysis in order to elucidate cranial anatomy and reevaluate phylogenetically informative characters.

The Brisbois Member thalattosaur possesses a ventrally deflected premaxilla with robust, external plications, a rugose textured prefrontal and postorbitofrontal and a frontal that bears a long anterior process and does not participate in the orbital margin. Tooth implantation is ankylothecodont, the premaxillary teeth are short and recurved and the maxillary teeth are straight and conical. Three dimensionally preserved braincases reveal that the occipital condyle is composed equally of the exoccipitals and basioccipital, with the latter excluded from forming the floor of the foramen magnum. The basitubera are massive and the paraoccipital processes are robust and broaden distally. Phylogenetic analysis places the Oregon thalattosaur as a basal member of Thalattosauroidea. Including material still in preparation, the Brisbois Member thalattosaur is the most completely known North American thalattosaur and provides new characters critical to understanding the relationships and biogeography among Tethyan and eastern Pacific taxa.

Grant Information
The Otto William Geist Fund
Doris O. and Samuel P. Welles Research Fund

Technical Session I (Wednesday, October 26, 2016, 9:30 AM)

IS DENTAL WEAR 'TAXON-FREE'? DIET, DENTAL WEAR, AND HUNTER-SHREGER BAND ORIENTATION IN RHINOCEROTIDAE

MIHLBACHLER, Matthew C., NYIT College of Osteopathic Medicine, Old Westbury, NY, United States of America; KAUR, Pawandeep, NYIT College of Osteopathic Medicine, Old Westbury, NY, United States of America; BEATTY, Brian L., NYIT College of Osteopathic Medicine, Old Westbury, NY, United States of America

Microwear and other dental wear (DW) studies often overlook the possibility that heritable properties of the consumers, such as the structural organization of dental tissues, may introduce phylogenetic bias into dental wear data. Browsing and grazing perissodactyls produce different microwear than browsing and grazing ruminants. Perissodactyls evolved several derived enamel ultrastructures that may bias DW. Rhinocerotid enamel has decussating vertical and horizontal Hunter-Shreger bands (HSB) that, as a result of differential wear rates, generate regularly spaced serration-like ridges on occlusal edges. To investigate the interaction of this type of enamel structure with diet and other dental wear processes (microwear and mesowear), we measured hardness of vertical and horizontal HSB in extant rhino molars using a microindentation hardness tester, and we developed a four-point scoring system to evaluate the development of HSB relief on molar wear surfaces. We recorded the degree of relief (ranging from no relief to extreme relief) on the labial and lingual enamel bands of 310 M2s of extant African and Asian rhinos and extinct Miocene North American rhinos. Microindentation analysis found horizontal HSB to be significantly harder than vertical HSB in the extant grazing rhino (*Ceratotherium*), but no hardness differences were found among other species. Nonetheless all rhinos develop visible HSB relief suggesting that variation in HSB hardness alone does not fully explain HSB relief development. The degree of HSB relief is strongly associated with feeding ecology among living species, with the highest relief in the short-grass grazer (*Ceratotherium*), lower relief in the tall-grass mixed feeder (*Rhinoceros unicornis*) and open habitat browser (*Diceros*) and the lowest relief in the forest browsers (*Rhinoceros sondiacus* and *Dicerorhinus*). In both extinct and extant rhinos, HSB relief was significantly correlated to microwear (scratch density) and mesowear (cusp sharpness) taken from the same molars. These results suggest a strong link between HSB relief and dietary abrasion. The differential rates of wear among vertical and horizontal HSB are strongly associated with feeding ecology in rhinos, suggesting that enamel ultrastructure plays a significant role in DW processes. Because of the great structural diversity of mammalian enamel, we suggest that dental wear methods may not be as 'taxon-free' as has been widely assumed.

Preparator's Session (Thursday, October 27, 2016, 11:15 AM)

PROJECT AIRLESS: A LARGE-SCALE CROSS-DISCIPLINE PROJECT TO PROTECT FOSSILS FROM PYRITE DECAY THROUGH THE USE OF ANOXIC MICROENVIRONMENTS

MILES, Kieran, The Natural History Museum, London, United Kingdom; PORTER, Matthew, The Natural History Museum, London, United Kingdom

Airless is a three year project currently being undertaken by a small dedicated team at the Natural History Museum (NHM) in London, UK. The aim of the project is to ascertain how much of the museum's historic fossil and mineral collections are at risk of pyrite decay, and to take measures to conserve and protect these specimens. This involves conducting surveys of the collections to identify the location of all pyritic specimens, and assessing the severity of oxidation. The specimens are then allocated a unique barcode, photographed, and condition assessed. Following any necessary remedial treatment, the specimens are then placed in specially constructed anoxic microenvironments. In collaboration with data managers, conservators, curators, and other staff from across the

museum, the project merges large-scale preventative conservation with collection management and digitisation.

Pyrite, commonly known as 'fool's gold', is an iron sulphide mineral that can often be involved in fossilisation, or present in the surrounding matrix. In its microcrystalline form, the mineral can be prone to oxidation (often referred to as pyrite 'decay'). This chemical process is greatly affected by relative humidity, and can produce harmful by-products such as ferrous sulphates, sulphur dioxide and sulphuric acid. These can have destructive effects on specimens, labels, and storage media, and also pose health risks.

The initial remedial conservation treatments involve removing oxidation products by dry brushing and airbrasive techniques. For more severe pyrite oxidation, ammonia gas and ethanolamine thioglycollate treatments can neutralise the by-products. Following remedial treatments, specimens are re-boxed in conservation-grade materials before being sealed in anoxic microenvironments. The latter are constructed from gas barrier film which prevents oxygen ingress from the surrounding environment. Oxygen scavengers are placed inside the enclosure to remove any oxygen already present. Bespoke web-based applications are utilised to combine the high-quality condition photographs with the registration number, specimen and location barcodes, to create digital surrogates on the museum's collection management system. The barcoding system allows more efficient tracking of a specimen's location, and rapid association of condition and treatment data. To date, the team have processed over one thousand specimens using this method, including pterosaurs, ichthyosaurs, and fossil fish. Thousands more fossils will be processed by project completion.

Technical Sesssion X (Friday, October 28, 2016, 10:45 AM)

EMPIRICAL EVIDENCE OF A PROCESS THROUGH WHICH COPE'S "LAW OF THE UNSPECIALIZED" CAN BE BROKEN

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Alligatorines have mistakenly been called "living fossils, unchanged since the time of the dinosaurs". This has resulted in them being mostly ignored in studies of evolution. However, many extinct alligatorines, with their small bodies, short snouts, and globidont dentition, look dramatically different from their living counterparts. We use a newly-updated phylogenetic dataset for eusuchian crocodyliforms to run the most inclusive phylogenetic analysis of alligatorines to date, providing context through which to explore their ecomorphology and its potential to address questions of the nature of evolution. We conducted ancestral state reconstruction (ACR) for traits related to dietary niche and analyzed the growth curve of snout length vs. size. We then compiled co-occurrences with potential competitors. An almost fully-resolved topology within Alligatorinae was recovered, with several putative alligatorines not returned as such (e.g., *Eoalligator*) and others recovered within it (e.g., *Alligator luicus*). ACR returned Alligatorinae as ancestrally brevirostrine and small, in contrast to basal crocodyloids. They also initially possessed globidont dentition, which is taken to an extreme in some Eocene species and lost in derived members of the lineage including the extant species. These traits are consistent with specialization for a durophagous diet. In southern Florida, where crocodiles and alligators co-occur today, alligators tend to avoid confrontation with the more aggressively competitive crocodiles. Generalist crocodyloids co-occur with alligatorines during much of the Paleogene, but are extirpated from the former's range by cooling climate. The more cold-tolerant alligatorines persist in mid-latitude North America and, though there is a drop in taxonomic diversity, incrementally switch to a more generalist morphology. This is most fully realized in *Alligator mississippiensis*, the modern American alligator. The growth of relative snout length in *A. mississippiensis* is comparable to that of modern *Crocodylus* and achieved through a combination of all three forms of peramorphism relative to other alligatorines, with acceleration being the most influential. *Alligator* is an example of a lineage breaking Cope's "Law of the Unspecialized", being ancestrally specialized and evolving into a generalist form rather than going extinct. They were able to do this by filling a niche vacated by likely more aggressive crocodyloids due to the latter's inability to tolerate the change in climate as well as the former.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

THE "POWELL FOSSIL TRACK BLOCK": THEROPOD TRACKS WITH ORNITHOPOD-LIKE MORPHOLOGY FROM THE LOWER JURASSIC NAVAJO SANDSTONE FORMATION, GLEN CANYON NATIONAL RECREATION AREA, UTAH

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A large fallen block of Lower Jurassic Navajo Sandstone Formation was discovered in 2009 by visitors to Glen Canyon National Recreation Area and subsequently reported to the State Paleontologists Office at the Utah Geological Survey. The block is located along the eastern shore of Lake Powell in south-central Utah and preserves natural casts of vertebrate tracks on at least three track-bearing horizons. Two large parallel trackways on the lowest track horizon superficially resemble ornithopod tracks, but they were actually produced by theropods. The animals had walked upon substrate dominated by microbial mats and stromatolitic horizons. This, coupled with the compression of finer-grained layers to produce flattened tracks likely produced the distinct ichnomorphologic variation as a result of substrate consistency and the elastic properties of the microbial mats. In addition, another large theropod trackway on the same surface, made up of two shallow tracks, and another single, large track were probably made by the same ichnotaxon (cf. *Eubrontes*) as the ornithopod-like tracks. Track surfaces are preserved on and between stromatolitic horizons. These stromatolitic surfaces likely represent interdunal pooling of water probably as a result of increased precipitation and/or rise of the water table during wet seasons.

Twelve tracks in three trackways from medium-size theropods occur on the lowest surface. They superficially resemble *Kayentapus*. Small *Grallator* tracks produced by coelophysoid theropods are the most common track type on all track horizons with approximately 40 tracks preserved on the lowest surface. Both track surfaces have many unidentified tracks (probably theropod) and possible tracks preserved as circular or elongate depressions preserving no morphological details. The lowest surface also preserves four closely associated four-toed tracks that are tentatively identified as *Brasilichnium*. A nearby and associated block from the same stratigraphic levels also preserves *Batrachopus* tracks.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

THINKING INSIDE THE BOX: CONSTRUCTION OF INEXPENSIVE, LIGHTWEIGHT STORAGE CONTAINERS FOR MEDIUM-SIZED FOSSIL SPECIMENS

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Vertebrate fossil collections of the University of Michigan Museum of Paleontology are being moved from their campus home to a new off-site research and storage facility that utilizes mobile compact storage cabinets. Transfer of these collections necessitates construction of cradles and other storage devices for numerous fragile specimens, both for safe transport and long-term housing in the new facility. Methods for constructing large-scale cradles and encapsulating microvertebrates are established, but there are no consensus storage solutions for medium-sized specimens.

We developed a versatile, inexpensive protocol for building padded archival specimen boxes that can accommodate objects of varying shapes and dimensions—from sirenian skulls to long-spined Edaphosaurus vertebrae—providing distributed weight support and security for transport of objects between facilities and their long-term storage in mobile, compacted cabinets. Materials utilized include sheets of Coroplast™ twin layered, corrugated polypropylene, remnants and ¼" thick sheets of Ethafoam™, Tyvek® spunbonded polyethylene fabric, Paraloid™ B-72 acrylic resin and acetone in adhesive tubes, and polyester batting. Tools required are standard in collections facilities (e.g., scissors, hot glue gun, clamps, box cutter). Corrugated polypropylene sheets are cut to provide a base slightly larger than the dimensions of the specimen with attached cutouts to make vertical walls and flaps. Assembled, walls and flaps extend above the specimen, and are scored and sliced so that they overlap in corners. These are held together with hot glue and clamped until firm. Ethafoam™ cut to the shape of the specimen is used as an internal support base. This is topped with batting and covered with Tyvek® to reduce friction. The internal base and Tyvek® are glued to the bottom of the box with B-72. A scaffold of form-fitting cradle supports are then added around the specimen for stability. These are constructed of small Ethafoam™ blocks with support "pillows" of batting-filled Tyvek® attached using a groove-and-tuck technique.

The materials and methods to make these box cradles are readily accessible and produce a rugged, inexpensive mode of long-term protection for vertebrate fossils.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

FIRST ARTICULATED MULTITUBERCULATE SKELETON FROM THE LOWER CRETACEOUS KITADANI FORMATION (TETORI GROUP), FUKUI, JAPAN

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A skull associated with a postcranial skeleton of a Mesozoic mammal was discovered from Japan for the first time. The new fossil is from the Lower Cretaceous Kitadani Formation (upper part of the Tetori Group, Barremian and/or early Aptian) at Kitadani Quarry for dinosaur excavation, Katsuyama, Fukui Prefecture. Microfocus X-ray computed tomography (CT) scanning of the fossil in rock has revealed a partial skull and a partial postcranium of a multituberculate mammal in excellent three dimensional preservation. The new fossil has a nearly complete shoulder girdle, both forelimbs except for the left manus, vertebrae from the atlas to a possible second lumbar vertebra (7 cervicals, likely 13 thoracics, and possibly 2 lumbars), and a laterally compressed thoracic rib cage in articulation. The fossil also shows the distal condyles of a possible right femur. The CT scanning shows that the partial skull includes well-preserved petrosals and some middle ear structure. The preserved posterior parts of the cranium and dentaries have intact left upper and lower molars (M1–2 and m1–2) with the labial-lingual cusp formulae: 3:4 (M1), 2:3 (M2), 3:2 (m1), and 1:2 (m2), respectively. The posterolingual wing (cusp) is absent on M1, a plesiomorphy of more basal multituberculates. M2 has a trapezoidal occlusal outline and shows a depressed anterior margin and a shelf-like mesiolabial wing. The lower m2 shows a more derived feature of a coalesced, long labial cusp, lingually ornamented with three visible notches. The Kitadani multituberculate represents a new taxon, distinguished by molar characters from paulchoffatiids, arbinobaatarids, arginbaatarids, and cimolodontans. Among known multituberculates, it shows more similarity to eobaatarids, but certainly is a new taxon, being larger in molar size than the known eobaatarids, except for *Liaobaatar*. Because most of Early Cretaceous multituberculates are known from the less well-preserved materials, the new fossil is very significant in its well-preserved basicranium, shoulder girdle, forelimb, and vertebral column. Multituberculates are the most abundant group of Mesozoic mammals, known for diverse ecomorphologies and great morphological evolution. The new fossil will be of critical importance for estimating the relationship of derived cimolodontans with other basal multituberculate clades and in elucidating the evolution of the adaptive diversification of multituberculates during the Early Cretaceous.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

COMPARISON BETWEEN TERRESTRIAL MAMMAL ANKLE JOINT AND FOOT BONE MORPHOLOGY

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Mammals have greatly diversified not only in the number of species but also in their limb postures. Limb posture plays an essential role in locomotor behavior; therefore, it is important to reconstruct limb posture in extinct animals to better understand the evolution of locomotor strategies. However, reconstruction of limb posture in extinct taxa remains a challenging task, mainly because of our poor knowledge about relationships between posture and bone morphology, even in extant taxa. In an effort to make the reconstruction of limb posture in extinct taxa more reliable, we studied the ankle joints of terrestrial mammals, which contribute to sagittal hind limb posture. In the stance phase of digitigrade/unguligrade posture, the ankle joint angle is supported by the ankle extensors, which insert on to the heel bone (calcaneal) lever. The moment arm of the extensor is maximized at an angle where the shaft of the calcaneus and the extensor are perpendicular to each other. This angle (estimated angle: EA) can be estimated from the bone geometry. We videotaped the locomotion of several extant mammal taxa (Carnivora; Perissodactyla; Cetartiodactyla; Diprotodontia; Lagomorpha) and determined the ankle joint angles (observed angle: OA) on the stance phase. The difference between EA and OA were less than 30°. This result indicates that pedal bone morphology can be used as a powerful tool to estimate the ankle joint angles of extinct terrestrial mammals.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

EVOLUTIONARY HISTORY OF LATE JURASSIC SAUROPODS OF THE LUSITANIAN BASIN (PORTUGAL) AND PRESENTATION OF A NEW BASAL MACRONARIAN FORM

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Sauropods are a well-represented group in the Upper Jurassic of Portugal, represented by four taxa: *Zby atlanticus*; *Dinheirosaurus lourinhanensis*; *Lourinhasaurus alenquerensis* and *Lusotitan atalaiensis*. However, the recent systematic review of older specimens as well as the discovery of several new ones (including partial skeletons) allows recognition of a higher diversity for this group and improves the understanding of the Iberian Late Jurassic sauropod faunas.

The systematic study of the sauropod fossil record of the Upper Jurassic of the Lusitanian Basin is performed here, based on a new phylogenetic analysis. It includes, for the first time, all Late Jurassic-basal Cretaceous sauropod taxa from both Portugal (*Lourinhasaurus*, *Dinheirosaurus*, *Zby* and *Lusotitan*) and Spain (*Turiasaurus*, *Aragosaurus*, *Losillasaurus* and *Galveosaurus*) and two new specimens: SHN 181 and SHN (JJS) 177. SHN 181 (from Lourinhã, Portugal) represents a new basal macronarian taxon featured by an exclusive combination of characters.

The proposed phylogenetic hypothesis is based on a dataset composed by 95 taxa and 464 morphological characters. The results of the phylogenetic analysis support that: i) *Zby* is a turiasaur more closely related to *Turiasaurus* than *Losillasaurus*; ii) Turiasauria is clade of non-neosauropod eusauropods more derived than Mamenchisauridae and composed by three Iberian taxa; iii) *Dinheirosaurus* is a diplodocine more derived than *Supersaurus*, *Tornieria* and *Kaatedocus*; iv) SHN (JJS) 177 is a diplodocine more closely related to *Diplodocus* than to *Barosaurus*, supporting the presence of more than one diplodocine in the Portuguese Late Jurassic; v) *Lourinhasaurus* is a camarasaurid, sister taxa of *Camarasaurus*; vi) Camarasauridae is a monophyletic clade; vii) *Lusotitan* is a brachiosaurid titanosauriform; viii) SHN 181, is a new basal macronarian more derived than *Aragosaurus* and more primitive than *Europasaurus* + Titanosauriformes.

The relationship of the Portuguese sauropods with taxa from the North American Upper Jurassic Morrison Formation is less close than that interpreted from other dinosaur groups. Diplodocines and camarasaurids of the Upper Jurassic record of Portugal are more closely related to those of the Morrison Fm. in the USA, than to the Gondwanan representatives. The closer relationship among Portuguese and North-American forms can be explained by the recent common history of these territories. On the other hand, Turiasauria is probably so far restricted to the European territory during the Late Jurassic.

Grant Information
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Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

AN ORNITHURINE CORACOID FROM THE LATE CRETACEOUS OF ALBERTA, CANADA

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The clade Ornithurae is the most abundant and diverse avian group in the Late Cretaceous of North America and includes taxa such as *Hesperornis* and *Ichthyornis*, as well the group comprising of modern birds, Neornithes. Diagnosis and systematic relationships are difficult to determine as many ornithurine birds are represented by incomplete material. Cretaceous bird material particularly in Alberta is fragmentary and often unidentifiable, although the majority of determinable specimens have been assigned to Ornithurae. Many ornithurine birds are Maastrichtian in age, and detailed examination of Campanian material from Alberta will provide valuable information on Late Cretaceous avian diversity and the evolutionary transition of neornithine birds.

We describe a partial avian coracoid from the upper Campanian Dinosaur Park Formation (77–75.5 Ma), Dinosaur Provincial Park, Alberta, Canada. It is assigned to Ornithurae based on a set of distinct characteristics, including the presence of a procoracoid process, an anteriorly-projecting glenoid, and a concave scapular cotyle. The coracoid head is over 10 mm in length, and is one of the largest of similar examples from other localities in North America. Structurally it bears particular resemblance to the fossil anseriform *Anatalavis oxfordi*, as well as several unnamed derived ornithurine coracoids from Alberta and other localities from the Maastrichtian of North America, including those belonging to the genus *Cimolopteryx*. A comparison of these elements indicates that the Dinosaur Park coracoid is a separate taxon. CT scans of the coracoid revealed potential pneumatism, allowing for a possibly more precise diagnosis as a neornithine bird. It could represent one of the first recognized Cretaceous neornithine birds in Alberta, and offer insight into the evolutionary time frame of Neornithes. However, earlier systematic analyses including derived ornithurine and neornithine coracoid material were largely unresolved. A new preliminary phylogenetic analysis consisting of coracoid characters confirms the Dinosaur Park specimen belongs to a distinct taxon and recovers it in a polytomy with neornithine birds, as many taxa are fragmentary and tend to code similarly for multiple characters. The addition of new characters may help to resolve currently uncertain relationships amongst the Dinosaur Park coracoid and other similar specimens.

Technical Session VI (Thursday, October 27, 2016, 9:45 AM)

STABLE ISOTOPE VARIABILITY IN EXTANT AND EXTINCT FAUNIVORES: IMPLICATIONS FOR UNDERSTANDING NON-HERBIVOROUS MAMMALIAN ECOLOGY ACROSS TIME SCALES

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Little is known about how dietary differences in small faunivorous mammals are reflected in stable carbon and oxygen isotopes. Thus, it is vital to obtain a baseline in modern faunivores for interpretation of extinct species. In this analysis, carbon and oxygen isotope ratios are measured from extant faunivorous British mammals and faunivorous genera of Paleocene mammals from the San Juan Basin of New Mexico. We seek to reveal any dietary variability in small to medium sized non-herbivorous mammals in extant communities to better understand isotope variability in the fossil record.

Data from modern British mammals show a separation of oxygen and carbon isotope values between species in this temperate ecosystem. Carbon isotope ratios are distinct between species and range from -16.9 ‰ (American mink) to -12.9 ‰ (hedgehog), reflecting the primary vegetation isotope ratios of the forest environment. Oxygen isotopes are also distinctly variable, ranging between -7.0 ‰ (badger) to -3.9 ‰ (least weasel). Overall, results indicate distinctly different habitat usage among the British taxa. Stable isotope data from contemporaneous herbivores, such as rabbits, are also compared to try and discern any systematic isotopic offsets between average plant isotope values and values in faunivores.

Carbon isotope values (mean, -12.42 ± 0.04‰) from the fossil specimens lack any strong indication of dietary partitioning in post-hoc tests between pairs of genera but are significantly different overall (ANOVA, $p = 0.03$). Carbon isotope values are also similar to average values of contemporaneous fossil herbivores. There appears to be homogeneity when considering the faunivore oxygen isotope ratios (ANOVA, $p = 0.21$), which could reflect drinking behavior and/or the general environment in which the animals lived. The overlap in carbon isotope ratios could be a potential indicator for generalist, overlapping dietary categories between genera. Future work will explore correlations of modern stable isotope ratios with variables such as body size, physiology, and ecology to better understand variation in the fossil specimens.

Grant Information
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Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

A COMPREHENSIVE, TIME-CALIBRATED PHYLOGENY OF THE DIVERSE 'WATERBIRD' ASSEMBLAGE INFERRED USING BAYESIAN TOTAL EVIDENCE METHODS

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Although the relationships of major neoavian groups have remained notoriously difficult to resolve, consensus is emerging across studies in support of a large 'waterbird' clade. This diverse assemblage of aquatic and semi-aquatic birds includes most members of the traditional Pelecaniformes (pelicans, frigatebirds, gannets, boobies, darters, cormorants), Ciconiiformes (storks, herons, ibises, Shoebill, Hamerkop), Procellariiformes (tube-nosed seabirds), Sphenisciformes (penguins), and Gaviiformes (loons). However, phylogenetic hypotheses for the group vary considerably across studies differing in data type and taxon sampling, hindering analyses of trait evolution in this diverse lineage.

We apply Bayesian phylogenetic methods that incorporate fossils as tip taxa to a combined matrix of 660 morphological characters and 14,497 basepairs from 12 genes for 174 taxa (117 living, 57 fossils). Importantly, we assess the phylogenetic affinities of the Plotopteridae — an extinct lineage of wing-propelled diving birds often interpreted as convergent with penguins — alongside a dense sampling of stem and extant penguins.

Equal weights parsimony analysis of morphology recovers Plotopteridae as sister to Sphenisciformes and places the flightless Galapagos Cormorant (*Phalacrocorax harrisi*) at the base of Phalacrocoracidae. Calibrated Bayesian analysis of morphology supports plotopterids as stem penguins and recovers *P. harrisi* as well-nested in Phalacrocoracidae; the latter hypothesis is also supported by molecular and combined data, suggesting morphological models can be more robust to homoplasy than parsimony. Results from preliminary total evidence, time-calibrated Bayesian analyses must be interpreted with caution, as several parameters show low effective sample sizes. Nevertheless, these initial results place plotopterids in 'core' Pelecaniformes, weakly support the putative suliform *Mangystania* as a stem tropicbird, and recover *Oligocorax* as sister to extant cormorants. Divergence times for several nodes do not differ substantially between total evidence and root-calibrated molecular analyses, but the range of the 95% Highest Posterior Density interval on node age narrows in a total evidence framework.

This study highlights the potential utility of morphological models, temporal information and molecular data in resolving morphological character conflict and indicates that taxon sampling, character sampling and model adequacy remain major hurdles to achieving consensus in avian phylogenetics.

Grant Information
Support: Cosmos Club and NSF grant DGE 1246908 to AJM

Technical Session VI (Thursday, October 27, 2016, 10:30 AM)

VERTEBRATE PALEONTOLOGY AND TAPHONOMY IN A DISTRIBUTIVE FLUVIAL SYSTEM FRAMEWORK: A NEW MODEL FOR STUDYING TERRESTRIAL FOSSIL SEQUENCES

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There is increasing evidence that most modern fluvial systems, deposited in degradational settings, provide poor analogues for fluvial systems in the rock record that will have been deposited in aggradational settings. A more appropriate model to understand the facies distributions and depositional processes of such deposits may be that of Distributive Fluvial Systems (DFS), a term used to describe features such as alluvial fans and fluvial megafans, which cover large parts of modern sedimentary basins. Recognition of these differences may change our understanding of the taphonomic and paleoecologial patterns exhibited by most fossil assemblages from terrestrial fluvial environments.

DFS sediment packets are predicted to show a consistent drying-upwards pattern as coarser, proximal deposits prograde over finer distal deposits. Any lengthy DFS fossil successions should reflect this trend with a shift from more water-dependent taxa to more arid-tolerant taxa up section, which will be diachronous across the DFS. Eocene–Oligocene faunal data support such a trend for the White River System DFS in WY, NE, and SD.

Unlike tributary systems, where stream order increases downstream, channels in a DFS commonly become smaller and more dispersed distally from the apex. Additionally, as deposition in a DFS is not constrained to a valley, reworking may be concentrated in proximal deposits, with distal deposition building alluvial ridges and filling accommodation through avulsion, rather than incising. Two-dimensional sedimentological modeling of extra-sedimentary basin tributary systems vs. DFS shows that these properties lead to different patterns of fossil concentration and residency within the taphonomically active zone (TAZ), with contingent taphonomic and paleoecological implications.

Finally, distal-most DFS environments can be extremely extensive (100s of kilometers in length and 10s to 100s of kilometers in width) and uniform in channel and interfluve morphology. Fossil assemblages sampled from these distal-most deposits should show a greater degree of temporal and spatial uniformity than many modern ecosystems. Examples of such deposits include the Hell Creek/Fort Union Formations of MT, WY, SD, and ND, and eastern exposures of the White River System.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

PRINCIPAL COMPONENT ANALYSIS OF VARIABLES OF THE LOWER 3RD PREMOLAR OF *AZTLANOLAGUS AGILIS* (MAMMALIA, LAGOMORPHA)

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Fossil leporids are defined based on the enamel pattern morphology of the lower 3rd premolar (p3). While providing a basis for comparison and taxonomic diagnosis, standard p3 measurements fail to characterize quantitatively the observed qualitative variation in pattern form. This variation exists among related taxa and within individual species. *Aztlanolagus agilis* is a Pleistocene rabbit that exhibits notable qualitative variation throughout its chronologic range. While enamel crenulations have been used to characterize this chronologically progressive variation, the degree of crenulation is not reflected in standard p3 measurements. Further, observed variation in the *A. agilis* pattern form extends to variables beyond crenulation complexity. Descriptions and counts of crenulations, therefore, fail to characterize the broader morphologic change occurring through time in the p3 pattern. A combined sample of 26 p3s have been subjected to a principal component analysis (PCA) in an attempt to identify enamel pattern features that comprehensively characterize the observed temporal variation in *A. agilis*. PCA results indicate that two retained components characterized 83% of variance. These principal components are interpreted as an anteroposterior (AP) length/transverse (TR) width component and an anterointernal reentrant (AIR)/posteroexternal reentrant (PER) depth component. Overall p3 size is correlated with reentrant depth and these PC1 and PC2 gradients (AP length/TR width and AIR/PER depth) collectively represent the majority of variation observed in p3 pattern form. The emphasis placed on the AIR/PER by the PCA is concordant with the significance placed on these reentrants in characterizing *Aztlanolagus*.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

REVISION OF POLYCOTYLID PLESIOSAUR SYSTEMATICS (SAUROPTERYGIA, PLESIOSAURIA) AND DESCRIPTION OF THE AXIAL OSTEOLOGY OF THE WALLACE RANCH POLYCOTYLIDS

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The polycotylids were a clade of plesiosaurs that proliferated during the Cretaceous period. Despite recent research efforts, evolutionary relationships among polycotylid species remain unresolved. In this study, a phylogenetic analysis incorporating a large taxon sampling from the Polycotylidae was used to parse out the evolutionary relationships among the taxa. The main focus was to assign two polycotylid specimens from the Wallace Ranch to a formal species. A study on the axial osteology of the juvenile Wallace Ranch polycotylid was also performed, as the development of the axial column of a polycotylid plesiosaur has been poorly understood and may have phylogenetic implications. This study revealed that the two Wallace Ranch specimens form a well-supported clade, and feature a mosaic of character states found in currently described species, and may represent a new species. The monophyly of the genus *Dolichorhynchops*, was not supported in the current analysis. *D. bonneri*, *D. tropicensis*, and the Wallace Ranch specimens are more closely related to *Trinacromerum*. Therefore a formal re-description of the two genera *Dolichorhynchops* and *Trinacromerum* is required. The study also revealed that the three skeletons attributed to the species *Polycotylus latipinnis* do represent members of the same species. However, the study did not support the close relationship between *D. bonneri* and *P. latipinnis*, and that the similarity seen between the two species is attributed to a convergence in large body size. The cranial osteology of the juvenile Wallace Ranch polycotylid provides a rare insight into the development and fusion pattern of a polycotylid skull, and reveals some possible ontogenetic characters, which should be excluded from future phylogenetic analyses. After analyzing the axial osteology of the juvenile Wallace Ranch specimen, the individual was most likely a neonate at the time of death. The understanding of the morphological changes during ontogeny provides better insight into intraspecific variation in a polycotylid species. The current study revealed that Polycotylidae feature a basal clade, a polyphyletic genus *Dolichorhynchops,* with an expanded *Trinacromerum*, and supports the previous assignment of three specimens to the species *P. latipinnis*.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

FIRST OCCURRENCE OF AN ARKANSAS ANKYLOSAUR

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The state of Arkansas is not known for its dinosaur fossils. To date, only one body fossil has been documented, that of the coelurosaurian *Arkansaurus fridayi*, discovered in 1972 by J.B Friday in a gravel pit near Lockesburg, Arkansas. The Cretaceous beds of Arkansas crop out in the southwest of the state and consists predominately of an on-lap of sand, clay, and marl that rest uncomfortably on faulted and eroded Palaeozoic beds. This area has previously yielded copious dinosaur trackways as well as vertebrate remains including turtles and crocodiles. Here we describe the first occurrence of an ankylosaurian dinosaur to be recovered from the state, consisting of a caudal plate, a small spine, and several osteoderms. It was recovered by Jeff Pittman from a plant-rich horizon at the top of the lower Cretaceous Holly Creek Formation, which crops out at Briar Quarry near Murfreesboro, Arkansas. The age of the formation ranges from late Aptian into the early Albian, about 115-105 million years old.

Histological analysis will determine whether the material belongs to a polacanthid or a nodosaurid type ankylosaur. Previous studies have shown the two families to have distinct internal morphologies that can be of systematic value. Polacanthids typically display a thicker layer of cortical bone completely surrounding the inner cancellous bone, whereas nodosaurs only exhibit a cortex on the external surface of osteoderms, forming a flattened base with a larger internal area of spongy cancellous bone underneath. Comparisons between the armor of ankylosaurs is being increasingly recognized as a method of highlighting differences in ankylosaur specimens, particularly with regard to the Polacanthidae. Using imageJ we will conduct a shape analysis of various ankylosaur caudal plates in order to isolate patterns in an attempt to constrain a genus for the specimen.

Romer Prize Session (Thursday, October 27, 2016, 9:30 AM)

PALEONEUROLOGY OF ARCHOSAURS IN THE 21ST CENTURY: NEW ANATOMICAL AND STATISTICAL APPROACHES SHED LIGHT ON THE COMPLEX EVOLUTIONARY HISTORY OF NON-AVIAN DINOSAUR BRAINS

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Since its inception, paleoneurology has shown the value of studying brain evolution in extinct taxa, revealing the complex history of neurological change and associated cognitive and behavioral innovation. Brains almost never fossilize, and thus vertebrate paleoneurology relies on fidelity between the brain and its surrounding endocranial cavity wall, which is reflected on an endocast for study. However, if the brain fails to fill the cavity in life, a resultant endocast may lack clear evidence of brain size and shape. Due to poor brain-filling in life, many non-avian dinosaur endocasts lack evidence of brain impressions. Previous quantitative studies of dinosaur brain size corrected for brain-filling discrepancies by reducing endocast volumes by some percentage. However, corrections were often subjective. Additionally, past whole-brain studies masked underlying regional changes that 1) contributed to overall relative brain-size change and 2) provided functional information. A new approach, Gross Anatomical Brain Region Approximation (GABRA), permits study of archosaur brain and brain-region size and shape, even when endocasts lack details of the brain itself. GABRA uses anatomical landmarks on virtual endocasts as criteria for delimiting underlying brain regions. GABRA criteria are validated osteological correlates of endocranial soft tissues (e.g., cranial nerves, blood vessels) that provide consistent topological information for brain regions. Following GABRA assessment of the endocast, brain regions are modeled within it, providing volumetric estimates, which, when summed, offer a whole-brain estimate. Such data from several dinosaurs have permitted analyses using modern comparative methods of relative brain-size evolution (e.g., encephalization quotient), with results indicating that brain sizes for many dinosaurs were previously underestimated. Additionally, analyses of GABRA data show a mix of concerted and mosaic patterns of brain evolution, wherein olfactory bulbs and optic lobes emerge as evolving independently from the rest of the brain, often with functional implications. Finally, evolutionary-rate studies of GABRA brain regions show complex changes across lineages over time, including several independent instances of cerebral expansion. In sum, GABRA provides insight into how brains evolved across dinosaur lineages. Future studies will examine within-lineage changes, offering greater insight into how and why dinosaur brains evolved.

Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

ECOLOGICAL RESPONSE OF SMALL-MAMMAL ASSEMBLAGES TO ENVIRONMENTAL CHANGE OVER THE MIOCENE CLIMATIC OPTIMUM IN SOUTHERN CALIFORNIA

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Rich small-mammal assemblages from the Cenozoic of North America allow us to investigate ecological and evolutionary responses to environmental change over geologic time. We evaluated two records of small-mammal faunas from the Crowder and Cajon Valley formations, southern California, to assess how increasing temperature and aridity during the Miocene Climatic Optimum (MCO; 17–14 Ma) influenced basin-scale environmental conditions, small-mammal paleoecology and community assembly. Using cheek teeth from these small-mammal faunas, we measured two dental metrics, hypsodonty index and occlusal area, and used in situ laser ablation mass spectrometry to sample the carbon and oxygen isotopic composition of tooth enamel. Dental traits and isotopic composition reflect aspects of an animal's body size and diet, thus allowing us to evaluate changes in small-mammal paleoecology through the MCO.

Within both formations, we found stable values in carbon and oxygen isotopic composition, occlusal area and hypsodonty index through time. These results indicate remarkable ecological stability in each basin during the MCO. In contrast, we found significant differences in isotopic composition between the Crowder (17–16 Ma) and Cajon Valley (16–13.7 Ma) faunas, implying differences in small-mammal diet from adjacent basins over extended geologic time. The isotopic composition of rodents from these formations suggests an early regional presence of C_4 grasses with increased consumption of this resource among younger Cajon Valley faunas. With small home ranges and rapid metabolism, rodents document available vegetation at fine temporal and spatial scales and, therefore, provide unique information about habitat heterogeneity and the patchy presence of C_4 resources prior to C_4-grassland expansion in the late Miocene. There is little evidence to suggest significant ecological differentiation based on isotopic composition and dental traits among co-occurring rodents within Crowder and Cajon Valley assemblages. This contrasts with modern desert rodent assemblages in which heteromyid species differ significantly in isotopic composition, body size and hypsodonty. These results indicate differences in community assembly during the MCO, when we find greater ecological similarity among co-occurring species than we find in modern ecosystems. Divergence in ecological and morphological traits among heteromyids following the MCO may have led to the strong interspecific differences found in present-day communities.

Grant Information

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Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

A NEW PHYLOGENETIC AND BIOGEOGRAPHIC ANALYSIS OF BASAL NEOCERATOPSIA (ORNITHISCHIA, DINOSAURIA) RECOVERS UNCERTAIN GEOGRAPHIC ORIGIN OF CERATOPSOIDEA

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The phylogenetic relationships of neoceratopsians have been well studied in recent years, however, new species continue to be described with some regularity. An updated parsimony-based phylogenetic analysis of 32 taxa and 230 characters was conducted to include several newly described taxa and characters. The strict consensus tree recovered *Liaoceratops* as the most basal neoceratopsian, in contrast to other recent analyses that have recovered *Aquilops*, or the unusual genus *Mosaiceratops*, at the base of neoceratopsia. *Mosaiceratops* displays a strange combination of some characters otherwise only seen in *Psittacosaurus* and basal ceratopsians, and other more derived characters seen in neoceratopsians, such as *Liaoceratops*, *Archaeoceratops*, and *Yamaceratops*. This analysis recovers *Mosaiceratops* as deeply nested in Neoceratopsia and sister to *Yamaceratops*. This placement is more stratigraphically congruent than a more basal position given the proposed Turonian to Campanian age of *Mosaiceratops*, compared to Aptian-Albian ages for *Psittacosaurus* and a number of basal neoceratopsians. Additionally the fragmentary European ceratopsian *Ajkaceratops* is recovered within Ceratopsoidea, in contrast with some recent analyses that recover it as a sister-taxon to *Bagaceratops*.

The Dispersal-Extinction-Cladogenesis (DEC) model was used to evaluate the biogeographic implications of this new tree topology. The DEC model uses information about the geographic and temporal range of terminal taxa and maximum likelihood to estimate the likelihood of ancestral ranges at branch points. This analysis recovered an Asian origin for most ceratopsian clades. It also reconstructed an Asian origin for Leptoceratopsidae, while most of the ancestors of clades in Leptoceratopsidae spanned Asia and North America. Both points agree with previous results. The range of the ancestors of Coronosauria, Ceratopsoidea, and a clade including Coronosauria and the enigmatic specimen ZPAL MgD I/156 (type specimen of *Gracilicera tops*) all had conflicting reconstructions, with a plurality between ranges that spanned Asia and either Europe or North America. The uncertainty at these nodes is likely driven by the placement of *Ajkaceratops* as the most basal Ceratopsoid. Previous work strongly indicates Asian origins for all three clades. These results highlight the need for further fossil material from the Cenomanian through the Santonian to clarify the migration and radiation of the speciose Latest Cretaceous Ceratopsian clades.

Technical Session VIII (Thursday, October 27, 2016, 2:15 PM)

MORPHOLOGICAL VARIATION IN THE OLDEST NORTH AMERICAN EUPRIMATE, *TEILHARDINA BRANDTI*, AND ITS IMPLICATIONS FOR EARLY PRIMATE EVOLUTION

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The oldest fossil euprimates from North America include adapoids (*Cantius*) and omomyoids (*Teilhardina*) that appear during a major global warming event known as the Paleocene–Eocene Thermal Maximum (PETM) ~56 Ma. *Teilhardina* had a Holarctic distribution during the earliest Eocene, represented in North America by *T. brandti*, *T. gingerichi*, and *T. magnoliana*, in Asia by *T. asiatica*, and in Europe by *T. belgica*. Specific relationships and dispersal routes among continents are disputed, in part due to small sample sizes and fragmentary specimens. Over a decade of fossil collecting from PETM sections in the southeastern Bighorn Basin, Wyoming, has resulted in recovery of an additional 138 dental specimens of *T. brandti*, allowing for a new assessment of morphological variation. The M_1 crown linear dimensions of *T. gingerichi* (n = 1) are outside the range of *T. brandti* (n = 21) and more than two standard deviations from the sample mean, consistent with its diagnosis as a separate species based on larger size. The P_4 metaconid of *T. brandti* (n = 10) is also consistently higher than that of *T. gingerichi* (n = 1), although the range of variation in this character overlaps with that of *T. belgica*, *T. magnoliana*, and *T. asiatica*, and its measurement is sensitive to wear. Two dentaries of *T. brandti* (UF 333700 and UF 254929) are the only known to preserve alveoli for single-rooted P_1 and P_2. UF 254929 has a small and buccally displaced P_1, similar to that of *T. belgica* and younger *T. americana* (occasionally lacking the P_1 entirely), while UF 333700 has a P_1 alveolus that is enlarged and in line with that of P_2, most similar to that of *T. asiatica* (n = 1). UF 333700 has P_1 and P_2 alveolar areas that are absolutely and relatively larger, when standardized to M_1 crown area, than those of any previously described specimen of *Teilhardina*. Among species of *Teilhardina*, *T. asiatica* has been argued as most primitive based on the relatively large size of its P_1, position of the P_1 in line with P_2, loose spacing separating these teeth, and a relatively low P_4 metaconid. The new sample of *T. brandti* shows that neither the size or position of P_1, nor the height of the P_4 metaconid, are unique to *T. asiatica*. While the anterior premolar teeth of UF 333700 are not loosely spaced as in *T. asiatica*, their large and in-line positions relative to the rest of the tooth row bear a resemblance to *T. asiatica* not shared by *T. belgica* or *T. americana*. This similarity lends support to the hypothesis of a rapid dispersal of *Teilhardina* into North America from Asia during the PETM and subsequent dispersal into Europe from North America.

Grant Information

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Technical Session XVII (Saturday, October 29, 2016, 10:45 AM)

TESTING SEXUAL SELECTION OF FOSSIL VERTEBRATES WITH SEXUAL SIZE DIMORPHISM AND ADULT SEX RATIO, WITH AN EXAMPLE OF *KEICHOUSAURUS HUI* (REPTILIA, SAUROPTERYGIA)

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Sexual selection is a mechanism that is often invoked when interpreting the evolution of fossil vertebrates but is notoriously difficult to test. We propose to use sexual size dimorphism (SSD) and adult sex ratio (ASR) to test hypotheses of sexual selection, and provide a test case using *Keichousaurus hui*, a small sauropterygian marine reptile from the Ladinian of southwest China. Males have enlarged and more robust forelimbs than females in this species, as in some modern salamanders that exhibit amplexus behaviors during courtship. Given that the enlarged forelimb is considered to have been sexually selected in these salamanders, we hypothesize that it was also sexually selected in *K. hui*. We tested this hypothesis with SSD and ASR, both of which have been suggested to correlate with sexual selection in extant vertebrates. The accuracy of these metrics largely depends on that of sexing of fossil specimens, whereas the existing sexing method, based on skeletal ratios of secondary sexual characters, does not account for scaling of the threshold ratio with size. We therefore started by implementing a new multivariate approach for sexing specimens from skeletal measurements of secondary sexual characters. The resulting sex sets of individuals (n= 86 in total) suggested that SSD was weakly skewed toward males while ASR was slightly female dominated. Male-biased SSD is a common feature of extant amniotes that are sexually selected, for which it has been suggested that larger males tended have higher mating success. The female biased ASR is also observed in sexually selected species of squamates. It suggests higher mortality rate in males than females because the sex ratio at birth is expected to have been neutral on the basis of a previous study that concluded sex determination in Sauropterygia to have been genetic. The high male mortality rate may reflect increased injuries through male-male competition, as well as predation caused by display behaviors and added foraging efforts to grow larger. To summarize, both SSD and ASR support the hypothesis of sexual selection in *K. hui*. We also used Gompertz allometric equation to examine the changing growth rates of secondary sexual features in *K. hui* that cannot be captured by the standard allometric equation. The result suggested that most of the features were not pronounced at birth but exhibited accelerated growth toward sexual maturity, after which growth decelerated, as expected in secondary sexual characters.

Symposium I (Wednesday, October 26, 2016, 10:45 AM)

MICROSCOPIC AND MOLECULAR PRESERVATION OF EPIDERMALLY DERIVED FOSSILS

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Fossils of epidermally derived tissues originally composed of keratin, such as skin, claws, beaks and feathers, have been found in association with dinosaurs since the mid-1800s. However, most of these fossils have only been examined macroscopically. The frequency with which these types of fossil are discovered and/or described is inversely proportional to their significance for understanding the biology of these long extinct animals. Because non-biomineralized tissues are generally subject to rapid degradation, the preservation of these soft tissue structures supports their stabilization prior to complete degradation. The primary structural protein comprising these structures in sauropsids is beta-keratin. The hydrophobic core of the molecule, as well as incorporation of the sulfur-containing amino acid cysteine which participate in disulfide crosslinks makes beta-keratin a rigid and resistant molecule; thus a good target for molecular paleontological studies. I employed electron microscopy and *in situ* immunohistochemical methods to analyze modern samples from taphonomic experiments, as well as fossil specimens for the retention of microscopic and molecular features. I used the resulting data to : 1) test alternative hypotheses regarding the origin of microbodies observed in fossils, primarily feathers, as bacteria or the pigment-containing organelles, melanosomes, 2) monitor degradation processes affecting modern feathers in varying temperature and moisture conditions, 3) validate a previous study supporting the keratinous nature of hollow filaments associated with an articulated skeleton of *Shuvuuia deserti*, and 4) characterize claw material from the ungual of the breeding oviraptor, *Citipati osmolskae*. These studies show that despite the passing of millions of years, these fossils preserve microscopic features and molecular responses similar to extant analogs. Furthermore, bio-mediated mineral precipitation is supported as an important preservational mode for these fossils. I also addressed how changes induced by diagenesis present a challenge for sample preparation for these analytical methods, which must be accounted for and customized in all analytical studies of fossil tissues. Future studies will provide insight into the strategies and evolutionary features used by the ancestors of present-day archosaurs, especially the early history of beta-keratin evolution and distribution, which remains largely unknown and can only be *directly* elucidated by fossils.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

A DIVERSE LATE TRIASSIC (NORIAN) TETRAPOD FAUNA AND TAPHONOMY OF MOTT VPL 3869 FROM THE TECOVAS FORMATION (DOCKUM GROUP) IN GARZA COUNTY, TEXAS, USA

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Sampling single localities in the Dockum Group over decades scale has illuminated high diversity in important time slices with the Triassic Period. One locality, MOTT VPL 3869, has been collected diligently for the past 16 years with over 200 visits to the locality. The locality occurs in the lower portion of the Late Triassic Tecovas Formation (Norian) of the Dockum Group in southeastern Garza County, Texas. The locality covers approximately 0.4 km^2 and has a total Tecovas Formation section of 28 m. The lower 4 m of section are comprised of lacustrine deposits and the upper 24 m of section are comprised of flood plain deposits. Fossils collected at the locality were found mostly as isolated elements. The locality has produced a diverse variety of tetrapod taxa including complete to near complete "*Metoposaurus*" *bakeri* skulls, a number of partial dicynodont skulls and isolated elements, a single element of a ?Eucynodont, and a procolophonid. The most abundant and taxonomically diverse group of taxa that the locality has produced is the archosauromorphs. MOTT VPL 3869 has produced remains of early archosauromorphs including drepanosaurids, tanystropheids, *Malerisaurus*, trilophosaurids, *Vancleavea*, and *Doswellia*. Three basal phytosaur taxa have been collected from the locality. Aetosaurs are not common at MOTT VPL 3869 but they do occur there. MOTT VPL 3869 has also produced a variety of paracrocodylomorphs including *Shuvosaurus*, *Poposaurus*, *Postosuchus* and an indeterminate crocodylomorph. Dinosauromorph taxa are represented by *Dromomeron* and two theropod taxa. Some of these taxa (e.g., dicynodont skulls, ?Eucynodont) recovered from the locality are exceedingly rare in the Dockum Group.

Vertebrate specimens are found throughout the locality in different paleoenvironments. Two of the phytosaur taxa have been collected from the flood plain deposits whereas the third taxon has been collected from both lacustrine and flood plain deposits. A phytosaur skull in the flood plain sediments had the posterior portion of the skull disarticulated prior to burial whereas the anterior portion of the skull remained intact. One partial dicynodont skull was found imbedded in paleo-mud cracks. There was a variety of taxa that were washed into the lacustrine basin with a crevasse splay. MOTT VPL 3869 has produced a diverse fauna in a variety of paleonenviroments in the past and will continuing to produce interesting tetrapod fossils

Poster Symposium I (Wednesday–Thursday, October 26–27, 2016, 4:15–6:15 PM)

GEOGRAPHIC PATTERNING IN MAMMAL COMMUNITY DYNAMICS ACROSS THE WASATCHIAN–BRIDGERIAN BOUNDARY AT SOUTH PASS, WYOMING

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Basin margins are hypothesized to provide heterogeneous habitats conducive to evolutionary innovation. Basin margin samples have also been discussed as evidence of upland refugia as competitor taxa appeared in basin center settings. Field work in the earliest Bridgerian (Biochron Br1a, early middle Eocene) along the northeastern edge of the Green River Basin at South Pass, Wyoming, has yielded a large and diverse sample of vertebrates. Here, we examine changes in the distributions of individual taxa and their effects upon mammal community composition across the Wasatchian-Bridgerian boundary using GIS (Geographic Information System; ArcGIS software). We assembled a database of mammal occurrences at 201 fossil localities. Variables collected for each locality include taxon occurrence, geographic coordinates, meter level, and biostratigraphic zone. Our results indicate important spatial and temporal patterns of mammal occurrence. Wa7 and Br1a localities were clustered along the margin of fossil Lake Gosiute, with Br1a localities located closer to the mountain front during a transgressive lake phase. In addition, species associations of putative ancestor-descendent pairs occurred only on the basin margin. A possible explanation for the unusual co-occurrence of species at South Pass relates to fluctuating lake levels in the Green River Basin, which intermittently would have made lowland environments inhospitable for terrestrial fauna. This would have created a situation whereby species that would normally have been allopatric became sympatric. Understanding of the processes important in microevolutionary change and speciation is necessarily based on extrapolations from evolutionary patterns, such as species ranges. Our results suggest that the differences encompassed in the South Pass sample, when compared with basin center faunas, result not only from differences in the distribution of animals in an ecological zone, but also as the result of evolutionary processes, and most likely a combination of both factors. Our results demonstrate how GIS can be used to predict paleoecological associations and test ecological and evolutionary hypotheses in the fossil record.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

FOSSIL CYPRINIDS (OSTARIOPHYSI, CYPRINIFORMES) FROM SUMATRA, INDONESIA

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The order Cypriniformes, based on ostariophysan relationships in which they are often placed as basal to either Characiformes, Siluriformes, or both, is expected to have an age equivalent to that of Siluriformes or Characiformes. Siluriform (catfish) remains are known from the late Campanian to early Maastrichtian of Bolivia, whereas characiform teeth are known from the Cenomanian of Sudan and Morocco, and so cypriniform fishes should be represented in Late Cretaceous deposits. However, within the Cypriniformes, the earliest representative is a single bone of Paleocene age from Canada assigned to the Catostomidae. In the Eocene, representatives of two living families (Catostomidae and Cyprinidae) and one extinct family (Jianghanichthyidae) are present. Along with Eocene cyprinids from China, some of the oldest cyprinids known are those from deposits of the Sangkarewang Formation, Sumatra, Indonesia. The age of the Sangkarewang deposits has been reported as being anywhere from Cretaceous to Miocene; however, recent work establishes the middle to late Eocene age of this formation. Fishes from the formation were described more than 80 years ago, but the descriptions were not greatly detailed, and much of the previously described material cannot now be found. New material collected from localities in the Sangkarewang Formation in 2009 and 2014 provides the opportunity to better describe previously named species (e.g., *Puntius bussyi* and *Thynnichthys amblyostoma*), as well as documents the presence of at least one new species, based on the morphology of the unbranched dorsal fin ray with minute denticles along the posterior edge, which is unique among the cyprinids from the locality. The relationships of cyprinid fishes are not clear, and are the subject of ongoing morphological and molecular studies; however, the Sumatran fossils enhance understanding of the early diversity of morphologies present in cyprinid fishes in the early Cenozoic.

Grant Information

National Geographic Society (to GF Gunnell for field work); Natural Sciences and Engineering Research Council of Canada (to AM Murray)

Technical Session XVII (Saturday, October 29, 2016, 11:15 AM)

WHY DID PLESIOSAURS HAVE FOUR FLIPPERS? AN EXPERIMENTAL APPROACH

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The swimming method of plesiosaurs has been debated since their discovery. There have been many theories as to how they used their four large flippers to propel themselves through the water. Did they use all four flippers for active propulsion? If so, how did the front and hind flipper pairs move in relation to each other? In this study, we adopt a novel multi-disciplinary approach to address these questions and provide the first quantitative experimental data on the swimming method of plesiosaurs. Over the last three years, an experimental test rig has been constructed using engineering principles along with fossil evidence and comparative anatomy. This 'robotic plesiosaur' is able to flap a front and hind flipper in a similar way to the real animals, to enable the forces on the flippers to be found, and therefore determine if the fore flippers had a noticeable effect on the hind flippers, and which motions were the most effective and efficient. The results show that 1) the hind flippers are able to produce much more thrust (around 50% extra) and achieve a higher efficiency compared to if they were operating on their own, due to being in the wake of the fore flippers. This shows that hind flippers were indeed very useful for locomotion, and imply that the plesiosaurs did use all four for propulsion, at least during moderate to high speed swimming; 2) this increased performance is dependent on the spacing and relative motion between the flippers, so the plesiosaur would need to control the movement of its flippers accurately to achieve the benefit; 3) an increase in thrust and efficiency is apparent over the entire range of angles of attack,

flapping frequencies (Strouhal numbers), and flapping amplitudes that plesiosaurs are likely to have used.

Grant Information
EPSRC, Ginko investments

Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

WHAT IS 'NATURAL' AFTER 10,000 YEARS OF EXTINCTIONS AND INVASIONS? CONSERVATION PALEOBIOLOGICAL APPROACHES IN PARQUE NACIONAL JARAGUA, DOMINICAN REPUBLIC

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Paleontologists are increasingly sharing geohistorical data with conservation practitioners to inform management decisions. This approach is of particular relevance to island systems, where recent extinctions and invasions have obscured our understanding of pre-human ecosystem conditions. Here, we apply a conservation paleobiological approach on the Caribbean island of Hispaniola as part of a multi-year collaboration between researchers, the Museo Nacional de Historia Natural of the Dominican Republic, and members of the grassroots conservation group Grupo Jaragua.

We combine paleontological excavations with ecological surveys in Parque Nacional Jaragua, located in the southwestern Dominican Republic, to 1) contrast the past vertebrate diversity of the park with its modern constituents, 2) elucidate the interactions of native-invasive species, and 3) provide temporal baselines of ecosystem change. Our paleontological work has revealed a network of 20+ limestone karst caves, which allowed us to create faunal inventories that document the recent loss of biodiversity in the region. For example, Jaragua is home to two native small mammal species today, but we recovered 11+ species, including extinct sloths, primates, and large-bodied rodents. Abundance data reveals that the Hispaniolan solenodon, an endemic insectivorous mammal, has been rare throughout the Holocene, in contrast with the past high abundance and subsequent modern endangerment of the endemic rodent, the Hispaniolan hutia.

We augment these paleontological data with transect and camera-trapping studies that reveal the mechanisms underlying interactions of native species with invasive species, including spatial and temporal partitioning of resources within the Jaragua. By combining paleontological and modern data, we provide a unique perspective for managing grazing by non-native herbivores and affirm the need for a broader understanding of what constitutes 'natural' in an island system.

Grant Information
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Technical Sesssion X (Friday, October 28, 2016, 11:15 AM)

A NEW CHELONIOID TURTLE FROM THE PALEOCENE OF CABINDA, ANGOLA

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We report a new chelonioid turtle on the basis of a nearly complete skull collected in lower Paleocene, shallow marine deposits, equivalent to the offshore Landana Formation, near the town of Landana in Cabinda Province, Angola. Chelonioid material previously reported from this locality is likely referable to this new taxon. The well-preserved skull is missing the left quadrate, squamosal, and prootic, both opisthotics, and the mandible. The skull possesses a rod-like basisphenoid rostrum, which is a synapomorphy of Chelonioidea, but it differs from other chelonioid skulls in that the contact between the parietal and squamosal is absent, and the posterior palatine foramen is present. Phylogenetic analysis recovers the new taxon as a basal chelonioid. The Paleocene–Eocene strata near Landana have produced a wealth of turtle fossils, including the holotype of the pleurodire *Taphrosphys congolensis*. A turtle humerus collected from the Landana locality differs morphologically from the humeri of chelonioids and *Taphrosphys*, indicating the presence of a third taxon. Chelonioid fossil material in the Landana assemblage is rare compared to the abundant fragmentary remains of *Taphrosphys* that are found throughout the stratigraphic section. This disparity in abundance suggests the new chelonioid taxon preferred open marine habitats, whereas *Taphrosphys* frequented nearshore environments.

Technical Session XIV (Friday, October 28, 2016, 3:45 PM)

THE EVOLUTION OF JAW MECHANICS AND CRANIAL MUSCULATURE IN DICYNODONTS (THERAPSIDA, ANOMODONTIA)

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Dicynodont therapsids were arguably the most successful herbivorous amniotes spanning the Permian–Triassic boundary, although the detailed evolution of dicynodont jaw mechanics remains largely unexplored. Here, we integrate key functional cranial traits and muscular mechanical advantage (MA) in a phylogenetic context for a synthesis of dicynodont feeding evolution. We mapped lateral origins and insertions of m. adductor mandibulae externus medialis (mAMEM), a temporalis homologue, and m. adductor mandibulae externus lateralis (mAMEL), a masseter analogue, in 32 dicynodonts and basal anomodonts. We then reconstructed muscle vectors by connecting centroids of each origin and insertion to calculate MA relative to a mesial bite point at the beak. With sliding quadrate-articular joints, blunt snouts, intramandibular kinesis, and a transition to toothless, keratinous beaks, dicynodont skulls are highly modified to allow variable degrees of palinal feeding. A transition is seen to an emarginated temporal bar and a laterally facing squamosal adductor fossa, relocating mAMEL lateral to the temporal bar outside of the adductor chamber, with mAMEM remaining within the adductor chamber originating at the sagittal crest. Dicynodonts score higher in MA values than more basal anomodonts, indicating increased efficiency in herbivorous feeding. Among dicynodonts, MA was highly variable depending on craniomandibular proportions while still indicating strong palinal feeding in a majority of dicynodont taxa. Many dicynodonts with larger muscle attachments and dorsoventrally deeper mandibles, such as *Angonisaurus*, *Daptocephalus*, and *Lystrosaurus,* present relatively high MA values. Notably, emydopoids exhibit a more pronounced lateral dentary shelf for greater muscular support for the insertion of mAMEL, also enhancing palinal performance. A secondary transition to relatively lower MA values and more orthal feeding is seen among the derived kannemeyeriiforms, but stahleckeriids and kannemeyeriids accomplish this in different ways; whereas stahleckeriids possess higher adductor angles, kannemeyeriids possess rostrally displaced muscle insertions and lower adductor angles. Lower MA values in kannemeyeriiforms suggest a likely enhancement of pterygoideus musculature inducing a secondarily stronger orthal feeding stroke. These results demonstrate that the dicynodont radiation was facilitated by functional diversification of their highly derived feeding systems.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

FIRST RECORD OF *PROTEROZETES ULYSSES* (CARNIVORA, OTARIIDAE) FROM THE WESTERN NORTH PACIFIC, AND ITS IMPLICATIONS FOR PALEOBIOGEOGRAPHY OF THE PLEISTOCENE OTARIID PINNIPEDS IN THE NORTH PACIFIC

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The Otariidae belong to the Pinnipedia (Carnivora) and consist of seven extant genera and 14 extant species. Today, they are more diverse in the Southern Hemisphere (4 genera and 11 species) than in the Northern Hemisphere (3 genera and 3 species), but the fossil record suggests that they evolved and diversified in the Northern Hemisphere. However, the otariid fossil record is too insufficient in preservation to accurately discuss their taxonomic validity and evolutionary relationships. Recently, almost complete skulls of otariids were found from the middle Pleistocene Mandano Formation (0.6 Ma) on the Boso Peninsula, central Japan, which are the first to be reported from the western North Pacific realm. The middle Pleistocene is a transitional period for the Otariidae due to the changes in climate and sea-level stands that occurred during this time, and therefore, the information gathered from these new finds from the middle Pleistocene is significant. Determination of the taxonomic and phylogenetic positions of the above-mentioned new specimens bring us new insights into their evolutionary processes in the North Pacific Ocean. For this purpose, we investigated almost all of the morphological characters and taxa of the otariids, including fossil taxa, with backbone constraint by the molecular information for their phylogenetic relationships.

Our analysis revealed that the new fossils belonged in the family Otariidae, and one of them was almost identical to the middle Pleistocene extinct sea lion *Proterozetes ulysses* that was previously known only from the eastern North Pacific. In addition, *P. ulysses* was confirmed to be closely related to the Steller sea lion *Eumetopias jubatus*. Our results also revealed that the number of otariid species in the middle Pleistocene of the western North Pacific was much more than in the present-day western North Pacific, and their distribution during that time was extended southerly along the coast of the western North Pacific. Although *P. ulysses* is only known in the short period (middle Pleistocene) and restricted area (mid-latitude of both sides of the North Pacific), the circum-North Pacific distribution of all the northern otariids suggests that their diversification in the Northern Hemisphere was much higher until the late Pleistocene.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

MORPHOLOGICALLY AND HISTOLOGICALLY DIAGNOSTIC SOFTSHELL TURTLES FROM THE LOWER CRETACEOUS OF JAPAN

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Softshell turtles (Trionychidae) are highly aquatic, freshwater turtles that currently have a global distribution. The group has been present in Asia since the late Early Cretaceous (Aptian, 125.0–113.0 Ma). A possibly older, single fragment of turtle shell from Japan (FPDM-0127) has been suggested to belong to this family; however, that material preserves only a few characteristics of Trionychidae. Here we report four morphologically and histologically diagnostic trionychid specimens from the Barremian–Aptian (129.4–113.0 Ma) of Japan. One specimen (FPDM-V9487) is an associated skeleton, which consists of a scapula, a humerus, an ischium and hypoplastra. The limb and girdle bones are similar in morphology to those of modern trionychids. The hypoplastra resemble that of modern trionychids, but distinctive from other known trionychids in totally lacking callosities. The other three specimens are fragmentary costals. These costals show flat shape, reduction of sutural contact with peripherals and absence of scute sulci, suggesting a flexible shell without keratinous shields. Two of the newly reported costals and FPDM-0127 were examined histologically. As a result, bone fiber bundles organized as a plywood-like structure, which is unique to Aptian–recent trionychids was found. Fossil occurrence data indicate that morphologically and histologically typical trionychids have already inhabited coastal region of Asia as early as the Aptian. On the other hand, the Hauterivian–Aptian stem trionychid *Kappachelys okurai* did not show plywood-like shell microstructure, suggesting that *K. okurai* could be the basal-most taxon of known stem trionychids. Our paleobiogeographical compilation suggested that the spread of wetlands in the Northern Hemisphere and high global temperature during the mid-Cretaceous (Aptian–Turonian, 125.0–89.8 Ma) might have contributed to the high frequency of trionychids, which exemplifies the

establishment of this modern freshwater reptilian fauna. The leathery skin and flattened body of early trionychids would probably have improved their camouflage ability at the water bottom, so that they would have been difficult to notice by prey or predators, helping habitation of trionychids in fluviolacustrine environments.

Grant Information
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Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

SEX IDENTIFICATION IN *SMILODON* AS EXTRAPOLATED FROM RECOGNIZED MARKERS IN CONTEMPORARY FELIDAE AND PRIMATES

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Maxillary porosity allows sexing of museum specimens as male or female in *Panthera leo* (but not other contemporary felidae), as can also be done in lemurs. The usefulness of this character for male-female identification in Cenozoic feline ecomorphs was investigated, and the presence or absence of pore-like maxillary defects was assessed by macroscopic examination. For Recent specimens, the results were the presence of such porosity in 14 of 14 *Panthera leo* males contrasted with zero of 24 females. In *Eulemur macaco,* five of five males manifested porosity, compared with zero of six females. Porosity in *Varecia variegata* was present in seven of seven males and zero of 13 females; in *Otolemur crassicaudatus garnetti*, 16 of 16 males and zero of three females; and in *Daubentonia madagascarensis,* three of three males showed this trait. Extinct taxa from the Cenozoic examined include: *Panthera spelaea*, with porosity noted in 14/14 males and zero of seven females. Porosity was also found in additional animals for which gender was unknown: *Panthera atrox* (one of one), *Smilodon* (eight of 17), *Megantereon nihowanensis* (one of two), but not in *Homotherium* (zero of 12), *Machairodus* (zero of five), *Hoplophoneus* (zero of six) and *Dinictis* (zero of one). The presence of maxillary porosity is a valid independent indicator of sex in *Panthera leo* and its ancestor, *Panthera leo spelaea*. While the ossuary nature of *Smilodon* and *Megantereon* samples precludes study of independent postcranial morphology for sex identification, maxillary porosity is present in 50% of *Smilodon* crania. The results suggest that this character identifies sex in these genera. The absence of this dichotomous character in *Homotherium, Machairodus, Hoplophoneus* and *Dinictis* precludes sex allocation using this method for these taxa. Maxillary porosity appears to be a phenomenon limited in felidae and its ecomorphs to the lineage that resulted in the modern lion.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

PLAYING THE "GAME" OF VERTEBRATE PALEONTOLOGY: A NEW CLASSROOM TEACHING AND LEARNING TOOL FOR INCREASING STUDENT KNOWLEDGE OF AND INTEREST IN AN EVOLUTIONARY CONTEXT.

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As is the case with many scientific disciplines, learning relevant facts is difficult and fraught with errors. Contemporary university students frequently seek lists of specific items or concepts they must know for examinations. This tightly focused, targeted method of assimilating information may allow a student to pass a test, but does not enrich overall disciplinary understanding. In information dense subject areas such as vertebrate paleontology, lists are not a feasible learning tool because they rapidly enlarge to become too cumbersome. To remedy this concern, I created a vertebrate paleontology "board game" that includes elements from a variety of those played for entertainment. The main goal is to encourage students to make associations between often long, complex terms frequently derived from Latin and Greek, their meanings and the role they play in revealing the biological patterns. The game board depicts the evolutionary process with contestants initially achieving protovertebrate status and answering questions to earn the number of spaces through which they can move according to the roll of a single die. As the game is played by a class of 20–30 students they are divided into teams. Each team may look up answers to questions written on cards they take from draw pile using any chosen sources. A timer limits them to two minutes. Two card types are required. The first is an "evolution card." This poses a concept question, and the second is a "vertebrate card". Students have to explain both the evolutionary concept and describe how the animal on the vertebrate card typifies the principle involved. There are 150 cards for each type, yielding 22,500 possible combinations. Once a question is answered, the class judges whether the answer is sufficient to award the move. Because the team seeking to advance must answer the question, they remain engaged, and the opposing team members must judge the answers, they also remain involved, usually looking up information they do not already know so as to outdo the opposing team. Because the evolutionary process is unpredictable, the game board and draw card categories include unpredictable surprises, such as "you are scared by a predator, lose a turn, swap places with the first place token, move an opponent token backward the number of spaces on your die (in which case you do not get to advance, but might prevent a competitor from doing so)," among others. Results from pre- and post-testing and student opinion surveys suggest that most enjoy this exercise as well as gain additional information as a result of their group research.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

A DIGITAL ENDOCRANIAL CAST OF THE EARLY PALEOCENE (PUERCAN) *ONYCHODECTES TISONENSIS* (EUTHERIA, TAENIODONTA)

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Eutherian mammals underwent an explosive radiation immediately following the Cretaceous–Paleogene (K–Pg) extinction, during which they evolved disparate anatomy, expanded into newly vacant ecospace, and established new terrestrial ecosystems. This event is of particular interest due to its rapid pace and because it seems to have included the radiation of Placentalia, the most diverse clade of modern mammals. A comprehensive understanding of this event is predicated on understanding the biology of the mammals that survived the K–Pg extinction and radiated in the Paleocene. The brain is ultimately responsible for an animal's behavior; therefore, investigations of the neural anatomy of 'archaic' Paleocene mammals yield valuable insight into their ecology, and in turn, may suggest what allowed them to become so successful. We describe the first digital endocranial cast of a taeniodont, a bizarre group of eutherians that flourished in the early Paleogene, reconstructed from a CT scan of a late Puercan (65.4 Ma) specimen of *Onychodectes tisonensis* (AMNH 785) that recovered most of the forebrain and midbrain and portions of the inner ear. Notable features of the endocast include long and broad olfactory bulbs, dorsally positioned rhinal fissures, and a lissencephalic (smooth) cerebrum. Comparison with other taxa shows that *Onychodectes* possessed the largest olfactory bulbs (relative to cerebral size) of any known Paleogene eutherian. Integrating observations from the skeleton with this endocast, we present a general ecological and behavioral model for *Onychodectes* and similar taeniodonts. Overall, they seem to have been animals of relatively simple behavior that relied on a strong sense of smell to locate roots and tubers, which they extracted using skeletal adaptations for digging and processed with dental specializations for masticating tough and abrasive food.

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Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

A DIGITAL MENAGERIE: BUILDING THE WITMERLAB'S VISIBLE INTERACTIVE ANATOMY LIBRARY AS AN OPEN-ACCESS RESOURCE FOR RESEARCH AND EDUCATION

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Engaging a broad audience in scientific research remains a challenge when access to original material of biological specimens is limited. To address this challenge, the WitmerLab at Ohio University has been assembling an online collection of virtually-reconstructed vertebrate species, both extinct and extant, since 2011, called the Visible Interactive Anatomy (VIA) series. To date, the species include a range of mammals (opossum, human, rhino, bobcat), reptiles (iguana, alligator), birds (ostrich, moa, parrot), and nonavian dinosaurs (pachycephalosaurs). To reconstruct the bone and soft tissues, specimens were CT scanned and the anatomy was segmented in Avizo and modeled in Maya. 3D PDFs were generated in Deep Exploration and Acrobat, and movies in QuickTime and Adobe Premiere. Interactive 3D models were also published on Sketchfab. These assets are then made available as open-access resources on the WitmerLab website within the Visible Interactive Animal series, with mirrors on social media (Facebook, YouTube, Sketchfab). The VIA websites seek to provide basic anatomical information that can serve as STEM educational aids for K–12 and undergraduate students, as well as for researchers. Ultimately, the goal is to put the user in control of what aspects of anatomy they want to see, and then let the user manipulate that anatomy as they see fit, using different interactive tools. 3D PDFs and videos are provided in varying sizes and may be downloaded and used offline, whereas Sketchfab models are only available online but are mobile-friendly. If possible, the original CT scan data are provided in DICOM format. These interactive 3D models often emerge as "incidental findings" from our hypothesis-driven, question-based research. That is, although virtual skulls, brain endocasts, etc. are often necessary for the lab's research, they are not usually themselves the intended scientific outcome and thus can be shared more or less immediately, as we continue on with our scientific studies. As we complete and publish those studies, the published results are then added to the Visible Interactive Anatomy library. In addition, generating new VIA content has been incorporated into the training process for students entering the lab, giving them not only comprehensive training in 3D programs but also tangible output. As more scientific work continues to be completed, the scope and depth of the series will continue to expand to include additional taxa, both living and extinct.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

A PRIMITIVE CONFUCIUSORNITHID BIRD FROM THE HUAJIYING FORMATION (HEBEI, NORTHEASTERN CHINA) SHEDS NEW LIGHT ON THE DIVERSITY AND EVOLUTION OF CONFUCIUSORNITHIDAE

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Confuciusornithids are basal pygostylian birds from the Early Cretaceous of northeastern China. Although hundreds of nearly complete articulated specimens are known, they show low diversity with a consensus of four valid species. Three of them (*Changchengornis hengdaoziensis*, *Confuciusornis sanctus* and *C. dui*) occur in the approximately 125-MY-old sediments of the Yixian Formation, with two controversial reports of *C. sanctus* from the younger Jiufotang Fm. (~120.3 MYa). The fourth species, *Eoconfuciusornis zhengi*, comes from the Huajiying Fm. (~131 MYa). Although the holotype of *E. zhengi* shows unique traits, its immature ontogenetic stage makes

anatomical comparisons with stratigraphically younger confuciusornithids problematic; hence, the validity of this species has remained controversial.

Here we report an osteologically adult specimen of a small-sized confuciusornithid from the same locality and horizon as the holotype of *E. zhengi*. The new fossil and *E. zhengi* share similarities in humeral anatomy, a scapula without a prominent acromion, and weakly fused or unfused metatarsals. This new specimen, however, also shares unique traits with the stratigraphically younger confuciusornithids.

The humerus of the new fossil is slenderer, straighter and has a less developed deltopectoral crest than in similarly sized, or even smaller, specimens of geologically younger confuciusornithids. Its morphology is intermediate between *E. zhengi* and *Confuciusornis* with the proximal portion pierced by a minuscule deltopectoral foramen which is, however, much smaller than in any other confuciusornithid.

Statistical tests with chord measurements of skeletal elements and a geometric morphometric analysis of the shape of the humerus in Confuciusornithidae and other basal birds quantitatively support our observations. Namely, we found that changes in shape of the humerus and proportions of other elements within *C. sanctus* do not correlate with ontogenetic size changes but show a high disparity, a fraction of which is attributable to taphonomic deformation.

In turn, differences between *E. zhengi* and the new specimen are not easily explained as ontogenetic variation within a single species. The unique character combination of the new fossil fills the anatomical gap between stratigraphically older and younger confuciusornithids. This new evidence stresses the distinctiveness of *E. zhengi* and suggests the presence of two different early confuciusornithids in the Huajiying Formation, the second oldest avian-bearing deposit in the world.

Technical Session XVII (Saturday, October 29, 2016, 11:45 AM)

THE EVOLUTION OF INNER EAR MORPHOLOGY IN SAUROPTERYGIA

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Sauropterygia, an extremely successful radiation of marine reptiles, dominated aquatic environments globally for almost the entire Mesozoic. Triassic sauropterygians were widely diverse and disparate, with nearshore forms (placodonts, pachypleurosaurs, and nothosaurs) as well as the open-water pistosaurs. After the Triassic-Jurassic boundary, the pelagic Plesiosauria persisted for the remainder of the Mesozoic. As an independent replicate of the evolutionary transition to pelagic life in tetrapods (seen elsewhere in e.g. cetaceans, ichthyosaurs and chelonioids), sauropterygians provide valuable data on general patterns of the transition from terrestrial/semi-aquatic to obligate aquatic life. We studied the evolution of the inner ear (containing the labyrinth organ of balance and orientation) in sauropterygians to determine how its morphology, and therefore function, changed during the nearshore to open water transition, and among the distinct long and short-necked morphotypes that evolved repeatedly.

Computed tomographic models of 22 sauropterygian labyrinths representing their entire evolutionary history indicate a morphological transition between nearshore, Triassic taxa and open water plesiosaurians of the Jurassic–Cretaceous. Triassic sauropterygians possess anteroposteriorly elongate labyrinths, with narrow canal diameters, and anterior and posterior canals that turn ventrally at the dorsal end of the crus, producing an ‘M’-shaped morphology. In contrast, plesiosaurs have bulbous labyrinths with thicker canals and a rounded, horizontal junction of the anterior and posterior canals dorsal to the crus (in most taxa). With the exception of the basal, near-shore placodonts, sauropterygian labyrinth diameters scale positively and significantly with skull size (basicranial length) and proportional neck length; thus taxa with shorter necks have smaller labyrinths relative to body size. Labyrinth size reduces in response to the evolution of pelagic life, and is further reduced in response to reduction in neck function. Placodont labyrinths are proportionally larger than in eosauropterygians, with intermediate and long-necked taxa exhibiting reduced ears, and pliosauromorphs, with cetacean-like body proportions, having the proportionally smallest labyrinths. This mirrors the condition seen in cetaceans, which also evolved reduced labyrinths and neck lengths with increasing degrees of aquatic adaptation and underlines an apparently general feature of sensory adaptation in marine tetrapods.

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Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

THE EARLY EVOLUTION OF BIRD-LINE ARCHOSAURS: A POSSIBLE NEW CLADE OF GLOBALLY DISTRIBUTED AVEMETATARSALIANS JUST OUTSIDE THE DINOSAUR-PTEROSAUR SPLIT

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Bird-line archosaurs (=Avemetatarsalia, the clade containing dinosaurs, pterosaurs, and their kin) had their origin in the Triassic Period. However, that origin is poorly documented as fossils from their early evolutionary history are extremely rare and consist mostly of postcrania. Here, we report the discovery of a new reptile (femoral length = 17 cm) from the lower portion of the Middle Triassic Lifua Member (Manda beds) of the Ruhuhu Basin, southwestern Tanzania. Material referred to the new taxon includes a partial skeleton of a single individual including cervical, trunk, and caudal vertebrae, pectoral, pelvic, forelimb, and hind limb material (= ‘*Teleocrater*’ of A. Charig), and parts (skull elements, vertebrae, pectoral, pelvic, and limb elements) of a minimum of three individuals collected from a bonebed discovered in 2015 very close to Charig's original partial skeleton. Character states of the limbs, vertebrae, and ilium indicate a close relationship with early dinosauromorphs including: elongated cervical vertebrae, an ilium with a slightly concave ischial peduncle and clear anterior crest, a weakly developed anterior trochanter of the femur, an anteriorly compressed fibula with long strap-like iliofibularis crest, and absence of osteoderms. Many character states suggest that the new reptile taxon falls outside of the pterosaur-dinosaur clade (=Ornithodira). However, the distributions of some of these character states at the base of Archosauria are unclear and some character states of the new taxon suggest a more basal relationship outside Archosauria (e.g., absence of two medial tubera of the proximal femur). No matter the position within or outside Archosauria, the new Lifua taxon shares seemingly unique character states with the poorly known *Dongusuchus* from the Middle Triassic of Russia (known from femora) and *Yarasuchus* from the Middle Triassic of India (known from partial skeletons), rather than with other archosauriforms. As a result, these forms appear to represent a globally distributed clade of early diverging avemetatarsalians. The larger body size of the Manda form and its potential phylogenetic position outside of pterosaurs and dinosauromorphs indicates that there was a size decrease at the origin of Ornithodira. This new taxon, and other new discoveries from the Middle to Late Triassic, are elucidating the sequence of character acquisitions in Avemetatarsalia and fill a crucial gap in the evolutionary history that led to the flourishing of dinosaurs later in the Mesozoic.

Grant Information
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Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

REVISION OF *KYPHOSICHTHYS GRANDEI* FROM THE MIDDLE TRIASSIC OF YUNNAN PROVINCE, SOUTH CHINA: IMPLICATIONS FOR PHYLOGENETIC INTERRELATIONSHIPS OF GINGLYMODIAN FISHES

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The deep-bodied ginglymodian fish *Kyphosichthys grandei*, from Middle/Late Anisian of South China, is re-described herein. The revised description presents previously unknown or misidentified anatomical information in detail, which substantially enhances our understanding of character evolution within basal ginglymodians and, consequently, their phylogenetic relationships. A more comprehensive cladogram incorporating these new data resolves *Kyphosichthys* as the most basal taxon of the Ginglymodi which still possesses a number of primitive traits (e.g., the presence of gular plates, a short squarish rostral bone, a splint-like quadratojugal lateral to the quadrate, a short maxilla with a prominent supramaxillary process, the dorsal body lobe lacking additional scale rows). *Robustichthys*, from the same unit yielding *Kyphosichthys* and previously misidentified as an ionoscopiform halecomorph, is resolved as the latest stem ginglymodian, thus indicating an eastern Tethyan (South China) origin for Ginglymodi. This clade is supported by one unique derived (i.e., the presence of splint-like quadratojugal) and eight homoplastic features, as well as a Bremer value of six. The other basal ginglymodian, the Anisian–Ladinian Tethyan *Sangiorgioichthys*, is sequentially sister group to more advanced ginglymodians. The clade is supported by two unique derived features (i.e., the splint-like quadratojugal strongly buttressing the quadrate and the absence of gular plates) and a Bremer value of three. Additionally, this study also makes better insight into the intrarelationships of ginglymodians above the level of *Sangiorgioichthys*.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

NEW MATERIAL OF THE ITALIAN CASEID *ALIERASAURUS RONCHII* (SYNAPSIDA, CASEIDAE) AND ITS PHYLOGENETIC POSITION WITHIN CASEASAURIA

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Additional material referable to the giant caseid *Alierasaurus ronchii* has been recovered during new fieldwork at the holotypic quarry in the Permian deposits of the Cala del Vino Formation (Torre del Porticciolo promontory, about 13 km northeast of Alghero, northwest Sardinia). Thanks to the new finding and further preparation of the previously collected material, we present new interesting and highly diagnostic anatomical features for the Sardinian taxon. All new described osteological elements are characterized by the same size category and state of preservation and, considering the absence of duplicated elements, the new material can be attributed without doubt to the same single adult individual of *Alierasaurus ronchii*. A caudal neural spine, characterized by a broad and bifid distal termination, represents one of the most diagnostic elements. Such peculiar spine conformation represents a synapomorphy of derived caseids, thus confirming the attribution of the incomplete Sardinian specimen to Caseidae. Newly collected ribs and associated vertebral material also show a typical caseid structure, fully consistent with the previously described bones. We included *Alierasaurus* in a recently published phylogenetic dataset of caseids in order to investigate its phylogenetic position within Caseasauria, resulting in a sister-taxon relationship with *Cotylorhynchus* and characterized by consistently autapomorphic phalanx IV-I and metatarsal IV. The absolute dimensions of the newly recovered ribs confirm a gigantic body size for *Alierasaurus ronchii*, possibly greater than that of *Cotylorhynchus hancocki*, often considered the largest caseid. This gigantic adult body size should have resulted in numerous advantages in the evolution of the group, e.g., by decreasing the possibility of attack by predators, by improving metabolic efficiency and by making the animals more independent from the external environment through an increase in heat retention. The evolution of the giant size was certainly triggered by a herbivorous lifestyle, with a colossal gut promoting the cellulysis of high-fiber plant tissue.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

LARGE FOSSIL RODENTS FROM THAILAND

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The Chiang Muan Coal Mine, northern Thailand, is known as the fossil locality of Miocene hominoids (*Khoratpithecus chiangmuanensis*). The Chiang Muan Formation at the locality includes two lignite beds, or the Sa Tai Member (Lower Lignite) and the Kon Member (Upper Lignite), which yield many terrestrial mammalian fossils. Rodent fossils are very rare in the fossil assemblages from Chiang Muan. Recently, a total of seven isolated teeth of large rodents were described from the Sa Tai Member that is dated to the late middle Miocene (ca. 13.0–12.4 Ma) based on paleomagnetic analysis. The rodent fossils are classified into two species: a castorid (*Anchitheriomys* sp.) and an indeterminate species (Rodentia fam., gen. et sp. indet.). *Anchitheriomys* sp. from the Sa Tai Member has large cheek teeth with a high crown, the crown base is wider buccolingually, there are basically six fossettes/sinuses, enamel foldings are strongly complicated, and the hypoflexus/flexid is shallow dorsoventrally. *Anchitheriomys* species are known from the Miocene of Europe (*A. suevicus*), northern China (*A. tungurensis*), and North America (*A. stouti*, *A. nanus*, *A. senrudi*, and *A. fluminis*). The distribution of these species is restricted between the latitudes 30°N and 50°N, but the occurrence of *Anchitheriomys* in northern Thailand (around 19°N) suggests that it had wider distribution on the Eurasian continent. Dental morphology of *Anchitheriomys* sp. is more similar to that of *A. suevicus* than that of *A. tungurensis* or the other species from North America. Only one lower incisor fragment is associated with six cheek teeth belonging to *Anchitheriomys* sp. This incisor is considerably larger than that of all *Anchitheriomys* species. Moreover, it lacks longitudinal grooves or deep ridges on the enamel surface, which are generally diagnostic of large castorids, such as *Anchitheriomys* and *Youngofiber*. On the other hand, the inner enamel observed by scanning electron microscope has uniserial Hunter-Schreger bands, similar to castorids rather than hystricids. *Castoroides* is well-known as the largest castorid in North America, but there is no record of such giant species from Eurasia. Currently, *Youngofiber sinensis* from the lower Miocene of eastern China and Japan is recorded as the largest rodent in Eurasia, but it is slightly smaller than the species from the Chiang Muan Formation. This species is taxonomically indeterminate at present, but seems to represent a new member of Neogene rodents in Eurasia.

Technical Session VII (Thursday, October 27, 2016, 3:15 PM)

REMARKABLE PRESERVATION OF BRAIN TISSUES IN AN EARLY CRETACEOUS IGUANODONTIAN DINOSAUR

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It has become accepted in recent years that the fossil record can preserve labile tissues. Here we report highly detailed mineralization of soft tissues associated with a naturally occurring brain endocast of an iguanodontian dinosaur, found in ~133 Ma fluvial sediments of the Wealden at Bexhill, Sussex, U.K. Moulding of the braincase wall, and mineral replacement of adjacent brain tissues by phosphates and carbonates (qualitatively analyzed for elemental and mineral content using EDS) permits direct examination of petrified brain tissues. SEM imaging and CT-scanning reveal preservation of the tough membranes (meninges) that enveloped and supported the brain proper. Collagen strands of the meningeal layers are preserved in collophane. Blood vessels, also preserved in collophane, are either lined by, or infilled with, microcrystalline siderite. Meninges are preserved in the hindbrain region, and exhibit structural similarities with those of living archosaurs. Greater definition of the forebrain (cerebrum) compared to the hindbrain (cerebellar and medullary regions) is consistent with the anatomical and implied behavioural complexity previously described in iguanodontian-grade ornithopods. However, we caution that the observed proximity of probable cortical layers to the braincase walls likely results from settling of brain tissues against the roof of braincase following inversion of the skull during decay and burial.

Grant Information

DN - Odell Trust Fund, Christ's College, Cambridge; AL - NERC (NE/L011409/1)

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

NEW THEROPODS FROM THE WOODBINE FORMATION OF TEXAS: INSIGHTS INTO CENOMANIAN APPALACHIAN ECOSYSTEMS

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The terrestrial record of the mid-Cretaceous interval (Aptian to Santonian) in North America remains poorly known. Recent discoveries from the western United States have significantly to recorded vertebrate diversity, providing important new details about ecosystem dynamics and faunal turnovers on Laramidia. However, little is known of terrestrial communities from the early Late Cretaceous of Appalachia, which provides a necessary comparison to the faunal patterns seen in the west. The Woodbine Formation of north central Texas was deposited during the middle to late Cenomanian (95-100 mya). Around Dallas–Fort Worth the Woodbine is divided into the Rush Creek, Dexter, Lewisville, and Arlington Members, consisting of deposits representing shallow marine, deltaic, and fluvial environments. These deposits have yielded a wealth of vertebrate remains, yet the only non-avian theropods previously described include two teeth attributed to cf. *Richardoestesia*. Recently, multiple localities in the Woodbine Formation have yielded new theropod material, including numerous isolated teeth, postcranial remains, and tracks. While largely fragmentary, this material can be attributed to: a large allosauroid, a small tyrannosauroid, a large dromaeosaurine, small dromaeosaurids, a troodontid, and an indeterminate coelurosaur. These new specimens add significantly to the taxonomic diversity of Cenomanian theropods in Texas, including groups previously undocumented in Appalachia. The Woodbine theropod fauna is similar in taxonomic composition to contemporaneous deposits in Laramidia, including a large, dominant allosauroid, smaller tyrannosauroid, troodontids, and high dromaeosaurid diversity, confirming that these groups were widespread across the continent prior to completion of the Western Interior Seaway. Furthermore, the taxonomic similarity between east and west suggests that a similar reorganization of terrestrial ecosystems was underway and was most likely initiated prior to separation of the landmasses.

Poster Symposium II (Friday–Saturday, October 28–29, 2016, 4:18 PM)

LIZARDS AND SNAKES OF THE MORRISON FORMATION (UPPER JURASSIC, USA) AND THE EARLY GLOBAL DISTRIBUTION AND DIVERSITY OF SQUAMATES

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Squamates from the Morrison Formation are the oldest known lizards and snakes from North America. Most of the known specimens have been recovered from Como Bluff, Wyoming; Dinosaur National Monument, Utah; and the Fruita Paleontological Area, Colorado, but rare/isolated specimens are known from several localities—all of which are associated with a meandering river system. Currently, the known taxa include the putative stem lizard *Shillerosaurus utahensis*; the paramacellodid-grade scincomorphan lizards *Paramacellodus* sp., *Paramacellodus* sp. cf. *P. oweni*, *Saurillodon* sp.; the anguimorphan lizard *Dorsetisaurus* sp.; and the primitive snake *Diablophis gilmorei*. Indeterminate skeletal elements may represent additional lizard taxa.

The presence of paramacellodids in the Morrison Formation is part of a nearly global Late Jurassic distribution (across Laurasia and into central Gondwana) of this grade of lizards. *Dorsetisaurus*-grade anguimorphans have a more limited western Laurasian distribution. The presence of a snake in the Morrison Formation is part of a distribution of morphologically similar primitive snakes in the Middle Jurassic–Early Cretaceous of Europe and North America. The combination of *Paramacellodus*-grade and *Dorsetisaurus*-grade lizards and a *Parviraptor*-grade primitive snake—informally referred to here as a "Purbeckian-type" squamate fauna—is also found only in the Late Jurassic coal of Guimarota, Portugal and the Early Cretaceous Purbeck Limestone in England.

This "Purbeckian-type" squamate fauna stands in contrast to taxonomically distinct paracontemporaneous faunas. The Late Jurassic–Early Cretaceous of Germany, Italy, and Spain, are notable for early gekkonomorphs. A gekkonomorph is also known from China, but the faunas of the Chinese Upper Jurassic are dominated by the stem scincomorphans *Dalingosaurus* and *Yabeinosaurus*. Early acrodontan iguanians have been found in the Upper Jurassic of India and the Early Cretaceous of Brazil and China.

By the Late Jurassic, squamates were diverse and globally distributed. Even though many are considered "stem taxa" it is clear that by the Late Jurassic scincomorphans, anguimorphans, acrodontan iguanians, gekkonomorphans, and snakes (all major branches of the squamate tree) were established, widespread, and diverse. This supports earlier hypotheses that the major clades within Squamata likely originated in and radiated across Pangaea. The lizards and snakes of the Morrison Formation represents a valuable sample of an early resultant regional distribution.

Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

RECONSTRUCTING BODY MASS FROM MARSUPIAL DENTAL DIMENSIONS

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Because teeth are the most commonly-preserved species-diagnostic mammalian fossil remains, dental measurements are often used for predicting body mass. We use the allometric relationships between dental dimensions and mass from extant species to infer body mass for taxa we are unable to directly measure. While this approach has been widely used for a variety of placental lineages, we are applying this concept to marsupials to create a molar area/body mass proxy that will accurately predict body mass in both modern and fossil marsupials. While m1 is the tooth that generates the best predictions of body mass for placental mammals, many of the upper and lower cheek teeth, especially those bracketed by other teeth in the dentition, have been shown to be accurate predictors of species' size. Because upper molars are well-known and easily identified for fossil marsupials, we test their utility in estimating body mass of extinct species. We measured upper dentition for 42 species of North American, South American, and Australian marsupials spanning a range of sizes (0.007 – 29 kg) and across the phylogenetic diversity of the lineage. We estimated molar area on the occlusal surface using anteroposterior length of the stylar shelf (stylar cusps A–E) and the longest buccolingual length of the tooth (stylar cusp E to lingual edge of the protocone for M1–M3, but stylar cusp A to lingual edge of the protocone for M4). When the area of each molar was regressed against species average body mass, we found that upper molar area in all four molars is highly correlated with body mass. M2 area has the strongest correlation ($R2 = 0.90$, $p = 4.44e\text{-}16$), while M1 area, M3 area, and M4 area are still strongly correlated (M1: $R2 = 0.88$, $p = 1.11e\text{-}14$, M3: $R2 = 0.88$, $p = 2.20e\text{-}14$, M4: $R2 = 0.86$, $p = 5.39e\text{-}13$). We used this linear relationship to predict body masses and found that the estimations vary with taxa and size. When applying the estimations to fossils, we find that North American marsupials varied over a wide size range (0.27 to 1.08 kg) through the Paleogene prior to their extinction in the late Oligocene.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

AN UPDATE ON THE MIDDLE JURASSIC TURTLE ASSEMBLAGE OF THE BEREZOVSK QUARRY (WEST SIBERIA, RUSSIA)

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The Berezovsk Quarry locality (Krasnoyarsk Territory, West Siberia, Russia) yields a rich assemblage of Middle Jurassic (Bathonian) vertebrates. Turtles are absolutely dominant among vertebrates of this locality by material, which consists of thousands of isolated bones and several more complete specimens, including partial braincases and larger portions of the shell. Previously all this material was attributed to a single taxon – *Annemys* sp. (Xinjiangchelyidae). A recent reexamination of this material revealed four specimens, which cannot be attributed to *Annemys* sp. and belong to different turtle taxa (Testudines indet. 1–3). Testudines indet. 1 is represented by a single costal 8, which is significantly thicker than costals 8 of *Annemys* sp., lacks scute sulci and sculpturing on the external surface and has a very strong rib thickening on the internal surface. The absence of scute sulci on this costal suggests that vertebral scutes were wide, that is typical for basal turtles. Testudines indet. 2 is represented by two shell fragments (presumably, plastron) with surface sculpturing consisting of elongated tubercles. Such kind of sculpturing is not known in other Jurassic turtles of Asia and somewhat similar to surface sculpturing of Pleurosternidae and Solemydidae, having Jurassic record outside Asia. An alternative interpretation is that Testudines indet. 2 specimens belong to abnormal individuals of *Annemys* sp. Testudines indet. 3 is represented by a distal fragment of the humerus, which is twice larger than those of *Annemys* sp. and distinguished from the latter by wider and lower distal condyle. Similar morphology of the humerus is demonstrated by some basal turtles (*Mongolochelys efremovi* from the Late Cretaceous of Asia). Testudines indet. 3 may belong to one of two other indeterminate shell-taxa (Testudines indet. 1 or 2). Thus, the new specimens have characteristics of basal turtles, although their precise taxonomic position and number of taxa is unclear. The presence of two to four turtle taxa in the Berezovsk Quarry, including representatives of basal turtles (Testudines indet. 1-3) and basal cryptodires (*Annemys* sp.), agrees with similar diversity of some Middle Jurassic turtle assemblages of China. Further determination of the systematic position of new turtle taxa of the Berezovsk Quarry requires a histological study.

Grant Information
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Romer Prize Session (Thursday, October 27, 2016, 10:45 AM)

THE ROLE OF CRANIAL VASCULATURE IN ARTIODACTYL MACROEVOLUTION: SELECTIVE BRAIN COOLING AS A VITAL PREREQUISITE FOR FOREGUT FERMENTATION

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Artiodactyls are the most speciose large-bodied, terrestrial vertebrates alive today, and processes driving their diversification have long been of interest. The prevailing view is that foregut fermentation digestive physiology (FF) is a key innovation responsible for artiodactyl evolutionary success. This hypothesis may be incomplete, however, as other unique physiologies of modern artiodactyls, such as selective brain cooling (SBC), may also be influencing diversification. SBC effectively decouples brain and body temperature, prolonging exercise duration and increasing water economy by delaying hydrologically-costly panting and sweating. In this study, I trace SBC evolution across Cenozoic climate shifts to test the hypothesis that SBC is an artiodactyl key innovation using a combination of anatomical and evolutionary modeling approaches.

In artiodactyls, SBC is mediated by the carotid rete (CR), an arterial meshwork that anatomically replaces the internal carotid artery. A soft tissue survey, conducted using CT imaging, revealed unique basicranial osteology among artiodactyls with a CR, which allowed identification of SBC distribution in recent and fossil skulls from all extant and 16 extinct artiodactyl families. Digestive physiology was scored where possible for the same taxa. Distributions of SBC and FF were compared using phylogenetic comparative methods and paleobiology modeling approaches. Extant artiodactyls show significant overlap in SBC and FF (87%), however, surveys of fossil specimens reveal higher disparity among extinct species. Occurrence-based turnover rate models revealed that artiodactyls with a CR arise earlier, speciate faster, and are more insulated from extinction. This relative timing of trait acquisition, combined with patterns of Neogene trait overlap, suggests that SBC may be a prerequisite for ruminant digestion, necessary to protect the brain from high core temperatures sustained during FF. Instead of considering each trait independently, a more inclusive diversification paradigm may be that of correlated progression: in the Eocene, SBC and FF do not evolve in a correlated manner; however, once SBC is established, thermally intensive FF can be accomplished without damaging the brain. By the Miocene, SBC and FF are functionally and evolutionarily linked, responding to selective pressures as a unit. Thus, SBC is a demonstrably important component of artiodactyl macroevolution, and its role in sustained diversity of other mammalian groups (e.g., Carnivora) merits further investigation.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

THE BIOLOGY OF *EOCONFUCIUSORNIS*

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The basal confuciusornithiform *Eoconfuciusornis* is the oldest and most primitive bird with a beak and pygostyle. New information on this taxon reveals evolutionary trends in the Confuciusornithiformes, the most numerous clade of birds in the Jehol. The manual ungual disparity present in *Confuciusornis* is lesser developed in *Eoconfuciusornis*, and the deltopectoral crest of the humerus is not perforated by a foramen as it is in *Confuciusornis*. The second known specimen of *Eoconfuciusornis* preserves unusual soft tissue traces of the ovary, propatagium, and nearly its complete plumage including pennaceous feathers on the alular digit shorter than those that form the alula in ornithothoracines. The ovarian follicles preserve a stronger hierarchy than observed in *Jeholornis* and enantiornithines, consistent with osteohistological data, which both indicate that a higher basal metabolic rate evolved independently and apparently early in the evolution of the confuciusornithiforms. The preserved internal soft tissue of the propatagium, documented for the first time, is interpreted as the perimineralized remnants of the collagenous fascial sheet and fascial curtain. The internal structure bears remarkable similarity to that in living birds although the apparent absence of the propatagial ligament suggests that the confuciusornithiform propatagium could produce lift but not prevent hyperextension. The remiges preserve remnants of their original patterning, supported by observable differences in melanosome morphology. The tail lacks rectrices, indicating that the earliest known confuciusornithiforms were sexually dimorphic in their plumage.

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Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

NEW AVIALANS FROM THE LATE CRETACEOUS MAEVARANO FORMATION, MAHAJANAGA BASIN, NORTHWESTERN MADAGASCAR

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The Upper Cretaceous (Maastrichtian) Maevarano Formation has yielded a fantastic diversity of latest Cretaceous terrestrial and freshwater vertebrates, including a surprising diversity of avialan theropods. Included among these are representatives of multiple non-neornithine groups, including early-branching pygostylian, enantiornithine, and ornithuromorph forms, with only a single taxon (*Vorona berivotrensis*) named to date.

Field research over the past several years has resulted in the collection of additional avialans, many of which have been recovered from the spectacular MAD 05-42 quarry. These range from isolated bones to nearly complete, articulated partial skeletons. The majority of specimens retain near-3D quality, with the most exquisite preservation represented by multiple, articulated pedal skeletons consisting of individual elements <2 mm in length. Moreover, there are numerous examples of exquisite preservation in the form of both tendinous and keratinous (e.g., claw sheaths) tissues.

A number of the new specimens (e.g., both pelvic and pectoral girdle and hind limb bones, vertebrae) are referable to the previously described *Vorona berivotrensis*, an avialan historically placed either within Enantiornithes or in various positions among early-branching ornithuromorphs. Other forelimb and pectoral girdle materials pertain to a novel avialan (formerly referred to as Humeral Taxon A), providing additional insight into this form. A mosaic of characters (e.g., a proximally position deltopectoral crest, a non-expanded distal end of humerus) are present, precluding confident placement among early branching ornithothoracines. Finally, other materials (e.g., a synsacrum with 10 fused vertebrae) clearly pertain to Ornithurae.

These new avialan discoveries are important in that they add to the growing diversity of Late Cretaceous vertebrates on Madagascar, representing one of most diverse clades represented in the fauna. It is significant that they pertain to clades that are best known from Early Cretaceous deposits on Laurasian landmasses (mostly present day China) and even more so that there are neither stem nor definitive neornithine birds represented in this diverse Maastrichtian Malagasy avifauna.

Grant Information
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Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

PAEDOMORPHISM IN MODERN CAMELIDS

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Paedomorphism is a developmental change where adult species retain juvenile characters. Cranial paedomorphosis has been measured in several animals, including Reduncinae antelope, but has not been explored in Camelidae. The two extant tribes of camelids split in the early Miocene (17–18 Ma): the South American Lamini (llamas and vicugnas) and African and Asian Camelini (dromedary and Bactrian camels). Despite their considerable temporal divergence, both tribes of modern camels have very similar skulls, with adult Lamini retaining characteristics typical of juvenile Camelini. The Lamini are smaller and have shortened lifespans compared to the Camelini. Smaller size in mammals is generally associated with shorter time to maturation, an adaptation which could be quickly gained through paedomorphic genetic changes. It is possible that the size differences between the two clades are driven by a paedomorphic response to change in ecology, but Bergmann's rule may also have played a role: larger *Camelus* species crossed the Bering land bridge 8 million years ago, while *Lama* and *Vicugna* species migrated south 2 million years ago. Evolution of paedomorphic features in Lamini could also relate to niche separation in sympatric species.

We evaluated 48 specimens of modern camelids (*Camelus bactrianus, Camelus dromedarius, Lama guanaco,* and *Vicugna vicugna)* for cranial paedomorphic traits using 3D geometric morphometrics. We used a Procrustes ANOVA in the R package 'geomorph' to test the hypothesis that juvenile *Camelus* would more appropriately grouped in shape space with adult *Lama* and *Vicugna*. We found no significant difference between the two camelid tribes ($p = 0.21$), but found significant difference ($p = 0.01$) when younger *Camelus* species were grouped with adult *Vicugna* and *Lama*. Ontogenetic trajectories of all four species were nearly identical in slope, but had different intercepts. Juvenile *Camelus* are more similar to adult Lamini than adult *Camelus* until eruption of the second molar (about 3 years of age), indicating that paedomorphosis is present in Camelidae.

Grant Information
Ernst Mayr Travel Grant, Field Museum Research Grant, Thomas Condon Award, and Smith Scholarship

Technical Session VI (Thursday, October 27, 2016, 9:15 AM)

QUANTITATIVE ASSESEMENT OF CURRENT PIT CHRONOLOGY AT RANCHO LA BREA AND PROSPECTS FOR ITS IMPROVMENT

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The Rancho La Brea tar pits are famous for the quantity, quality, and diversity of fossil organisms they contain, ranging from microfauna to plants to mammoths. So pivotal is the role of the tar pits in our understanding of the terminal Pleistocene that the Rancholabrean North American Land Mammal Age bears its name. The tar pits contain many thousands of Pleistocene carnivore fossils, and these large samples allow population-level studies of Pleistocene carnivore biology. Moreover, the fossils at Rancho La Brea (RLB) span a critical time in Earth's history (approximately 50,000 to 8,000 years ago) that includes major climatic fluctuations, the arrival of humans to North America, and the subsequent mammalian megafaunal extinctions. However, RLB is underutilized for climate and evolutionary studies because of uncertainty surrounding the ages of the fossils. While the deposits at RLB have been extensively carbon dated, efforts have been haphazard with no overall dating scheme for the entire deposit. Early carbon dates were expensive in dollars and material, laborious, and vulnerable to contamination. Recent advances in AMS carbon dating have ameliorated these concerns, but Pit 91 is currently the only deposit with a statistically adequate number of dates. Lastly, much confusion exists in the literature concerning calibration of dates with some reported in radiocarbon years before present and others in calendar years. Here we report the current state of chronology at RLB, gathering all extant dates, including many new, unpublished AMS dates. All dates are calibrated to the CalPal2007 calibration curve, insuring uniform and accurate calendar dates for the first time. We report dependable mean calendar dates for Pits 10, 61/67, 13, 3, 91, and 77, and show that they vary significantly. Date ranges also vary significantly from pit to pit. Small pits appear to represent single entrapment events, while the large Pits 3 and 91 may contain multiple events. A partition analysis based on kmeans clustering is also performed, demonstrating the different date clusters can be isolated and then tested for spatial concentration. This research presents the current state of knowledge of RLB chronology and is, therefore, of interest to all who study the biota in the deposit and its relationship to chronologically dependent variables such as climate and human arrival. We also advance a coherent sampling plan that will comprehensively date the entire deposit for the first time.

Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

RECENT TETRAPOD DISCOVERIES FROM THE MIDDLE PERMIAN (GUADALUPIAN) OF TANZANIA AND ZAMBIA, WITH BIOGEOGRAPHIC CONSIDERATIONS

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To date, studies on Guadalupian tetrapods relied almost exclusively on the Karoo Basin of South Africa and the Cis-Urals region of Russia, limiting progress towards understanding global middle Permian biogeography. Fortunately, recent work has been dedicated to studying other Guadalupian tetrapod-bearing basins. Here we present the most recent findings from the mid-Permian in Tanzania and Zambia. We also review studies from other basins preserving Guadalupian strata to compare assemblages more globally.

Recent studies of the Ruhuhu Formation of Tanzania have revealed two potentially mid-Permian tetrapod horizons. The R2 horizon contains emydopoid dicynodont jaws and the dicynodont *Endothiodon*, and likely correlates with the *Pristerognathus* Assemblage Zone (AZ) of the Karoo. The R1 horizon contains tapinocephalid dinocephalians, temnospondyls, and the dicynodont *Abajudon kaayai*. Field work in the lower Madumabisa Mudstone Formation of Zambia (Mid-Zambezi Basin) has yielded anteosaurid and tapinocephalid dinocephalians, temnospondyls, gorgonopsians, burnetiamorphs, a possible archosauromorph, and the possible biarmosuchian *Wantulignathus gwembensis*. *Abajudon kaayai* was also found here, providing a biostratigraphic link to the R1 horizon of Tanzania. In the Karoo, dinocephalians are only found in Guadalupian strata, implying a similar age for the R1 horizon and the lower Madumabisa Mudstone Formation.

The mid-Permian faunas of Tanzania and Zambia are similar to the *Eodicynodon* and *Tapinocephalus* AZs in their higher-level taxonomic composition. However, these faunas differ from the Karoo at lower taxonomic levels. They contain the basal endothiodont *Abajudon kaayai*, which, along with the primitive *Endothiodon tolani* of the R2 horizon, may be evidence that *Endothiodon* had its origins north of the Karoo Basin. In general, there are strikingly few tetrapod genera shared between mid-Permian basins, a pattern starkly different from the generic cosmopolitanism typically seen in the upper Permian. The lower Madumabisa Mudstone also contains evidence of an archosauromorph, a clade that is not recorded in the Karoo until the Triassic. An archosauromorph was recently reported in a putatively mid-Permian locality in the Rio do Rasto Formation of Brazil, although the age of the locality is poorly constrained. Recent work on Guadalupian biogeography reveals a surprising level of regional endemism and complexity in dispersal patterns.

Grant Information

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Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

USING AUGMENT SOFTWARE TO CREATE MOBILE FOSSIL COLLECTIONS: TECHNOLOGY AND WORKFLOW

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3D technology, specifically augmented reality (AR), virtual reality (VR), and simple computer manipulation of 3D models, has been relatively inaccessible for K-12 and post secondary education with the exception of pre-packaged software used for teaching subjects such as organic chemistry. The recent increase in availability of these software products in addition to 3D digitization advances are changing that. AR software products can be of particular importance to museums and research groups with outreach programs. AR platforms, in particular, allow science educators to bring fossil collections with them wherever their students have access to technology (iPads and tablets). A fossil specimen that might otherwise be too valuable to move for educational outreach, can be digitized and brought along using AR. This is more useful than using photographs of these specimens because suggests that students using mixed reality learning platforms engage in more discussion with each other and their teachers during class. For this project, students and staff working in the Idaho Museum of Natural History's (IMNH) Idaho Virtualization Lab (IVL) created scientifically accurate 3D models of extinct animals using 3D scans and reference images. The finished 3D models have been used for K-12 education and outreach, utilizing Augment software. Students and teachers can download the Augment application for free, and view paleontological material from the museum's collections anywhere. Unlike 2D images, students are able to rotate and manipulate these 3D models. 3D models of fossils and extinct organisms are presumably enhancing student understanding of these objects in the same way students use 3D models to learn organic chemistry. This poster presentation aims to demonstrate how Augment software works, and provide information to others interested in integrating augmented reality into their education and outreach programming.

Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

A HISTOLOGICAL STUDY OF ONTOGENETIC AND TAXONOMIC VARIATION IN SHELL ORNAMENTATION OF TRIONYCHOID TURTLES FROM THE UPPER CRETACEOUS (CAMPANIAN) KAIPAROWITS FORMATION OF UTAH

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Trionychoid turtles possess highly varied ornamentation on their shell, which has led to a vast array of taxonomic problems with extinct species. This problem is exacerbated because ontogeny and variation of this ornamentation is poorly understood. The Upper Cretaceous (Campanian) Kaiparowits Formation of southern Utah, U.S.A., preserves an ideal fossil assemblage to help resolve this problem, with abundant remains of the trionychoids *Adocus*, *Heloplanoplia*, and *Aspideretoides* and another cryptodire with similar ornamentation, *Basilemys*. To examine ontogenetic variation in the bone histology of trionychoids, we sampled 18 carapacial and 9 plastral elements from all four genera from the Kaiparowits Formation, comprising a range of ontogenetic stages for each genus.

Adult shells display four major histological zones: an uppermost layer associated with the superficial ornamentation, a zone with plywood-like layers as described by previous studies, an interior cancellous region, and finally a basal unornamented layer of compact bone. The uppermost layer displays primary parallel-fibered bone with sparse simple canals and lamellae that parallel the ornamentation surface. The interior of this layer preserves evidence of previous generations of ornamentation, which are generally more rounded and broader than structures deposited later in life. Later ornamentation is slightly offset from earlier structures. The plywood region is just below this compact bone. It contains alternating bands of dorsoventrally and mediolaterally arranged parallel-fibered bone tissue. Vascular spaces in the cancellous zone intrude into the external cortex and are irregular ellipsoids; they are often remodeled with secondary tissue. The compact basal layer is unusual in that it possesses vascular canals that almost reach the shell margin in some areas. In contrast, juvenile specimens possess the uppermost layer, cancellous zone, and basal compact layer; no plywood-like tissue is present. The ornamentation is rounded and wide like the adult subsurface records, but this layer is thinner and avascular. In the cancellous region, vascular spaces are more circular and rounded, gradually increase in density towards the interior of the bone, and are not remodeled. The basal compact layer shows very little vascularization. Thus, trionychoid ornamentation changes shape and location through ontogeny, and the characteristic plywood-like structure of trionychid shells, which some suggest confers a mechanical advantage, was not present in young individuals.

Grant Information

This project was funded by the Undergrad Research Opportunity Program at the University of Utah.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

TESTING THE DIAGNOSTIC POTENTIAL OF FELID POSTCRANIA USING GEOMETRIC MORPHOMETRICS

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Species, genera, and higher taxa of felids and other feliform carnivorans have classically been differentiated from one another on the basis of cranial and dental characters. This focus on craniodental traits, along with the conserved nature of felid postcrania, means that isolated skeletal elements have generally been treated as undiagnostic, leading to many potentially important specimens being identified only to family level or used as the basis of nomina dubia. The resulting taxonomic uncertainty can handicap analyses of feliform richness, abundance, and ecological interactions. Such is the case during the late Miocene (Clarendonian and Hemphillian North American Land

Mammal Ages), a critical period of time in the evolution of North American feliforms as a consequence of the immigration and diversification of true felids (both conical- and saber-toothed) as well as the appearance and extinction of the saber-toothed feliform *Barbourofelis*. Craniodental remains constitute only a small fraction of the late Miocene feliform fossil record. Postcrania, most notably humeri, are common and, in the case of aberrantly large specimens from Oregon, Nevada, and Texas, suggest that a giant, previously unrecognized felid species may have existed in the Hemphillian. Can isolated postcrania provide the taxonomic framework necessary for paleobiological analyses or do they reflect a functional, rather than phylogenetic, signal? Recent work has suggested that humeral trochlea morphology can be used to distinguish modern felid species. We use a geometric morphometric analysis of the distal humeri of 15 fossil feliform species to test the hypothesis that trochlea shape can be used to differentiate extinct North American felid species, as well as distinguish true felids from contemporaneous feliforms (*Barbourofelis* and Nimravidae). By applying the results of our discriminant function analysis to the postcrania-dominated feliform fossil record of the Hemphillian of the Northwest United States, we demonstrate the diagnostic utility of humeral trochleae and provide a new tool for analyses of carnivoran paleobiology.

Technical Session XII (Friday, October 28, 2016, 4:00 PM)

ADVANCING BEYOND THE PHYLOGENETIC BRACKET

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Inferring the biology and behavior of extinct species has always been a central aim for paleontology. For most of the field's history, Cuvier's "correlation of parts" was the tool of choice to infer the biological attributes of extinct organisms. In the early 1990s, Bryant, Russell, and Witmer formalized a cladistic approach for reconstructing such unpreserved traits in extinct organisms. The method uses binary character states in the closest two extant outgroups of an extinct organism to predict the presence or absence of a binary trait that does not fossilize. Because nodes on a cladogram can be revolved without changing the topology, the extinct organism can be "bracketed" by extant relatives. Witmer called this the extant phylogenetic bracket (EPB). The EPB was a great advance in its day, but as a parsimony-based method it has serious drawbacks and is commonly misused in paleobiological research. Here I discuss a new generation of model based approaches for making phylogenetically-informed predictions for continuous and discrete data. Such models are statistically rigorous and can explicitly evaluate different hypotheses using likelihood ratio tests or Bayes factor tests. They can accommodate multiple sources of uncertainty, including the model itself, varying rates of evolution, character state values, and phylogenetic relationships. Like the EPB, stronger estimates of character state values can be made for fossil taxa using osteological or other correlates. However, model based approaches also yield confidence intervals or posterior distributions on the prediction, quantifying the range of plausible values the character may have taken. We can also leverage more phylogenetic information in the form of branch lengths, varying rates of evolution, and patterns of repeated evolution (convergence). This model based approach can be called "phylogenetically-formed predictions" or "retrodictions" (predictions of past events).

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

MORPHOLOGICAL AND LAMINAE PATTERN VARIATION IN THE DORSAL SERIES OF A NEW TITANOSAURIAN SPECIMEN FROM LO HUECO (CUENCA, SPAIN).

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The Lo Hueco site (Campanian-Maastrichtian. Cuenca, Spain) has provided several partial titanosaurian skeletons in articulation or with a low dispersion, producing a unique record in Europe. HUE-EC-11 is a partially articulated specimen preserving a series of anterior-middle dorsals in articulation, several appendicular bones and osteoderms in possible association. Only a few European titanosaurs preserve relatively complete dorsal series, and HUE-EC-11 provides important information about the morphological changes related with laminae patterns, pneumaticity, the hyposphene-hypantrum articulation and neural spine.The anatomical observed changes are mainly related to the morphology of the transverse process and the neural spine. The diapophysis migrates to a more anterior position than the parapophysis. In the anteriormost dorsals, the transverse processes are transversely long, reducing their length by half in the middle dorsals. A drastic change in the neural spine orientation and morphology is observed in the transition between anterior and middle dorsals. The neural spine of the anteriormost dorsals bears a pronounced posterior inclination (<40°), and becomes vertical and latter anteriorly projected. A similar transition is observed in *Dreadnoughtus*. The lamination is relatively simple and, as far as available, no important secondary lamination is present. The diapophyseal laminae complex is composed by the pcdl, acpl, pcpl (present in the middle dorsals, and joins to the acpl dorsally before reaching the parapophysis), and prdl. The neural spine bears well-developed spol, spdl (with an accessory spdl), prsl and posl. This titanosaur features the presence of a hyposphene-hypantrum articulation composed of a short hyposphenic crest, which appears in the middle dorsals. HUE-EC-11 shares with several titanosaurs a dorsally facing diapophysis: the absence of sprl in the anterior and middle dorsals; or the absence of the podl. The vertical orientation of the neural spines is also shared with several titanosaurs, like Isisaurus and *Diamantinasaurus*. The presence of a hyposphenic crest is common in basal titanosaurs and in some European titanosaurs, as *Ampelosaurus* and the dwarf form *Magyarosaurus*. The phylogenetic context of the Lo Hueco titanosaurs is uncertain, and therefore their relationship with aeolosaurine and saltasaurid lineages is still unknown. Furthermore, a preliminary analysis of the axial remains suggests the presence of at least two, but maybe three, different vertebral morphotypes in the site.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

NEW INFORMATION ON THE LATE CRETACEOUS ARGENTINEAN SAUROPOD DINOSAUR *MENDOZASAURUS* AND ITS IMPLICATIONS FOR BASAL TITANOSAUR RELATIONSHIPS

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The sauropod dinosaur *Mendozasaurus neguyelap* is represented by several partial skeletons from a single locality within the Coniacian Sierra Barrosa Formation in the south of Mendoza Province, northern Neuquén Basin, Argentina. A detailed revision of *Mendozasaurus*, including previously undocumented remains, allows us to more firmly establish its position within Titanosauria, as well as enabling an emended diagnosis of this taxon. Two cervical vertebrae, five metacarpals, a complete femur, an astragalus, six metatarsals, three phalanges and one ungual phalanx are the new bones recovered from the holotype site.

Characters of the emended diagnosis include: a) middle and posterior cervical vertebrae with tall and transversely expanded neural spines that are wider than the centra, formed laterally by spinodiapophyseal laminae that are not connected with the pre- or postzygapophyses; b) anterior caudal vertebrae (excluding anteriormost) with ventrolateral ridge-like expansion of prezygapophyses; c) humerus with divided lateral distal condyle on anterior surface. Comparative studies of articulated pedes of other taxa allow us to interpret that the pedal formula was 2-2-2-2-0, based on disarticulated bones that form a right hind foot.

Mendozasaurus was incorporated into an expanded version of a titanosauriform-focused phylogenetic data matrix, along with several other contemporaneous South American titanosaurs. The resultant data matrix comprises 75 taxa scored for 403 characters, and our analyses recover *Mendozasaurus* as the sister taxon to *Futalognkosaurus*, supporting previous analyses that resolve a monophyletic Lognkosauria. Lognkosauria forms a clade with the rinconsaurian *Muyelensaurus* + (*Notocolossus* + *Pitekunsaurus*). Novel to our study, *Epachthosaurus* is recovered just outside of this grouping. A basal lithostrotian position for this South American clade is well supported, contrasting with some analyses that have placed these taxa outside of Lithostrotia or closer to Saltasauridae. Unlike many previous studies, we find that *Aeolosaurus* is more closely related to Saltasauridae than to these taxa. Our new data on *Mendozasaurus* and related forms provides a platform for elucidating the interrelationships of derived titanosaurs.

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Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

WHITE RIVER CHRONOFAUNA MAMMALS SHOWED MARGINAL NICHE RESPONSES TO SUBSTANTIAL CLIMATIC CHANGE

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Animals respond to environmental change in modern ecosystems by (1) adapting to new niches through natural selection, (2) migrating to track their habitual niches, or (3) going extinct. During the Cenozoic, mammals weathered several climate change intervals, and each of these three responses has been recorded in the fossil record. In this study, we wanted to determine how changes in tooth shape caused by enamel wear can be used to reconstruct the diets of species that lived through the Eocene–Oligocene climatic transition (EOCT), a period of cooling and drying from about 38–25 million years ago. During this time interval, ungulate communities first shifted from browsing to grazing as the western grasslands opened up. This dietary shift is associated with changes in average tooth shape as the result of wear over million-year timescales.

We used mesowear analysis of teeth to evaluate the degree of wear of ungulate molars by observing (1) the cusp shape and (2) the relief between these cusps as indicators of diet. This method allowed us to classify fossil species into one of three typical ungulate diets—fruit and leaf browsing, mixed feeding, and grazing. We studied a sample of casts of tooth crowns (n = 338) from artiodactyls and perissodactyls of the White River System (WRS) that spans the EOCT in the American West.

Despite the large-scale climatic change known for the EOCT, the dietary response by these species when combined into families was muted. The overall mesowear scores for each of the three time intervals of the EOCT showed no significant difference in overall diets of species in the community ($F_{2,156}$ = 2.17, P = 0.116). Additionally, mesowear scores for families that occurred in two or more time divisions of the WRS were also not significantly different, with the marginal exception of Rhinocerotidae ($F_{2,22}$ = 3.45, P = 0.0496).

Why aren't mammalian diets tied more closely to the landscape? These White River species represented the survivors of a number of earlier extinction events. It is possible that these 'hardier' species were better able to weather a climate change interval than others that had either gone extinct or migrated elsewhere already. The taxonomic makeup of the community was relatively stable across the interval, and the fauna represented the survivors of earlier extinctions, so we think that the generalized niches of these WRS species were the result of their resilience to extinction.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

NUTRIENT FORAMEN SIZE DOES NOT PREDICT EXERCISE OR GROWTH PHYSIOLOGY IN AN EXPERIMENTAL ARCHOSAUR MODEL WITH IN-PARALLEL AND IN-SERIES CIRCULATION

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Size of the femoral nutrient foramen (NF) has been found to correlate strongly with the aerobic capacity (VO_2max) across extant vertebrate taxa. Since VO_2max is significantly higher in endotherms than in similar-sized ectotherms, this suggests that a simple measurement—NF cross-sectional area (CSA)—can be used to predict the metabolic physiology of extinct vertebrates, and inform the debate on the evolution of endothermy. We tested the hypothesised mechanistic relationship between NF CSA and VO_2max in 72 juveniles of the American alligator, a model archosaur. Given that acquisition of an in-series circulatory design (where only one aorta leaves the heart's ventricle) must have preceded the origin of endothermy, the pulmonary bypass shunt was surgically removed in half of the animals. While shunt removal did not alter the animals' ectothermic metabolism, it did significantly elevate left ventricular pressures, and likely altered systemic haemodynamics. The aerobic capacity of alligators was elevated by long-term exercise training, their whole-body growth was tracked longitudinally, and bone formation was labelled by fluorescent dye injections. Aerobic capacity was determined for each animal with a ramped treadmill test. In each femur, the NF was imaged under a stereoscope, its minor diameter measured in duplicate, and the total NF CSA calculated. Femoral mineral apposition rate (MAR) was determined histologically from mid-diaphyseal cross-sections imaged under UV light. We calculated residuals from separate least-squares regressions of NF CSA and MAR against femur length, and VO_2max on body mass. A residuals analysis revealed no significant relationship between NF CSA and VO_2max, and between NF CSA and MAR. This suggests that NF size is not a predictor of either aerobic capacity or growth rate in ectothermic archosaurs, and this is not affected by their circulatory pattern. Even if NF size is found to correlate with VO_2max in extant endothermic archosaurs, this method is probably of limited value to physiologic analysis of the fossil record because it requires an a priori determination of endothermy using an independent approach. By itself, the nutrient foramen does not shed light on the timing and origin of endothermy.

Grant Information
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Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

FINDING NEMO: TRAUMATIC PATHOLOGY IN THE LEFT FORELIMB OF A *PLATECARPUS PLANIFRONS* FROM THE NIOBRARA FORMATION (UPPER CRETACEOUS) OF SOUTH DAKOTA, USA

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Pathologies in the crania and axial elements within Mosasauridae are well-documented, while instances involving limbs are comparatively rare. Here we report on a specimen of *Platecarpus planifrons* from the Niobrara Formation of South Dakota with traumatic pathology to the left forelimb.

SDSM 32720 is approximately 40% complete, including skull and lower jaw elements; vertebrae; ribs; right scapula and coracoid; left scapula, coracoid, humerus, radius, ulna, and associated phalanges. The left scapula and coracoid are fused at the medial surface of the scapula coracoid facet via extensive exostosis, but the glenoid fossa remains unaffected. Malunion along the scapula coracoid facet has resulted in the scapula occupying a nearly horizontal position relative to the coracoid, in contrast to the 40° angle observed between the two, normally unfused, elements in *Platecarpus*. The proximal and distal ends of the left humerus exhibit no trauma, but a transverse fracture occurred at the narrowest portion of the shaft. Malunion of the proximal and distal ends resulted in rotation of the distal end dorsally approximately 30° from the midline. Extensive exostosis is observed at the fracture site due to excess callus formation from either osteomyelitis or death of the individual prior to callus resorption. The left radius and ulna remain unaffected, as do the right scapula and coracoid.

The pathologies associated with the forelimb of SDSM 32720 are likely the result of traumatic injury. Although no direct evidence (e.g. bite marks) is observed, the most obvious source of injury is an encounter with a large predator, possibly another mosasaur or shark. A literature survey of mosasaur pathology reveals comparatively few reports in limb elements. The most commonly described pathologies occur in the ribs and vertebrae, which are likely under reported. The relative paucity of documented, healed injuries in mosasaur limb elements suggests that, despite primary propulsion by the tail, paddles played a crucial role in mosasaur locomotion. Survival in mosasaurs after limb injury appears low.

Grant Information
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Symposium I (Wednesday, October 26, 2016, 11:00 AM)

MOLECULAR ANALYSES OF *EOCONFUCIUSORNIS* (BIRD) FEATHERS SUPPORT THE PRESENCE OF ORIGINAL KERATIN PROTEINS AND MELANOSOMES FOR AT LEAST 130 MA

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The hypothesis that melanin-containing microbodies are preserved in fossil feathers is contentious, because the majority of data presented are based only upon morphology, and often not of the bodies themselves, but more often of impressions within an uncharacterized amorphous matrix. We contend that if these bodies are indeed melanosomes, they should be contained within a keratinous matrix; if microbial in origin, this matrix should be exopolymeric substance (EPS) secreted by microbes, and subsequently mineralized. Thus, to distinguish between these alternative hypotheses, we employ multiple methods, well established for the molecular characterization of modern materials, including feathers, to feathers preserved with an exceptional new specimen of a 130Ma *Eoconfuciusornis* (STM 7-144), from Qingyan, northern Hebei, China. Our results support the retention of original protein components, and are consistent with the melanin and melanosomes in these ancient (about 130 Ma) keratinous tissues. We also outline a mechanism for this preservation, and note that a microbial role in early diagenetic precipitation of mineral to stabilize these materials is likely.

Grant Information
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Technical Session IX (Thursday, October 27, 2016, 2:15 PM)

EUANTIARCH PLACODERMS FROM THE EMSIAN (LOWER DEVONIAN) OF WUDING, YUNNAN, CHINA

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Antiarch placoderms are currently recognized as the most basal group of jawed vertebrates, and comprise yunnanolepiforms, sinolepids, and euantiarchs. Euantiarchs are characterized by the helmet-shaped brachial articulation of the pectoral appendage, and are highly diversified with two major subgroups (bothriolepidoids and asterolepidoids). The diverse euantiarchs (exemplified by *Bothriolepis* and *Remigolepis*) are commonly known from the Middle and Late Devonian deposits worldwide, however their earlier occurrences are very few. So far, only five euantiarchs (*Wudinolepis*, *Luquanolepis*, *Microbrachius, Hyrcanaspis*, and *Bothriolepis*) have been described from the Lower Devonian of South China and Iran. Here we report a new euantiarch from the Emsian (Lower Devonian) of Wuding, Yunnan, which is also the type locality and horizon of *Wudinolepis*. Based on high-resolution computed tomography scanning, several three-dimensionally preserved specimens of the new form and *Wudinolepis* have been restored to show the morphological details of primitive euantiarchs. *Wudinolepis*, a close relative of *Microbrachius*, is re-described to show many previously unknown features for the clade comprising *Wudinolepis* and *Microbrachius*. The *Dianolepis*-like new form is characterized by a large orbital fenestra, the arched dermal skeleton around the orbital fenestra, and the large obtected nuchal area of the head shield. The phylogenetic analysis places the new form at an intermediate position between *Dianolepis* and the clade comprising *Bothriolepis* and *Grossilepis*, and corroborates the paraphyly of the Bothriolepidoidei.

Grant Information
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Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

RE-EXAMINATION OF *STEREOGNATHUS HEBRIDICUS* (SYNAPSIDA, TRITYLODONTIDAE) FROM THE MIDDLE JURASSIC OF SKYE, SCOTLAND

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Tritylodontidae are advanced non-mammalian mammaliamorph synapsids that persisted from the Late Triassic to the Early Cretaceous. They share apomorphies of the orbital wall and sphenoid with Mammalia, but lack the squamosal-dentary joint. Their dentition is characterised by postcanine longitudinal rows of multiple cusps. Tritylodontidae are one of the closest sister-groups to Mammalia, providing important information on the development of mammalian morphological characters. Their specialisations for herbivory—unusual among stem mammal groups—are relevant to our understanding of stem mammal niche partitioning.

Despite being the first named tritylodontid genus, *Stereognathus* remains one of the most poorly understood. It was initially represented by *S. ooliticus* from the Bathonian Stonesfield Slate, England. This material mainly comprises teeth, while the holotype is a fragment of maxilla possessing three molars. A second species was later assigned to the genus: *S. hebridicus,* from the Middle Jurassic of the Isle of Skye, Scotland. This species is represented by only a handful of molars, mainly held in the National Museum of Scotland (Edinburgh), and University of Bristol Geology Collection (Bristol). However, these molars were never fully described; being only briefly outlined and named over 40 years ago, alongside stem mammalian material from Skye.

We have carried out a full taxonomic review of all available *Stereognathus hebridicus* material. This includes molars collected in the 1970s (including the holotype

and paratype), and during field work since 2010 from the same locality (the Middle Jurassic Kilmaluag Formation of Skye). Previous character analysis suggests *Stereognathus* belongs to a clade comprising *Beintheroides*, *Bocatherium*, *Polistodon*, *Xenocretosuchus,* and the recently described *Montricus*. We compare *S. hebridicus* with these genera and reassess the evidence in support of these phylogenetic relationships. We examine the size difference between *S. hebridicus* and *S. ooliticus* (*S. hebridicus* reportedly being larger) that was originally considered to be diagnostic. This allows us to provide a revised diagnosis of both species, in which we find support for this size difference. However, given the clustering of small and large material recently described for *Montricus* still being assigned to a single genus, we explore the possibility that *S. ooliticus* and *S. hebridicus* may be the same species, with variation in size being explained by intraspecies variation, such as sexual dimorphism or geographic distribution.

Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

A COMPARATIVE AND MORPHOMETRIC APPROACH TO THE INVESTIGATION OF THE CONVERGENT ADAPTATIONS IN SECONDARY AQUATIC AMNIOTES

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The analysis of secondary aquatic adaptations in different groups of amniotes was performed from a comparative and morphometric point of view, in order to define the main features that contribute to a body plan (bauplan) suitable for an aquatic lifestyle. Seventeen taxa from amongst the mesosaurs (Amniota, Mesosauridae), ichthyosaurs (Ichthyosauria, Parvipelvia), and pythonomorphs (Squamate, Pythonomorpha) were selected in order to: (1) ensure variability in terms of diversification of the bauplan, and thus of morphometric dissimilarities; (2) analyse the intraspecific morphometric variability, by including different specimens of the same species; (3) analyse intrageneric variability, by including different species of the same genus; (4) evaluate the effect of ontogeny, by including both juveniles and adults of the same taxon. A preliminary comparative phase was necessary to define the set of morphometric characters, based on both measurements and counts (number of vertebrae per body region, number of digits, number of phalanges). The quantitative data were then processed with two different ordination methods: the data matrix of characters (ratios and counts) was used to perform an agglomerative Hierarchical Cluster Analysis, whereas the raw data (measurements and counts) were processed using a Principal Component Analysis. The mutual integration of comparative and morphometric results produced a detailed picture of the convergent trends that illuminated important information on how the transition from land to water, and from facultatively to obligatory aquatic lifestyles happened in the different lineages. The in-depth study of the differential regionalization of both the axial and appendicular skeleton led to some considerations about the portions of the body involved in swimming, and how the internal configuration and proportions of the limbs can help in inferring their role during locomotion. Common tendencies in the different lineages include the loss of regionalization in the limbs (to build true 'hydrofoils' for steering during an almost exclusively tail–mediated swimming style) and a general loss of regionalization in the vertebral column (e.g., virtually undifferentiated vertebrae as in 'fishes'), as a result of the interaction of natural selection and evolutionary constraints, in an environment where limited forms for fast, efficient, and sustained swimming are allowed.

Technical Session XX (Saturday, October 29, 2016, 2:45 PM)

A CAECILIAN-LIKE TEMNOSPONDYL FROM THE TRIASSIC CHINLE FORMATION OF COLORADO AND ITS BEARING ON THE ORIGINS OF LISSAMPHIBIA

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The origin of modern amphibian orders is one of the most important remaining mysteries of tetrapod phylogeny. Substantial morphological and molecular evidence supports lissamphibian monophyly within the Temnospondyli, but the origin of the lissamphibian crown, and of each lissamphibian order, is poorly understood. New fossils, such as *Gerobatrachus*, suggest that modern lissamphibian orders diverged by the early Permian, but few crown lissamphibians have been recognized from rock formations earlier than the Jurassic. This is particularly the case for the limbless caecilians given recent challenges to the purported relationship with the early Permian recumbirostran *Rhynchonkos*. Caecilians are represented by two stem taxa, the Early Jurassic *Eocaecilia* and the Early Cretaceous *Rubricaecilia*, but have no recognized fossil record from the Permian or Triassic. Caecilians are especially problematic in the question of lissamphibian origins, as they exhibit highly derived morphology that is not closely comparable to other lissamphibian groups. Here, we report a new diminutive temnospondyl from the Late Triassic of the USA, with clear lissamphibian affinities. The specimens were found in the 'red siltstone' member of the Chinle Formation in the Eagle Basin, Colorado. In addition to an expanded parasphenoid cultriform process and reduced, laterally positioned orbits, high-resolution computed tomography reveals an incipient maxillopalatine enclosing the lacrimal duct, a possible pterygoquadrate, and a complete secondary tooth row on the coronoids. These features, among several others, support the new taxon's affinities with caecilians, although it is substantially more plesiomorphic than *Eocaecilia*, retaining a tympanic middle ear, separate postdentary bones (but with a reduced compliment), and a well-developed appendicular skeleton. Phylogenetic analysis robustly places the Chinle taxon and *Eocaecilia* within stereospondyls (e.g., rhytidosteoids, brachyopoids), a novel hypothesis of caecilian origins. The hypothesis that stereospondyls represent stem caecilians both eliminates an 80 million year ghost lineage at the base of the caecilian stem and identifies protracted trends in the stepwise acquisition of the caecilian body plan. A majority of temnospondyls are found to be crown lissamphibians, and fossil calibrations for the divergence between caecilians and batrachians should be constrained to the divergence between stereospondylomorphs and dissorophoids in the early Pennsylvanian.

Technical Sesssion X (Friday, October 28, 2016, 9:00 AM)

THE DECLINE OF EARLY ARCHOSAUROMORPHS IN THE NORIAN (UPPER TRIASSIC) IN THE LOW LATITUDES: NEW INSIGHTS FROM THE UPPER TRIASSIC CHINLE FORMATION OF ARIZONA

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Following the end-Permian mass extinction, archosauromorph reptiles experienced two major terrestrial radiations in the Late Triassic. The latter of these began in the Norian (228.4–209.5 Ma) as Archosauria, including the highly successful dinosaurs, further diversified across the globe. However, non-archosaur archosauromorph diversity reached its peak in the Middle Triassic through the Carnian and declined into the Norian. Combined with apomorphy-based identification of skeletal anatomy, recent fieldwork in the Upper Triassic Chinle Formation at Petrified Forest National Park has resulted in the recovery of new Norian records of non-archosaurian archosauromorphs that were previously unknown or not yet recognized in western North America. An ilium and associated dermal osteoderms represent the first record of the archosauriform *Doswellia kaltenbachi* from the Chinle Formation. Additionally, isolated vertebrae from the same stratum represent the first unambiguous record of tanystrophieds from the park that are consistent with those found in the Chinle Formation at Ghost Ranch, New Mexico and in the Dockum Group. Finally, 500 bones from a monodominant bonebed of an archosauromorph belongs to the newly named clade Allokotosauria. Besides *Trilophosaurus*, this is the first allokotosaur from the Chinle Formation. The new material consists of a minimum of nine individuals of different sizes that represent nearly the entire skeleton. The presence of *Doswellia*, tanystropheids, and allokotosaurs at Petrified Forest National Park provides strong biostratigraphic ties for Late Triassic strata across North America in Virginia, New Mexico, Arizona, and Texas. These finds demonstrate that though species-level differences may exist, many non-archosaur archosauromorph clades had much wider distributions than previously recognized and were contemporaneous with archosaurs for more than ten million years, but did not experience the same diversification as archosaurs after the mid-Norian.

Grant Information
A portion of this work is supported by the Petrified Forest Museum Association.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

A DIVERSE NEW LATE BATHONIAN MICROVERTEBRATE ASSEMBLAGE FROM WOODEATON QUARRY, OXFORDSHIRE, UK

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Woodeaton Quarry (Oxfordshire) exposes one of the most complete sequences of the middle to late Bathonian in the UK. The continuous section ranges from the top of the Taynton Limestone Formation to the lower part of the Forest Marble Formation (Great Oolite Group). Screen washing and subsequent picking of material from a carbonate rich clay horizon at the top of the Bladon Member (White Limestone Formation) has established the presence of a rich, and hitherto unknown, microvertebrate assemblage. This assemblage has produced a mixture of marine (possibly reworked), aquatic/semi-aquatic and terrestrial taxa. Vertebrate remains are typically fragmentary small postcranial elements along with isolated teeth and scales showing little sign of transportation. Taxa are represented by mammals (amphitheriids, amphilestids, docodonts, multituberculates, and haramyiids), dinosaurs (dromaeosaurs and possible thyreophorans), pterosaurs, fish, frogs, albanerpetontids, salamanders, lizards, crocodiles, and (reworked) shark. Plant remains ranging from rootlets to fusinite are common and the presence of charophyte algae suggests deposition in freshwater.

Oxygen and carbon stable isotope analysis of theropod and crocodile teeth was undertaken along with analysis of shelly invertebrate material and bulk rock samples. The results suggest that the isotopic signature is primary rather than reflecting diagenetic overprint and do not show any partitioning between primary water supplies for either of these taxa. This suggests a somewhat self-contained local ecosystem for at least theropods and crocodiles. The stratigraphy of the site, sedimentology and presence of charophyte algae is suggestive of the littoral zone of a warm shallow freshwater body of water that collected on an emergent carbonate platform during the late Bathonian.

There are now four recognised late Bathonian microsites in the UK, each representing a different local palaeoenvironment. Together these sites have the potential to provide a more complete understanding of the late Bathonian terrestrial environment, at a pivotal time in the evolutionary history of key vertebrate groups.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

A COMPLETE DESCRIPTION AND PHYLOGENETIC ANALYSIS OF *PUIJILA DARWINI*, A TRANSITIONAL PINNIPED FROM THE CANADIAN HIGH ARCTIC

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Whereas the land-to-sea transition is well-documented in many secondarily aquatic mammals, the fossil record of stem pinnipeds is relatively sparse, offering few well-preserved transitional fossils. Due to this paucity of transitional pinniped forms, it remains unclear how such divergent locomotory modes and associated morphologies evolved within pinnipeds. In 2009, Rybczynski and colleagues reported the discovery of *Puijila darwini*, a putative stem pinniped from the Miocene of Canada's high arctic. A

brief description of the otter-like *Puijila* was complemented with a preliminary phylogenetic analysis that united *Puijila* in a clade with *Enaliarctos* (the earliest flippered pinniped), *Potamotherium* (an arctoid of unresolved phylogenetic position) and *Amphicticeps* (a terrestrial Carnivoran from the Oligocene of Eurasia). The present study offers a complete description of *Puijila* and further identifications of new potentially taxonomically informative traits shared by *Puijila* and other proposed stem pinnipeds. Such traits include reduced, lingually-located upper and lower second molars, posteriorly expanded and moderately excavated basioccipitals, presence of a fossa muscularis anteromedially to the enlarged circular infraorbital foramen, lateral expansion of the mastoid process, reduction of the post-glenoid foramen, presence of a secondary scapular spine, and presence of a sharp keel continuous with an expansive process on the centrum of the axis. An expanded phylogenetic analysis provides further support for a clade of Puijila, Potamotherium, and *Enaliarctos*, and aligns additional fossil arctoids, including the enigmatic 'sea-bear' *Kolponomos*, with the aforementioned group of stem pinnipeds. To make inferences on the locomotor habits of *Puijila,* a principal component analysis (PCA) was performed to determine how various linear skeletal measurements interact with body size and ecological variables. PC scores for PC2 (level of aquatic adaptation) and PC3 (preference for forelimb or hind limb-powered propulsion) were calculated for *Puijila*, which plots out as well-adapted to aquatic environments (PC2) and as a forelimb-dominated swimmer (PC3).

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

VERTEBRATE PALEONTOLOGICAL RESOURCE SITE MONITORING AT POINT REYES NATIONAL SEASHORE

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Recent collaboration between the National Park Service, the Geological Society of America and the University of California Museum of Paleontology has culminated in the development of a Paleontological Resource Site Monitoring Program at Point Reyes National Seashore. The geologic units at Point Reyes National Seashore include several Miocene and Pliocene marine sediments (Monterey Formation, Santa Margarita Sandstone, Santa Cruz Mudstone, Purisima Formation). Point Reyes National Seashore contains rich and significant marine vertebrate fossil localities in northern California and offers valuable opportunities for scientific research and public education. The majority of the fossiliferous outcrops occur along the Pacific coastline and are vulnerable to natural processes and/or human disturbance. Future climate change induced sea level rise, and an increase in the frequency and intensity of storm events will likely accelerate erosion of the fossiliferous exposures. Published earlier this year, the report provides a protocol used by the National Park Service for monitoring the paleontological resources in coastal areas. The report additionally compiles an inventory of paleontological resource localities and evaluates fossiliferous formations within the park boundaries. Over the course of 2015, more than 140 paleontological sites were documented and eighteen localities were selected as candidates for paleontological resource monitoring. The paleontological localities selected are representative of the most significant and abundant fossils within the park that are vulnerable to natural processes and/or human disturbances. The monitoring methodology will document long-term changes in the condition and stability of paleontological resources and provide scientific basis for mitigation strategies.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

THE OLDEST CROWN-GROUP SAURIAN? A LARGE-BODIED ARCHOSAUROMORPH FROM THE MIDDLE PERMIAN OF ZAMBIA

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Within amniotes, the Permian record of sauropsids is meager when compared to that of synapsids. Most sauropsid clades with Permian records do not cross the Permo–Triassic (P–T) boundary (e.g., captorhinids, pareiasaurs, tangasaurids). However, at least four archosauromorph genera are known from upper Permian deposits, pushing the divergence date of crown-group Sauria to approximately the middle–late Permian boundary. No Permian record exists for Lepidosauromorpha. Molecular data now robustly places turtles as archosauromorphs, and recent morphological work has found the mid-Permian *Eunotosaurus* as the earliest-diverging turtle (though *Eunotosaurus* + turtles is not found with Archosauromorpha).

An unusual isolated cervical vertebra was discovered in 2014 in the lower Madumabisa Mudstone (Mid-Zambezi Basin), Zambia. Broad, thin laminae connect the diapophyses to the posterior face of the centrum and to the prezygapophyses. These laminae form deep fossae along the side of the centrum and below the prezygapophyses. The anteroventral margin of the neural spine has a small anteriorly-directed process. The postzygapophyses are connected by a transpostzygapophyseal lamina with a midline notch flanked by two processes that extend posteriorly as in *Spinosuchus* and *Trilophosaurus*. The body of the centrum is parallelogram-shaped in lateral view, but in ventral view it is barely wider transversely than the strong ventral keel. The centrum is deeply amphicoelous, and possesses raised longitudinal laminae along the ventrolateral margin, as in *Aenigmastropheus parringtoni*. Placement of the vertebra in several phylogenetic analyses of early amniotes consistently supports its position within Archosauromorpha. The centrum is 35 mm long, which implies a body length of approximately 1.5 meters based on comparisons with the largest specimen of the upper Permian archosauromorph *Protorosaurus speneri*.

The archosauromorph vertebra was found alongside dinocephalian remains, which in the Karoo Basin (South Africa) are restricted to the middle Permian *Eodicynodon* and *Tapinocephalus* Assemblage Zones. The top of the latter has been radiometrically dated to 260.26 Ma, thus implying a middle Permian age for the lower Madumabisa Mudstone. This vertebra implies that crown-group Sauria had diverged and that Archosauromorpha had begun to diversify by the middle Permian, a pattern not evidenced in the Karoo Basin.

Grant Information

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Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

A REVIEW OF PARAVIAN PHYLOGENY WITH NEW DATA

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Paraves are theropod dinosaurs comprising of living and fossil birds and their closest fossil relatives, the dromaeosaurid and troodontid dinosaurs. Traditionally, birds have been recovered as the sister group to Deinonychosauria, the clade made up of the two subclades Dromaeosauridae and Troodontidae. However, spectacular Late Jurassic paravian fossils discovered from northeastern China - including *Anchiornis* and *Xiaotingia* - preserve anatomy that seemingly challenges the *status quo*. To resolve this debate we performed an up-to-date phylogenetic analysis for paravians using the latest Theropod Working Group (TWiG) coelurosaur data matrix which we supplemented with new data from recently described Mesozoic paravians from Asia and North America (e.g., *Zhenyuanlong* and *Acheroraptor*). This includes data from the unnamed dromaeosaurid IVPP V22530 and *Luanchuanraptor*, which are included in a phylogenetic analysis for the first time. We also incorporate new data from iconic paravians such as *Archaeopteryx* and *Velociraptor* based on firsthand study. The analysis adopted the maximum parsimony criterion and was performed in the phylogenetic software TNT. Our preliminary results support the monophyly of each of the traditionally recognized paravian clades. The Late Jurassic paravians from northeastern China (e.g., *Anchiornis* and *Xiaotingia*) are recovered as avialans rather than deinonychosaurians, at a position more basal than *Archaeopteryx* and other derived avialans. The traditional sister group status of Troodontidae and Dromaeosauridae is reaffirmed and is supported by a laterally exposed splenial and a characteristic raptorial pedal digit II. Recently reported Early Cretaceous dromaeosaurids from northern and northeastern China, including *Zhenyuanlong*, *Changyuraptor* and IVPP V22530, are closely related to other microraptorines as expected. *Luanchuanraptor*, a dromaeosaurid from the Late Cretaceous of central China is recovered as a more advanced eudromaeosaurian. By tracing character evolution on the current tree topology we report on the latest insights into the adaptive radiation amongst early paravians, including the origin of flight and changes in body size and diet.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

DOUBLE OR NOTHING: AN ANKYLOSAURID RIOT IN NORTHERN LARAMIDIA, WITH NEW DATA ON CERVICAL ARMOUR MORPHOLOGY AND DISPLAYS

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Euoplocephalus tutus was long considered a single, highly variable taxon represented by more specimens than any other ankylosaur. Recent work has divided the referred material into five taxa, four of which date to the early 20th century. Further work on variation in the skull, teeth, endoskeleton, and armour indicates even greater diversity, including at least three and possibly as many as six previously unrecognized taxa.

North American ankylosaurid systematics are bedeviled by non-complementary holotypes and conservative skull evolution, making armour critical in discriminating taxa. The pattern of cranial scales or caputegulae is semi-diagnostic and can be used with poorly preserved specimens. Cervical half-ring morphology is diagnostic at the generic level. For the first time, a resorption sequence is documented in half-rings referred to *E. tutus*, showing progressively smaller and more irregular medial osteoderms on half-rings that are otherwise similar. Dramatic changes also occurred in the squamosal horns of some taxa. This resorption and remodeling occurred after the animal was close to adult size and is plausibly sexual. The half-rings of *Ankylosaurus* have the same basic construction as in other ankylosaurids, including the Asian *Saichania*: bilateral pairs of superficial, keeled osteoderms variably fused to an underlying arch of bone.

Ankylosaurids were a rare faunal component and evolved more rapidly than most other dinosaurs, with taxa separating stratigraphically. A specimen-level cladistic analysis indicates a second species of *Scolosaurus* and an unrecognized species of *Dyoplosaurus* in the upper Dinosaur Park Formation (DPF). The persistent lineages suggest anagenesis. Another undescribed taxon characterized by large, *Ankylosaurus*-like plates is present in the lower DPF, and another with unusual caudal morphology is present in the Judith River Formation of Montana. Nor is *Oohkotokia horneri* synonymous with *Scolosaurus cutleri*. Although these two taxa are similar, so are most Campanian ankylosaurids from Alberta and Montana. *O. horneri* differs from *S. cutleri* in humeral, sacral, cervical half-ring, and osteoderm morphology and was a smaller animal. The *Scolosaurus* quarry has been relocated and lies at the contact between the Dinosaur Park and Oldman formations, making *S. cutleri* the oldest known ankylosaurine from Alberta or Montana—predating the Two Medicine *O. horneri* by at least 2.5 Ma. Ankylosaurid postcervical armour is diagnostic at the specific level.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

TARSAL DIVERSITY OF MIDDLE EOCENE (UINTAN) RODENTS FROM SAN DIEGO COUNTY, CALIFORNIA

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North American middle Eocene rodent assemblages are characterized by increasing taxonomic and morphological diversity, including the first appearances of several additional families. This increase in diversity is primarily documented by craniodental remains. Aside from the conservative paramyid/ischyromyid radiation, postcranial morphology of middle Eocene rodents is poorly documented. The richly sampled mammalian faunas from the Uintan of San Diego County, California provide an opportunity to address this imbalance. Large dental samples from two particularly rich late Uintan localities permit identification of several isolated rodent tarsal morphs based on size and abundance. These include (in increasing order of size) the enigmatic myomorph *Simimys*, the small paramyid *Microparamys*, the cylindrodontid *Pareumys*, and the basal aplodontoid *Eohaplomys*. Tarsals of all four genera are recognizably rodent in morphology, but significant differences are evident, indicating probable locomotor disparity and probably different habitat preferences.

Tarsals of *Eohaplomys* are conservative, differing minimally from early Eocene paramyids. This suggests that, like those taxa, *Eohaplomys* was comparable to generalized sciurids in its habitat preferences. *Simimys* has features associated with terrestriality such as a more distally positioned peroneal tubercle and inclined cuboid facet on the calcaneum and more symmetrical trochlear crests and a relatively oblique head on the astragalus. On the other hand, tarsals of *Microparamys* show features suggestive of more arboreal habitat preferences, including a peroneal tubercle shifted proximally to be opposite the sustentaculum and a transverse astragalar head. Finally, the astragalus of *Pareumys* is notable for having a particularly asymmetric trochlea, with the medial ridge much shorter than the lateral, and an extremely short neck. The latter feature, in particular, is common in digging mammals and is consistent with inferences from cranial morphology that cylindrodontids were fossorial.

Poster Symposium I (Wednesday–Thursday, October 26–27, 2016, 4:15–6:15 PM)

MORPHOLOGICAL VARIATION AND SEXUAL DIMORPHISM IN SYMPATRIC NOTHARCTINE (EUPRIMATES, ADAPIFORMES) SPECIES

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Sexual dimorphism and intrasexual competition between males is hypothesized to have appeared early in primate evolution, based on inferred canine dimorphism in the most basal adapiform, *Cantius torresi*, and its later occurring notharctine relatives. Previous studies assessing canine dimorphism in notharctines have only made comparisons with a limited sample of anthropoids and did not examine variation in canines relative to molar size. We compared multiple notharctine species to a large and diverse sample of both anthropoids and strepsirrhines using intra-individual ratios of canine to molar (CMR) size. CMR is a preferable means of assessing sexual dimorphism in fossil samples because it does not explicitly assume that inter-individual canine variance correlates with inter-sex canine variance. We test this assumption for extant samples where sex is known by plotting CMR variance against canine sexual dimorphism, measured as average male and female canine size difference. A positive correlation is found in anthropoids but not in strepsirrhines. Thus, large canine variance in strepsirrhine samples lacking sex information cannot be interpreted as evidence of canine sexual dimorphism. CMR variance observed in some notharctines is in the middle of the anthropoid range and high compared to monomorphic species but also falls within the range of monomorphic strepsirrhines. Thus, without independent means of assigning sex, large canine variance in notharctine samples alone does not provide evidence of sexual dimorphism. While high variance in notharctine canines and molars from some localities might be interpreted to suggest high sexual dimorphism in all tooth positions (like in orangutans), we reject this possibility based on 1) the lack of a consistent pattern of high variance in both canines and molars across notharctine-bearing localities and 2) the correlation of non-metric dental traits with size at certain localities. Instead, we conclude that sites with large size variation most likely represent multiple sympatric notharctine species rather than sexual dimorphism.

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Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

ESTIMATING BODY MASS IN FOSSIL RODENTS: CAN LOG BIAS BE REMOVED BY NONLINEAR REGRESSION?

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Body mass is a characteristic with implications for many ecological parameters, from diet and predator-prey interactions to life history and habitat use. As such, it is a key factor in paleoecological reconstruction. Size estimates of extinct mammals are commonly inferred from tooth or skeletal measurements using allometric analyses of extant species. While body mass estimation is a useful tool, there is controversy about the appropriate statistical methods to apply. A common method of reconstruction is to log-transform mass and skeletal dimensions to obtain homoscedastic variation and to linearize the exponential relationships between skeletal dimensions and body mass. Estimating masses of extinct taxa then require detransformation of predicted values into arithmetic units. However, the geometric mean generated in log-log space is typically less than the arithmetic mean, resulting in consistently underestimated mass predictions once detransformed. This bias is problematic and has raised the question as to whether nonlinear regression may be a better technique.

To assess this possibility, we jackknifed a dataset of known dental and body mass measurements of 75 species of extant rodents. We performed nonlinear (NL) and log-linear (LL) regressions to assess the error with which jackknifed mass values are predicted when excluded from the dataset. Mass prediction for the NL regression was consistently incorrect, with a median error of +217%, whereas LL mass predictions were generally much closer to the actual value, with a median error of +3%. Additionally, 99% of mass values were overestimated using NL methods, while 56% were underestimated with LL methods.

These results indicate higher mass prediction accuracy from LL regression techniques, despite concerns regarding transformation bias. There is evidence for substantial overestimation by NL regression and for consistent (although slight) underestimation bias in LL regression predictions, indicating that use of corrective terms should be explored. While further efforts will explore whether there are NL regression methods that can accurately predict mass, our results suggest that this approach does not offer a simple solution to the LL transformation bias problem.

Technical Session IV (Wednesday, October 26, 2016, 3:00 PM)

MORPHOLOGICAL CONSEQUENCES OF TOOTH LOSS: A COMPARISON OF THE COURSE OF THE MANDIBULAR CANAL IN MYSTICETE CETACEANS USING 3D MODELS

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Mysticete cetaceans (baleen whales) are a diverse and successful clade of mammals that have evolved to include the largest animals in the history of the earth. The success of this clade has been, in large part, to a shift in their feeding mechanism. Over their evolutionary history mysticete cetaceans lost functional teeth and instead evolved baleen plates. These keratinous structures hang down from the palate and allow mysticetes to bulk filter feed on small to medium-sized prey. While baleen plates replace the dentition of the palate, no secondary structure is developed in the mandible whatsoever. Though tooth buds are known to form in embryonic mysticetes, they are completely resorbed prior to birth. The result is an entirely edentulous mandible in mysticete cetaceans. Despite the lack of teeth, a shallow alveolar groove persists on the dorsomedial surface of the mandible. The internal anatomy of the mandible, specifically the course of the mandibular canal and any connections made with the alveolar groove, has never been studied and described.

Here, we use computed tomography scans to create 3D models of the internal anatomy of the mandibles of a typical artiodactyl (*Sus scrofa*), an archaeocete cetacean (*Zygorhiza kochii*), an extant odontocete (*Tursiops truncatus*), and an extant mysticete (*Balaenoptera acutorostrata*). In doing so, we compare the internal anatomy of the mandible by charting the course of the mandibular canal and all of its distributaries. Our results confirm a highly unique morphology in the mandibles of mysticete cetaceans compared to their artiodactyl relatives and archaeocete ancestors. Our results verify the persistence of dorsomedial branches of the mandibular canal to feed the alveolar groove. This evidence for vestigial remnants of the embryonic dentition sheds light on the processes shaping the transition to an edentate mandible.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

STABLE ISOTOPIC DIETS OF PLEISTOCENE HORSES FROM SOUTHERN NORTH AMERICA AND SOUTH AMERICA: SIMILARITIES AND DIFFERENCES

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Horses were a group of animals that in the past had great diversity of species and naturally lived on most of the planet, with the exception of Antarctica and Australia. This group originated during the Eocene in North America and diversified into several genera and species, moving across the continent into South America during the late Pliocene where it diversified again. Several species within the genus *Equus* lived in southern North America (USA: California, Arizona, Nevada, Texas and Florida; and México), as well as in South America during the Pleistocene. Carbon isotopic analyses show that horses from southern North America and South America were C3/C4 mixed feeders that fed upon important amounts of C4 plants—more in South American horses. However, some specimens lived on both continents with either C3 or C4 plant exclusive diets. This may suggest that the genus *Equus* was a generalist in its diet, but during the transition into the Holocene, all of those groups disappeared in the Americas. It is possible that due to climatic change, plants eaten by horses were replaced by other less nutritive ones; however, human hunting should not be ruled out as a contributing factor for their extinction.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

THE FAUNA OF REPTILES FROM THE CENOMANIAN OF ALGORA (GUADALAJARA, SPAIN): SYSTEMATIC AND PALEOBIOGEOGRAPHIC IMPLICATIONS

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The European faunas of reptiles from both the Early Cretaceous as the lattermost Cretaceous are well-represented. However, little information about the taxa living between both periods is available. Scarce and fragmentary remains of turtles, crocodiles and theropod dinosaurs were found in the Spanish site of Algora in the 1980s, as result of geological surveys. Algora is located in the Guadalajara Province (Castilla-La Mancha), in the Castilian Branch of the Iberian Ranges. Its fossiliferous levels correspond to the upper part of the Arenas de Utrillas Fm., deposited in the transition between the middle

and the upper Cenomanian. They represent sandy coastal deposits, with subtidal and intertidal events. Considering the potential systematic and paleobiogeographic implications, a first excavation in Algora was recently performed. This yielded numerous remains of reptiles, the turtles being the most abundant.

New and relevant data on the clades previously identified were obtained. In addition to scarce remains of the Laurasian terrestrial turtles Solemydidae, abundant fossils of a second taxon are identified. Thus, a skull, complete and partial shells, abundant plates, and appendicular elements correspond to a new bothremydid. It is the oldest member of the crown Pleurodira in Europe, showing the first evidence of dispersion of the group from Gondwana to Laurasia. The previously discovered crocodyliform remains lack diagnostic features for an accurate attribution. The new findings allow recognizing the presence of at least a eusuchian, not attributed to any described taxon. New teeth of theropods allow confirming the presence of carcharodontosaurids, and improving the understanding of their positional variation.

Several groups hitherto not identified in this site were found. The partial pelvis and a caudal vertebra of an individual of Plesiosauria are recognized. Some characters allow to refer it to Plesiosauroidea and, most probably, to Elasmosauridae. Pterosaur postcranial elements corresponding to a big taxon, tentatively referred to Ornithocheiroidea, were found. Pterosaurs are rare in the Iberian Cretaceous and only a few teeth were so far known in the early Late Cretaceous. Sauropods are identified by axial and appendicular elements that probably correspond to a derived titanosaur within Lithostrotia.

The reptile fauna from Algora is composed of terrestrial, freshwater, and coastal forms, but also of taxa from open marine environments. Both Laurasian lineages as well as others that originated in Gondwana are recognized.

Technical Session II (Wednesday, October 26, 2016, 9:15 AM)

GROWTH RINGS AND SUTURE FUSIONS REVEAL COMPLEX ORGANISM-ENVIRONMENT INTERACTION IN LIZARDS: NEW INSIGHTS FOR INFERENCES ABOUT SIZE, AGE, AND DEVELOPMENTAL STAGE IN FOSSILS

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Paleontologists often assume that larger individuals of a species are chronologically older than smaller ones, and that skeletally mature specimens are older than those with open sutures. Consequently, suture fusion and the osteohistological growth record are often used as proxies for (relative) age in fossils. However, potential correlations between annual growth rings (age), snout-vent length (SVL; size), and suture fusions associated with skeletal maturity, as well as how these variables might be influenced by environmental variables, have not been explored fully in many living vertebrates of known age. For example, despite accounting for 40% of extant amniote diversity, squamates are conspicuously lacking in this regard. To begin to address this shortcoming, we investigated growth patterns in 29 sexually mature individuals of the cnemidophorine teiid lizard *Aspidoscelis tigris* – the Western Whiptail – ranging in size from 71 to 100 mm SVL. We found that size and age are poorly correlated. The largest specimens could be as much as half as old as some of the smallest. More surprising, we found that suture fusions are only weakly coupled to age, but they are strongly correlated with size, suggesting that skeletal maturation is governed by size, not age.

Growth patterns among sexually mature *Aspidoscelis tigris* in the Mojave Desert appear little influenced by increased rainfall during a strong El Nino. Instead, growth appears largely governed by conditions – e.g., food availability – during the first two years of life, prior to sexual maturity. Size and age can thus differ significantly among sexually mature individuals of a local population of *A. tigris*. That is not the case with size and developmental stage, however, as terminal fusions occur near maximum size for the species regardless of how long it took to get there. Interestingly, smaller body sizes seem to favor longevity, as the oldest individuals are below median snout-vent lengths for the specimens sampled. This study reveals a complex organism-environment interaction that governs growth and differentiation in *A. tigris*, and serves as a basis for similar studies in fossil squamates. For example, a smaller specimen from a local fauna with a fused scapulocoracoid is very unlikely to be the same species as a larger specimen in which those elements remain unfused, regardless of age or how similar they might be otherwise.

Grant Information
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Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

MORPHOLOGICAL DIVERSITY OF THE ZALAMBDODONT MOLARS OF GOLDEN MOLES (MAMMALIA, CHRYSOCHLORIDAE) WITH INDICATION FOR DIFFERENT FOOD TEXTURE

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Golden moles have zalambdodont molars with a reduced metacone in the upper and a reduced talonid in the lower molars. Generally, the molar dentition of *Chrysochloris asiatica* is considered as representative for the molar pattern of golden moles, neglecting the morphological diversity within Chrysochloridae.

The functional morphology of 15 specimens of *Chrysochloris asiatica*, *Chrysochloris stuhlmanni*, *Amblysomus hottentotus*, *Huetia leucorhina* and *Chrysospalax trevelyani* was studied with focus on potential dietary adaptations.

Three patterns of the zalambdodont molar can be distinguished within golden moles: (i) protocone present in the upper molar and talonid in the lower molar (*C. stuhlmanni*, *A. hottentotus* and *C. trevelyani*), (ii) protocone present, talonid completely reduced (*C. asiatica*) and (iii) protocone and talonid both absent (*H. leucorhina*). Functionally, all molar patterns have a predominant shearing-cutting function. In species with pattern (i), a centric occlusion occurs, when the ridge between trigonid and entoconid of the lower molar occludes between the protocone and paracone of the upper molar stopping the chewing cycle in that way. The paracone occludes into the buccal hypoflexid ridge. In species with pattern (ii), the protocone does not lead to a centric occlusion because of the lacking talonid. In both patterns (i) and (ii), the protocone participates in the shearing-cutting function, which occurs between the mesial edge in the upper molar and the distal edge of the lower molar. Species with pattern (iii) have no centric occlusion and only shearing-cutting takes place at both edges of the molars. Pattern (i) is the most common among all golden mole species.

The relative cutting edge length is expressed by the quotient of cutting edge length and tooth length. Species of pattern (i) have the relatively shortest cutting edges, *Huetia leucorhina* (iii) has the relatively longest cutting edges and *Chrysochloris asiatica* (ii) is in between. The length of the cutting edge is known to correlate with the hardness of preferred food items. Longer cutting edges indicate a preference for softer food and shorter cutting edges for harder food items. Accordingly, the current results can be interpreted as adaptations for differing dietary specializations among chrysochlorids.

Poster Symposium II (Friday–Saturday, October 28–29, 2016, 4:21 PM)

NEW DATA TOWARDS A TAPHONOMIC FRAMEWORK FOR THE CLEVELAND-LLOYD DINOSAUR QUARRY

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Situated within the Brushy Basin Member of the Morrison Formation, the Cleveland-Lloyd Dinosaur Quarry (CLDQ) is the densest assemblage of Jurassic theropod skeletons discovered to date – a multitaxon bonebed composed predominantly of *Allosaurus fragilis*. Despite numerous proposed hypotheses to explain the nature of the CLDQ assemblage, such as a predator trap, a drought assemblage, and a poisoned spring, a comprehensive taphonomic assessment is lacking. Although sedimentological and microfossil analyses suggest that the CLDQ represents a small ephemeral pond, new information is required to form a robust taphonomic framework supported by all available data. Here we present three new data sets that contribute to the development of such a taphonomic framework for the CLDQ. First, small bone fragments (< 5mm) from quarry sediment were analyzed for relative degree of abrasion and hydraulic equivalency. The fragments have a hydraulic equivalence to grains larger than the encasing matrix, suggesting an autochthonous or parautochthonous origin. Furthermore, fragments possess a wide range of relative abrasion stages, suggesting multiple depositional and reworking events. Second, 3D photogrammetric mapping of the north quarry building reveals distinct orientations of bones in at least three layers, providing further evidence of multiple depositional events in addition to bone fragment data. Finally, XRD and XRF analyses of the sediments of the CLDQ indicate an enrichment in heavy metals relative to other sediments from the Morrison Formation in the San Raphael Swell. While some metals, such as uranium, may be diagenetic in origin, other metals present in elevated concentrations, such as As, Pb, Sr, and Cr, may have bioaccumulated in the shallow depression from the decay of a large quantity of predator carcasses. Such conditions would have promoted a reducing environment that further explain the lack of expected freshwater fauna, the rarity of feeding traces on remains recovered from the quarry, and the presence of sulfide minerals in the quarry cement. In order to further understand the taphonomy of the CLDQ, and thereby use it to gain insights into Jurassic paleoecology, future research will include three dimensional mapping of bones as they are exposed in the deposit, geochemical comparisons to other Morrison bonebeds, and geochemical and isotopic analysis of the bones in the quarry.

Grant Information
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Symposium I (Wednesday, October 26, 2016, 9:45 AM)

RAMAN SPECTROSCOPY OF EUMELANIN PRESERVED IN MID–LATE JURASSIC AND EARLY CRETACEOUS VERTEBRATES FROM NORTHEASTERN CHINA

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Recent studies of exceptionally-preserved integument in the fossil record have demonstrated that melanosomes, organelles containing the ubiquitous pigment melanin, are preserved in fossils at least as old as 300 million years. Preserved melanin has also been chemically detected in fossils using a variety of techniques such as mass spectrometry and XANES profiling. However, these techniques are indirect (i.e., only measuring metals that bind to melanin) or require destructive sampling. Here, we use Raman spectroscopy to detect melanin in the exceptionally-preserved skin of basal vertebrates (including lamprey, frog, and salamander fossils) and feathers from the Middle–Late Jurassic and Early Cretaceous of northeastern China. Raman spectroscopy is a rapid, non-destructive chemical technique in which a laser excites molecular bonds on the surface of a sample, causing them to vibrate. These vibrations are then detected by the instrument and the chemistry of the sample is characterized by the user based on comparisons with Raman spectra for known compounds. The small spot size of the Raman laser allows for the detection of chemical differences between minute, adjacent areas on the sample surface. We compare Raman spectra generated by the fossils to a variety of standards, including extracted and in situ eumelanin and phaeomelanin from modern feathers and skin from extant lampreys and amphibians, a eumelanin standard from the cuttlefish *Sepia officinalis*, non-melanin pigments, such as porphyrins and carotenoids, feather keratin, and potential contaminates, including associated minerals, adhesives, matrix, and carbon. Eumelanin is characterized by two major Raman peaks with distinct peak morphologies: a shorter peak at approximately 1370 cm^{-1} and a taller peak around 1580 cm^{-1}. We demonstrate that Raman spectra collected from fossil integument samples closely resemble those of Recent eumelanin samples. Further, Raman signals for eumelanin in these fossils are correlated with the preservation of melanosomes, providing further evidence for the preservation of melanin in the fossil record and an additional chemical method for its detection.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

TO LUMP OR NOT TO LUMP? ANALYZING FOSSIL MUSKRAT TAXONOMY USING MOLAR MORPHOLOGY

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The muskrat lineage is represented by a single modern species, *Ondatra zibethicus*. Muskrats are semiaquatic, herbivorous rodents and the largest member of the Arvicolinae subfamily. They are found throughout North America with specimens from the lineage dated to ca. 3.75 Ma. The lineage has historically been sorted into as many as six species and as few as one due to differing species concepts and interpretations of lower first molar morphology. Muskrats are described as one of the best examples of anagenetic evolution with never more than a single species present at any time. Our analysis examines the taxonomy and evolution of the lineage using both qualitative and quantitative traits of the lower first molar. Data from modern and fossil muskrat molars were tested with analysis of variance, analysis of covariance, and regression to examine levels of intra- and interspecific variation. Molar characters used to distinguish species of *Microtus* aided in determining interspecific variation for arvicoline rodents, such as triangle number, dentine tract height, and cement. Lower first molars (n = 243) from 12 of the 18 modern subspecies of *O. zibethicus* were examined. These subspecies span a wide range of habitats. Ninety-three molars from fossil localities were also analyzed. This non-modern sample included representatives from all six recognized species. Length, width, dentine tract height, and triangle number were all examined. Results suggest that the accepted number of six species should be condensed into two, and that only a single genus is supportable. Our findings suggest that both species of *Pliopotamys* should be subsumed by *Ondatra idahoensis*, while *O. annectens* and *O. nebracensis* should be folded into *O. zibethicus*. Triangle number was found as the most discriminating trait of the muskrat molar, showing little intraspecific variation in modern samples. Traits such as cement amount and dentine tract height were highly variable and of limited value for discriminating between fossil muskrat species. Several of the molar traits examined were found to have a potential link to molar size and, therefore, to body size. Data plots revealed a variable rate of size change and allowed an improved view of the tempo of muskrat evolution. This analysis provides insight into an important evolutionary step in muskrat biology; a shift from a five to a seven triangle morphology, which signals some change in the ecological conditions under which the muskrat evolved. Muskrats are a model for anagenetic evolution, but the mode is still mysterious and warrants more study.

Technical Session XVI (Saturday, October 29, 2016, 12:00 PM)

HUMAN IMPACT ON NORTH AMERICAN MAMMAL FAUNAS

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Humans have an outsized impact on modern ecosystems. Our recent research shows that community assembly patterns changed in the Holocene, coinciding with bigger human settlements and the expansion of agriculture. In particular, we observe a shift from a majority of aggregated associations over the last 300 Ma to a majority of segregated associations in the present. In order to explore the mechanistic reasons for this observed pattern, we compiled a database of North American fossil and modern mammal occurrences over the last 40 kyr. Our database includes 408 localities for three different time periods: late Pleistocene, Holocene and modern. We evaluated whether pairs of species co-occurred randomly or were statistically aggregated or segregated. Of the non-random pairs, the proportion of segregated pairs increased from 41% to 59% from the Pleistocene to the Modern. Additionally, 39.7% of the species pairs that changed their association mode across this time interval went from being randomly associated to significantly segregated while just 22% of them changed from random to aggregated. Could species' traits explain these patterns? To investigate this question, we compiled data on diet and body size for the species in our dataset. Overall, we find that differences in body mass are important for structuring species pairs in the Pleistocene and Holocene, but not the modern. Diet remains important in structuring species pairs across the overall time interval, but the particular types of interactions change. We observe, however, an increase in the proportion of significantly aggregated species pairs that include small to medium sized (100 g to 10 kg) insectivore and generalist mammals during the Holocene. We also observe an increase in significantly segregated species pairs that include carnivore-carnivore and carnivore-insectivore pairings. We suggest that larger predators are experiencing increased competition pressures or are being selectively hunted by humans, which might prevent them from co-occurring in modern ecosystems. Habitat fragmentation might also play a role in segregating modern species. Our results suggest that human impacts on modern ecosystems are affecting the ways in which species interact and share the landscape and that species' traits mediate these changes.

Grant Information
Postdoctoral fellow at NMNH Smithsonian Institution, NSF-DEB 1257625

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

150 YEAR OLD *ARCHAEOPTERYX* MYSTERY SOLVED

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The single feather initial holotype of *Archaeopteryx lithographica* is one of the world's most iconic fossils, but contains a 150 year old mystery. The specimen's 1862 description by Hermann von Meyer shows that the calamus is 15 mm long and 1 mm wide. However, the calamus is no longer visible on the fossil, and there is no record of when or how it disappeared. The specimen is a rare example of a lone *Archaeopteryx* feather, giving access to its entire morphology, as opposed to only parts of it in the overlapping feathers of articulated specimens. This makes it an important addition to the anatomical record of *Archaeopteryx* and basal birds more generally. After 150 years, laser stimulated fluorescence has recovered the calamus as a chemical signature in the matrix and reveals preparation marks where the original surface details have been obliterated. The feather has recently been imaged by others under UV light as well as with X-rays at the Stanford Linear Accelerator Center, with no reports of the existence of the calamus. This demonstrates the capability of laser stimulated fluorescence to visualize important data outside the range of current methodologies. The feather has at different times, been cited as a primary, secondary and covert, and has even been suggested to belong to another taxon. With the new calamus data in hand, the morphology of the feather was examined within the framework of modern feather anatomy. The percentage of calamus length to overall feather length, when plotted against a histogram of 30 phylogenetically and ecologically diverse modern birds, comes out in the middle of the range, placing it in the flight feather regime. The most recent identification of the feather as a primary dorsal covert can be discounted because the rachis is in line with the calamus rather than curving upwind of the calamus centre line. The curvature of the rachis is also too pronounced to function as a primary or tail feather. If the feather is scaled as a secondary in the wing of *Archaeopteryx*, only five feathers fit the reconstruction along the ulna, rather than the 9-13 that have been estimated for this taxon and the 7-14 that are found in modern birds. These inferences suggest that the isolated feather is fundamentally inconsistent with those of *Archaeopteryx* and is instead a secondary of another early bird taxon or potentially even a feather of a non-avialan pennaraptoran theropod.

Grant Information
This study was supported by the Faculty of Science of the University of Hong Kong.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

A FIRST APPROACH TO EVALUATE SYMMETRODONT MASTICATION

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Symmetrodonts are a paraphyletic group of early mammals with a reversed triangle tooth pattern and a two on one occlusion. In the evolution of mammalian molars, the symmetrodont pattern is intermediate between the cusps in line pattern of triconodonts and the tribosphenic molars of therian mammals. However, not much is known about the mastication process of symmetrodonts.

A partial skull of a symmetrodont from the Yixian Formation (Jehol Group) in northeastern China, housed in the Yizhou Fossil and Geology Park (Guangxi, China) was identified as *Maotherium sinense* based on phylogenetic analysis. The right mandible, including three premolars and five molars, the right maxilla with two molars and fragments of the cranium are preserved. No developing teeth were observed inside the mandible or maxilla, and neither were deciduous teeth detected. According to this stage of tooth development, the lack of any clear wear facets and very few striations, the specimen is considered to be a subadult.

The occlusal surface wear was mapped by a scanning electron microscope (SEM) study of a high resolution mold of the teeth. Based on X-ray computed microtomography (µCT), 3D models were created. The chewing cycle was reconstructed with the software Occlusal Fingerprint Analyser (OFA) using 3D models of the upper second, the lower second and the lower third molar.

Embayments found medial to the alveoli in the maxilla show that the apices of the protoconids reach above the level of the alveolar margin at the time of maximum occlusion. These embayments and striations at several crown bases indicate a deep intercuspation of the teeth.

The OFA reconstruction of the chewing cycle confirms a one phase chewing path. During occlusion the lower jaw moves almost orthal with a slight lateral shift towards lingual, which allows the deep intercuspation.

By application of the OFA, we were able to evaluate the chewing cycle of *Maotherium sinense*. During mastication food items were fixed and pierced by the three pointed main cusps of the upper and lower molars. With further occlusion the material got stretched and sheared between the molar flanks.

Technical Session V (Wednesday, October 26, 2016, 4:00 PM)

LONG-TERM DIRECTIONAL TRANSITIONS IN GLOBAL CLIMATE RATHER THAN SHORT-TERM FLUCTUATIONS DRIVE CHANGES IN VERTEBRATE DIVERSITY

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Does global climate change drive speciation and extinction? This question is controversial because patterns of Cenozoic vertebrate diversity do not map cleanly onto changes in global climate. For example, Quaternary climate cycles repeatedly caused geographic range shifts and changes in community composition without strongly affecting rates of speciation or extinction. Conversely, Neogene climatic transitions were associated with bursts of speciation and clade turnover. For example, radiations of lizard groups such as *Sceloporus* in the Miocene and other groups such as marmots (that flourished in the Quaternary) radiated in the Pliocene. Wholesale clade turnovers also occurred in Miocene groups such as hipparionine and equid horses, borophagine and canine dogs, and dryopithecine and hominin apes.

Using Monte Carlo numerical modeling, we show that one key factor driving changes in diversity is the gain and loss of biome-scale habitats, not climate change per se. It is well established that environmental gradients are prerequisite for maintaining diversity gradients in taxa and traits. If environments are divided into categories such as forest, grassland, desert, and tundra, they can be modeled as series of geographically distributed adaptive peaks, each of which favors a different combination of traits. What emerges from modeling runs are patterns like Simpson's classic adaptive zones: an ancestor with one set of traits diversifies on one adaptive peak and an occasional descendant lineage colonizes an adjacent peak with a corresponding change in traits and

with subsequent diversification. Climate cycles like in the Quaternary tend to shift the geographic locations of the adaptive peaks, which causes their associated lineages to move with them without driving change in morphology, speciation, or extinction. However, directional climatic transitions can produce new habitats (e.g., grasslands or tundra) or cause old ones to be lost (e.g., arctic forests). The associated gain and loss of adaptive peaks results in turnover between the clades that occupy them.

Our modeling suggests that long-term directional transitions in global climate are more likely to produce changes in diversity and clade turnover than are short-term cycles, even if the cycles are intense. The models fit patterns observed in the Late Cenozoic and provide a predictive hypothesis that can be tested in the Carboniferous, Permian, and Early Mesozoic.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

A SPECIMEN-LEVEL PHYLOGENY OF WEALDEN IGUANODONTIANS: IMPLICATIONS FOR TAXONOMY

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Recent taxonomic revisions of the many Wealden Group specimens once referred to *Iguanodon*have created more confusion than consensus.This study takes a phylogenetic approach to the problem, using a character matrix of 323 characters and 67 ornithopod taxa as well as 11 specimens from the Wealden Group.With this approach, no *a priori* assumptions were made regarding the validity of any taxon. Parsimony analysis was performed in TNT using a new technology search with sectorial search, ratchet, drift, and tree fusing, finding the minimum length tree 500 times.A strict consensus of 356 trees recovered a large polytomy among Styracosterna, but the pruned trees function found an improvement of 10 nodes by removing *Cedrorestes*, *Planicoxa*, and NHMUK R3788.

The resulting tree contains a large clade of styracosternans as the sister group to Hadrosauroidea. It includes *Mantellisaurus, Iguanodon, Proa, Fukuisaurus*, and *Lurdusaurus*. *Mantellisaurus* is represented by a clade of three specimens: the holotype (NHMUK R5764), the Maidstone specimen once referred to *Mantellodon* (NHMUK OR3741), and the small individual from Bernissart once referred to *Dollodon* (RBINS 1551).Although RBINS 1551 is the sister to the other two specimens, the only synapomorphy found for the English specimens is the caudodorsal (rather than horizontal) orientation of the postacetabular process of the ilium, but this character is prone to taphonomic distortion.This minor difference argues against the validity of *Dollodon* and *Mantellodon* as separate genera.

Also within this styracosternan clade is a grouping of *Lurdusaurus* and three Wealden specimens: the material described as the holotype of *Iguanodon hollingtoniensis,* NHMUK R1831 and associated postcrania, and the West Marina specimen (NHMUK 2357).This clade is distinguished by a notch in the proximal radius, a robust ulna, and an olecranon process over 17% of ulna length.This topology does not support the referral of these specimens to *Hypselospinus* or *Barilium*, which are recovered in a polytomy just outside the large clade of styracosternans.Thus, the assignment of "*I. hollingtoniensis"* to the genus *Huxleysaurus* is congruent with this topology, and NHMUK R1831 and NHMUK R2357 may be referable to the genus, as well.

Finally, NHMUK R28660, which has been referred both to its own genus, *Kukufeldia*, and to *Barilium*, is here recovered in a polytomy with *Iguanodon* and *Equijubus*. If this specimen does, in fact, pertain to *Barilium*, it would indicate mosaicism, with a dentary that displays characters more derived than those of the postcrania.

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Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

THE SARTANIAN BIODIVERSITY OF CENTRAL YAKUTIA, RUSSIA: THE ANALYSES OF THE NEW LATE PLEISTOCENE MEGIN SITE

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The new Megin Site, discovered in 2015 on the Suola River bank (the Lena River basin, Central Yakutia), yielded very rich faunal and floral material that fall between 31,180 and 9,130 calBP. These dates allow assigning the 8 meters of sediments composed by sands in highly developed syngenetic permafrost, to the Late Pleistocene Edoma suite. The bone coloration varies from black (the Megin Mammoth skeleton, horse and bison) to light brown (bison, musk ox), reflecting different taphonomic conditions. The recovered mammal bone remains and preserved dung belong to the dominating open-biotope species and include mammoth (*Mammuthus* sp.), reindeer (*Rangifer tarandus*), small-sized horse (*Equus cf. lenensis*), steppe bison (*Bison prisucs*), musk ox (*Ovibos moschatus*), and roe deer (*Capreolis capreolis)*. The grass clump clusters collected at the approximate Megin Mammoth skeleton level, yielded gastropods (three taxa), beetles (24), plant macro-remains (~60) and pollen (25). The gastropods were represented by three modern north Eurasian and Asian aquatic and wetland species, including *Cincinna ssorensis*, *Anisus stroemi*, and *Lymnaea auricularia*. The beetle fauna was dominated by four xerophylous cohorts and reflected the typical environmental conditions known for the inner parts of the Kolyma Lowland and western Chukotka during the late Pleistocene MIS 2 stage. The discovery of the *Stephanocleonus paradoxus* suggests that summer temperatures (mean July) were +12 C° or higher in the site area. The analysed pollen revealed nine taxa of trees and shrubs: eleven taxa of herbs, two taxa of spores, and three types of non-pollen palynomorphs (fungi *Glomus* and *Sordaria*, algae *Botryococcus*). The assemblage was dominated by steppe and tundra–steppe vegetation with the presence of shrubs (*Salix*) and sparse forested patches of *Betula* and *Larix*. The coprophilous *Sordaria* points to the habitation of grazing animals. The examined plant macro remains consisted of the taxa originating from a wide variety of habitats, including aquatic, steppe, meadows, and conifer forests. The discovered fruits of the aquatic *Ceratophyllum demersum* evidenced higher than +16 C° summer temperatures. Some aquatic plants indicated seasonally fluctuating water level and salt accumulations, reflecting a high evaporation rate and dry climate conditions in the area. The variety of habitats revealed by the plant remains represented an environment suitable for the existence of megaherbivores by providing water, food, shelter, minerals (salt in top soil), and open ground for wallowing in mud and dust.

Technical Session XIII (Friday, October 28, 2016, 4:00 PM)

HISTOLOGY OF THE EARLY PALEOGENE MAMMAL *CORYPHODON* (EUTHERIA, PANTODONTA): A DISTINCT APPROACH TO LARGE BODY SIZE?

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Little is known about the growth of the Paleogene mammals that radiated after the K/Pg extinction. Here I investigate histological growth patterns in *Coryphodon,* a late Paleocene to early Eocene member of the Pantodonta, one of the first large-bodied mammalian groups (~600 kg). To test whether *Coryphodon* bone histology differed from other lineages, I sampled three femora ranging from 26 cm to 50 cm in length from the Eocene Willwood Formation of Wyoming. The smallest specimen has a thin cortex of fibrolamellar bone with low vascularity where preserved and thick cancellous bone surrounding a small, irregular medullary cavity. A medium specimen preserves thin lamellar bone on the outer cortex with flattened osteocytes and subparallel fiber direction. The gradation from compacta to spongiosa is gradual and there is no distinct medullary cavity. The largest specimen shows extensive secondary remodeling. The cortex is remodeled to its surface by several generations of secondary osteons with some relict fibrolamellar bone. The struts of cancellous bone are covered with layers of secondary tissue, in places filling large erosion rooms entirely: these primarily compose the inner cortex. No calcified cartilage or Howship's lacunae are discernible.

Coryphodon is distinct from members of Laurasiatheria in that extensive remodeling reaches the outer cortex. Though a variety of amniotes do this across the cortex, most large-bodied mammals heavily remodel the inner third (e.g., *Equus*, *Cervus*) or a band between more lamellar cortical and endosteal bone (e.g., Carnivora, *Phenacodus*). Additionally, most secondary osteons are longitudinal, whereas in *Coryphodon*, oblique and radial orientations are common, resulting in less dense Haversian canals but high volume of bone replacement. Unlike most mammals, it did not increase its medullary cavity in response to circumferential growth but rather maintained or increased the extent of trabecular bone. These features suggest rapid growth and osteoclast inhibition later in ontogeny. *Coryphodon* has similarities to Xenarthra, where oblong secondary osteons and irregular vascularization are present. Similar bone distribution and trabecular osteosclerosis lacking calcified cartilage may also be found in South American aquatic giant sloths. The tissue of *Coryphodon* seems to represent a novel histological approach to achieving large body size and shows similarity with the bone histology and organization of some secondarily aquatic tetrapods, possibly supporting a previously suggested semi-aquatic lifestyle.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

AN EXAMINATION OF TROODONTID TOOTH ANATOMY AND THE IMPLICATIONS OF FUNCTIONAL MORPHOLOGY ON DIET

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Troodontids have had a convoluted history since their discovery, and have been identified as lizards, coelurosaurids, hypsilophodontids and pachycephalosaurids. These different taxonomic assignations have created a great deal of confusion regarding their paleoecology and behavior. However, they are known to be a sister taxon to Dromaeosauridae, and are considered to be one of the more specialized families of theropod dinosaurs. Ziphodonty and the presence of denticles on the carinae are characters shared by carnivorous animals like theropod dinosaurs, crocodiles, early archosaurs and varanids. However, because troodontid teeth are somewhat unusual, some authors have considered them to be omnivores based on the coarseness of the denticles. Coarse denticles are present in herbivorous animals like hypsilophodontids, pachycephalosaurs and even some modern herbivorous lepidosaurs. The apparent similarity between the serrated teeth of pachycephalosaurids and troodontids is why they were considered to be the same animals for many years. However, the enamel structure of these taxa is very different, and the shape and structure of a troodontid denticle is more characteristic of a highly carnivorous diet. Troodontid denticles are relatively large, but are also widely spaced, which provides greater cutting efficiency than the closely spaced serrations of herbivorous forms. Interesting structures that appear within the inter-denticle areas of troodontids, tyrannosaurids and other theropods are razor-sharp enamel ridges that form very narrow slots for efficiently cutting muscle fibres. The sharpness of these ridges is protected by the thickness of the serrations themselves. We have analysed the presence of these structures in theropod and ornithopod dinosaurs from Alberta. The presence of enamel ridges on the midlines of troodontid denticles, but not on the serrations of herbivorous dinosaurs, suggests they may be specialized to cut meat fibers. These in turn demonstrate strong support for a more carnivorous diet, and add to the repertoire of predatory adaptations of troodontids.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

A THIRD CANID FROM THE HAGERMAN FOSSIL BEDS (HAGERMAN FOSSIL BEDS NATIONAL MONUMENT), IDAHO, USA

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The earliest members of the genus *Canis* are the morphologically similar, coyote-sized *C. ferox* and *C. lepophagus. Canis ferox* occurs in late Hemphillian through medial

Blancan deposits and is generally smaller with a more gracile dentition than the Blancan-aged *C. lepophagus*. *Canis ferox* is a relatively common carnivoran at Hagerman Fossil Beds National Monument (HAFO, medial Blancan, approximately 4.2–3.2 Ma). The Hagerman specimens were originally assigned to *C. lepophagus*, and that amended diagnosis is supported here. An exception is a particularly robust-jawed specimen (HAFO 21175) that was collected by park staff in 2009.

HAFO 21175 is a left dentary that is broken anterior to the p3 with the p3–m3 intact and part of the masseteric fossa retained. It was compared to *Canis ferox* (twelve specimens), *C. lepophagus* (seven specimens), and to several other relevant fossil canids. Robust premolars, p4 with a large second posterior cuspid, p4 conid that extends above the m1 paraconid, robust m1, posteriorly-directed paraconid, and a deep masseteric fossa with clearly delineated margins align it with *C. lepophagus*. The hypoconid and entoconid are worn, but the base of the hypoconid is broad and connects to the entoconid by a well-defined transverse ridge as is more commonly observed in *C. lepophagus*. Some dental measurements overlap with larger specimens of *C. ferox*. However, the robust p3, p4 and m1 align in width and shape with the largest *C. lepophagus* specimens, while the dentary is deeper and has a greater buccal-lingual breadth below the carnassial than is observed in *C. lepophagus*. The specimen is assigned here to *C.* cf. *lepophagus* based on overall morphological similarity and known presence of this canid in medial Blancan deposits elsewhere in western North America. Wear to the m1 talonid, m2 and m3, and a lack of associated material preclude a more definitive diagnosis.

Canis cf. *lepophagus* and *C. ferox* both appear at Hagerman around 3.95 Ma. *Canis ferox* is found throughout the sequence, but it was more common prior to 3.7 Ma. A large borophagine, *Borophagus* c.f. *hilli*, is rare and only overlaps with the youngest *C. ferox* specimens. A large mustelid (*Ferinestrix vorax*) and several larger felids and ursids appear later on in the sequence. The absence of *C.* cf. *lepophagus* from younger deposits may reflect competition with what was an increasingly rich carnivoran guild: eighteen species from five families are now known from the Hagerman Fossil Beds.

Symposium I (Wednesday, October 26, 2016, 8:30 AM)

RADIOCARBON DATING AND PROTEOMIC ANALYSIS OF HIGHLY PURIFIED BONE COLLAGEN DERIVED FROM RANCHO LA BREA MAMMAL FOSSILS

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Recently, we devised a relatively rapid and inexpensive method to purify collagen from asphalt-impregnated bones from the Rancho La Brea (RLB) oil seeps, greatly enhancing our ability to acquire accurate radiocarbon dates and stable isotope ratios from such material. Our technique involves sonication in solvents of increasing polarity to remove residual asphalt plus any leftover solvents used historically for bulk asphalt removal, followed by decalcification, gelatinization, and selection of an optimal intermediate molecular weight fraction (3–30 kDa) by ultrafiltration.

To assess the quality of collagen purified by this method for amino acid profiling and systematic proteomics, we undertook racemization analyses and ZooMS (peptide fingerprinting) studies on a wide range of RLB taxa (*Sylvilagus* sp., *Spermophilus* sp., *Canis familiaris*, *C. dirus*, *Smilodon fatalis*, *Panthera atrox*, *Equus* sp., and *Bison antiquus*). Although there was a general trend in the sense that poorer spectra were clustered around older ^{14}C ages, good spectra were found throughout the range of radiocarbon dating. This indicates that taphonomic conditions of preservation rather than age per se have a very significant bearing on protein survival. Samples were taken from specimens collected in the course of previous RLB excavations (Pits 3, 10, 60, 61/67, and 91) as well as from Project 23, currently in progress. Although information concerning early preparation techniques used on these collections is scanty, by modern standards samples were often treated harshly (e.g., prolonged submersion in hot kerosene or 1,1,1-trichloroethane in order to remove asphalt encrustation). Nonetheless, we were able to recover collagen peptides from the majority of samples (21/34). Current methods of cleaning are much gentler, involving cold-soaking in n-propyl bromide.

These analyses confirm that the new protocol for asphalt removal and collagen purification is capable of routinely isolating ancient collagen without introducing new damage. Additionally, our results reveal the robust nature of bone collagen, the value of historical collections, and the great potential new methods may have for collecting molecular information on fossils from oil seeps worldwide.

Grant Information
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Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

REGIONAL MORPHOLOGICAL DISPARITY AND RATES OF EVOLUTION IN COELUROSAURIAN THEROPOD DINOSAURS

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The mode and tempo of avian evolution have received much attention in recent years, thanks to the assembly of more complete datasets, the ongoing flow of new specimens and taxa, and the development of new techniques of macroevolutionary analysis. Recent studies revealed an avian radiation characterized by gradual acquisition of apomorphies followed by accelerated (yet clade heterogeneous) rates of evolution. However, in the context of Coelurosauria (a diverse clade including *T. rex* and its kin, the ostrich-mimic ornithomimosaurs, and the sickle-clawed dromaeosaurids, among others), previous analyses have considered the skeleton as a whole, apart from studies focusing on single continuous traits. Here, we document the evolutionary dynamics of each anatomical region of the coelurosaurian skeleton. We aim at disentangling the relative role of each body part in the evolutionary dynamics of Coelurosauria.

We find that those avian accelerated rates are concentrated in the limbs and the pectoral and pelvic girdles, confirming the focus on limb module evolution in the transition to flight. The axial skeleton shows higher rates of evolution only at the base of alvarezsaurids. All postcranial regions in Avialae display greater disparity than in most other clades. Alvarezsaurids and therizinosauroids show highly disparate forelimbs and pelvic girdles, respectively. Overall, these postcranial regions increase in disparity during the Late Jurassic and most of the Cretaceous, all of them showing a post-Santonian disparity decrease. In the cranium, tyrannosauroids experienced accelerated evolutionary rates in the braincase, face and mandible. Higher dental rates are also present at the base of Ornithomimosauria. Accelerated mandibular rates appear at the base of alvarezsaurids and oviraptorosaurs. In birds, such rates are found only in the facial skeleton. Tyrannosauroids are remarkable in being more disparate than other coelurosaurs in the braincase, facial skeleton and mandible; dental disparity is remarkably high in alvarezsaurids. All these cranial regions increased in disparity throughout the Late Jurassic and Cretaceous, with a surge in braincase and facial disparity after the Coniacian.

Technical Sesssion X (Friday, October 28, 2016, 8:45 AM)

MOSAIC EVOLUTION OF THE EARLY SAURIAN POSTCRANIUM REVEALED BY THE POSTCRANIAL SKELETON OF *TERATERPETON HRYNEWICHORUM* (ARCHOSAUROMORPHA; LATE TRIASSIC)

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Basal saurian lineages, especially archosauromorphs, diversified widely during the Triassic Period, exploring a remarkable range of different ecological roles (e.g., terrestrial predators, herbivores with complex teeth, aerial gliders). Many of these early lineages differ greatly from one another in the structure of the postcranium. *Teraterpeton hrynewichorum*, from the Upper Triassic (Carnian) Wolfville Formation of Nova Scotia, is one of the more unusual early archosauromorphs, with an elongate edentulous snout, transversely broadened and cusped teeth, and a closed lateral temporal fenestra. Initial phylogenetic analyses recovered this species as the sister taxon to *Trilophosaurus* spp. New material of *Teraterpeton* includes the first-known complete pelvic girdle and hind limbs and the proximal portion of the tail. These bones differ radically from those in *Trilophosaurus*, and present a striking mosaic of anatomical features for an early saurian. The ilium has an elongate, dorsoventrally tall anterior process similar to that of hyperodapedontine rhynchosaurs. The pelvis has a well-developed thyroid fenestra, a feature shared by Tanystropheidae, Kuehneosauridae, and Lepidosauria. The calcaneum is ventrally concave, as in *Azendohsaurus*. The fifth metatarsal is proximodistally short, comparable to the condition in Tanystropheidae. Much as in the manus, the pedal unguals of *Teraterpeton* are transversely flattened and dorsoventrally deep.

Phylogenetic analysis of 57 taxa of Permo-Triassic diapsids and 315 characters supports the placement of *Teraterpeton* as the sister-taxon of *Trilophosaurus* in a clade that also includes Azendohsauridae and, rather unexpectedly, Kuehneosauridae. In the current phylogeny, the aforementioned amalgam of characters in *Teraterpeton* were all acquired independently from the other saurian lineages. We partitioned the dataset based on anatomical region to examine metrics of homoplasy across early Sauria. The CI of the partitions are not markedly different, but the RI of the pelvic girdle and hindlimb partitions are markedly higher than the others. Although the characters in the hindquarters partitions underwent a similar number of homoplastic changes, a higher proportion of them contribute to the overall structure of this phylogenetic reconstruction. The mosaic condition in *Teraterpeton* underscores the importance of thorough taxon sampling for understanding the dynamics of character change in Triassic reptiles and the use of apomorphies in identifying fragmentary fossils.

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Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

INVESTIGATING THE EVOLUTION OF LIMB MORPHOSPACE AND LOCOMOTOR BEHAVIOR DIVERSITY IN AVES

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Modern birds utilize both their forelimbs and hind limbs in an array of locomotor behaviors, such as flying, walking/running, swimming, and climbing. Furthermore, birds display diversity in how these behaviors are utilized, ranging from taxa that fly and walk, only walk, or almost exclusively fly. The evolution of separate locomotor modules, the forelimb and the hind limb, during the course of avian evolution has been hypothesized to be a major factor affecting diversity in avian locomotion, due to differential elaboration between modules. Subsequent work has shown that these modules are linked: the forelimb and hind limb changed concomitantly in the evolution of avian flight, and living birds that emphasize forelimb function often have reduced hind limbs, and vice versa. However, little is known about how the differential or linked evolution of locomotor modules has affected the evolution of diversity in avian morphology and locomotor behavior beyond flight and terrestrial locomotion. I investigated the evolution of avian forelimb and hind limb morphospace, assessing the relationship between limb morphology, morphospace size, locomotor behavior diversity, and phylogeny across Aves. I produced a dataset of forelimb and hind limb long bone lengths in 1,244 species of birds, sourced from both original measurements and the literature. I further analyzed these traits with a phylogenetic supertree of Aves consisting of 1,141 taxa to test phylogenetic signal. Morphospace volume correlated with diversity in locomotor behavior, and does not show an association diversity. Total morphospace volume shows a positive relationship with total locomotor diversity, although significant variation exists. This pattern holds in the hind limb alone, although not in the forelimb. Phylogenetic signal is high across the entire tree, with variance distributed within clades rather than between them, but this pattern differs when looking at individual clades. These data indicate that elaboration of the hind limb in birds can be linked to the high diversity of locomotor behaviors they perform, but that forelimb morphology is more constrained despite diversity in function. Furthermore, the existence of high phylogenetic signal and the distribution of limb variance between avian subclades indicates morphologic

conservativism within individual clades with different locomotor strategies. Ultimately, these data lend further support the hypothesis that the evolution of separate locomotor modules has influenced the diversity of locomotor behaviors in birds.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

A NEW GENUS OF HESPERHYINE PECCARY (ARTIODACTYLA, TAYASSUIDAE) FROM THE EARLY MIOCENE JOHN DAY BEDS OF OREGON: IMPLICATIONS FOR FOSSIL DATABASES

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The fossil peccary "*Thinohyus" osmonti* was named by W.J. Sinclair in 1905 based on a nearly complete skull (UCMP 393) from the middle John Day beds, 6 miles north of Clarno's Ferry, Oregon. Since its discovery, it has bounced from one invalid genus (e.g., *Bothriolabis*) to another and currently is assigned to the common John Day peccary *Thinohyus*. However, a cursory glance at the skull reveals that it is nothing like typical *Thinohyus*, which have conical, almost inflated snouts. UCMP 393 has a long, narrow, gracile rostrum with shallow facial fossae, which is typical of hesperhyine peccaries and not found in more primitive taxa. This skull and another referred specimen (UCMP 1988) have the distinctive shallow plesiochoanal fossa unique to the hesperhyines, as well as a narrow orbitomaxillary fossa. These characteristics place it among the more primitive hesperhyine peccaries, such as *Stuckyhyus* (formerly *Desmathyus*) *siouxensis* from the late Arikareean of Wyoming and *Floridachoerus olseni* from the early Hemingfordian Thomas Farm l.f. of Florida. The only reason it was assigned to *Thinohyus* was that its tooth size is similar to other John Day *Thinohyus*, but in skull morphology it is very different. However, its teeth were nowhere near as small as the dwarfed peccary *Marshochoerus* (formerly "*Cynorca*") *socialis* from the John Day beds. Thus, this species represents a previously unnamed genus of hesperhyine peccary, not a thinohyine. This increased the diversity of the hesperhyines to eight genera (five of them new since 2015) and eight species, whereas the previous literature and Fossilworks and the Paleobiology Database only mention *Hesperhys* and *Desmathyus*. Such discoveries further reinforce the point that databases of fossil taxa based on immature taxonomy or outdated systematics are often 'garbage in, garbage out.'

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

THE FROZEN CAVE LION (*PANTHERA SPELAEA*) NEWBORN CUBS FROM EASTERN SIBERIA, RUSSIA: THE FIRST DATA ON EARLY ONTOGENY OF THE EXTINCT SPECIES

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Bones, and especially complete skeletons, of the cave lion, *Panthera spelaea*, are among the rarest of megafaunal finds in the Holarctic. This is the first report on the discovery and analyses of the two frozen cave lion bodies found in slope deposits of the Uyandina River basin, a tributary of the Indigirka River (Abyi District, Yakutia [Sakha] Republic), in July 2015. The cave lion cubs were discovered about 4–5 meters below the surface in the Edoma permafrost deposits formed during the Karginskii interstadial (~ 55 – 25, 000 years BP). In addition to the two cave lions, bone remains from several other species were found within the site, including woolly mammoth (*Mammuthus primigenius*), steppe bison (*Bison priscus*), reindeer (*Rangifer tarandus*), wolf (*Canis lupus*), and brown bear (*Ursus arctos*). The lion cub remains were represented by a complete specimen named 'Uyan' and a partial specimen named 'Dina,' both of which were covered in light tan-yellowish fur. The Dina cub specimen includes the head, distal forelimb, and proximal fragment of the torso with skin. Ancient DNA identification confirmed the cubs to be cave lions. Both cubs had very short ears and relatively short tails, and their eyes were closed. The CT scans revealed the skeletons were in a state of intense growth. The deciduous teeth of both cubs had erupted beyond the bony alveoli but were still below the gingiva. Based on comparisons with the development and growth data of African lion cubs, the cave lion cubs were about 1–2 weeks old or possibly younger. Both cubs had unmodified postcranial skeletons but somewhat deformed crania. The brains were represented by a homogeneous mass of the same density. The brain masses were located closer to the inner neurocranium walls, reflecting the state of brains of live animals, in contradistinction to the shrunken brains of the Yuka Mammoth (*M. primigenius*) and Yukagir Bison (*B. priscus*). The Dina cub had misplaced and overlapping cranium bones in a lateral direction, causing the brain hemispheres to be expanded laterally. The brain of the partial Uyan cub was less deformed, allowing for better 3D reconstruction. It revealed a shape that is characteristic of modern cats. The brain morphology is particularly similar to the African lion (*Panthera leo*) with extensive piriform lobes, powerful olfactory tubercles, and modestly sized anterior region of the prorea (prorean gyrus). The average lion brain volumes measured about 60 cm^2 and probably had live weights of about 64 g. The most likely cause of death of the cave lion cubs was a collapse of their den.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

A LITTLE SQUIRRELY: RECONSTRUCTING LOCOMOTOR BEHAVIOR AND BODY MASS OF EARLY ISCHYROMYIDAE (RODENTIA) USING EXTANT SCIURIDAE

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Ischyromyidae are among the oldest and most primitive recognized members of Rodentia and were the first rodents to enter North America. Reconstructions of their locomotor repertoire have been inconsistent. The purpose of this study is to reassess the locomotor behavior of early (Eocene) North American ischyromyids and to utilize this information to select an appropriate locomotor group on which to base body mass estimations.

Living sciurids closely resemble early ischyromyids, consequently, they are used here as model taxa. Linear measurements of sciurid forelimbs and hind limbs were used to calculate 13 functional limb indices. In addition, humeral and femoral articular areas were estimated. Reduced major axis regressions of sciurid limb measurements against body mass were conducted to clarify allometric scaling and variation in limb index values and articular areas among locomotor groups. Body mass estimations were completed using least squares regressions and percent standard error of the estimate (%SEE) was calculated to assess predictive precision.

Comparisons of sciurids show that many limb index values are statistically distinguishable ($p < 0.05$) among locomotor groups; however, there is considerable overlap among arboreal and semifossorial taxa. The degree of similarity between arboreal and semifossorial squirrels is probably attributed to overlapping behaviors. Early ischyromyids were found to have generally greater mechanical advantages and limb robusticity than most living squirrels and thus were likely proficient scratch-diggers. However, this does not necessarily suggest that ischyromyids were strictly terrestrial animals, as the index values of some early ischyromyids are within the range of some arboreal sciurids. Instead, it suggests that ischyromyids were likely generalists, much like living squirrels today.

The results of the locomotor analysis, and their overall greater robusticity, suggest that body mass estimations for early ischyromyids should, therefore, be based on samples of semifossorial squirrels. Using the body mass equations with the lowest %SEEs, body masses of early ischyromyids range from 1315–1875 g for *Paramys copei*, 2364 g for *Thisbemys*, and 5455–5912 g for *Notoparamys costilloi*. These estimates are larger than previous estimates based on teeth and cranial measurements.

Preparator's Session (Thursday, October 27, 2016, 10:30 AM)

DIGITAL RECONSTRUCTION OF A HEAVILY TAPHONOMICALLY ALTERED PLESIOSAURIAN SKULL UTILIZING LASER SCAN DATA AND NOVEL 3D MODELLING TECHNIQUES

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A recently discovered new taxon of elasmosaurid plesiosaurian from Montana, U.S.A., was laser scanned for research and archiving purposes. The skull was obliquely deformed, being flattened on the left-right axis and skewed ventrodorsally and anteroposteriorly, which preserved most of the palatal view and the left lateral without deformation. This resulted in a state of preservation not conducive to standard analog reconstruction methods. We digitally reconstructed the skull of this elasmosaurid using a combination of techniques and software. 3D sculpting software, ZBrush, was used to cut and separate the mandible from the cranium and the individual cranial plates along distinct suture lines. The pieces were then retrodeformed, using photo references and CT scans of sister taxa as guides, and the pieces of the cranium that could not be salvaged were discarded and replaced by mirroring more complete components from the left side of the specimen. The mandible was dissected along the symphysis and corrected as distinct pieces and later merged into a solid structure. The cranial pieces were further retrodeformed and digitally merged to match natural sutures. Using morphometric data supplied by ongoing research of the plesiosaur the cranium was returned to life proportions and cleaned of taphonomic alterations such as fractures and pitting. The teeth were replaced with digitally sculpted analogs that were individually scaled and shaped on a tooth by tooth basis, matching the original teeth as closely as possible. The mandible was fitted to the cranium and the teeth were adjusted to allow for proper range of motion without occlusion. The reconstructed skull was 3D printed at full scale and used as a skeletal template for the manual addition of soft tissues in order to create a new life-like reconstruction of an elasmosaurid head for display at the University of Alaska Museum of the North. A full-body, digital model of the plesiosaur will also be used for research purposes and serve education and outreach roles.

Technical Session VI (Thursday, October 27, 2016, 8:30 AM)

CRANIAL BIOMECHANICS OF *LEPTARCTUS PRIMUS* (LEPTARCTINAE, CARNIVORA) AND FUNCTIONAL MORPHOLOGICAL ANALYSIS OF *L. PRIMUS* AND *HYPSOPARIA BOZEMANENSIS* USING FINITE ELEMENT SIMULATIONS

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Variation in cranial and dental morphology has long been correlated to feeding adaptations in living organisms and also as a proxy for discerning paleodiet. Although its phylogenetic placement is debated, the Miocene musteloid carnivoran *Leptarctus* has been interpreted as either a frugivore or insectivore based on distinctive dental morphology and comparisons to extant musteloids. We apply the first quantitative

analysis of *Leptarctus primus* cranial biomechanics to identify a close living analogue for its dietary ecology. Finite element (FE) cranial models of 21 extant and extinct carnivoramorphans (feliform, caniform, and stem) and an outgroup creodont were constructed to compare known diet-biomechanics relationships to the properties of an *L. primus* FE cranial model. Cluster analyses of simulated bite force efficiency and skull stiffness values indicate that *L. primus* is nearly identical to *Taxidea taxus* (American badger) in unilateral bite simulations. We thus interpret that *L. primus* had a skull capable of consuming vertebrate prey, while also possessing broad molars useful for crushing a wide range of foods. Based on biomechanical analyses, we postulate that *L. primus* more closely resembled the modern American badger in its ecology than any other taxon tested. We also evaluated potential synonymy between *L. primus* and *Hypsoparia bozemanensis* from a cranial biomechanics perspective. Characters previously used to distinguish *L. primus* from *H. bozemanensis* were tested for their viability at distinguishing biomechanical features in a 'design of experiments matrix,' applying permutations of the *L. primus* model morphed with every possible character configuration, then comparing each model to the 21-species sample. Models with bulkier zygomatic arches have less mechanical efficiency and higher strain energy than *L. primus*. Cluster analyses show high levels of similarity between the *H. bozemonensis*-like and *L. primus* models. Overall, few biomechanical differences can be inferred between *L. primus* and *H. bozemonensis*, and our analyses provide no functional morphology support for their generic distinction. Phylogenetic analyses of discrete characters combined with expanded assessments of cranial biomechanics may help us resolve the enigmatic placement of Leptarctinae within Musteloidea.

Grant Information
Research was supported by the Research Experience for Undergraduates program at the National Science Foundation as part of grant DEB-1257572 to J. Flynn and Z.J. Tseng.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

BONE HISTOLOGY IN *XIXIANYKUS ZHANGI* (THEROPODA, ALVAREZSAUROIDEA): IMPLICATIONS FOR THE MINIATURIZATION OF ALVAREZSAUROIDEA

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Alvarezsauroidea is a group of bizarre theropods with highly modified forelimbs and elongated hindlimbs. In addition, they represent one of the few theropod subgroups that present a trend towards miniaturization. *Xixianykus zhangi* is among the smallest alvarezsauroids collected from the Upper Cretaceous Majiacun Formation of Xixia County, Henan Province, north of China, whose bony histology has implications for the miniaturization of Alvarezsauroidea. Five different skeletal elements from XMDFEC V0011, the holotype of *Xixianykus zhangi*, were sampled in bone histology, revealing the microstructural variation between each element. Age was estimated at 11 by counting the preserved LAGs (lines of arrest growth) and speculating LAGs eroded in the histology sections from long bones. OCL (outer circumferential layer) structure is observed in the slices from femur and other long bones. Statistical works display a significant decline in both densities of canals and osteocyte lacunae. These visible growth retardation structures display a relative matured live stage of *X. zhangi*. Distinctive radial canals are founded in matatarsals, which could represent a pivotal histology evidence for Alvarezsaurids exclusive tarsometatarsus formed. Combining with recent phylogeny studies and body mass data of different alvarezsaurids dinosaurs, a new hypothesis is proposed to reveal the body size evolution in this family. Theropods in Alvarezsauroidea have gone through a process of drop in size and then appeared as a small rise in their size evolution, which is a rarity in theropods size evolution. Furthermore, comparing with previous histology studies, four growth strategies are found in Alvarezsauroide. Two inverse modes of miniaturization can be exhibited in alvarezsaurid body size evolution; one is like precocial birds, while the other is similar to that in altricial species.

Grant Information
This project was funded by the National Natural Science Foundation of China (41502018 and 41120124002), the Youth Innovation Promotion Association (CAS, 2015057).

Technical Sesssion X (Friday, October 28, 2016, 11:45 AM)

TRANSITIONAL FOSSILS SHED LIGHT ON THE BASAL DIVERGENCE OF ADVANCED MARINE TURTLES

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During the Cretaceous, three distinct turtle lineages adapted to a fully marine lifestyle; these include the extinct Cretaceous Protostegidae, and extant hard-shelled Pan-Cheloniidae and leatherbacks or Pan-Dermochelyidae. Pan-cheloniids and pan-dermochelyids constitute a monophyletic clade based on molecular and phenotypic data. However, phylogenies incorporating fossils place protostegids as the stem-lineage of leatherbacks. Because protostegids appeared in the Early Cretaceous (Late Barremian/ Early Aptian), this topological positioning implies emergence of the chelonioid sea turtle crown at least 35 million year earlier than current molecular clock estimates suggest, unless an unusually accelerated tempo of evolution occurred after the basal sea turtle split.

Here we evaluate the skeletal anatomy of *Eosphargis gigas*, a pan-dermochelyid from the Eocene of Belgium, which reveals that the key postcranial states uniting protostegids with leatherbacks are likely convergent. Indeed, our extensively revised and expanded sea turtle phylogeny shows that *E. gigas* is pivotal to reconstructing protostegid relationships because its transitional character state mosaic forces Protostegidae into a basal stem-lineage position relative to the chelonioid crown. The divergence timing of crown sea turtles thus no longer conflicts with molecular data, and extends between the Campanian–Eocene, although a more precise estimate remains problematic. Our new phylogeny also identifies the type-Maastrichtian taxon *Allopleuron hoffmanni* as a potential Cretaceous stem-dermochelyid based on shared combination of unique cranial, postcranial and histological traits. Protostegids share a vast number of characters with crown sea-turtles, although experimental weighting and deletions demonstrates that these all correlate with marine adaptations, which likewise influence the affinities of *A. hoffmanni*, inferring that although protostegids are robustly retrieved on the chelonioid stem, they may still represent a potentially independent marine cryptodiran radiation.

Grant Information
SYNTHESYS grants (AT-TAF, FR-TAF 4290, GB-TAF 1882, BE-TAF 5292); Train2Move-Marie Curie Fellowship; Student Research Program Application, Royal Tyrrell Museum of Alberta

Technical Session V (Wednesday, October 26, 2016, 3:00 PM)

DYNAMIC RATES OF DINOSAUR EVOLUTION THROUGH THE MESOZOIC

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The fossil record of dinosaurs is too incomplete to utilize many quantitative methods for understanding rates of speciation, extinction and morphological evolution that have been applied to marine invertebrates and Cenozoic mammals. However, the phylogeny of Dinosauria has been well studied, and advances in phylogenetic modeling allow for robust inference of evolutionary rate variation. We used a 614-tip tree of Dinosauria to calculate rates of speciation, extinction and body mass evolution through the Mesozoic. We analyzed these phylogenies using a model that allows for shifts in rates of evolution both across clades and through time, allowing the inference of complex patterns of hierarchical evolution. This method directly accounts for variation in preservation potential through time using stage-specific set of formation counts. Speciation and extinction rates fluctuated radically through the Mesozoic, with a general decline in net diversification across the Cretaceous. Sauropods show a high degree of dynamism with repeated replacement of earlier grades by derived clades at least four times in the history of the group. Theropods show a strong relationship between net diversification and turnover through time, while the other clades do not, suggesting that theropod radiations occur via rapid revolutions where new species replace older ones. Ornithischians have the least dynamic pattern, showing a long, slow decline in net diversification until the Early Cretaceous where they underwent an extremely rapid radiation. This is consistent with ideas about the Early Cretaceous Terrestrial Revolution, although in direct contradiction to previous suggestions that dinosaurs did not take advantage of the revolution. Macroevolutionary rates change through time, and even closely related clades may show radically divergent patterns of rate variation if, for instance one lineage undergoes and adaptive radiation or evolves a key innovation. By using a model that allows for more realistic patterns of hierarchical evolution, we are better able to test hypotheses about the dynamic nature of evolution.

Technical Session VI (Thursday, October 27, 2016, 8:00 AM)

PATTERNS OF FELID PRESACRAL VERTEBRAL ORGANISATION SHOW MORPHOLOGICAL INTEGRATION AND DEVELOPMENTAL MODULARITY

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Geometric morphometric analyses of the axial skeleton in Felidae (Mammalia) reveal regionalisation of shape in presacral vertebrae that correlates heterogeneously with ecomorphological specialisation in locomotion and prey size. While anterior vertebrae may either have evolved under stronger phylogenetic constraints or are ecologically conservative, posterior vertebrae, specifically in the post-T10 region, show clearer differentiation between ecomorphs.

Whereas these results imply that distinct vertebral sections are under different selection pressures, shape regionalisation in this complex serial structure may alternatively suggest organisation of vertebrae in modules, which may direct respondability to selection.

Here we have investigated hypotheses of modularity in the axial skeleton of nine living and three fossil Felidae species spanning the observed range in body size and ecology. Analyses were performed on a dataset of 1338 vertebrae composed of 19 vertebral types of 73 specimens. We tested hypotheses of regions of intervertebral shape gradient, addressing morphological and functional modularity, and of intravertebral structure, addressing the distinct developmental origins of vertebral components.

Two-block Partial Least Squares analyses, with and without phylogenetic correction, identified five modules in the presacral axial skeleton (atlas – T1, C6 – T2, C7 – T8, T10 – T11, and T12 – L7), whose identities strongly correspond with hypotheses of morpho-functional modularity. Additionally, correlations between the cervical (atlas – C7) and posterior (T12 – L7) modules reflect timing of vertebral ossification in felids.

Intravertebral modularity was explored with analyses of relative eigenvalue standard deviation, RV coefficients, and covariance ratios. Our results support the developmental hypothesis of two widespread intravertebral modules (centrum vs. laminae). Exceptions showing different modular patterns are concentrated on regional morphological boundaries, specifically on the axis, C7 and T1, T8, and L6 and L7.

The axis and vertebrae in the T10 – L7 region show the greatest overall integration. Additionally, we show that values of both overall integration and disparity are highest in posterior vertebrae, specifically T10, L6 and L7, thus offering an empirical example of how integration can promote broader ranges of morphological responses to selection.

Grant Information
Supported by the Leverhulme Trust grant RPG 2013-124 awarded to Anjali Goswami and the SYNTHESYS project grant awarded to Marcela Randau

Technical Session VIII (Thursday, October 27, 2016, 2:30 PM)

DIVERSIFICATION OF A NEWLY IDENTIFIED CLADE OF EARLY EOCENE OMOMYIDS FROM THE GREATER GREEN RIVER BASIN

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Our knowledge of the evolutionary dynamics of North American omomyid primates is based almost exclusively on the succession of lineages within the Bighorn Basin of northern Wyoming. Diversification events outside this area have conventionally been

viewed as few and comparatively minor contributions. However, new fossil material of members of two poorly known omomyid genera, *Anemorhysis* and *Tetonoides*, from the Main Body of the Wasatch Formation, Greater Green River Basin, southwestern Wyoming, documents a diversity of closely related omomyids from outside the Bighorn Basin. Over 250 specimens of *Anemorhysis sublettensis*, *A. savagei*, and *Tetonoides pearcei*, including several well-preserved jaws with teeth, were recovered from a series of twelve early Eocene (middle to late Wasatchian, Wa3-Wa7) assemblages. These new materials preserve parts of the anatomy of these taxa that were previously unknown, including much of the anterior-most and upper dentition. Based on these fossils, we coded characters for the three omomyids for a previously constructed phylogenetic character matrix composed of 1844 morphological and molecular characters and 159 primates. The evolutionary relationships of these taxa were evaluated with Tree Analysis Using New Technology (TNT). Although little resolution is recovered throughout much of the phylogeny, a clade uniting members of *Anemorhysis*, *Tetonoides*, and another omomyid from the Wasatch Formation, *Arapahovius*, is strongly supported. This clade is consistently present and well-represented within the Greater Green River Basin during the middle to later parts of the Wasatchian. Our findings suggest that more traditional scenarios for the evolution of the North American omomyids, particularly those that have centered on the faunal succession and dominance of anatomorphine omomyids within the Bighorn Basin, are missing a considerable portion of the evolutionary history of this group. Our results also outline a biogeographic mosaic within early Eocene omomyids in which members of the clade comprising *Anemorhysis*, *Tetonoides*, and *Arapahovius* diversified in more southerly regions and only extended into the Bighorn Basin during warmer intervals.

Grant Information
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Technical Session XX (Saturday, October 29, 2016, 2:00 PM)

A NEW SPECIES OF *ERYOPS* FROM THE LOWER PERMIAN CEDAR MESA SANDSTONE (CUTLER GROUP) OF SOUTHEASTERN UTAH AND ITS IMPLICATIONS FOR THE PHYLOGENY AND BIOGEOGRAPHY OF ERYOPIDS

RASMUSSEN, Cornelia, University of Utah, Salt Lake City, UT, United States of America; HUTTENLOCKER, Adam K., University of Utah, Salt Lake City, UT, United States of America; IRMIS, Randall, University of Utah, Salt Lake City, UT, United States of America

As exemplified by its appearance on the SVP logo, the temnospondyl amphibian *Eryops* is an iconic and widespread nonmarine tetrapod. The taxon is known from the uppermost Carboniferous and Permian of the western US, as well as the Lower Permian of the Midcontinent and Eastern U.S. Despite its abundance, a lack of comprehensive revision means the species-level taxonomy and phylogenetic relationships are poorly understood, limiting its use in phylogenetic, biogeographic, and paleoenvironmental analyses. Here, we describe new cranial material of *Eryops*, including a nearly complete skull and lower jaws, from the Lower Permian Cedar Mesa Sandstone of the Cutler Group in southeastern Utah. The specimen displays several *Eryops* synapomorphies, including: an interfrontal bone on the midline between the nasal and frontal; a slightly elongated prenarial region; and a weakly 'stepped' subnarial margin of the maxilla. A number of autapomorphies, such as a short skull length relative to its breadth (with a foreshortened temporal region), and four ectopterygoid tusks (as opposed to two tusks in other *Eryops* species and *Onchiodon*, and three tusks in *Glaukerpeton*), suggest that this specimen represents a separate species. We conducted a phylogenetic analysis based on the most inclusive sample of eryopids to date in order to better understand its phylogenetic relationships among other eryopid temnospondyls. These analyses recover the Cedar Mesa specimen as the sister taxon to a clade containing the other North American *Eryops* species (*E. megacephalus* and *E. grandis*) plus the Russian *Clamorosaurus*. Given the position of *Clamorosaurus* within the core *Eryops* clade (which excludes *Glaukerpeton* and the European taxa *Actinodon* and *Onchiodon*), we suggest that *Clamorosaurus* should be considered the first non-North American species of *Eryops*, considerably expanding the known geographic range of this taxon. Additional species diversity may be hidden among Euramerican specimens of *Eryops*, which span more than 20 million years from latest Pennsylvanian through early-middle Permian times.

Grant Information
Canyonlands Natural History Association

Poster Symposium II (Friday–Saturday, October 28–29, 2016, 4:33 PM)

LATE JURASSIC DINOSAURS FROM GONDWANA: MATERIALS FOR COMPARISON WITH THE MORRISON FORMATION

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The abundant dinosaur fauna of the Morrison Formation has dominated our view of dinosaurs from the Late Jurassic, but the question, in how far this fauna might represent a "typical" Late Jurassic dinosaur fauna has only recently come into focus. One reason for this is the sparse Late Jurassic dinosaur fossil record from other continents.

The Late Jurassic dinosaur fossil record is especially sparse for Gondwana. Here, the reference fauna has long been that of the Tendaguru Formation of Tanzania. When first described, many species from this fauna were referred to genera known from the Morrison Formation, such as *Brachiosaurus*, *Barosaurus*, *Allosaurus*, or *Labrosaurus*. Recent research has shown that, although on higher taxonomic levels the faunas are similar, there might actually be few if any shared genera. Furthermore, although the taxonomic composition might be similar, the contribution of different clades to the entire fauna seems to differ considerably. Whereas the fauna of the Morrison Formation is dominated by camarasaurid and diplodocid sauropods, allosaurid and coelurosaurian theropods and stegosaurian and basal ornithopodan ornithischians, the Tendaguru fauna is mainly made up of brachiosaurid and dicraeosaurid sauropods, ceratosaurian and, probably, carcharodontosaurian theropods and rather rare stegosaurs and basal ornithopods. All of the saurischian taxa mentioned, with the possible exception of carcharodontosaurians, are also known from the Morrison Formation, but constitute minor components of the fauna.

Additional data concerning the question whether the Tendaguru fauna can be considered a typical Gondwanan Late Jurassic fauna are still very sparse, with the most important data coming from the Kadzi Formation of Zimbabwe, Africa, and the Cañadón Calcáreo Formation of Argentinean Patagonia. Being composed of dicarosaurid, brachiosaurid, basal macronarian and diplodocid sauropods,these faunas seem to closely resemble the Tendaguru fauna, and the only identifiable theropod remains discovered from them so far represent a ceratosaurian and a basal tetanuran, respectively. In addition, the engimatic *Chilesaurus* from the Late Jurassic of southern Chile represents a clade that has not been reported from the northern Hemisphere so far.

Observed similarities between the faunas might thus stem from a rapid and probably global radiation of different clades in the Middle Jurassic, whereas the differences in faunal composition might reflect faunal differentiation following the isolation of Gondwana in the Late Jurassic.

Technical Session XII (Friday, October 28, 2016, 3:15 PM)

DID THEROPOD DINOSAURS HAVE LIPS?

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Theropod dinosaurs have been reconstructed in two dramatically different ways, either with the large marginal teeth exposed, or covered by peri-oral tissues or lips when the mouth was closed. We test these two competing hypotheses using comparative dental anatomy and development, and regression analyses using skull length to tooth size ratios in extant and extinct reptiles.

In extant crocodiles about ¼ of the tooth is covered by gingiva, but the crowns are exposed permanently. In contrast, in extant squamates teeth are covered by lips when the mouth is closed. Phylogenetic bracketing, in the absence of evidence from birds and from fossils would tend to support the hypothesis that the large teeth of theropod dinosaurs would be exposed when the mouth is closed.

Dental anatomy and development offer a different perspective. As the hardest vertebrate tissue, enamel has relatively low water content, but is hydrated from the outside by glandular secretions in the mouth. We propose that hydration, important for enamel integrity, is not possible if the tooth is exposed permanently, and exposed enamel could not be maintained in a terrestrial vertebrate. Histological thin sections show that exposed mammalian teeth (tusks) do not have enamel, supporting the hypothesis that theropod dinosaurs, all known to have well preserved and maintained ename,l were not exposed permanently, but covered by reptilian lips similar to those found in squamates.

Similarly, ordinary least squares regression analyses of skull lengths to tooth sizes in varanid lizards and theropod dinosaurs of various sizes indicate that the teeth of theropod dinosaurs conform to the same pattern as varanid lizards, and likely had lip-covered teeth, as teeth in theropod dinosaurs are no larger than would be expected in a similarly sized varanid lizard. This conclusion has wider implications, suggesting that peri-oral cover of marginal teeth is the primitive condition for all terrestrial vertebrates, allowing us to test whether the large, tusk-like structures of some basal ornithischians, or the large canine-like teeth of terrestrial synapsids were secondarily exposed or not.

Finally, we propose that the lip-covered dental pattern is also present in terrestrial stem crocodilians. They have teeth that are very similar to those of theropod dinosaurs, and thus, the prevalent condition seen in crown crocodilians represents the derived condition, possibly related to their secondary aquatic or semiaquatic adaptations.

Grant Information
NSERC Discovery Grant, Canada to RR

Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

MORPHOMETRIC COMPARISON WITH IMPLICATIONS FOR THE FOSSIL RECORD OF TWO LIZARDS (PHRYNOSOMATIDAE, SQUAMATA), WESTERN USA: *UTA STANSBURIANA* AND *UROSAURUS ORNATUS*

REJ, Julie, East Tennessee State University, Johnson City, TN, United States of America; MEAD, Jim I., East Tennessee State University, Johnson City, TN, United States of America

Squamate fossil identification has been challenging due to the incomplete understanding and sometimes complete lack of osteological research of extant species. To best understand the morphology of a species, a large sample size is required to determine which characters are significant in defining the species, and which characters show too much variability within individuals. Sufficient sample size of skeletonized lizards is exceedingly rare. East Tennessee State University has a substantial collection of skeletonized Phrynosomatidae; a diverse family of small lizards known throughout North America. Fossils have been collected from the American Southwest, however, identifications of select fossils are often limited to the family or sub-family level. Here we compared the maxilla of two similar species of phrynosomatids: *Uta stansburiana*(side-blotched lizard) and *Urosaurus ornatus* (ornate tree lizard). Through morphometric analysis of the maxilla, we determined which characters significantly separated the two species. Only adult specimens were used in this study (determined by snout-vent length). A principle component analysis (PCA) and a stepwise discriminant function analysis (DFA) were conducted, in which we compared 15 landmarks between 25 specimens of *U. stansburiana* and 24 specimens of *U. ornatus*. The PCA was plotted in a three-dimensional scatter-plot using the top three factor scores. The graph showed a separation between the two species, however, there was an outlier within *U. stansburiana*. With the removal of the outlier, there was still separation, but the separation was not as clear. The stepwise DFA bar-graph showed clear separation between species; 5 of the 15 characters were statistically significant. With the removal of the outlier, a stepwise DFA was conducted; 2 of the 5 significant characters were removed, but a new character was added. Two of the significant characters, show promise for fossil identification. The first character is in the ventral region of the posterior maxilla process; *U. ornatus* has a defined notch, while *U. stansburiana* does not. Second, the anterior portion of the maxilla is curved dorsally in *U. stansburiana*, while *U. ornatus* shows no curving. The results of this study are used to identify fossil *Uta* vs *Urosaurus*,

but more analyses need to be conducted on other phrynosomatid species for a comprehensive identification.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

TESTING THE WOODLAND HYPOTHESIS OF TETRAPOD ORIGINS IN POLAND AND GERMANY

RETALLACK, Gregory J., University of Oregon, Eugene, OR, United States of America

My woodland hypothesis of tetrapod evolution published in 2011 postulates limb differentiation as adaptation to shallow pond waters, which became widespread with Devonian evolution of trees in floodplains. The hypothesis was based on Devonian–Missisippian tetrapod trackways and bones in Pennylsvania associated with woodland paleosols (vertisols, alfisols), rather than with interbedded desert paleosols (aridisols). These same sequences interpreted as arid by Joseph Barrell were the basis for Romer's classical desert pond hypothesis, in which limbs evolved for moving overland between shrinking ponds. A third intertidal smorgasbord hypothesis was based on trackways in coastal lagoonal facies from Zachelmie in Poland by Niedzwiedzki and colleagues. This study reports new observations in the Eifelian Zachelmie Quarry in Poland and Emsian Alken Quarry in Germany. No fossil trees nor forested paleosols were found at Zachelmie, nor any typical marine fauna. This evidence is not supportive of any of these hypotheses. The setting of these trackways was a hypersaline lagoon surrounded by coastal vegetation no taller than shrubland. Geologically older nematophyte trunks at Alken were up to 28 cm in diameter, and plant scaling relationships suggest that these formed woodlands some 7 m tall in coastal gleyed paleosols. Trees evolved to greater stature earlier in the Devonian in Germany than in Poland, New York, or Pennsylvania. Trees also appeared by the Emsian in Spitzbergen, as represented by fossil trunks, and at least by the Frasnian on Ellesmere Island, as represented by large drab-haloed root traces discoloring type material of *Tiktaalik roseae*

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

QUANTIFYING INTRASPECIFIC VARIATION ACROSS THE TOOTH ROW IN CARNIVORANS (MAMMALIA, CARNIVORA)

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The range of diets within the order Carnivora has yielded a diverse array of dental adaptations. The order Carnivora contains both highly specialized species (from hypercarnivores to specialist herbivores) and more generalized omnivorous species. This wide range of diets correlates well to functional morphological differences in the teeth, especially in the carnassial pair and molars. The raw material from which dental morphologies evolve is variation within species. While we know that there are differences in interspecific variation between the carnivoran lineages, the variability in dental morphology within carnivore species is not well known. The goal of this study is to quantify the intraspecific variation along the tooth row to see whether carnivorans exhibit higher variance in the premolars or the molars. The generalized morphology of the premolars might be the result of lower levels of selective pressures or from their role in a variety of tasks. Also, the lack of occlusion between anterior premolars may remove some functional constraints allowing for a greater degree of morphological freedom within species. Carnassials occlude precisely and are functionally essential, and hence expected to be more tightly constrained. The posterior molars occlude precisely, but are functionally important only in omnivorous species. To test these expectations, we took measurements of the length and width of the canines, premolars, and molars from species within Felidae, Canidae, Ursidae, and Mustelidae, with each species being represented by 10 individuals. We then compared the intraspecific variation, represented by the coefficient of variation, of the dental dimensions. We found that there is a general pattern of higher levels of variation in the front and back of the tooth row, regardless of which tooth is present there. There was less variation in the carnassial, third premolar, and when it was constrained by the presence of posterior molars, first molar. This pattern was consistent across the families. Our findings show that the functional demands and position in the tooth row play a role in determining how much morphological constraint teeth experience and as a result how much variation is present within a species.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

A MULTI-ELEMENT HISTOLOGICAL ANALYSIS OF THE SABRE-TOOTHED CAT *SMILODON FATALIS* (FELIDAE, CARNIVORA)

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The osteohistology of fossil mammals is poorly studied, and there have been no detailed studies of extinct carnivores (Mammalia: Carnivora). Here, we describe the limb bone histology of *Smilodon fatalis* (Felidae) from the Pleistocene Talara tar pit locality of Peru. Transverse, diaphyseal sections were taken from two femora, a humerus, and a tibia. Prior to sectioning, age classes were assigned based on degree of epiphyseal fusion.

The juvenile femur is composed mainly of a fibrolamellar complex with an inner circumferential layer (ICL) and lamellar bone on the anteromedial edge of the outer cortex. Vascularity is longitudinal with some anastomosing canals. One line of arrested growth (LAG) can be traced circumferentially. The adult femur also exhibits an ICL, fibrolamellar complex in the mid cortex, and lamellar bone on the outer cortex. Vascular canals are again longitudinal, although some circumferential canals are present, along with a decrease in canal density, towards the outer cortex. Some remodelling is present as secondary osteons. At least six LAGs and one possible annulus are present in the cortex. The adult tibia is extensively remodelled with secondary osteons, but fibrolamellar primary tissue is visible in the anterolateral mid cortex. An ICL is present, as is lamellar bone on anterolateral outer cortex. Vascularity is longitudinal, with some canals anastomosing radially on the posteromedial side of the inner cortex. There is a marked decrease in density of vascular canals associated with the lamellar bone on the anterolateral outer cortex. Several growth marks can be seen in this anterolateral region, but they cannot be traced around the entire bone due to remodelling. The adult humerus consists largely of remodelled tissue, with overlapping generations of secondary osteons in the anterior cortex. Lamellar bone is present in the outer cortex, along with several growth marks.

This study represents the first multi-element histological analysis of a fossil felid. The majority of the primary bone tissue is fibrolamellar and dominated by longitudinal vascular canals. An ICL and lamellar outer cortex with LAGs is preserved in all samples. The growth record of the femur suggests that somatic maturation in *Smilodon* took multiple years and appears to be most similar to *Panthera leo* among extant large felids. Results suggest that the histology of *S. fatalis* is well suited to further quantitative analyses of growth and life history.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

NEW LOWER PERMIAN (CISURALIAN) ACTINOPTERYGIANS (OSTEICHTHYES) FROM THE PEDRA DO FOGO FORMATION, NORTHEAST BRAZIL

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To date, only one ray-finned fish has been recorded from the Pedra de Fogo Formation of the Parnaíba Basin in the State of Maranhão, namely *Brazilichthys macrognathus*, the post-cranium of which is unknown. Here we report on the discovery of three lower actinopterygian taxa from this formation that are new to science. One of them was collected in the State of Piauí and other two in the State of Maranhão. One specimen is preserved with an articulated fin and partially articulated squamation. The other two taxa are preserved as disarticulated dermal scales.

Taxon 1 is a large fish with an estimated length of at least 100 mm and bearing scales twice as deep as they are wide. These have a long mid-dorsal peg that articulates with an elongated socket on the inner side of the scale. The non-overlapping outer surface occupies two thirds of the length of the scale and bears numerous round tubercles and longitudinally elongated tubercles. The overlapping area is practically smooth. Cellular isopedine makes up half to three quarters of the scale thickness. The ornamental tubercles on the scale are made of ganoine-free orthodentine odontodes forming odontocomplexes that were extensively resorbed and redeposited. Taxon 2 is represented by hundreds of very elongated, rhombic, palaeoniscoid scales ornamented with strong longitudinal ridges and serrated posterior margins. Most of the flank scales have a strong, often recurved anterodorsal process, but a weak or absent peg-and-socket articulation system. In transverse section, the basal bone layer is generally straight except towards the anterior part of the scale, where it curves up, following the orientation of the anterior articulatory process. Three tissues are present, cellular isopedine at the base, single odontodes as well as odontocomplexes and thick layers of ganoine with 'pseudo-prismatic' microcrystalline ultrastructure. An extensive network of vascular canals crosses the scale mostly from the inner to the outer side. Taxon 3 is a small fish c. 120 mm in total length, represented by a pectoral fin showing very elongated marginal lepidotrichia and poorly preserved squamation. Its scales are as long as they are wide with the outer surface ornamented by longitudinal ridges and the inner side showing a peg-and-socket articulation.

The fishes come from lacustrine mudstones with a rich vertebrate fauna including dipnoans, coelacanths, xenacanth sharks, and holocephalians, as well as recently described temnospondyls and captorhinid reptile remains.

Grant Information

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Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

DESCRIPTION OF PENNY CREEK CHELONIAN FAUNA (MIOCENE: EARLY CLARENDONIAN), WEBSTER COUNTY, NEBRASKA AND DIVERSITY COMPARISON TO NORDEN BRIDGE CHELONIAN FAUNA (MIOCENE: MEDIAL BARSTOVIAN), BROWN COUNTY, NEBRASKA

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Herpetofauna are invaluable for inferring environmental conditions, both in modern and paleontological studies. Chelonians, due to their osteology and habitat preference, have a high preservation potential and are therefore oftentimes the only represented herpetofauna at fossil localities. However, they remain understudied and overlooked. As rapid changes in biodiversity are of impending concern, it is imperative to understand biodiversity shifts throughout time. The vertebrate fossil record of the Cenozoic in Nebraska preserves a rich record of many taxa, including chelonians, especially for the Miocene epoch. In previous work, an increase in chelonian generic biodiversity was measured from the Barstovian to the Clarendonian North American Land Mammal ages (NALMAs) in the central Great Plains of North America. This NALMA boundary is currently not correlated with any large shifts in climate or environment. A large collection of unstudied vertebrate fossils from southern Nebraska was recently donated to the University of Nebraska State Museum, including a rich chelonian fauna from the Penny Creek localities (Ash Hollow Formation, early Clarendonian). By studying new chelonian specimens from the Penny Creek local fauna, I was able to augment early Clarendonian collections, and test the previous observation that chelonian diversity increased in the early Clarendonian. Here I compare the Norden Bridge local chelonian fauna (Valentine Formation, medial Barstovian) with the Penny Creek local chelonian fauna and evaluate diversity changes between ~12 and 13 Ma. The Norden Bridge fauna was described by previous researchers. The Penny Creek fauna includes over 300 fossil chelonian specimens (primarily shell fragments). Of these I was able to identify over 200 of the specimens to the species or genus level. Identified taxa include: *Macroclemys sp., Chrysemys sp., Graptemys sp., Apalone sp., Geochelone* cf. *G. orthopygia, Geochelone* cf. *G. nordensis,* and *Geochelone sp.* I found the generic diversity of the Penny Creek chelonian fauna to be slightly higher than that of the Norden Bridge chelonian fauna,

primarily due to the extension of the first occurrence of the genus *Graptemys* from 2.5 to 12.5 Ma and the identification of a new species of *Geochelone*. However, both taxa are limited to single incomplete specimens and chelonian diversity appears to have been fairly stable through this interval.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

LONG-TERM PRESERVATION CHALLENGES IN THE CARNEGIE QUARRY, DINOSAUR NATIONAL MONUMENT, UTAH, USA

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Dinosaur National Monument was created in 1915 to preserve the Carnegie Quarry, a laterally extensive sandstone layer in the Morrison Formation containing thousands of dinosaur bones. This layer has a 70° dip. Approximately 2/3 of the bones were removed in the early 20th century. The remaining bones were left in place and in 1958 a visitor center was built over the quarry. This building was demolished and replaced in 2009–11.

Although the building protects the quarry from the elements, there are many other problems threatening the site. The most persistent problem, and potentially the most catastrophic, is the extensive natural system of cracks. For the most part, the depth and rate of expansion of these cracks is unknown. They are particularly challenging at the western end of the quarry where the upper layer of the sandstone has been left in place. Here, bedding planes maybe a weak point allowing the upper layer to slough off, doing incalculable damage and destroying the most complete skeleton in the quarry, a partially articulated *Camarasaurus* specimen with a complete skull. Throughout the quarry, cracks cut across bones and matrix. Some bones have been damaged and lost and many other bones are threatened.

Conservation issues also threaten the bones. Between 1950 and 1994 various adhesives, fillers, and coatings were used to stabilize and protect the bones. However most of the substances used were not archival and many are not clearly documented. Some examples include asbestos fiber filling and red shellac. These substances have an unknown effect on the bone. Other bones were never stabilized and thus are prone to cracking and chipping.

Finally, various health and safety issues make access potentially hazardous. Rodent feces and dust accumulate on the quarry face. The feces can carry Hantavirus and the dust captures naturally occurring radon progeny. Both are dangerous to inhale. The asbestos filler is also a potential threat. Because the quarry is at a 70° dip, the bones can only be accessed by climbing and 20% of the bones cannot be safely accessed without a crane and bucket.

Moving forward first steps include at a minimum: (1) measuring, mapping, and monitoring depth and rate of expansion of crack systems; (2) an assessment of the structural stability of the quarry sandstone; (3) testing and documentation of historic adhesives; and (4) a plan for cyclic cleaning and conservation of the bones and rock. These problems are typical of those faced by in situ fossil vertebrate exhibits around the world, and are an emerging area of study within the discipline of fossil conservation.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

A NOVEL APPROACH TO MODELING TOOTH GROWTH AND FORM IN EXTANT AND FOSSIL RODENTS

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A key evolutionary innovation of rodents was the development of evergrowing incisors, characterized by their arc-shaped form. These teeth grow and erupt throughout the life of the animal at approximately the same rate as wear occurs at their occlusal ends. Fortuitously, daily growth increments are visible on the surfaces of rodent incisors. These structures, known as periradicular bands, provide a moving, or kymographic, record of each tooth's growth history. This record can be used to reconstruct tooth growth and wear rates occurring during the period of the animal's life, represented by the bands and the total number of days over which the tooth formed. We studied the upper incisors of 19 wild-caught extant beavers (*Castor canadensis*) spanning ontogeny to develop a model incorporating gradients in incisor growth rates and form throughout the life of a typical individual. The specimens were digitized. Labial surface arc segments for representative size class incisors were sequentially aligned in ascending order of age and incisor size. Over 120 morphometric points were documented along the total alignment and a custom R-script used to fit spiral equations. This was used to describe the pattern of typical incisor growth throughout an individual's lifetime. Log-likelihood fitting suggests an Archimedean spiral best describes those data. We then incorporated the average periradicular band width (a proxy for developmental stage growth rates) for each tooth to estimate the placement of age classes on the spiral and infer the total amount of growth occurring in the lifetime of an individual (~1.8 meters for *C. canadensis*). The development of models such as this makes it possible to estimate size and age of individuals on the basis of their chronological position within the spiral, providing a new tool for estimating age and growth rates in fossil rodents using isolated incisors. Furthermore, the models serve to help facilitate our understanding of dental form, function, and scaling in rodents.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

PALEONTOLOGY IN THE "REAL WORLD": USING THE RECENT PALEONTOLOGICAL LITERATURE TO ENGAGE HIGH SCHOOL STUDENTS AND ENCOURAGE STEM-BASED LEARNING.

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A lesson titled,"Fossil Teeth: A Record of Climate and Evolutionary Change in the Fossil Record" is presented as a model to illustrate how secondary education lesson plans can be developed from primarysource data. The project was funded through a partnership with the Geologic Society of America GeoCorps Program and National Park Service at Hagerman Fossil Beds National Monument.

Data was derived from the literature and modified to match high school student learning levels. Readings and data are derived directly from the primary source paper. In the lesson, students examine changes in tooth morphology in the fossil record of herbivorous mammals in North America. Through graphical analysis and critical reading, students infer factors that caused the observed evolutionary adaptations and link biological adaptation to global climate change and localized habitat change. The lesson includes a pre-lesson to provide background about tooth morphology as well as extended resources for teachers (including assessments, supporting documents, etc.).

This lesson was designed for the National Park Service to be digitally accessible and downloadable for teachers across the country. Standards align with the Disciplinary Core Ideas from the Next Generation Science Standards (NGSS) and guidelines for reading and writing from the Common Core State Standards (CCSS). It is intended for high school biology students (Introductory, Honors and/or Advanced Placement level) in grades 9–12.

Technical Session XVII (Saturday, October 29, 2016, 11:00 AM)

THE CRANIAL ANATOMY OF A NEW CRYPTOCLIDIDS PLESIOSAUR FROM THE JURASSIC–CRETACEOUS BOUNDARY OF CENTRAL SPITSBERGEN, SVALBARD, NORWAY

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Cryptoclidids are a major clade of plesiosauromorph plesiosaurians of the Middle and Late Jurassic and with only a single lineage that survived into the Early Cretaceous. Of the thirteen known taxa, only five have preserved cranial material and of these only *Cryptoclidus* has a complete but deformed skull. The poor understanding of cranial anatomy among cryptoclids hinders phylogenetic studies of the clade, most of which is based on postcranial data. Here we present new data on the cranial anatomy of a nearly complete adult cryptoclidid (PMO 224.248) from the Jurassic-Cretaceous boundary of Svalbard. PMO 224.248 was found in the Slottsmøya Member of the Agardhfjellet Formation and preserves a complete skull, partial mandible, and much of postcranium. PMO 224.248 is significant in being a new taxon and the first and only complete cryptoclidid skull with an articulated braincase and undistorted palate. The specimen was imaged using a high resolution micro-CT scanner in order to obtain internal morphology of the skull. Although overall body length is estimated at 5-5.5 m, the skull of PMO 224.248 is only 23 cm long. It possesses very large orbits, which are 34% of total skull length, remarkably small temporal fenestrae which are just less than half the orbital length, a tooth count of approximately 20 teeth, similar to known Middle Jurassic cryptoclidids, a mediolaterally narrow and anteroposteriorly very short sagittal crest (unlike *Kimmerosaurus*), an unusual cavity on the ventral surfaces of the frontals along the midline, and an anteroposteriorly short basisphenoid. Stratigraphically, PMO 224.248 is possibly the second known cryptoclidid to have survived the Jurassic-Cretaceous boundary and thus is key to understanding cryptoclidid diversity into the Early Cretaceous.

Grant Information

AJR is funded by NERC, GSNOCS and the University of Oslo. The fieldwork to collect the specimen was funded by Tullow Oil, OMV, Spitsbergen Travel and Bayern Gas.

Technical Session XVI (Saturday, October 29, 2016, 10:30 AM)

THINKING LOCALLY: SPATIAL AND TEMPORAL VARIATION IN LATE QUATERNARY PALEOENVIRONMENTS OF SUB-SAHARAN AFRICA INFERRED FROM UNGULATE ISOTOPIC ECOLOGY

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Stable carbon and oxygen isotope analyses of fossil ungulate tooth enamel from three contemporaneous late Pleistocene–early Holocene sites in eastern and southeastern Africa (Lukenya Hill, Kenya; Porc Epic, Ethiopia; Kalemba Rockshelter, Zambia) provide local paleoecological records. These records are used here to test whether the onset of the Last Glacial Maximum (LGM; ~27,000 years ago) had a uniform effect on sub-Saharan African climate and environments. Based on previous work on the fossil mammal communities, it was expected that the isotopic data would indicate a uniform shift to drier and more open environments at all three sites over time. The isotopic results, however, indicate a much more complex picture. For example, oxygen isotope data does suggest a shift towards increased aridity in Kenya and Zambia coincident with the beginning of the LGM but not on the margin of the East African Rift in Ethiopia. In Zambia, the increasingly cool and arid conditions evinced by the oxygen isotope data resulted in the appearance of cooler growing C_3 grasses, as interpreted from the carbon isotope data. In contrast, no discernible changes in phytogeography are identified in the isotopic data from Kenya or Ethiopia. These results reveal spatial and temporal variation in aridity and phytogeography in sub-Saharan Africa during the late Pleistocene and early Holocene independent of changes in faunal community structure. The combined isotopic results suggests that it is likely that forested and wooded environments in Kenya and Zambia retreated at the onset of the LGM leaving more open habitats and revealing migratory corridors for ungulates that were not present during earlier, more humid, periods.

Grant Information

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Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

NEW SPECIES OF *HYAENICTITHERIUM* RECOVERED FROM THE LATE MIOCENE OF KYRGYZSTAN

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Hyenas originated in the early Miocene and were distributed throughout the Old World and the Holarctic by the Pliocene, with multiple species in Africa and Eurasia and one species in North America. A new assemblage from the Kyrgyz late Miocene offers an opportunity to add to the diversity of hyaenids in the tectonically active central Asian region. We report the first described hyena material from Kyrgyzstan, a specimen found in the Kochkor Basin, which contains some of the best-preserved mammal assemblages in the country. This hyena currently represents the only large carnivore out of over 500 collected specimens; the fauna is dominated by large ungulates such as *Chilotherium, Hipparion,* and *Paleotragus*. The hyena specimen is a left mandible with p3 to m2. This nearly complete mandible allows a species-level diagnosis and preserves the ecomorphology of the taxon. The fossil was recovered from the middle Chu Formation, which spans the latest Miocene and early Pliocene; we estimate the age of the horizon from which the hyena was obtained at around 7 Ma. Through comparison of the specimen to published species, we have determined that the Kyrgyz hyena represents a new species of *Hyaenictitherium.* The characteristics permitting assignment to the genus include: premolars with straight anterior margins and robust accessory cuspids, a trigonid with a distinct metaconid and a paraconid that is longer than the protoconid, and retention of m2. The new species differs from current species in that it has a reduced number of cusps on m2, a longer and narrower talonid, and relatively robust premolar cuspids. The reduction of the talonid basin and m2 and the increase in premolar robustness suggests a transition to a more bone-crushing diet relative to many other species in the genus, with the possible exception of the African species *H. namaquensis*. *Hyaenictitherium* is generally considered to have the most derived bone-craking morphology among members of the 'thalassictine' group. Hence, this new species of *Hyaenictitherium* offers evidence of increasing adaptation to bone-cracking hypercarnivory in the late Miocene of Kyrgyzstan.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

INSIGHTS ON THE NEUROANATOMY OF THE PTEROSAUR *PTERODACTYLUS* (PTERODACTYLOIDEA)

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Despite the broad use of non-invasive computed tomography (CT) techniques with fossil reptiles in recent years, studies on pterosaur brain morphology remain rare. So far, analyses on their neuroanatomy using CT scans have focused on only three genera: the basal, long-tailed Jurassic *Rhamphorhynchus*, and the highly-specialized Cretaceous *Anhanguera* and *Dsungaripterus*.

In order to understand the evolution of the pterosaur brain, we CT scanned two specimens of a phylogenetically intermediate genus, the Jurassic pterodactyloid *Pterodactylus*: the holotype of *P. kochi* (SNSB/BSPG AS XIX 3) and the holotype of *P. antiquus* (SNSB/BSPG AS I 739). As both specimens are flattened and broken in several points, both were used to reconstruct a single, unified view of the brain of *Pterodactylus*. The brain presents two flexure points, one dorsally and another ventrally. The latter is more accentuated, thus resulting in a slight sigmoidal shape. This morphology is intermediate between the non-pterodactyloid *Rhamphorhynchus*, with a more horizontal brain, and the derived *Anhanguera*, which showed a strongly flexed brain. Considering the horizontal brain morphology of basal coelurosaurs and recent crocodilians, the brain of *Rhamphorhynchus* is considered close to the plesiomorphic condition of the group. *Anhanguera* has a much modified brain that is more similar to that of modern birds such as the ostrich. In this matter, the intermediate brain morphology of *Pterodactylus* resembles some derived non-avian theropods and basal birds, such as *Archaeopteryx*. The olfactory bulbs are not preserved, but an enlarged portion of the frontals anteriorly to the endocast indicates their position. They are little expanded and reduced when in comparison to the rest of the brain. The cerebrum is anteroposteriorly elongate, but thinner anteriorly. The cerebelum occupies the posteriormost region of the brain and has no significant dorsal expansion. The shape of the anterior semicircular canal and its relation to the posterior semicircular canal and to the *crus communis* is more similar to *Anhanguera* than to *Rhamphorhynchus*.

For the first time, these preliminary results indicate the intermediate steps in the evolution of the brain in pterosaurs, from the more plesiomorphic condition seen in the long-tailed *Rhamphorhynchus* to the complex brain of the derived dsungaripteroid *Anhanguera*. Results also suggest a strong convergence between the morphology of the brain in pterosaurs and birds, the only other clade of flying archosaurs.

Grant Information

This project was funded by Fundação de Amparo à Pesquisa e Inovação do Espírito Santo (FAPES #54695899/2011).

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

EVOLUTION OF LONG BONES IN CASEID SYNAPSIDS: A COMBINED CLADISTIC AND MORPHOMETRIC APPROACH

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Since its emergence from the uniseriate monobasic fin of coanate fishes, the limb has played a pivotal role in the evolution of tetrapods, allowing an incredible radiation and differential success, conquering the land, sea and air. In the present study we analyzed the long bone evolution in an important group of basal synapsids, the Caseidae. Caseids, together with Varanopidae, represent one of two clades that co-existed with the more derived therapsid synapsids and one of the first Palaeozoic groups to explore the niche of obligate herbivores. In their evolution, caseids passed from small faunivorous forms like *Eocasea martini* to gigantic herbivores such as *Cotylorhynchus hancocki*, which could reach a colossal body size of seven meters in length. In the analysis presented here, phylogenetic methods and classic morphometric techniques (i.e., PCA, RMA slopes) were applied to investigate major changes in the appendicular skeleton during the radiation of caseids, and to identify in which nodes and terminal branches a higher repatterning of structures is concentrated. This revealed a decoupling of the long bones of the hind and fore limbs. In particular, the forelimbs (especially the ulna and radius) show a greater restructuring in the course of evolution, with an allometric strengthening not only in species of larger size. In contrast, the hind limb is rather conservative and quite stable. A stout and robust appendicular skeleton was already detected in small to medium sized taxa, indicating that the bone strengthening is not simply related to a structural response to gigantic body size. However, this overbuilt structure may have been a prerequisite for reaching the gigantic body size of more derived caseids.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

FIRST REPORT OF A LARGE TETRAPOD TRACKWAY IN THE LOWER PERMIAN (WOLFCAMPIAN) QUEANTOWEAP SANDSTONE OF SOUTHERN NEVADA

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We report the discovery of a plantigrade tetrapod trackway in the Lower Permian (Wolfcampian) Queantoweap Sandstone in the Gold Butte area of Clark County, Nevada. The Queantoweap Sandstone is correlative with the Esplanade Sandstone (uppermost formation of the Supai Group) of Grand Canyon. The preserved trackway consists of six strides, with an average stride length of about 15 cm and a trackway width that varies from 17 to 18 cm. Pes lengths are about 9.5 cm, and the pace angulation is 80°. Three distinct, forward-directed digits are present in the pes prints, which overprint and obscure the details of the manus tracks. Pes sole impressions are round. We tentatively refer this trackway to *Chelichnus gigas*.

Chelichnus trackways are very common in the Coconino Sandstone (Leonardian) of the Grand Canyon region, but they have not previously been reported from the older Esplanade Sandstone or the correlative Queantoweap Sandstone. Also, most *Chelichnus* tracks in the Coconino are much smaller than the tracks reported here. The occurrence of this trackway, if confirmed to be *C. gigas*, extends the range of *Chelichnus* downward into the Wolfcampian. The Queantoweap trackway is similar in size and morphology to a trackway reported in the 1980s in the Wescogame Formation of Grand Canyon, which suggests that the range may extend into the uppermost Carboniferous (Virgilian).

Chelichnus is commonly interpreted to occur in eolian deposits. However, the Queantoweap Sandstone section examined in this study consists of tidally-dominated and storm-dominated facies. The fossil trackway occurs near the top of the formation within a ripple-marked bed that we interpret to represent a ripple-marked tidal flat. We therefore conclude that the trackmaker lived at least part of the time in a shallow marine environment.

Technical Session VI (Thursday, October 27, 2016, 11:30 AM)

BACTERIA OR MELANOSOMES?

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While the vertebrate color gamut is achieved using various pigments, melanin (housed in melanosomes) is the most common. Current research suggest a correlation between the color and the shape of melanosomes. Rod-shaped eumelanosomes contain eumelanin and impart black to dark brown color. Likewise, red to buff coloration is imparted by sphere shaped pheomelanin containing pheomelanosomes. These microstructures have also been documented in exceptionally preserved fossils allowing us to reconstruct ancient color patterns.

However, the use of melanosomes in reconstructing the colors of fossil taxa hasn't been universally accepted and the view that these microstructures are 'misidentified fossil bacteria' still persists. But this hypothesis does not explain why rod and sphere shaped microstructures are the most prevalent morphologies in the fossil record, when the present bacterial morphology is so diverse. Also, arguments have been put forward to explain the fact that since these microstructures are only found in melanized regions, bacteria exclusively colonize such areas using melanin as a nutrition source.

We set up bacterial decay studies on chicken (*Gallus gallus*) feathers lasting for up to one month. The feathers, both melanized and non-melanized, were subjected to stagnating conditions in jars with mud (containing bacterial inoculum from intertidal mudflats). Similar feathers were also placed at the bottom of an artificial saline water tank with varied microflora and fauna. These treatments were poised to simulate the taphonomic conditions in Konservat-Lagerstätten settings. At defined time points, the decayed feathers were imaged using a scanning electron microscope, to study the bacterial morphology.

Our results demonstrate that the bacilliform and coccoid bacteria showed no preference as to the colonization of either melanized or non-melanized feathers. The bacterial growth in the tank occurred preferentially along the rachis (which infrequently preserve in fossils) rather than the barbs or barbules where melanosomes are normally found, contradicting the interpretation of these microstructures as bacteria. The morphological diversity of bacteria was recorded in terms of length, width and the aspect ratio and then statistically compared to the morphology of melanosomes from various fossil avian taxa using Welch's one way-MANOVA. The statistical analyses indicated significant differences in length, width and aspect ratio between bacteria and melanosomes.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

SYSTEMATICS OF A NEW SAUROPOD FROM THE BASAL YELLOW CAT MEMBER (EARLY CRETACEOUS) FROM DOELLING'S BOWL (EASTERN, UTAH, USA)

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A new sauropod species (DBS) has been identified in the Doelling's Bowl bonebed within the lower Yellow Cat Member (YC) of the Cedar Mountain Formation of east-central Utah (United States). A massive complex calcrete separates two distinct dinosaur faunas in the YC of the Cedar Mountain Formation. Dinosaurs at this lower YC site include an iguanodont close to *Iguanocolossus*, a new species of polacanthid ankylosaur intermediate between those from the Upper Jurassic and *Gastonia* from upper YC, and the dromeosaurid *Yurgovuchia doellingi*.

The 2010 discovery of a sub-adult, mired sauropod was associated with parts of two others. Much of the skeleton is preserved, including skull material with teeth, axial skeleton including atlas, cervical, dorsal and caudal vertebrae with 10 semi-articulated distal procoelous vertebrae of the tail, scapular and pelvic elements, and limb bones with an articulated manus and pes. The DBS differs from a similar sauropod from the upper YC in lacking bifid cervical ribs. The DBS sauropod has a braincase that resembles those of non-titanosauriform and non-diplodocoid eusauropods. All of its spatulate teeth are distinct from those of *Camarasaurus* and its posterior teeth possess the heart-shape of Iberian turiasaurs. The cervical spines are simple or with a very shallow bifurcation and the centra have lateral pneumatic openings that are sometimes divided by a septum. Caudal vertebrae are procoelous and lack a ventral fossa and lateral pneumatic openings. The anterior chevrons are opened proximally. Phylogenetic analysis places the DBS sauropod outside of Titanosauriformes, supported by characters including the lack of a lateral femoral shoulder and complex 'pleurocoels'. It is recovered outside of Macronaria because of a lack of opisthocoelous posterior dorsal centra. The procoelous caudals are different from *Haplocanthosaurus* and more similar to those of the basal eusauropods *Mamenchisaurus* and *Losillasaurus*. Other characters include a subtriangular outline of the preacetabular process of the ilium that projects anterolaterally, a cnemial crest of the tibia that projects anterolaterally, and a posterior rim of the ascending process of the astragalus that terminates just anterior to its posterior margin. The long ungual claw is 50% the length of metacarpal I.

These and other characters in the phylogenetic analysis position the DBS sauropod as a new taxon of basal eusauropod outside of Neosauropoda and indicates that it may represent the most primitive sauropod from North America.

Grant Information
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Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

FEEDING BIOMECHANICS IN GALLIFORM BIRDS AND ITS SIGNIFICANCE FOR AVIAN CRANIAL EVOLUTION

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A critical component of the avian feeding apparatus is cranial kinesis: the mobility of bones within the skull about several key intracranial joints. The underlying patterns of avian skull function and joint shape, as well as their significance for ecology and evolution remain largely unknown. Although the cranial musculoskeletal system is modestly understood, ecomorphological patterns of avian cranial joints have yet to be explored. Galliform birds, including chickens, grouse, quail, and turkeys vary widely in size, have diverse diets, but feed similarly via pecking and have superficially similar skull morphologies. Therefore, we expect their cranial joints will only differ relative to size and the forces loading them as opposed to phylogenetic effects. To explore this relationship we developed 3D models of over ten species of galliform and related outgroup taxa and quantified joint size and shape using 3D measurement tools to determine relationships between joint form and function in the complex 3D biomechanical environment of the bird skull. We found that joint surface area expectedly increased with overall increase in skull size. The jaw joint, otic joint, and pterygoquadrate joint all scale isometrically, suggesting that they are under similar biomechanical regimens. However, the palatobasal joint scaled with positive allometry, suggesting that the relationship between the palate and the braincase may differ across taxa and may be important for insulating the braincase from cranial loading. This is the first quantitative, comparative analysis of cranial joint function in birds. In the future, these findings will be complemented with 3D muscle force data to better understand the loading environment of the joints. Data gathered from this study will provide valuable groundwork for further studies in the biomechanics and evolution of cranial kinesis in other bird clades as well as in their extinct dinosaur ancestors.

Grant Information
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Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

DIETARY ECOLOGY OF DIPROTODONTIDS FROM SAHUL

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The dietary ecology of diprotodontids is largely based on the morphology of cranial dental features. Some diprotodontids such as *Kolopsoides*, an extinct Zygomaturinae marsupial from Papua New Guinea, are not well understood. Dental microwear texture analysis offers a non-destructive method to infer the dietary ecology of animals and can reveal the textural properties of food consumed by analyzing surfaces in three-dimensions. Here, we examined a diversity of diprotodontids through time to assess their dietary ecology. Consistent with morphological interpretations, both *Diprotodon* and *Zygomaturus* have dental microwear textures indicative of woody browsing, as compared to both tapirs (which share similar bilophodont teeth) and extant macropodids. In contrast, *Kolopsoides* from Papua New Guinea was likely more folivorous based on dental microwear textures. It has lower complexity and higher anisotropy than the more frugivorous and hard object consuming Baird's tapir, *Tapirus bairdii* (which is also known to eat hard palm seeds and exhibits high complexity), and statistically indistinguishable from the more folivorous lowland tapir, *Tapirus terrestris*. When compared to extant macropods, its dietary ecology is more challenging to assess and may indicate a more mixed diet consisting of softer foods. In contrast to other diprotodontids, such as *Diprotodon* and *Zygomaturus*, *Kolopsoides* ate softer food (lower complexity) than *Diprotodon* and *Zygomaturus* and tougher foods (higher anisotropy) than *Zygomaturus*. *Neohelos stirtoni* from Bullock Creek has dental microwear consisting of a diet of woody browse and is significantly different from the grazing kangaroos in complexity and anisotropy and indistinguishable from browsing macropods in dental microwear features. Further, *Neohelos stirtoni* is indistinguishable from both extant tapirs here examined, indicating a diet largely dominated by woody browse—and not specializing on either tougher or harder food objects. Collectively, these data confirm the browsing diet of the majority of diprotodontids with some more nuanced differences in *Kolopsoides*.

Grant Information
NSF 1053839 and 1455198

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

PALAEOECOLOGICAL INFERENCES FROM FOSSIL FISH AT THE KANAPOI SITE, KENYA

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In 2014, an expedition headed by Ward, Manthi, and Plavcan was made to the Pliocene-aged Kanapoi site, northwestern Kenya, which has yielded remains of the early hominin *Australopithecus anamensis*. Part of the expedition involved gathering data on the palaeoecology and palaeoenvironment of the freshwater deposits at the site. Fish fossils were collected specifically to garner this information, and were collected from transects located in lacustrine, fluvial, or deltaic depositional contexts. Analysis is in progress so these statements are preliminary, but to date, a total of 404 fish specimens were recovered, representing nine genera. Our early findings indicate that each depositional context has a unique taxonomic signature, therefore implying that each of the ecological contexts is also unique. While researchers in the past inferred depositional contexts and palaeoecology based on the fish taxa recovered, these have rarely been verified by studies such as this one. This study first describes the past depositional context, and then identifies and quantifies the fossil fish taxa associated with that context. The findings from this study have the potential to contribute more accurate and more detailed palaeoecological and palaeoenvironmental information on freshwater environments associated with early hominins, and may be a model for future studies.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

EVOLUTION OF PACHYROSTRAN CENTROSAURINES IN THE LATE CRETACEOUS OF NORTHERN LARAMIDIA

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Pachyrostran centrosaurines (*Achelousaurus*, RTMP 2001.76.1, and *Pachyrhinosaurus*) are characterized by nasal and supraorbital bosses in adults, and have been recovered from localities in Alaska, Alberta, and Montana. They are the last clade of centrosaurines to evolve, first appearing in the fossil record (*Achelousaurus*, RTMP 2001.76.1) as the Bearpaw Sea inundated northern Laramidia, and being the only group present (*Pachyrhinosaurus*) after its regression. Based on palynological and sedimentological evidence, RTMP 2001.76.1 is the oldest pachyrostran, with *Achelousaurus horneri*, *Pachyrhinosaurus lakustai*, *P. canadensis* (all Campanian), and *P. perotorum* (early Maastrichtian) being successively younger. A new parsimony-based phylogenetic analysis of Centrosaurinae was conducted to clarify the ingroup relationships of Pachyrostra. Three new characters pertaining to the nasal boss (anterior pommel and posterior saddle shape, and sulcus development between nasal and postorbital bosses) were added, as the current number of nasal boss characters (1 vs. 8 for supraorbital horncores) is insufficient to capture the variation within this phylogenetically important character. Additionally, the recognition of new characters (e.g., accessory nasal bosses on *P. canadensis*), and the presence of the formerly apomorphic (*P. lakustai*) midline parietal horn in at least one Alaskan *Pachyrhinosaurus* specimen, assists in the clarification of the relationships of *Pachyrhinosaurus* species [*P. lakustai*+[*P. canadensis*+*P. perotorum*]] that have been previously been recovered as a trichotomy. RTMP 2001.76.1 is an almost complete skeleton missing most of the parietal; however, the lack of this taxonomically important element prevented it from being unequivocally assigned to a previously recognized pachyrostran taxon. Our analysis recovers it as the sister taxon to the slightly younger *Achelousaurus horneri*. It is potentially recognizable as a distinct species based on the presence of large, open accessory antorbital fenestrae and having postorbital ornamentation that is less deeply ridged, with a dorsolaterally oriented base. The appearance of the apomorphic pachyrostran cranial bosses appears to correlate with the transgressing Western Interior Seaway, but they are foreshadowed in the fossil record by the boss-like shape of resorbed postorbital horncores in centrosaurine taxa such as *Coronosaurus*.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

ENIGMATIC CROCODYLIFORM REMAINS FROM THE UPPER CRETACEOUS QUSEIR FORMATION OF DAKHLA OASIS, WESTERN DESERT, EGYPT

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Non-marine vertebrate fossils, including many crocodyliform clades, remain poorly documented from the uppermost Cretaceous deposits of Afro-Arabia. Recent exploratory fieldwork in the Upper Cretaceous (middle Campanian) Qusier Formation of the Dakhla and Kharga Oases in the Western Desert of Egypt has revealed tantalizing new fossils from continental and marginal marine settings that include titanosaurian sauropods, abelisauriod theropods, pleurodire turtles, and abundant crocodyliform remains. In particular, new materials of an enigmatic crocodyliform from a marginal marine setting, represented by both cranial and postcranial remains, suggest the presence of a unique fauna from northern Afro-Arabia during the Late Cretaceous. Materials recovered of this taxon thus far include fragmentary portions of the skull and mandible, amphicoelous dorsal vertebrae, and appendicular remains. This form is distinguished by a number of unique features including a generally platyrostral skull, four premaxillary alveoli with the second alveolus being the largest, a maxilla divided into two laterally convex portions separated by a deep occlusal notch, an enlarged third maxillary alveolus, a distinctly broad anterior process of the jugal relative to the posterior process, a low straight dentary with short symphysis, contribution of the splenials to the mandibular symphysis, and close coupling of the fourth and fifth dentary alveoli. The new crocodyliform suggests a potentially unique Late Cretaceous assemblage from northern Afro-Arabia, markedly different from the better-known Late Cretaceous crocodile assemblages of South America and Madagascar, or from earlier (pre-Turonian) deposits in Afro-Arabia. This pattern may reveal a distinct regional fauna along the southern Tethys, or potential Cretaceous relationships with European assemblages.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

SOME PECULIAR FEATURES OF *TAMBATITANIS AMICITIAE* (SAUROPODA, TITANOSAURIFORMS) REVEALED BY VIRTUAL SKELETAL RECONSTRUCTION.

SAEGUSA, Haruo, Museum of Nature & Human Activities, Sanda Hyogo, Japan; IKEDA, Tadahiro, Museum of Nature & Human Activities, Sanda Hyogo, Japan

Tambatitanis amicitiae is a titanosauriform sauropod known only from the holotype partial skeleton excavated from the Lower Cretaceous Sasayama Group of Tamba city, Hyogo Prefecture, SW Japan. Generally speaking, partial skeletal remains are not suitable for the reconstruction of whole skeleton. However, receiving the strong requests from the general public of the city, an attempt was made to construct a virtual skeleton of *Tambatitanis* by combining the virtual bones of *Tambatitanis* with those of other titanosauriforms. Using several 3D modeling softwares, the virtual bones of other titanosauriforms were modified so as to fit them to the known elements of *Tambatitanis*. Several peculiar features of *Tambatitanis* were illuminated by the virtual skeleton, which was originally made for exhibition and outreach. A slender fragmentary dentary, pointed squamosal articulation surface of the postorbital, slender teeth, anteroposteriorly compressed braincase and strong ventral flection of the occipital condyle suggest the skull of *Tambatitanis* may have been similar to those of early titanosaurs, such as *Tapuiasaurus*. The cervical condyle projects far anteriorly beyond the caput of cervical ribs, like those of *Sauroposeidon* and several other brachiosaurids. Unlike other Euhelopodidae, cervical parapophyis is not pendant. The ilium is strongly flared anteriorly and pneumatic foramina are located on the anteromedial surface of the bone. The pubis is very long dorsoventrally. Though only the centra of two dorsals are preserved, rib bones can be arranged in appropriate anatomical positions based on the direction of the head and tubercle of well preserved rib bones. Reconstructed ribcage is strongly expanded laterally, and can surround the balloon shaped large abdominal cavity. The large size of the abdominal cavity is also suggested by the anteriorly flaring ilium and large pubis mentioned above. However, it is not clear whether the peculiar shape of the rib cage of *Tambatitanis* is an autapomorphy of the taxon or a feature also shared by other titanosauriforms, because their ribs have been rarely described and thus their rib cage morphology is barely known.

Technical Session VI (Thursday, October 27, 2016, 11:15 AM)

THE TAPHONOMY OF KERATIN IN ARCHOSAURS

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Feather evolution in archosaurs and the preservation potential of proteins in fossils has received much scientific and popular attention in recent years, yet requires further investigation into the taphonomy of keratin, a diverse and common protein. Claims of original keratin proteins in fossils likely used inconclusive methods. This project aims to examine two major questions: (1) Do different keratin types and integumentary structures have different taphonomic patterns which might provide novel information in regards to the evolution of archosaur integument? (2) Does keratin leave any sort of signature in the fossil record? Here, decay and maturation experiments on a variety of keratin types and integumentary structures were carried out to characterize taphonomic changes in archosaur keratin. Morphological, ultrastructural, and chemical changes were observed using scanning electron microscopy and pyrolysis gas chromatography mass spectrometry. Experiments revealed, in contradiction to previous studies, that the rate of bacterial decay in feathers is likely more dependent on the structure of the feather rather than the degree of melanization. Additionally, compression experiments demonstrate that the interpretation of proto-feather morphology in dinosaurs is likely accurate despite criticism. Some variation in taphonomic patterns was observed between different types of keratin resulting in different textures. However, none of these textures have been confidently described in fossils. Feathers matured at 200°C/250 bars and 250°C/250 bars for 24 hours become a viscous, foul-smelling fluid suggesting that over time, proteins fragment and become volatile, meaning that keratins likely do not fossilize. Researchers wishing to study archosaur integument evolution must take into consideration the loss of keratin through taphonomic processes.

Grant Information
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Romer Prize Session (Thursday, October 27, 2016, 9:15 AM)

THE EVOLUTION OF ORBITAL SHAPE IN GAVIALOID CROCODYLIANS IS ASSOCIATED WITH HABITATS AND VISUAL-FORAGING STRATEGIES

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Vision is an acute perception system in crocodylians but little is known about the role of this sense in the evolution of foraging strategies across living and extinct forms. Through the integration of phylogenetics, morphometrics, and exceptional fossils from proto-Amazonian deposits, I examined ecological associations of the orbital region throughout crocodylian history. In contrast to the conservative morphology of taxa with moderate snout length, these analyses reveal high orbital shape plasticity in longirostrine (elongate- and slender-snouted) crocodylians, probably in relation to visually enhanced feeding strategies. Previous studies showed that the archetypal longirostrine crocodylian, *Gavialis gangeticus*, uses sight for underwater fishing in riverine environments. This Indian species, the only extant gavialoid crocodylian, possesses a distinctive orbital region with widely separated and protruding eyes or "telescoped" orbits (TO). Relative to Brevirostres, the TO of *Gavialis* resulted from conspicuous rearrangements of the circumorbital bones. The degree of development of the TO condition varies significantly among Cenozoic gavialoids.

My quantitative analyses of circumorbital shapes yield divergent gavialoid morphospaces occupied by coastal marine and riverine specialists, with South American forms covering the entire gavialoid range. The morphospace of forms with fully developed TO, such as the extant and extinct Asian *Gavialis* and extinct South American *Gryposuchus colombianus* and *Gr. croizati*, typically correlates with taxa from riverine ecosystems. The orbital region of taxa from coastal marine deposits (e.g., *Piscogavialis*, *Argochampsa*) is closer in shape to that of Brevirostres and might represent the ancestral gavialoid morphotype. The lacustrine proto-Amazonian *Gr. pachakamue* and African *Eogavialis* exemplify an intermediate morphospace. These results suggest that, in association with longirostry, orbital features can evolve rapidly for shifting to more visual foraging strategies and new habitats. My phylogenetic analysis confirms that TO bone-associated features are highly homoplasic and reveals that acquisition of fully TO morphologies and riverine ecologies within South American and Indian gavialoids are the result of parallel evolution. In South America, TO forms in a fluvial habitat are derived from ancestral lacustrine proto-Amazonian taxa with incipient protruding eyes. This novel anatomical-ecological association should be tested in other longirostrine archosaurs.

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Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

A NEW LONG-SNOUTED DYROSAURID (MESOEUCROCODYLIA) FROM THE LATE CRETACEOUS OF NORTH CENTRAL SUDAN

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The Late Cretaceous Campanian–Maastrichtian Kababish Formation of north central Sudan has previously been unknown to yield macrovertebrate assemblage and has remained largely unstudied. Here we report on a new taxon of dyrosaurid crocodyliform, which represents the first articulated vertebrate remains from this formation, as well as from Sudan. The material, which was recovered in situ at a previously unexplored locality near Jebel Abyad west of Dongola, is almost 7 m in length and preserves an almost complete skull and postcranium. The material can be assigned to Dyrosauridae on the basis of elongate supratemporal fenestrae, the presence of the occipital tuberosities and a reduced seventh alveolus on the mandible. Morphological features of the skull and mandible differ from other members of this family and suggest that this taxon is not referable to any known species of dyrosaurids and thus represents a new taxon. It is characterized by an elongate snout, representing about 67% of total skull length. The nasal is fused and does not penetrate between the posterodorsal premaxillary processes. The posterior margin of the skull roof tapers posteromedially and the occipital tuberosities are small and dorsoventrally flattened. The mandibular symphysis is relatively long, wider than high, and ending posteriorly at the level of the thirteenth tooth, where the splenials end dorsally at the level of the eighth tooth. Associated postcranial material of this individual includes several vertebrae, ribs, fore- and hindlimbs, and pelvic bones. It is notable that the forelimbs are overall longer than the hindlimbs, suggesting specialized aquatic locomotion. A phylogenetic analysis using parsimony places the new taxon as a sister taxon to a clade including *Arambourgisuchus, Dyrosaurus, Acherontisuchus, Hyposaurus, Congosaurus, Rhabdognathus, Atlantosuchus,* and *Guarinisuchus*. The African *Chenanisuchus*, *Sokotosuchus*, *Phosphatosaurus,* and the South American short-snouted dyrosaurids *Anthracosuchus* and *Cerrejonisuchus* are more basally positioned within Dyrosauridae. The occurrence of this new dyrosaurid within the Late Cretaceous Kababish Formation of Sudan potentially extends the temporal range of the Dyrosauridae to the Campanian and supports previous hypotheses of an African origin for this family.

Grant Information
JSQ Student Travel Award

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

NEW MATERIAL OF A NEW METRIACANTHOSAURID (DINOSAURIA, THEROPODA) FROM THE PHU NOI LOCALITY (LATE JURASSIC–EARLY CRETACEOUS) OF THAILAND

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Metriacanthosauridae (= Sinraptoridae) are large-bodied, basal allosauroid theropods from the Middle to Late Jurassic and possibly the Early Cretaceous. Metriacanthosaurids were previously thought to be endemic to China but were later found in Europe and Thailand. Metriacanthosauridae consists of the subclade Metriacanthosaurinae (*Metriacanthosaurus* and *Sinraptor*), the '*Yangchuanosaurus*' group, and possibly the basal forms *Xuanhanosaurus* and *Shidaisaurus* as well as some problematic taxa (*Lourinhanosaurus*, *Poekilopleuron*, and *Siamotyrannus*).

In Thailand, two metriacanthosaurids (the Kham Phok and Phu Noi specimens) have been reported from the Late Jurassic to Early Cretaceous Phu Kradung Formation, in addition to the possible metriacanthosaurid *Siamotyrannus* from the Early Cretaceous Sao Khua Formation. The Kham Phok specimen can be referred to the Metriacanthosaurinae based on the bulbous fibular crest on the tibia.

The Phu Noi specimen from the Phu Noi locality, Kalasin Province, was first reported in 2013 and referred to Metriacanthosauridae based on maxillary pneumaticity. In 2015, new information suggested the Phu Noi fossil is closer to *Sinraptor* (i.e., Metriacanthosaurinae) from the Late Jurassic of China than to *Yangchuanosaurus* from the Middle Jurassic of China. In addition to isolated large theropod remains, the Phu Noi locality also yielded partially articulated sauropod and ornithopod bones, and remains of small theropods.

Here we report new material (skull elements, an ulna, and metatarsals) discovered from Phu Noi locality and refer it to the Phu Noi metriacanthosaurid based on size and apomorphies. We found that there are at least two individuals of a metriacanthosaurid at Phu Noi based on the morphology of the left and right maxillae as well as the metatarsals. The Phu Noi metriacanthosaurid appears to have a robust and a gracile morph, possibly due to sexual dimorphism. Preliminary phylogenetic analysis (40 most parsimonious trees, 1054 steps, consistency index = 0.412) found the Phu Noi specimen to represent a new taxon nested within Metriacanthosauridae. The Phu Noi metriacanthosaurid may not be a metriacanthosaurine since the anteroventral border of the maxillary antorbital fossa is not demarcated by a raised ridge, the synapomorphy of this subclade.

Metriacanthosaurids probably originated in China before the Middle Jurassic and later spread to Europe and Southeast Asia. Depending on the age of the Phu Noi locality and the affinities of *Siamotyrannus*, they might have survived into the Early Cretaceous.

Grant Information
Department of Mineral Resources, Ministry of Natural Resources and Environment and Ministry of Science and Technology, Bangkok, Thailand

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

LATE MIOCENE CETACEAN FROM NORTHWESTERN MADAGASCAR

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Fossil cetaceans are rarely reported from around the margins of the Indian Ocean. Here, a single lumbar vertebra from the island of Nosy Makamby represents a small as-yet undetermined species of dolphin (Cetacea: Odontoceti) and is the first fossil cetacean reported from Madagascar. The matrix surrounding the fossil is bioclastic limestone with benthic foraminifera that suggests a late Miocene age and warm shallow water setting. Previous work at this site has yielded sharks, rays, bony fishes, turtles, crocodyliforms, and sirenian mammals and is providing our first glimpse into Madagascar's fossil record during this time.

The vertebral body is subrhomboidal in anterior (broken) section and elongate with a length of 53+ mm and a posterior epiphysis that is 35–36 mm in diameter. Transverse processes descend obliquely. Ventrally, paired vascular sulci converge anteriorly on either side of the ventral crest. There are no articulations for chevrons. The neural canal has a deep narrow elliptical outline. Elongate neural pedicles pass into a narrow, tall, anteroposteriorly elongate neural spine with a notched posterior margin. Nodular remnants represent the postzygapophyses, with slightly more prominent bases for the prezygapophyses. The zygapophyses, and slightly curved dorsal margin on the epiphysis, suggest limited dorsoventral flexion.

Phylogenetic patterns of vertebral morphology are poorly understood for crown Cetacea, so that identification relies on comparison of form and elimination of distant matches. Amongst the extant family-level clades of Odontoceti, the Physeteridae, Kogiidae and Ziphiidae differ in overall larger size and orientation of the neural spine. The Platanistidae and the Inioidea differ in their more robust neural spines and/or metapophyses and/or wide-based alate transverse processes. Species of Delphinoidea generally have relatively short vertebral bodies and tall and anteroposteriorly narrow neural spines. Beyond those crown clades, few fossil odontocetes are known from reliably identified fossil postcrania; it is possible that the element represents a species of Eurhinodelphinidae, Kentriodontidae, or archaic Platanistoidea.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

THE FIRST LATE EOCENE AND EARLIEST OLIGOCENE FAUNAS FROM THE JOHN DAY BASIN OF OREGON: FILLING GAPS IN THE MOST COMPLETE RECORD OF MAMMAL EVOLUTION IN NORTH AMERICA

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The John Day Basin is well-known for having a detailed and dated sequence of rocks and fossils that span about 50 million years of time, documenting plant and animal evolution through most of the Cenozoic. One of the major gaps in that sequence is the late Eocene and earliest Oligocene. A number of diverse floras have been documented from that interval, but few animals described to date. Here we describe the first Duchesnean, Chadronian, and Orellan faunas from the Pacific Northwest.

From the western facies of the John Day Formation near Clarno is a small fauna recovered between tuffs dated 39.22 and 38.4 Ma. That Duchesnean age fauna has *Pseudotomus*, *Teletaceras*, an entelodont, and a merycoidodontid. Along the Crooked River in the southern facies there is a larger fauna collected above a tuff dated 36.21 Ma. That Chadronian age fauna includes a new genus of ischyromyid, an oromerycid, a leptochoerid, an entelodont?, a tapiroid, *Mesohippus*, *Megacerops*, an amynodontid, *Teletaceras*, and cf. *Daphoenus*. Four sites from Big Basin Member strata are known from the eastern facies, these sites are early Orellan in age, as evidenced by radiometric dates and magnetostratigraphy. Sites from the middle Big Basin Member have yielded *Novumbra oregonensis*, *Taricha lindoei*, cf. *Eopelobates*, a chiropteran, *Archaeotherium* cf. *crassum*, *Mesohippus*, and *Diceratherium*. The fauna from a site at the very top of the Big Basin member has yielded an amphisbaenian, cf. *Haplomys*, *Leptochoerus*, *Archaeotherium* cf. *crassum*, *Perchoerus*, *Eporeodon*, *Miohippus annectens*, *Diceratherium*, and *Phlaocyon latidens*.

Among these faunas are the earliest rodents and carnivorans documented from the Pacific Northwest. Late Eocene occurrences of entelodonts and oreodonts extend the ranges of these groups in the region by more than five million years. The Chadronian occurrence of *Megacerops* is the first record of the genus west of the Rocky Mountains. The pelobatid frog, cf. *Eopelobates*, represents the first frog described from the John Day Basin and the latest record of the family in North America. These faunas help improve understanding of biogeography in western North America and fill important gaps in the John Day Basin's detailed record of faunal evolution through the Cenozoic.

Symposium III (Saturday, October 29, 2016, 9:15 AM)

THE INDEPENDENT EVOLUTION OF ENDOTHERMY IN PLESIOSAURIA: EVIDENCE FROM THEIR UNIQUE LONG BONE HISTOLOGY

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Plesiosaurs are iconic Mesozoic marine reptiles documented from the latest Triassic to the end of the Cretaceous. Plesiosaurs used their four hydrofoil-like flippers in some kind of four-winged underwater flight unknown in extant taxa. While poorly quantified, plesiosaurian body mass was >100 kg to several tonnes. Here we describe plesiosaurian propodial histology from midshaft cross sections of seven small to medium-sized taxa representing much of their diversity and temporal range. Medullary resorption was suppressed, preserving nearly the entire cortical growth record. Primary cortical bone is a unique kind of radial fibrolamellar tissue (FLB) that later in ontogeny was replaced by dense Haversian tissue. Deposition of FLB started with static osteogenesis, producing a framework of woven bone with isometric osteocytes around radial, densely spaced vascular canals. Bone formation continued with dynamic osteogenesis producing primary osteons. Plesiosaurian FLB differs from therapsid and ornithodiran FLB in the predominantly radial arrangement of the vascular canals. Growth marks are distinctive, the first appearing at >70% final cortical thickness, and annual growth mark counts indicate that asymptotic size was reached within 4-6 years. Propodial bone histology thus suggests high growth rates that must have exceeded those of non-avian dinosaurs. Such rapid growth is only observed in endothermic amniotes today, i.e., mammals and birds. This applies to dense Haversian tissue in propodials as well, which in extant amniotes is restricted to endotherms and in extinct ones to non-mammalian therapsids and non-avian dinosaurs which either were endothermic or had an intermediate metabolic rate. Sampling of successive taxa on the Triassic plesiosaurian stem (pachypleurosaurs, *Nothosaurus*, *Cymatosaurus*, *Pistosaurus*) records a gradual increase in growth rate and FLB in *Pistosaurus*. However, the oldest plesiosaur, a newly discovered taxon from the Rhaetian of Germany, already sports the same unique and uniform histology as all later plesiosaurs examined. This suggests that plesiosaur endothermy evolved in concert with the changes in their axial skeleton and limbs linked to the evolution of underwater flight. Endothermy thus may have been an adaptation to cruising in the open marine habitat, as predicted by the aerobic scope hypothesis of endothermy origins. Attaining >70% of final size in the first year suggests energy transfer from parent to offspring, consistent with the parental care hypothesis of endothermy origins.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

DID THE GIANT, TUSK-TOOTHED SALMON (*ONCORHYNCHUS RASTROSUS*) MORPH BEFORE MIGRATION UPRIVER LIKE MODERN SALMON DO TODAY?

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A great deal is known about the giant, tusk-toothed salmon (*Oncorhynchus rastrosus*) from previous studies. They lived from the mid-Miocene to early Pliocene in the Pacific Northwest (California to Washington). They were large, approximately 1–3 meters long and 177 kg in weight. They had two, large (2–3 cm long), upper tusk (or saber) shaped teeth. These 'breeding' teeth were probably used for fighting and display. They migrated from the Pacific Ocean to inland rivers to spawn, as salmon do today. And they were planktivorous, based on numerous gill-rakers, and a few, small teeth. However, there are gaps in our knowledge about this fascinating giant salmon. For example, modern salmon developmentally change (especially in their skull) before they migrate upriver to spawn. Did this extinct giant salmon also morph before migration upriver? Our working hypothesis was that the breeding teeth from the freshwater specimens should be

larger, reflecting their function in display and fighting during the spawning period in inland rivers. To test this hypothesis, we compared the shapes and sizes of breeding teeth from freshwater and coastal marine deposits. Freshwater specimens are from the Mehrten Formation, Stanislaus County, California. Coastal marine specimens are from the following formations and counties: Pinole Tuff (Contra Costa), Drakes Bay (Marin), San Mateo (San Diego), Purisima (Santa Cruz), and Santa Margarita (Santa Cruz). We measured 51 specimens total. All specimens are from the Museum of Natural History of Los Angeles County and the University of California, Berkeley Museum of Paleontology. The results supported this hypothesis. Teeth from freshwater deposits are not only larger, but they are also more recurved, and the tooth tips more worn and blunt. In addition, their bony tooth bases are considerably larger. Teeth from coastal marine deposits are smaller, straighter, their tooth tips sharper, and their tooth bases smaller. This supports our hypothesis that *O. rastrosus* did developmentally change between the marine and freshwater stages of their lives, as modern salmon do today. They probably did this in preparation for the vigorous fighting and display that occurred during spawning in the inland rivers of California.

Preparator's Session (Thursday, October 27, 2016, 9:45 AM)

PHOTOGRAMMETRY OF MICROFOSSIL VERTEBRATE TEETH FROM THE LOWER JURASSIC KAYENTA FORMATION OF SOUTHWESTERN UTAH

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A macrophotography technique coupled with focus stacking was developed and successfully used to produce source images for subsequent photogrammetry of two isolated microvertebrate teeth from the Lower Jurassic Kayenta Formation of southwestern Utah. Macrophotography was conducted using a sensor format digital camera and a 65 mm macro lens. A focusing rail coupled to a rotation stage was used to manipulate specimens for photography. Focus stacking software was used to produce completely focused images for input into Agisoft® Photoscan photogrammetry software. The digital models created by the photogrammetry software were exported as both pdf-formatted files and stereo lithography files. These three-dimensional PDF files are then available for other purposes, such as examination, sharing, and storing information about specimens outside of the photogrammetry software. Photogrammetry of microvertebrate fossils, especially for type and figured specimens, would prove extremely important for research, collections management, and exhibition purposes. It would allow for the study of tiny, delicate, and unique specimens without actually having to risk handling and/or transporting fossils. The use of a stereo lithography files to produce a 3D-printed rapid prototype model of one tooth was also demonstrated.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

NEW RECORDS OF TERRESTRIAL AND MARINE MAMMALS FROM THE OSO SAND MEMBER, CAPISTRANO FORMATION, ORANGE COUNTY, CALIFORNIA

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The late Hemphillian Oso Sand Member of the Capistrano Formation is a highly fossiliferous unit of the Los Angeles Basin that has produced well-preserved specimens of both terrestrial and marine taxa. No formal descriptions of mammal specimens have been published, but a large number of specimens have been reported in paleontological mitigation reports. Despite the fact that there are many specimens from the Oso Sand Member in museum collections, reports of the mammal faunal assemblage has been limited to only two publications that merely mention the presence of a few taxa. In order to provide an overview of fauna, we examined every known collection of fossils from the Oso Sand Member. Identifications of terrestrial taxa indicate the presence of the equid *Dinohippus interpolatus*, antilocaprids, rhinocerotids, proboscideans, three genera of camelids (*Alforjas, Hemiauchenia,* and *Megatylopus*), leporids, suids, lutrines, and the borophagine *Borophagus*. The identified marine taxa include the sea cow *Hydrodamalis*, at least three species of odobenids (including *Gomphotaria pugnax*), otariids, and several taxa of cetaceans including balaenopterids (e.g., *Megaptera*), lipotids, and physeteroids. One of the more intriguing specimens is a partial tooth of a desmostylian. If this desmostylian specimen is not reworked from older strata, it is the latest record of the lineage. In addition to describing the Oso Sand Member mammal faunal assemblage, we provide comparisons with other late Miocene fossil assemblages (both terrestrial and marine) from the Eastern Pacific.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

PILING, SLOTTING, AND SURROUNDING: SHIPPING FOSSILS FROM CHINA TO ITALY

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Shipping fossils has always been a serious challenge since every fossil is one and only and it requires maximum safety while traveling. Especially in the case of overseas transportation, languages and customs could be a barrier for handling specimens. To avoid unnecessary damage and misunderstanding, the fossils should be packed in secure and straightforward methods. In the summer of 2015, the Land and Resources Bureau of Xingyi City shipped twenty-six specimens to the University of Milan with a help of Peking University. Xingyi, a city in Guizhou Province in China, had held paleontologists' attention over the last decade due to its rich and well-preserved Triassic marine fauna represented by numerous vertebrate and invertebrate fossils such as the sauropterygian *Keichousaurus*. The University of Milan had conducted fieldwork and research in Monte San Giorgio, a UNESCO World Heritage Site, where they also recorded Triassic marine fauna, and planned to hold a special exhibition indicating similarities between these two fossil faunas and connection between Italy and China during Triassic Period. In order to ship the fossils, we required packing methods specialized for limestone and mudstone slab specimens in different sizes.

Here we described three packing methods: "Piling", "Slotting", and "Surrounding". The slabs were securely placed in shipment boxes without any spaces that could potentially cause movement and friction during transportation. Since the fragility level of each specimen varied depending on the thickness of its slab, we categorized the specimens into three groups: thin-layer (less than 1 mm), medium-layer (1–10 mm) and thick-layer (more than 10 mm). "Piling" was a stack of 40 mm-thick polyethylene foam (Ethafoam) layers with cavity-mounted lightweight/thin-layered specimens. "Slotting" was to place the medium-thick slabs vertically, like vinyl records in a music store, into slots surrounded by the polyethylene foam. "Surrounding" was to enclose the thick-layered specimens by the walls of the polyethylene foam and fill gaps with the blocks and pieces of the foam. Even though pre-shipment conservation on the fossils was essential for safe transportation, these glue-free space-saving packing methods made it possible to give a very simple orientation for handling and take in and out individual specimens easily.

Preparator's Session (Thursday, October 27, 2016, 8:15 AM)

A COMPARISON OF FOUR DRYING TECHNIQUES FOR THE CONSERVATION OF WATER-SATURATED BONE REMAINS FROM COLD LAKE, ALBERTA, CANADA

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Over the past four years, the Quaternary Palaeontology program at the Royal Alberta Museum has been accessioning vertebrate remains collected from three underwater areas of Cold Lake, on the Alberta-Saskatchewan border. Initial remains from the lake were allowed to air dry at ambient temperature and humidity. Those specimens proved highly sensitive to damage caused by water loss. The most common types of damage were delamination, twisting, and cracking. To address those issues, we initiated a series of conservation tests for additional vertebrate remains collected from Cold Lake.

We tested four drying methods on ungulate vertebrae of comparable size: vacuum freeze-drying, controlled air-drying, solvent-drying, and vacuum freeze-drying with Acrysol™ WS-94, an acrylic dispersion. Specimen weight was monitored and drying was deemed completed when weight stabilized for 5 consecutive measurements, except in the case of solvent-drying where specific gravity was monitored and drying was deemed completed when specific gravity stabilized. We evaluated the methods in terms of the damage observed on the specimens after the treatment and time it took for them to dry. In addition, the vertebrae were measured in multiple dimensions prior and post treatment to evaluate size change related to water loss. We predicted that damage and size change would be positively correlated. Damage was judged by the amount and severity of delamination, twisting, and cracking. Surprisingly, size change due to water loss was not correlated with the amount of damage observed.

Solvent-drying and controlled air-drying produced the best results. The specimens treated with these two methods did not show appreciable damage. Vacuum freeze-drying was associated with substantial delamination and cracking, whereas vacuum freeze-drying with Acrysol™ WS-94 showed minor delamination and cracking. Controlled air-drying took over three months to complete while the other treatments took between one and two weeks. Although controlled air-drying took a considerable amount of time to complete, it has some advantages over solvent-drying that need to be considered when selecting a drying method. Controlled air-drying is considerably cheaper and does not require the addition of chemicals to dry the bone, which may interfere with certain analytic techniques.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

NEW INSIGHTS INTO THE EVOLUTION OF THE PREMAXILLA IN THE TRICERATOPSINI (CERATOPSIDAE, CHASMOSAURINAE) AS REVEALED BY A SPECIMEN FROM THE BASAL SANDSTONE OF THE HELL CREEK FORMATION, MONTANA

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A stratigraphic succession of *Triceratops* (Ceratopsidae: Chasmosaurinae) from the Cretaceous Hell Creek Formation (HCF) of Montana reveals trends in cranial morphology which are consistent with the presence of a single, evolving lineage. Despite being the most abundant dinosaur in the HCF (n>100), *Triceratops* remains are less commonly recovered in the lower unit of the formation and thus specimens from this stratigraphic zone can provide critical insights into evolutionary trends. In 2000, a large articulated skull (Museum of the Rockies [MOR] specimen 1122) was collected from the basal sandstone of the HCF. MOR 1122 is one of the stratigraphically lowest specimens from the HCF and one of the most complete examples of the "*Torosaurus latus*" morphology, which is hypothesized to represent an advanced growth stage of *Triceratops* or, alternatively, a distinct chasmosaurine taxon. Unfortunately, much of the detailed morphology of the premaxillae of MOR 1122 is not preserved; however, a large (preserved length ~ 55 cm) right premaxilla representing a second individual (MOR 1122-7-22-00-1) was collected from the same quarry. MOR 1122-7-22-00-1 compares favorably with the partial premaxillae of the articulated skull and reveals new anatomical details, including the presence of a thin septal flange at the base of the narial strut and a wide sulcus that extends ventrocaudally from the interpremaxillary fenestra into two medial chambers. These chambers connect with large, closely spaced foramina on the ventromedial surface of the premaxilla. The nasal process is narrow and exhibits a bifurcated dorsal surface reminiscent of the morphology of the stratigraphically lower *Eotriceratops xerinsularis* from the Horseshoe Canyon Formation of Alberta. A deep recess extends medial to the lateral wall of the triangular process, a feature which is shared with *Triceratops* found higher in the HCF but which is not present in the stratigraphically lower triceratopsins *Eotriceratops xerinsularis* and *Regaliceratops peterhewsi*. MOR 1122-7-22-00-1 exhibits morphology consistent with its position at the

base of the HCF and sheds light on details of chasmosaurine premaxillae in this important stratigraphic zone. This specimen highlights increasing complexity of the narial apparatus over the course of the latest Cretaceous, which may indicate selection for greater physiological capabilities within the Triceratopsini.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

CRANIAL OSTEOLOGY OF EXTINCT AND EXTANT GERRHONOTINE LIZARDS

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Gerrhonotinae is an extant clade of anguid lizards with a rich Cenozoic fossil record in the Americas and a diverse assemblage of species that still inhabit regions of North America and much of Central America. My preliminary analysis of x-ray computer tomography (CT) scans of a previously known but as of yet unidentified Pliocene lizard specimen from the PalmSpring Formation in Anza Borrego Desert State Park in southern California has determined it to be a potentially new species of gerrhonotine most likely belonging to the genus *Elgaria*. More specific taxonomic and phylogenetic affiliation has yet to be determined. Species belonging to the genus *Elgaria* are currently found in western and central North America, often in mesic habitats. Despite the relative familiarity of some species to biologists and paleontologists, comprehensive studies of the cranial anatomy of *Elgaria* are currently lacking. Description of the bones in the skull supplies useful data for examining morphological variation and phylogeny, and thus provides an excellent tool for any morphological study. Here, I aim to describe the anatomy of the skulls of the nine species of *Elgaria* as well as select other gerrhonotine taxa, especially species from the genus *Gerrhonotus* as well as the genera *Mesaspis*, *Barisia*, and *Abronia*. This method will provide novel anatomical information for many of the almost 60 modern gerrhonotine species, greatly expanding the currently limited cranial osteological data available. Comprehensive cranial descriptions will supply the framework for diagnosing phylogenetic placement of fossils, in particular the Anza Borrego gerrhonotine specimen. I will employ traditionally prepared skeletons as well as CT scans; the latter enables me to generate data about rare specimens of many gerrhonotine species for which no skeletal data exists.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

REMARKABLE CARPAL BONES IN *PROSANTORHINUS GERMANICUS* (MAMMALIA, RHINOCEROTIDAE)

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Prosantorhinus germanicus is a small teleoceratine rhino and is highly abundant in the German locality Sandelzhausen. This Miocene locality belongs to the Neogene mammal zone MN 5 and has an age of around 16 Ma, belonging stratigraphically to the Upper Freshwater Molasse region. Within the large number of specimens found in this locality, the remains of rhinos are dominant. For example, besides postcranial remains, more than 1800 teeth were found. These rhino remains belong to three different taxa. *Prosantorhinus germanicus* the smallest and most abundant rhino from Sandelzhausen is short-legged and bulky like most other teleoceratines. Also, like other members of the tribe, a semi-aquatic lifestyle is proposed. This species has four fingers and three toes like extant tapirs do. Among the assemblage of isolated carpal bones that have been found, some are highly variable in morphology. The variation is largest in the intermedium and the carpale IV, where additional articulation facets occur but not in every specimen. These contact facets are located at the palmar part of the bones and are antagonists between the intermedium in the proximal row of carpal bones and the carpale IV in the distal row of carpal bones. These additional facets are not seen in other rhinos and restrict the possible movement (flexion) between the two rows of carpal bones, the so called mid-carpal joint. The presence of these contact facets allows three different interpretations. First, this stiffening of the wrist region could be an adaptation to the semi-aquatic mode of life or at least an adaptation to walk in a muddy environment. A second possibility could be an adaptation to a large body mass of these bulky rhinos where, for example, the older and heavier individuals develop the additional facets to increase the maximum load supported by the forelimb. Or a third interpretation, also linked to body mass, could be a sexual dimorphism where the heavier males develop these facets to support their higher body mass. To answer this question, further studies of the forelimb and the whole postcranial skeleton are needed and will be conducted. Additional palmar facets also occur in *Teleoceras*, the type genus of the tribe Teleoceratini, but these facets are located between carpale III and carpale IV. This is interpreted as a beginning in the reduction of carpal bones, but such a proposed carpal bone reduction has not been seen in any rhino yet.

Grant Information

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Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

AN ARCHAIC BALEEN WHALE (CETACEA, MYSTICETI) FROM THE VAQUEROS FORMATION AND OTHER FOSSIL MATERIAL FROM THE SKYRIDGE PROJECT, ORANGE COUNTY, CALIFORNIA

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The Skyridge Project is a 30-acre residential development in the city of Mission Viejo, Orange County, California. Mass grading for Phase II of the project began in January of 2015 with archeological and paleontological monitoring provided by DUKE Cultural Resources Management. The area contained in the project is composed of landslide deposits sourced predominantly by beds from the Vaqueros Formation (late Oligocene to early Miocene). Due to the prevalence of landslide deposits, excavation reached depths exceeding 120 feet in order to meet geotechnical recommendations.

Over the course of 12 months of paleontological monitoring, over 200 fossil specimens were found, including bivalves (*Panopea*, *Pecten*, Pteriomorphia, *Solen,* Tellenidae, Veneridae), molluscs (*Cancellaria*, Scaphoda, *Trophon, Turritella,* Vetigastropoda), barnacles (*Tamiosoma*), Chondrichthyes (Batoidea, Lamniformes), possible Crocodilia, and trace fossils (*Chondrites*, *Gastrochaenolites*, *Ophiomorpha*, *Thalassinoides*, coprolites).

Also recovered were the remains of at least three cetaceans: (1) a right mandible and strongly associated articulated postcranial material (including at least one scapula) of a baleen whale (Cetacea: Mysticeti), and (2) cranial material (two braincase fragments and a tympanic bulla) with associated articulated postcranial material. The baleen whale specimen is particularly significant, as material from this group is rare for similarly aged deposits in southern California. In addition, the right mandible exhibits archaic features that are commonly found in aetiocetids and eomysticetids from Oligocene-age deposits but absent in similar members from Miocene-age deposits. Depending on the potential for precise dating of the deposits using invertebrate and microfossil specimens, the recovered material may represent a previously unknown archaic Miocene-age mysticete. Such a specimen would contribute greatly to our understanding of a key point in cetacean evolution that is currently sparsely represented in the fossil record.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

LATE MIOCENE CAIMANINES (CROCODYLIA, ALLIGATOROIDEA) FROM THE URUMACO FORMATION, VENEZUELA

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The late Miocene Urumaco Formation at Urumaco, Falcón state, Venezuela, is an important site of Neogene vertebrate fossils. The formation is very rich in extinct crocodylians, presenting a diversity hotspot in the Neotropics for the group. One of the main components of the crocodylian fauna are the caimanines (a subgroup within Alligatoroidea), the other being the gharials. We revised the caimaninine fauna by including novel fossil material, as well as the already described specimens assignable to this clade. In many cases the taxonomic status of species could be confirmed, which is the case in *Caiman brevirostris*, *Globidentosuchus brevirostris*, and *Purussaurus mirandai.* In other cases, specimens were reassigned to different taxa. As such, material previously identified as *Caiman lutescens* we consider as belonging to either *Caiman latirostris* (based on overall outline and shape of a snout fragment) or *Caiman wannlangstoni* (based mainly on the strongly sinuous lateral margins in dorsal view of a rostrum and the presence of tightly packed, large, and globular posterior teeth) respectively, whereas material of *Melanosuchus fisheri* is reassigned to Caimaninae aff. *Melanosuchus fisheri*. Furthermore, we propose that the presence/absence of: (1) squamosal eminences; (2) pronounced knobs at the orbits; (3) a prominent notch of the jugals; and (4) a median crest or ridge on the parietal are not sufficient to separate *Mourasuchus arendsi* from *M. nativus*. Based on this synonymy *M. arendsi* would have priority, which implies that there are only three species of the duck-billed caimanine *Mourasuchus* present in the Miocene of South America. Other specimens, which were previously identified as belonging to the genus *Caiman*, lack diagnostic features of the modern genus and are instead considered as Caimaninae indet. Besides improving the knowledge of the late Miocene crocodylians of South America, our results confirm the high taxonomic diversity of the fauna and the outstanding level of sympatry previously reported for the Urumaco Formation.

Grant Information

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Symposium I (Wednesday, October 26, 2016, 8:15 AM)

PALEOPROTEOMICS: THE BENEFITS AND CHALLENGES OF USING TANDEM MASS SPECTROMETRY TO INVESTIGATE EXTINCT PROTEOMES DERIVED FROM SOFT-TISSUES PRESERVED IN FOSSIL REMAINS

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Molecular investigations of fossil materials have provided new avenues to explore the biology, physiology, and phylogenetic relationships of long-extinct organisms. Specifically, paleoproteomics—the identification and characterization of proteins from fossil material—has the potential to elucidate previously inaccessible aspects of paleobiology that can only be detected through characterization of proteins themselves (e.g., post-translational modifications). To fully benefit from a paleoproteomics approach, researchers must account for many challenges inherent in applying liquid-chromatography tandem mass spectrometry (LC/MS/MS) to fossil tissue. Some of these challenges include: diagenetic alterations to preserved molecules that make them unrecognizable by current analytical tools; compounds that co-extract with proteinaceous materials during extraction or sample preparation that can cause ion suppression; and extraction methods that may cause sample loss or preferentially recover only limited parts of the proteome. Additionally, identification of protein sequences in MS relies on matching acquired spectra to known sequences reposited in protein databases. These databases lack protein sequence information from most extinct organisms, and the ones that are present are limited to Pleistocene and younger taxa; thus, we must rely on proteomes and genomes from related, extant taxa for analyses. This causes difficulty in finding identical matches of fossil spectra to peptide sequences when there are no closely related extant species, when the genome of a related species is unknown, when the peptide is not phylogenetically conserved, or when the recovered protein sequences include either biological or diagenetic modifications that are not accounted for in extant taxa. Here, we describe the mechanics of how LC/MS/MS is employed to obtain sequences, its utility for paleoproteomics, and some of the challenges of proteomic investigations on extinct organisms. Using bone protein extractions from extant archosaur taxa with known genomes (*Gallus gallus* and *Alligator mississippiensis*), we demonstrate how variations in protein extraction methods and bioinformatics software programs used to analyze data (e.g., Mascot, PEAKS, Byonic) may affect the results and influence success of proteomic investigations of vertebrate bone. Finally, we suggest ways to

optimize workflows to increase the chances of successful protein recovery from paleontological specimens.

Grant Information
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Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

THE 'SOUTH AMERICAN' SHORT-FACED BEAR *ARCTOTHERIUM* FROM THE YUCATÁN PENINSULA OF BELIZE AND MEXICO: IMPLICATIONS FOR THEIR BIOGEOGRAPHY, PALEOBIOLOGY, EVOLUTION, AND EXTINCTION

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Short-faced bears (subfamily Tremarctinae) are a group of American ursids that are mostly extinct. The earliest member of the group, *Plionarctos*, appears in the latest Miocene of North America and disappears by the middle Pliocene. *Tremarctos* emerges in the Pliocene and is best represented in the southeastern United States from the Pleistocene. *Tremarctos ornatus* is the only extant tremarctine and is currently restricted to South America. The fossil record of *T. ornatus* is sparse and isn't known until the Holocene. *Arctodus* first occurs in the late Pliocene of North America and by the middle Pleistocene was represented by *A. simus*, an exceedingly large bear that occurred across the continent. The genus *Arctotherium* appears in South America in the early Pleistocene, and in contrast to the evolutionary trajectory of *Arctodus*, the earliest *Arctotherium* species (*A. angustidens*) was the largest, and the terminal Pleistocene species (*A. wingei*) was diminutive. Here we add to the understanding of tremarctines by describing the first records of *Arctotherium* outside South America. These specimens are from the Yucatán Peninsula and are recorded from three cave sites. This includes a partial right maxilla with M1 and M2 from Actun Halal, Cayo District, Belize, and two underwater sites from Mexico that have multiple individual skeletons preserved. One of these caves, Hoyo Negro from Quintana Roo, has at least six skeletons and some material has been collected. This includes complete crania from an adult and subadult as well as dentaries and cervical vertebrae from the subadult. The adult skull has been radiocarbon dated as latest Pleistocene and is similar in age to other large mammals from the site, including an early human (*Homo sapiens*) partial skeleton (known as 'Naia'). The bear material analyzed from Hoyo Negro represents the most complete examples of *Arctotherium* skulls from the late Pleistocene, and together with the material still in the underwater caves, represents the most complete fossil skeletons known for the entire subfamily from Miocene through Pleistocene. The occurrence of *Arctotherium* in the Yucatán indicates a range extension for the genus of at least 1500 km outside South America and demonstrates our limited knowledge of late Pleistocene communities of this region. The relative absence of *Tremarctos* and other bears in South America during the Pleistocene may be a reflection of *Arctotherium* filling the bear niche throughout Central America until their extinction in the latest Pleistocene or early Holocene.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

TRANSPARENT MATRIX: BRINGING X-RAY GOGGLES TO THE PREP LAB

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There is probably not a single palaeontologist or fossil preparator who has not pondered the benefits of having a pair of proverbial X-ray goggles in the lab. We developed an early prototype of a visualization workflow that delivers just that: "live" 3D X-ray vision into a fossiliferous block of matrix.

Our experimental setup consists of a 3D workstation coupled with a 3D augmented reality device, which projects CT-data (acquired earlier) in real-time over the matrix block or plaster jacket-enclosed fossil. A usable 3D augmented reality experience however, is not easily achieved; most challenging is the seamless, real-time registration and mapping of the virtual image over the real-world objects. Particularly when applied in a paleo lab setting where preparation work requires sub-millimeter precision, perfect registration of the virtual image is essential. Thanks to recent developments in consumer electronics, many components required to achieve this have become available off the shelf at an affordable price point. Also, fueled by developments in the gaming industry, hardware allowing for high-speed 3D-rendering of complex data sets has become more readily available.

We expect, as technology matures, the "live X-ray vision" our setup provides could be of help in planning the approach of preparing more complex fossils, and can be helpful, too, during the preparation process itself. Providing haptic feedback through the airscribe, or image-analysis-driven shutoff of the airscribes upon approaching the fossil are among the next steps we consider.

The same setup used in a Virtual Reality setting rather than in Augmented Reality mode can help in more rapidly segmenting CT data sets; in this case the virtual matrix surrounding the virtual fossil can be removed using a toolbox of virtual scissors, brushes, and airscribes.

Technical Session XIX (Saturday, October 29, 2016, 1:45 PM)

THE ANATOMY OF THE MEMBRANOUS LABYRINTH OF MONOTREMES AND IMPLICATIONS FOR THE EVOLUTION OF THE MAMMALIAN INNER EAR

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Re-studying the membranous labyrinth and its innervation in the platypus (*Ornithorhynchus anatinus*) and short beaked echidna (*Tachyglossus aculeatus*), using histological serial sections and 3D segmentation, has revealed new features that were previously not described or only poorly understood. Our results demonstrate that in monotremes, each of the three membranous scalae that hold the organ of Corti and macula lagena is coiled to a different degree. Scala tympani is not involved in the apical coil of the bony labyrinth and is shorter than scala vestibuli and scala media. The helicotrema, a conduit between scala vestibuli and scala tympani, is in sub-apical position near the bending (isthmus) of the apically coiled scala media. This pattern is common in extant non-mammalian amniotes. Thus, monotremes retain an ancestral amniote condition of the helicotrema. Scala vestibuli and scala media extend beyond the helicotrema forming coiled blind sacs holding the macula lagena. In comparison, the therian inner ear anatomy is different in that all three scalae show equal lengths, coiling to the same degree, and the helicotrema in apical position. Both histological sections and CT scans of the adult ear region of the platypus and echidna show that the lagenar nerve fibers run in separate osseous channels from the cochlear nerve fibers, which enter the cochlear canal via the multiple openings of the tractus foraminosus, also termed the cribriform plate. The cochlear ganglion lies in the membranous connective tissue and is not supported by a bony lamina. The newly documented features have broad implications on the ancestral condition of the mammaliaform inner ear, which is likely characterized by a macula lagena, a lagenar nerve separated from the bundle of cochlear nerve fibers, an organ of Corti, and an intra-otic cochlear ganglion suspended by connective tissue. Among major Mesozoic mammalian clades, cladotherians and gondwanatherians most likely acquired a fully functioning organ of Corti but lost the sensory lagenar macula, like extant therians. Mesozoic spalacotherioids, multituberculates, and eutriconodonts, however, very likely retained the mammaliaform condition.

Symposium I (Wednesday, October 26, 2016, 8:00 AM)

"PROVE TO ME THEY'RE NOT": MOLECULAR CHEMISTRY AS A TOOL FOR HYPOTHESES TESTING

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Advances in technology have provided the opportunity for paleontologists to ask questions that were once considered unanswerable. Aspects of organismal physiology, molecular evidence for evolutionary relationships, and the attainment of genetic/molecular novelties are now possible to assess through the careful application of multiple analytical and experimental tools. More importantly, molecular analyses of ancient remains allow us to distinguish between competing hypotheses with empirical data. However, more complex questions require more rigorous and varied data to support initial hypotheses. Science cannot *prove*, nor should that be our goal. Science can only disprove or support. The advantage of initiating paleontological studies with the express goal of *disproving* a hypotheses rather than "proving" it helps to eliminate bias, thereby making conclusions more rigorous. Here, we elucidate the process of alternative hypothesis testing that guided two case studies: the source of vessel-like structures derived from dinosaur bone, and the identification and characterization of dinosaurian reproductive bone tissues. These investigations aimed to disprove *multiple* hypotheses, including: Are the vessel-like structures original to the dinosaur and hence part of the vascular system? Do they arise from later contamination with biofilm or glue? Are they fungal in origin? *And*, Is the tissue we first identified in the bones of the *T.rex* MOR 1125 reproductive medullary bone? Or is it a pathology? We use various forms of analytical data, discussed here, to eliminate alternative hypotheses in each case. Conclusions are robustly supported when *all* data align to say the same thing.

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Technical Session IX (Thursday, October 27, 2016, 2:45 PM)

THE LIMITATIONS OF GAPE-BASED SUCTION MECHANICS IN ARTHRODIRA (PLACODERMI)

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Placodermi are a primitive clade, or grade of jawed vertebrates (gnathostomes) basal to the living groups of jawed vertebrates (crown gnathostomes) including Osteichthyes and Chondrichthyes. Feeding mechanisms shared among placoderms may represent the primitive condition for other gnathostomes, as well as the incumbent feeding strategies for many niches during the Devonian Period. Previous studies have examined one of the most derived placoderm groups, Arthrodira, and shown a capability for rapid, high force closure of the jaws, as well as rapid expansion of the gape through cranial elevation. Extant gnathostomes that utilize suction for prey capture generate sufficient force of flow at, and in front of, the mouth by occluding gape, and by generating exceptional pressures in their oral cavity through rapid expansion of their hyoid arch out of phase with gape expansion. Peak pressure in extant suction feeders typically coincides with peak rate of volume change in the oral cavity. In arthrodires rapid gape expansion has been proposed to enhance suction during feeding by increasing buccal volume with cranial elevation. Here I discuss the problems inherent in suction by expanding gape and their implications for feeding strategies in arthrodires and other placoderms. A simple model of gape expansion as a tetrahedron expanding along a single edge, shows that an increase in gape volume results in a proportionate increase in gape area and a corresponding exponential drop in mouth pressure, relative to rate of fluid flow. Further, cranial elevation may also increase volume in the hyoid cavity; however, flow rate would still increase in phase with the rate of gape increase. This spreads the change in buccal volume throughout gape expansion and reduces the peak rate of volume change, a close correlate of peak buccal pressure. The expanding gape of placoderms likely allowed for compensatory suction during ram or bite feeding; however, any suction specific feeding in placoderms requires a model that separates buccal expansion and gape expansion. The implications for constraints on feeding strategies in placoderms, as well as competition with crown gnathostomes during the Devonian period are discussed. Further study requires both a

model for volumetric expansion of the hyoid and pharyngeal cavities and tests for models of suction forces at the gape during expansion.

Technical Session I (Wednesday, October 26, 2016, 10:45 AM)

WHAT'S IN A NAME? RESOLVING THE TAXONOMY OF PLEISTOCENE LARGE *EQUUS* FROM THE NORTHERN GREAT BASIN OF NEVADA AND OREGON

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Horses (genus *Equus*) are among the most common large mammals represented in Pleistocene localities throughout the Great Basin in western North America. Despite the wealth of fossil material, the taxonomy of these animals remains largely unresolved for much of this region. The recent documentation of the large horse species *Equus scotti* Gidley from the Tule Springs locality outside of Las Vegas, Nevada, in the southern Great Basin, prompted a reappraisal of more northerly large horse fossils.

Many fossils of large *Equus* from the northern Great Basin are too incomplete to warrant assignment to species. However, at two localities—Fossil Lake in southeastern Oregon (~646 ka to ~13 ka) and Wizards Beach in northwestern Nevada (~25.5 ka)—large horse fossils are more complete, and have been assigned to *Equus pacificus* Leidy. This species was originally based upon an isolated left P3 from Martinez, California, exhibiting large size but with no other diagnostic features. The inadequacy of this holotype effectively invalidates the taxon, and the fossils from Fossil Lake and Wizards Beach require reassignment.

Craniodental specimens of large *Equus* from both Fossil Lake and Wizards Beach exhibit short molar ectoflexids, broad linguaflexids, and infundibula in the lower incisors. These characters correspond closely with the large horse *Equus scotti*. Postcranial elements are large but not unusually so, plotting within the size range of both *E. scotti* and *E. occidentalis* Leidy. The combination of morphology and size warrants referral of the Fossil Lake and Wizards Beach large horses to *E. scotti*.

Other Pleistocene occurrences of *Equus* in the northern Great Basin can also be re-evaluated. Large horse fossils from Rye Patch Reservoir, northwestern Nevada (~29 ka to ~23 ka), exhibit a size and morphology consistent with *Equus scotti* and are here assigned to that species. Large horses from Mineral Hill Cave, northeastern Nevada (>50 ka to 2 ka) have been assigned to *Equus* cf. *occidentalis*; although diagnostic craniodental remains are not known from this site, postcranial remains fall in the size range of both *E. occidentalis* and *E. scotti*.

The presence of *Equus scotti* in the northern Great Basin, and to the south at Tule Springs, demonstrates that these horses were common throughout the Great Basin during the Pleistocene. This offers intriguing biogeographical implications when compared to more coastal localities in California, where the only large horse confirmed from late Pleistocene faunas in Los Angeles, Orange, Kern, and Riverside Counties is *E. occidentalis*.

Symposium II (Friday, October 28, 2016, 9:45 AM)

THE DEVELOPMENTAL BASIS OF MAMMALIAN LIMB DIVERSIFICATION

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From bat wings to horse hooves, mammalian limb diversification has been crucial to the evolutionary success of the group. Indirect evidence from studies of mammalian limb evolution suggests that limb diversification, including the frequent limb reduction that characterizes many mammalian groups, has not occurred primarily by the evolution of new genes but by differential regulation of existing genes shared by all mammals and inherited from an ancestral genetic toolkit. However, the specific genes and regulatory mutations that are responsible for limb diversification remain unknown for most mammalian groups. To begin to identify these genes and regulatory mutations, we used RNASeq to compare the transcriptomes of the developing limbs of several mammals, including pentadactyl mice, bats, and opossums, and tetradactyl pigs. Results suggest that gene expression varies more during later than earlier stages of limb development, both within and among species. Consistent with this, results suggest that the evolutionary age of each species' transcriptome decreases as developmental age increases. Within the more variable, later-expressed genes, we identified significant differences in the expression levels of HoxA and HoxD genes within and among species. WISH generally confirmed these RNASeq results and uncovered key differences in expression domains as well. We used computational approaches to identify candidate enhancers for HoxA and HoxD genes and functionally tested candidate enhancers using transgenic assays. Through this approach, we identified several candidate enhancers with the potential to drive lineage-specific Hox expression levels. In parallel research, we used morphometric approaches within a phylogenetic framework to investigate morphological change across the Cenozoic in fossil mammalian groups (artiodactyls, perissodactyls), and modern mammalian species. Results from both fossil and modern mammals suggest that morphological events occurring earlier in development are more conserved across species than those occurring later. Taken together, our results support the hypothesis that the hierarchical nature of development translates into increasing variation as development progresses, and that divergence of *Hox* gene expression during these later stages of development plays a role in mammalian limb diversification.

Grant Information
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Technical Session XIII (Friday, October 28, 2016, 2:15 PM)

FIRST RECOGNITION OF CLIMATE HYPERTHERMALS IN THE LOWER PALEOCENE RECORD OF THE SAN JUAN BASIN, NEW MEXICO, USA

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The greenhouse climate of the early Paleogene is punctuated by numerous short-term, transient warming events, known as 'hyperthermals.' The largest and best known of these is the Paleocene–Eocene Thermal Maximum (PETM). The PETM is characterized by dramatic faunal and floral changes linked to rapid warming; numerous mammalian immigrants enter North America during the PETM, resulting in a reorganization of the fauna, and about 40% of lineages exhibit 'dwarfing' to smaller body sizes. Paleocene floras are replaced by a largely unique PETM flora. These and other biotic phenomena may have important implications for future climate change; however, in order to understand whether these patterns are repeating or are unique to the PETM, biotic records from other hyperthermals must be studied. Hyperthermals can be identified by rapid negative excursions in $\delta^{13}C$ values. To test for hyperthermals in the lower Paleocene of the San Juan Basin, we analyze the carbon isotope content of bulk organics in fine-grained rocks in the Nacimiento Formation. Bulk carbon $\delta^{13}C$ values reflect values in ancient vegetation, which are influenced by atmospheric values and by local environmental conditions. We find two large (3–4‰) negative shifts in $\delta^{13}C$ values in the late Torrejonian, one at the top of the *Pantolambda caviirictum-Mixodectes pungens* zone (Tj5) and one at the top of the *M. pungens* zone (Tj6). These excursions are present in both Torreon Wash and Escavada Wash sections. The upper excursion occurs at the top of polarity chron C27n and is correlated to the Latest Danian Event (LDE), previously known with confidence only from the marine record. The lower Tj5 excursion is previously unrecognized. Teeth of the phenacodontid 'condylarth' *Tetraclaenodon puercensis* appear to be from localities within the LDE in Escavada Wash based on preliminary marker-bed correlation. A decrease in m1 size in *T. puercensis* suggests a decrease in body mass of ~20% ($p = 0.002$) in the LDE relative to stratigraphically lower individuals in Tj6. This suggests that the mechanism responsible for dwarfing during the PETM was also operating in the LDE. Few mammal fossils have been found in or near the level of the Tj5 hyperthermal. Previous research suggests that 'arctocyonid' and 'plesiadapiform' mammals dispersed from North America to Europe near the Torrejonian–Tiffanian boundary, which is close to the C27n–C26r chron reversal. We hypothesize that these dispersals correspond with warming during the LDE, but we find no evidence of European immigrants reaching the San Juan Basin at this time.

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Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

BIOMECHANICS AND THE EVOLUTION OF THE CROCODYLIFORM SKULL

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The evolution of the derived crocodyliform skull from that of basal suchians involved the acquisition of a number of functionally salient features. Skull flattening resulted in a reorganization of the jaw muscles and a rotation of the quadrate, placing the jaw joint caudal to the braincase. These changes were preceded by an expansion of the pterygoid buttress, which in crocodyliforms is elaborated into a second articulation of the skull with the mandible known as the pterygomandibular joint (PMJ). While the fossil record demonstrates the pattern of morphological changes, the biomechanics of the system is less well known. This study uses high-fidelity biomechanical modeling to investigate muscle, bite, and joint force magnitude and orientation in *Gracilisuchus*, *Postosuchus*, protosuchians, and *Alligator*. We made finite element and free body models to estimate how individual muscles contribute to cranial forces. Osteological correlates of jaw muscle attachments informed reconstructed muscle maps on 3D models built through the Boneload computational modeling workflow. Three-dimensional muscle force vectors were projected into ternary space to visualize how muscular geometry changes with osteology. We compared the surface area of cranial joints with the magnitudes of the loads they experienced. The orientations of joint surface and joint reaction force were also compared. Results show a progressive increase in medially-oriented muscle force along the lineage leading to crocodyliforms concomitant with the expansion of the pterygoid buttress and PMJ. Results also reveal that jaw joint reaction forces align with the quadrate across the transition in quadrate orientation, suggesting that a shift in muscular geometry in more derived taxa increased the rostral component of jaw joint reaction force, thereby avoiding excessive bending of the suspensorium. This study provides evidence that two pairs of craniomandibular joints played a key role in the evolution of the crocodyliform skull.

Grant Information
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Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

A NEW APPROACH FOR ESTIMATING THE RELATIVE DURATION OF MORTALITY EVENTS OF LARGE HUNTED GAME AT ARCHAEOLOGICAL SITES USING ENAMEL MICROWEAR

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Determining seasonality of human occupations of archaeological sites is highly significant for elucidating the strategies employed by hominins when hunting large game. Enamel microwear, which analyzes the microscopic features produced by food items on the surface of teeth, is sensitive enough to reflect seasonal shifts in the diets of ungulates—thus providing a useful proxy for estimating the relative duration of ungulate mortality events. We describe a new tool for estimating seasonality and duration of mortality events from tooth microwear scratch patterns based on a reference framework of ten large samples of extant ungulates from single populations or those resulting from a catastrophic death with precise records of their date of death and with mortality durations spanning from one day to several years. The tool is based on using a two-dimensional approach of combining two different measures of variability of scratch density, namely standard deviation and coefficient of variation. We used the integration of these two scratch variability measures to classify each mortality case into one of the following three categories: (1) short season-long or shorter events; (2) long-continued event; and (3) two separated short events occurring in non-contiguous seasons. We then tested the reliability of our classification tool by applying it to modern known samples and then applied the tool to a selection of eleven fossil samples from five Palaeolithic localities in Western Europe. Results from the application of the classification tool on modern known samples properly classified them into their actual death event time frames. Results also show significant agreement between our classifications of the five Paleolithic localities and previous interpretations of the archeological record using different approaches. We confirm our hypothesis that more than one measure of heterogeneity in scratch density is necessary to distinguish all three mortality temporal events. This bi-dimensional approach of quantifying the two sources of variability affecting values of scratch density in a sample—heterogeneity due to differences among individuals, and variability resulting from seasonal variations in vegetation—differentiates short and long mortality events as well as two short events occurring in non-consecutive, different seasons and provides a visual way to easily assess the accuracy of assessing the duration of mortality events from microwear data obtained from the fossil record.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

NICHE SHARING AMONG EARLY TRIASSIC TEMNOSPONDYL AMPHIBIANS OF EASTERN INDIA

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The Early Triassic Panchet Formation of Eastern India is known for its temnospondyl content. Many temnospondyl taxa have been identified from the better preserved material and many more are yet to come from the fragments. So far, families like Brachyopidae, Trematosauridae, Lydekkerinidae, Rhyteidostidae, Plagiosauridae,Lapillopsidae, and probable Capitosauridae, Tupilacosauridae, and Benthosuchidae are noted from the Panchet. The Panchet Formation is made up of alternating brown, multistoreyed, medium to coarse grained sandstones, and red and green coloured mudstones. The temnospondyls, though high in diversity, are restricted within the sandstones, whereas red mudstones are dominated by *Lystrosaurus* spp. *Chasmatosaurus,* rare cynodonts, and fishes are other elements of the fauna. Recently, about 400 bone fragments have been studied from Panchet. Almost half of the fragments are non-diagnostic and weathered. The rest are dominated by lystrosaurid fragments in the flood plain red mudstones and by different temnospondyls in the channel sands. The flood plain deposits have almost 90% of lystrosaurids. The channel sands have most of the temnospondyl fragments. The fragments are mostly clustered around a 2 cm × 2 cm size range. That is the size that could come with the medium to coarse sands in which they are preserved as clasts. Hence, there were more amphibian fragments initially. Nevertheless, the identified fragments indicate the temnospondyls with all long-snouted, triangular, and short faced (with vaulted pterygoids) skulls. The trematosaurids had a different niche as they are actively piscivorous. The brachiopids are strong suction feeders with large area for adductor and depressor mandibulae. The capitosaurids and benthosuchids are less agile with their triangular robust skulls. All these temnospondyls were mostly aquatic and that is supported by their occurrences in the channel sandstones. From Indian Triassic deposits, nearly 34 post glenoid parts (PGA) of temnospondyls have been found. The Early Triassic Panchet contains 70% of those PGAs. These PGAs are highly variable in nature and suggest more new taxa of temnospondyls are yet to be identified. Hence, within the Early Triassic, Indian temnospondyls show rare niche-sharing within aquatic realms that are unique and unprecedented.

Symposium III (Saturday, October 29, 2016, 8:45 AM)

THE HOLES IN THE FOSSIL RECORD: FEMORAL NUTRIENT FORAMINA REVEAL THE ANTIQUITY OF ENDOTHERMY IN ARCHOSAURS, AND THE CONSEQUENCES OF REVERSION TO ECTOTHERMY WITHIN THE CROCODYLIAN LINEAGE

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The maximum aerobic metabolic rate of an organism is matched to the anatomy and physiology of the oxygen supply system. Endotherms therefore have larger hearts and circulatory systems than ectotherms, because higher metabolic rates demand greater blood flow rates and consequently larger arteries. Metabolic rates determine the structure and function of the cardiovascular system, not the reverse. The radius and wall thickness of major arteries are dynamically adjusted in life to accommodate required flow rates and blood pressures. Where vessels pass through bone, the size of the foramen can be used to gauge the maximum metabolic rate of the organs they supply. In particular, nutrient foramina on the shafts of long bones can provide an index of blood flow to the interior of the bone, which is necessary for bone remodeling to repair microfractures caused by locomotion.

Blood flow indices from fossil femora of 10 dinosaur species, including Theropoda, Ornithopoda, Sauropodomorpha, Ceratopsidae, and Stegosauridae, were compared allometrically to data from extant mammals (n = 59), birds (n = 100), and reptiles (n = 32). Dinosaurs had significantly higher bone blood flow than mammals, which in turn were 10-fold higher than reptiles. Birds were indistinguishable from mammals. These results indicate a highly active and aerobic lifestyle of dinosaurs, consistent with an endothermic physiology. Large femoral foramina can be traced back to the basal archosaurs, indicating that endothermy originated among, or earlier than, the first archosaurs, some 100 million years before the first birds.

There are several lines of evidence indicating that modern crocodylians evolved ectothermy from endothermic ancestors some time during the Mesozoic Era. Living crocodylians have cardiovascular and respiratory features that are clearly associated with high aerobic capacity, namely a completely separated, 4-chambered heart and flow-through lung ventilation. The shift to ectothermy in crocodylians was associated with sit-and-wait predation in water. In this niche, endothermy and aerobic capacity should be selected against, because ectotherms can hold their breath longer and do not lose body heat to the water. Predation by crocodylians involves primarily anaerobic metabolism in explosive feeding events. Aerobic power generation is so low in a 200 kg estuarine crocodile that total power during maximal exercise is only 8% of that of a mammal of similar size. Therefore, the loss of endothermy in the crocodylian lineage greatly reduced total power output during exercise.

Grant Information
Supported by the Australian Research Council

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

FOSSIL WALRUS SKULLS FROM THE EMPIRE FORMATION OF OREGON REPRESENT A NEW LINEAGE FROM THE LATE MIOCENE AND SUPPORT A SIGNIFICANT LATE MIOCENE RADIATION OF ODOBENIDS

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Walruses are represented by a single extant species (*Odobenus rosmarus*) that is restricted to the Arctic, but from the Miocene to the Pliocene a diversity of fossil odobenids (20 species, 16 genera) are known throughout the North Pacific. Most fossil odobenids lack the highly specialized and characteristic cranial morphology found in *O. rosmarus*, which is easily recognized by its elongated canines (tusks) and squat rostrum. Instead, fossil walruses show a wide range of cranial morphologies that represent distinctive feeding strategies. Adding ghost lineages to counts of described lineages suggest that there were two radiations of walruses in the Miocene: a middle Miocene radiation that includes a paraphyletic grade of "imagotariines," and a late Miocene radiation that includes odobenines, dusignathines, and a long-skulled walrus from the late Miocene Empire Formation of Oregon, *Pontolis magnus*. Here we report on additional fossil walrus skulls from the Empire Formation (Emlong collection at USNM) that belong to an "imagotariine"-grade taxon. The new Empire "imagotariine" shows superficial similarities to an undescribed new genus and species of "imagotariine" from the late Miocene Capistrano Formation of southern California. Phylogenetic analyses place both the new late Miocene "imagotariines" (Empire and Capistrano) as close to *P. magnus* but overall recover low support for relationships among the middle Miocene "imagotariines" and the monophyly of dusignathines. Despite this phylogenetic uncertainty, the new late Miocene "imagotariines" and *P. magnus* are found to be more closely related to odobenines and dusignathines than to any middle Miocene walrus. This result emphasizes the proposed pattern of a late Miocene radiation of walruses.

Grant Information
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Preparator's Session (Thursday, October 27, 2016, 10:45 AM)

WHEN THE SMOKE CLEARS: A DISCUSSION ON FOSSIL WHITENING AND AN EVALUATION OF CLEANING METHODS FOR SPECIMENS SMOKED WITH AMMONIUM CHLORIDE

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Smoking describes a family of techniques wherein chemical powder is sublimed and deposited onto specimens. Smoking has long been employed for enhancing the relief of fossils and other natural history objects during photography. Several different chemicals can be used for smoking, but the most common is ammonium chloride. Though there are many documented methods for coating specimens in ammonium chloride, there are few published explanations on how best to remove this coating after application. Ammonium chloride is acidic and dissolves in the presence of moisture, potentially etching specimens and posing a risk to museum collections. To test the efficacy of several cleaning techniques for the removal of an ammonium chloride coating, we smoked a series of calcitic invertebrate fossil specimens and cleaned those using eight commonly used or suggested cleaning techniques. The experiment was split into two experimental groups. In Group 1, we tested the following cleaning techniques: brushing with a dry brush, puffing with a camera lens puffer, breathing on the specimens, and rinsing in deionized (di) water. In Group 2, we tested the following cleaning techniques: blowing with a compressed air gun, brushing with di water, brushing with 95% ethanol, and rinsing in 95% ethanol. We performed six trials per experimental group using six specimens per trial: two control specimens and four experimental specimens upon which the cleaning methods were performed. After performing the appropriate cleaning method, we thoroughly rinsed each specimen in di water. We then tested the rinse water by mixing it with a silver nitrate solution. Chloride ions react with silver nitrate to produce a white precipitant, turning the solution an opaque, milky color. Using their relative opacities as a guide, we visually compared each silver nitrate solution in order to create a qualitative scale to measure the efficacy of each method. Using this procedure, we found the di water rinse to be the most effective cleaning method. Every brushing method was moderately effective. Every other cleaning method was either ineffective, or potentially dangerous to the specimen. Breathing on the specimen, a commonly used method, was ineffective at removing the ammonium chloride coating, and likely exacerbates the problem of etching by dissolving remaining residue. Smoking procedures and methods of smoke removal should always be carefully planned out in advance and recorded in the

collections database, with specimen safety being taken into consideration before smoking.

Technical Session XIII (Friday, October 28, 2016, 2:30 PM)

THE ANATOMY OF *PERIPTYCHUS CARINIDENS* WITH COMMENTS ON FUNCTIONAL MORPHOLOGY AND THE PHYLOGENY OF 'ARCHAIC' PALEOCENE MAMMALS

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The diversification of mammals after the Cretaceous–Paleogene (K–Pg) mass extinction was a critical event in mammalian history. It has been difficult to address macroevolutionary questions among early placental mammals because the phylogenetic affinities among 'archaic' taxa remain poorly resolved. *Periptychus* and its kin provide crucial information towards understanding the radiation of placental mammals. *Periptychus* is the archetypal genus of Periptychidae, a clade of prolific Paleocene 'condylarths' known from North America, and remarkable for their distinctive dental anatomy. Periptychids were among the first mammals to appear after the K–Pg mass extinction, attaining a maximum standing taxonomic diversity of 16 species and body sizes of up to 100 kg within 500 ka of the K–Pg boundary. Previous work has suggested a generalist mode of life for *Periptychus carinidens*, but a comprehensive understanding of the anatomy, ecology and evolution of *P. carinidens* has been hindered by a lack of cranial and postcranial material. New fossil material from the Early Paleocene (Torrejonian) of New Mexico has enabled a comprehensive anatomical re-description of this enigmatic taxon, facilitated an understanding of its ecology and functional morphology, and supplied new data for phylogenetic analyses. *Periptychus carinidens* was a robust, stout-limbed animal that was incipiently graviportal and adopted a plantigrade mode of locomotion. Examination of the manus and pes indicate that *P. carinidens* retained a moderately high degree of multiaxial movement and dexterity in its distal extremities. The manual elements are elongate relative to the forelimb and terminate in short, fissured hoof-like unguals suggestive of some fossorial ability. We ran a cladistic analysis to determine the phylogenetic affinities of Periptychidae within Placentalia. We scored 169 extant and extinct taxa for 693 dental, cranial and postcranial characters, incorporating new morphological and taxonomic data. Our analysis finds Periptychidae as a monophyletic group positioned at the base of Laurasiatheria. *Periptychus carinidens* is sister taxon to *Carsioptychus coarctatus,* in a monophyletic group inclusive of *Ectoconus* and *Tinuviel*. The anatomy of *Periptychus* is unique and lacks any extant analogue; it combines a basic early placental body plan with numerous unique specializations in its dental, cranial and postcranial anatomy that exemplify the ability of mammals to adapt and evolve following catastrophic environmental upheaval.

Symposium III (Saturday, October 29, 2016, 8:30 AM)

POSTCRANIAL BONE HISTOLOGY OF DINOCEPHALIANS (THERAPSIDA) REVEALS PERIODIC RAPID RATES OF BONE DEPOSITION AND EVIDENCE OF A PATHOLOGY IN A TITANOSUCHID

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Dinocephalia is a monophyletic clade of early Therapsida that flourished during the Middle Permian between 272 and 260 million years ago. Even though these basal synapsids were the most diverse and dominant taxa at that time, they went extinct by the end of the *Tapinocephalus* Assemblage Zone and were succeeded by the highly successful Dicynodontia. Dinocephalians are most easily recognized by their pachyostotic skulls and large size. Due to the unresolved phylogeny of Dinocephalia, the focus here will be on three currently recognized groups: the basal carnivorous anteosaurids, the omnivorous titanosuchids, and the derived herbivorous tapinocephalids. Dinocephalian bone histology has remained unstudied since the early work of Armand de Ricqlès during the 1970s. The current study assesses the bone histology of nine anteosaurid elements (two ulnae, two radii, two femora, two fibulae and a possible tibia), five titanosuchid elements (a scapula, humerus, femur, tarsal, and a fragmented epiphysis), and five tapinocephalid elements (two humerii, two ulnae, and a femur). The skeletal elements examined have revealed that all three groups possess episodic deposits of fibrolamellar bone (FLB) tissue within zonal bone, which is known to result from rapid rates of bone deposition. Only slight differences in bone microstructure, secondary remodeling, and vascularity are noted among the dinocephalians. More specifically, the orientation of the vascular channels in the cortical bone in anteosaurids is mostly longitudinal and radial, whereas the titanosuchid and tapinocephalid cortical bone consists of a combination of circumferential, plexiform, and reticular vascularization. The titanosuchid femur showed an abrupt change in the deposition of FLB with circumferential vascularization to form well-vascularized, radially-oriented bony struts perpendicular to the periosteal surface. The associated skeletal elements of this individual did not demonstrate this unusual bone growth nor has it been observed in any of the other dinocephalian bones analyzed in this study. A similar 'sunburst' pattern of bone tissue has been recognized as pathological in several extant and extinct vertebrates and to be the result of reactive growth at the periosteum. We therefore propose that the occurrence of these unusual radially oriented bony struts along the peripheral margin of the titanosuchid femur represents a pathologic response.

Grant Information
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Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

ENDOCRANIAL ANATOMY OF *SIRINDHORNA KHORATENSIS* (ORNITHOPODA, HADROSAUROIDEA) AND ITS IMPLICATION

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Sirindhorna khoratensis, an Early Cretaceous basal hadrosauroid of Thailand, is represented by premaxillla, maxillae, braincases, quadrate, and mandibles, making it the best-preserved ornithopod from Southeast Asia. Fortunately, attentive preparation and CT-scannig of one braincase permit the detailed reconstruction of the endocranial anatomy of this hadrosauroid. *S. khoratensis* exhibited a typical reptilian brain morphology with a rostrocaudally-elongated posture. The rostrally projecting olfactory tract marks the rostral end of the cerebrum. The cerebral hemisphere is broad and dorsoventrally compressed. A constriction caudal to the cerebrum possibly marks a boundary with the midbrain. A large peak of the midbrain gives the brain a triangular shape in lateral aspect. This peak likely represents the pineal peak, similar to the dural space for the pineal appraratus. A second constriction occurrs caudal to this peak. This area contains the inner ear (endosseous labyrinth). The left endosseous labyrinth is well-reconstructed but lacks the ventral portion. The general shape of this brain is similar to those of basal iguanodonitans, such as *Iguanodon bernissartensis, Batyrosaurus rozhdestvenskyi,* and *Tenontosaurus tilletti.* The rostrocaudal length of the endocast is 136 mm, with a maximum width of 52 mm at the cerebrum. Significantly, the ratio of the cerebrum volume to that of the endocast is approximately 30% and much higher than any other non-hadrosaurid iguanodontians and close to those of hadrosaurids. This implies that this basal hadrosauroid probably had similar social behaviors, such as herding, as in hadrosaurids. Despite the large number of iguanodontians specimens, reconstructions of the endocranial anatomy are still limited, particularly among non-hadorsaurid hadrosauroids. Consequently, our report provides fundamental information on the endocranial anatomy of a non-hadrosaurid hadrosauroid and insight into the evolution of the brain in iguanodontians.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

THE OLDEST FOSSIL RECORD OF THE MEGAMOUTH SHARK (LAMNIFORMES, MEGACHASMIDAE) FROM THE LATE EOCENE OF DENMARK

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The megamouth shark (Lamniformes, Megachasmidae) has enigmatic occurrences both in the present-day oceans and in the fossil record, where the geologically oldest record of megachasmids in literature is represented by the teeth of *Megachasma applegatei* from the late Oligocene (late Chattian; ca. 23 Ma) of the western USA. NHMUK PV P73711 is a previously undescribed, nearly complete megachasmid tooth (*M.* aff. *M. applegatei*) housed in the Natural History Museum, London, UK, measuring 4 mm in tooth height and 4.5 mm in tooth width. It was sorted from a 1,600 kg bulk sample of sediment collected from the uppermost 50 cm of the Pyt Member of the late Eocene Søvind Marl Formation at Moesgård Strand in Denmark and represents the geologically oldest (ca. 36 Ma ago) known *Megachasma*, pushing back the geological record of the genus by approximately 13 Ma NHMUK PV P73711 is not specifically identified as *M. applegatei*, but rather as *M.* aff. *M. applegatei*, because it appears to differ from *M. applegatei* in having a much smaller lingual protuberance, more labially situated and relatively larger lateral cusps, and more widely spaced root lobes than conventional *M. applegatei*. The tooth likely came from an individual that measured somewhere between 1.3 and 3.5 m long, and its morphology and chipped cusp tips suggest that it possibly fed on macrozooplankton and small fishes that had hard skeletal components. Its occurrence in the mid-Priabonian Pyt Member at least suggests that the shark inhabited a relatively deep (200–600 m?), open marine environment. This Eocene specimen is significant because it illustrates the dental condition of early megachasmids, which is distinctively odontaspidid-like morphologically.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

NEW SAUROPOD MATERIAL FROM THE EARLY CRETACEOUS OF THAILAND

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Various non-marine vertebrate remains have been found from terrestrial sedimentary Mesozoic red-beds of Thailand, particularly in the Khorat Group situated in the Indochina block in the northeastern Thailand. Khorat Group is subdivided into eight formations, ranges in age from Late Triassic to late Early Cretaceous. One of the most abundant and most diverse dinosaur remains are known from the Sao Khua Formation, which is now considered Berriasian-early Barremian (Early Cretaceous) based on the presence of palynomorph *Dicheiropollis etruscus*. The dinosaur assemblage consists of theropods (e.g., basal coelurosaurid, allosaurid or metriacanthosaurid *Siamotyrannus isanensis*; spinosaurid *Siamosaurus suteethorni*; ornithomimosaurid *Kinnareemimus khonkaenensis*) and sauropods (basal titanosauriform *Phuwiangosaurus sirindhornae*). Among this assemblage, sauropod remains are probably the most abundant dinosaur fossils found in the Sao Khua Formation. In addition to *P. sirindhornae*, recent studies suggested that the Sao Khua Formation has yielded another two sauropod species, which is referred to *Camarasaurus* or *Brachiosaurus* like "Taxon B" and diplodocoid sauropod like "Taxon C".

In 2001, more than twenty sauropod bones were discovered along with a theropod phalanx, spinosaurid tooth and a chelonioid carapace fragment, over 10m^2 from the Sao Khua Formation at the foot of Phu Peng hill (KS16), which is located in Kalasin Province in northeastern Thailand. These sauropod bones include scapula, sternal plate, ilium, pubis, ischia, humerus, femora, tibia, fibula, teeth, cervical, dorsal and caudal vertebrae, ribs and chevrons. These bones show significant difference in size, so it is clear that they contain several individuals. The cervical vertebrae of Phu Peng specimens have a bifurcated low neural spine; nearly complete hemisphere shape of articular condyle; anteriorly straight centroprezygapophyseal lamina, which differs from that of *P. sirindhornae* where the articular condyle is dorsoventrally flattened; centroprezygapophyseal lamina bends toward anteriorly and the bifurcated neural spine is high in "Taxon C". Comparison with "Taxon B", which consists of only cranial elements, has been excluded here. This study suggests the existence of fourth sauropod taxon from the Sao Khua Formation and the diversity of sauropods in the Early Cretaceous of Thailand.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

PALEODIETARY RECONSTRUCTION USING STEROIDS IN PALEOGENE FOSSIL BONES OF MARINE MAMMALS FROM HOKKAIDO, JAPAN

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The paleodietary preference of ancient animals can be reconstructed by stable carbon isotope ratios ($\delta^{13}C$) of steroids in fossil bones. Steroids are abundantly contained in bones, and their $\delta^{13}C$ signals are applicable to fossil bones as old as 10 Ma. To obtain more precise paleodietary information, it is necessary to distinguish indigenous steroids and their derivatives from the external ones by contamination from natural environment and laboratory. In the present study, we analyzed steroids in Oligocene fossil bones to evaluate their applicability as a paleodietary indicator.

We investigated two cetacean and three desmostilyan fossils including type specimens of *Ashoroa laticosta* and *Behemotops katsuiei* from the late Oligocene marine sediments of the Morawan Formation (25 Ma) distributed in Ashoro, Hokkaido, Japan. From all specimens, C_{27} to C_{29} steroids are detected as free components, and only C_{27} steroids are detected as the components bound in fossil molecules. The C_{27} steroid, cholesterol, is a typical biosterol synthesized by vertebrates, whereas the C_{28} and C_{29} steroids are basically derived from algae and plants. Therefore, the C_{28} - C_{29} steroids identified from fossil bones are not indigenous compounds of animal bones. In addition, humans commonly have cholesterol, so this compound can be a 'fresh' contaminant from a researcher's body during sampling and preparation. However, the bound form of cholesterol is not a contaminant because the biosterol is thought to be incorporated with other molecules during diagenetic processes. Desmostilyan fossils *A. laticosta* and *B. katsuiei* were found to contain free C_{27} to C_{29} steroids and bound C_{27} ones. The bound C_{27} steroids are likely indigenous, although most of the free C_{27} steroids may be contaminants. From two cetacean fossils and a desmostilyan fossil, only free C_{27} steroids, which mainly constitute steroid hydrocarbons such as cholestanes, were identified. The cholestanes are diagenetic products of cholesterol, and thus, these are not directly derived from living vertebrates including humans. These results confirmed that the indigenous steroids are preserved as free and bound components in the fossil bones of Oligocene cetaceans and desmostilyans from Ashoro. Hence, these steroids can be useful for paleodietary reconstruction by $\delta^{13}C$ analysis.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

FACIES ANALYSIS AND DEPOSITIONAL ENVIRONMENTS OF THE SAINTS & SINNERS QUARRY (SSQ) IN THE LOWER NUGGET SANDSTONE (LATE TRIASSIC) OF NORTHEASTERN UTAH SHOW THAT THE DIVERSE VERTEBRATE ASSEMBLAGE WAS PRESERVED IN A LACUSTRINE INTERDUNAL ENVIRONMENT

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The Saints & Sinners Quarry preserves the only vertebrate body fossils in the Nugget Sandstone and the most diverse fauna known from the Nugget-Navajo-Aztec sandstone erg. The fauna includes 8 genera and >15,000 bone and bone fragments assignable to >50 individuals, including theropods, sphenosuchians, sphenodontians, drepanosaurs and a dimorphodontid pterosaur. Cycadeoid fronds are the only plant fossils. There are no aquatic fossils.

The geology of this unique site shows there are two depositional environments – dune and interdune. Dune facies are 1) large to small trough cross-stratified (TCS) sandstones = dry dunes and 2) massive sandstones with relict TCS stratification = bioturbated, damp dunes. Interdune facies are: 1) adhesion/wrinkle laminated sandstones with cm-scale dunes = wet-damp flats with biofilms and tridactyl tracks; 2) green clays (mm scale) = quiet water lacustrine; (3) laminated very fine sands = lacustrine dust/sand storm deposits which grade laterally into 4) massive sands with relict ripples and articulated to disarticulated bones = shoreline facies (bonebeds).

The interdune flat developed by deflation of dunes down to, or near to, the water table. The flat variably hosted biofilms, sand adhering to the damp surface, salt pressure ridges, and cm-scale dunes. As the water table rose, a shallow lake developed and trapped wind-blown sediment during haboobs (dust/sand storms) and dunes migrated into the lake. There was a mass die off (?drought). The carcasses and bones were buried during three distinct haboobs resulting in three, stacked sandstones (wave action on beach) – each a bonebed (BB) - separated by very thin clays (quiet water). Small, complete carcasses are preserved at the top of BB1, between BBs1-2, and up to the middle of BB2. Larger associated to disarticulated bones are at the top of BB2 indicating increasing maceration and reworking. BB3 contains reworked, disarticulated bones (some with weathering cracks) and strongly oriented elongate bones due to wave action. The shoreline fluctuated dramatically and small theropod tracks are preserved in the wrinkled beds that developed above the shorelines during water level drops. Then, the interdune was buried by dunes, the lower portions of which are highly bioturbated.

The site indicates a previously unrecognized, remarkably diverse vertebrate fauna thrived in the interdunes of western North America's Late Triassic erg system. At the Saints and Sinners site conditions were ideal to rapidly bury the carcasses and delicate bones and preserve them largely uncrushed.

Technical Session XIV (Friday, October 28, 2016, 2:15 PM)

A NEW SPECIES OF TRAVERSODONT CYNODONT WITH TRITYLODONT-LIKE FEATURES AND POSSIBLE ARBOREAL ADAPTATIONS FROM THE UPPER NTAWERE FORMATION, NORTHEASTERN ZAMBIA

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The phylogenetic position of Tritylodontidae remains problematic. Two main hypotheses concerning the closest cynodont relatives of tritylodontids are active: (1) they are derived gomphodonts; or (2) they are the sister taxon to Mammaliaformes within an otherwise carnivorous clade (Probainognathia). As with some other problematic taxa, tritylodontids first appear in the fossil record with nearly all of their derived features in place; 'stem-tritylodontids' have yet to be recognized. Here we describe a new taxon that may help bridge this gap.

The Triassic rocks of the Ntawere Formation in northeastern Zambia include two horizons that have yielded tetrapod assemblages suggesting two distinct ages. The lower horizon includes fossils typical of the *Cynognathus* Assemblage Zone of the Karoo Basin, including *Cynognathus*, *Diademodon*, and *Kannemeyeria*. The upper horizon, which has been interpreted as representing a more aquatic environment, includes lungfish, temnospondyls, the silesaurid archosaur *Lutungutali*, dicynodonts, and the cynodonts *Cricodon* and *Luangwa*. We add to this list a new traversodont species based on two nearly complete skulls, one with articulated postcrania, as well as a third fragmentary mandible.

The two skulls are relatively small, with a maximum length of ~4 cm. The more complete specimen preserves an articulated anterior postcranial skeleton including both forelimbs. The new taxon has typical gomphodont features such as transversely expanded postcanine teeth and a very deep zygomatic arch. However, a number of features point to its recognition as a new species: three small upper incisors coupled with one greatly enlarged and chisel-shaped lower incisor, upper and lower canines reduced in size, and a reduced number of postcanine teeth (4–5). Postcranially, the scapula bears a distinctive, rod-like acromion process. The manual phalangeal formula is 2,3,3,3,3, but the individual phalanges are relatively long and gracile when compared to other eucynodonts, with well-developed unguals and especially elongate penultimate phalanges, features suggestive of arboreality.

Adding the Ntawere cynodont to a taxonomically broad analysis of cynodont relationships yields twelve minimum length trees. In six of these trees, the Ntawere form is recovered as the sister taxon to Tritylodontidae and most other arrangements show it just outside of the clade (Tritylodontidae+*Gomphodontosuchus*+*Exaeretodon*). Although preliminary, this analysis suggests that tritylodontids are derived gomphodonts.

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Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

THE OLDEST CRANIODENTAL REMAINS OF ANTHRACOTHERIIDAE (MAMMALIA, ARTIODACTYLA) FROM THE PALEOGENE OF AFRICA

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Anthracotheriidae has long been recognized as an extinct family of artiodactyls that likely originated in the middle Eocene in Asia, and by the late Eocene and early Oligocene had diversified broadly throughout Africa, Eurasia, and North America. In the Fayum Depression, Egypt, anthracotheres appear to be absent from locality BQ-2 (~37 Ma) as well as from Dur at-Talah (~36 Ma) in Libya. This absence may be ecological but is likely not taphonomic given the wide range of mammalian body sizes represented at both localities. The oldest definitive anthracotheres from Africa are fragmentary postcrania of a relatively large taxon from the uppermost part of the late Eocene Qasr el Sagha Formation (~35 Ma) in the Fayum Depression. However, paleontological work at the latest Eocene Fayum Quarry L-41 (~34 Ma) has led to the recovery of additional specimens of a smaller anthracothere, including many craniodental remains that preserve nearly complete upper and lower dentitions. These specimens exhibit a combination of distinctive features not seen together in other African anthracotheres, including a simplified P1/p1, a caniniform i3, and more low crowned and bunodont molars than other Fayum anthracotheres. The L-41 anthracotheres differ from early Oligocene *Siamotherium* from Thailand in having M3 larger than M2, upper molars with much better developed and labially projecting mesostyles, much stronger parastyles, narrower, less robust lower premolars and in having a distinct c1–p1 diastema. They further differ from early late Eocene *Anthracokeryx* from Myanmar in lacking relatively long p2–3 and p1–2 diastemata, in having relatively small and short upper and lower canines, and in

lacking a long P1–C1 diastema. Results from these comparisons between the new L-41 specimens and presumed primitive Asian anthracotheres confirms the presence of at least one, and possibly two, new species of anthracothere in the Fayum by ~34 Ma. It is apparent that an extensive assemblage of anthracotheres was present in North Africa in the late Eocene suggesting that a rapid adaptive radiation occurred after the arrival of ancestral forms at approximately 36 Ma.

Grant Information
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Technical Session II (Wednesday, October 26, 2016, 8:15 AM)

OSTEOLOGY, PHYLOGENY AND FUNCTIONAL MORPHOLOGY OF TWO JURASSIC LIZARD SPECIES INDICATE THE EARLY EVOLUTION OF SCANSORIALITY IN GECKOES

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Late Jurassic lizards from Solnhofen, Germany, are some of the oldest known articulated lizard specimens in the world, and are also the most complete Jurassic squamates. These specimens are thus very important to our understanding of early squamate evolution, with valuable information regarding morphology, taxonomy, and phylogeny. *Eichstaettisaurus schroederi* and *Ardeosaurus digitatellus* are two of the best-preserved species from that locality, the former being represented by the most complete Jurassic lizard specimen known anywhere in the world. Despite their relevance to broad questions in squamate evolution, their morphology has never been described in detail, and their systematic placement has been under debate for decades. Here, we provide the first detailed morphological description, species level phylogeny and functional morphological evaluation of *E. schroederi* and *A. digitatellus*. We identified previously undescribed features of *E. schroederi* linking this taxon to gekkotans, such as the Meckelian canal being closed and fused medially, ectopterygoid lying dorsal to transverse process of pterygoid, and autopodial digit symmetry. Using a revised and updated dataset containing 610 characters and 193 taxa, we corroborate their initial placement as geckoes—stem gekkotans, more specifically. This is of fundamental importance to the early evolution of squamates, as it demonstrates the existence of yet another major extant squamate clade (Gekkonomorpha) in the Jurassic. Additionally, both taxa illustrate a number of climbing adaptations (e.g. shape of unguals, penultimate phalanges, and body proportions), which indicates a scansorial lifestyle arose earlier in the evolution of geckos than previously known. Autopodial modifications associated with digital hyperextension and adhesive toepads (e.g. depressed and reduced intermediate phalanges, and arcuate penultimate phalanges), which provide geckoes with a highly sophisticated climbing apparatus, are not present. Therefore, our findings further suggest that morphological adaptations for scansoriality evolved in geckoes prior to the first known occurrence of adhesive toepads in the Cretaceous. Our results provide support from the fossil record to most molecular and combined evidence estimates of the origin of most major clades of squamates, including geckoes, which usually place divergence times for their stem back in the Jurassic or the Triassic.

Grant Information
Vanier Canada Graduate Scholarship

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

BONE MODIFICATIONS INDICATING PATHOLOGY WITHIN A MONOSPECIFIC HADROSAUR BONEBED FROM THE LANCE FORMATION (MAASTRICHTIAN), WYOMING

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A monospecific hadrosaur bonebed (*Edmontosaurus annectens*) from Upper Cretaceous (Maastrichtian) of the Lance Formation Wyoming, USA contains abundant examples of bone modifications/natural occurring abnormalities. Bones suggest various pathologies that troubled this dinosaur population. The study of bone modifications/abnormalities contributes to a better understanding of population behavior and specific features of individual species.

Bones within the bonebed are very well preserved, scattered and disarticulated. We examined over 2,000 bone specimens ranging from skull bones, vertebrae, ribs to proximal-distal limbs and hind limbs bones. Eighty-two of these specimens have one or some modifications suggesting pathology. Examples of these modifications are: tooth traces, fractures (associated with callus), bone fusion, non-alignment, osteophytes, osteomyelitis, osteochondrosis, ossification of interspinous ligaments and other atypical bone texture. We classified modified bones according to probable causes such as trauma, infection, traumatic-infection, development, and idiopathy.

Results indicated that the most frequently found bone types with modifications are vertebrae and pedal phalanges. Sixty-two vertebrae have various modifications within the caudal portion of the tail suggesting mostly traumatic injuries and some traumatic-infectious injuries. Thirteen pedal phalanges have subcircular-elliptical depressions indicative of osteochondrosis suggesting developmental abnormalities. We also observed other bones with modifications indicating developmental and idiopathic causes.

The common occurrence of bone modification of the tail suggests that the probable cause for these traumatic injuries is intraspecific trampling. Numerous occurrences of osteochondrosis in pedal phalanges indicates possible hadrosaur developmental predisposition to this pathology. Previous studies of other hadrosaur bone collections indicate similar types of pathology and behavioral interactions such as trampling.

Symposium I (Wednesday, October 26, 2016, 9:00 AM)

TOF-SIMS AS A TOOL FOR MOLECULAR IDENTIFICATION IN VERTEBRATE FOSSILS—CAPABILITIES AND LIMITATIONS

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Time-of-flight secondary ion mass spectrometry (TOF-SIMS) is a chemical surface analysis technique that is increasingly used for molecular identification in fossils. Like other mass spectrometry methods, TOF-SIMS can generate spectra that uniquely identify molecular species but, however, it does not require chemical extraction, thus minimizing the associated potential for molecular loss or modification. TOF-SIMS spectra show characteristic signals from molecular species in the mass range up to 1000–2000 Da that derive from the sample surface and can be mapped at a spatial resolution down to the < 1 µm range. TOF-SIMS data have recently been used as chemical evidence for the pigment eumelanin in several fossil samples, including Eocene fish eyes, Mesozoic marine reptile skin and Jurassic dinosaur plumage, based on detailed agreement between the fossil spectra and modern eumelanin standards. However, TOF-SIMS is a relatively complex method, and careful evaluation of the data is critical for accurate interpretations. Furthermore, the chemical evidence provided by TOF-SIMS is limited to the molecular information that is contained in the mass spectra, which thus needs to be considered when evaluating the data.

Here, we discuss the capabilities and limitations of TOF-SIMS for molecular identification in vertebrate fossils with particular emphasis on melanic pigments. We examine TOF-SIMS spectra from a variety of fossils, with and without expected melanin content, and compare these to a selection of relevant modern standard compounds, including different types of melanins and porphyrins. We show that TOF-SIMS can provide reliable evidence for the presence of eumelanin-like moieties in the mass range up to 150–200 Da. This evidence is based on detailed agreement between fossil and standard spectra, including both peak positions and the relative signal intensity distributions of all major peaks. Conversely, the identification of pheomelanin is less reliable, because sulfur can be diagenetically incorporated into the eumelanin molecular structure, generating spectral features similar to those of pheomelanin. Furthermore, taphonomic and diagenetic alterations of the macromolecular properties of the eumelanin polymer structure, such as cross linking, cannot be probed by TOF-SIMS.

Grant Information
Swedish Research Council

Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

PLEISTOCENE PRIMATES AND RODENTIA FROM MARKAYTOLI, LOWER AWASH VALLEY, ETHIOPIA: TAPHONOMIC AND PALEOENVIRONMENTAL IMPLICATIONS

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The Markaytoli watershed is a fossiliferous region in the Ledi-Geraru Research Project area in the Lower Awash Valley of Ethiopia. The Markaytoli collection area encompasses a single square kilometer and has yielded a variety of fossil vertebrates including primates, rodents, ungulates, crocodiles, fishes, and squamates. Biochronological analyses tentatively suggest a middle Pleistocene age. Here, we offer a preliminary report on fossil primates and rodents based on field surveys from 2004 and fossils collected from 2012 through 2015. Primate remains make up 18.6% of the assemblage. Colobines and cercopithecines are represented in a total sample of 40 craniodental specimens belonging to both juvenile and adult individuals. Ecomorphological analysis of primate postcrania indicates arboreal adaptations. Rodents comprise 10.2% of the Markaytoli specimens, with 42 craniodental specimens assigned to at least three taxa. The rodent assemblage is dominated by *Thryonomys* cf. *T. swinderianus*. The presence of intact owl pellets in association with smaller-bodied, non-*Thryonomys* rodents suggests that owls were responsible for the accumulation of at least part of the assemblage.

The preservation of small and relatively complete rodent and primate specimens, including multiple elements in association, indicates a low-energy depositional environment. Sedimentology of the site and surrounding area suggests a dynamic depositional paleolandscape dominated by river systems. The abundance of *Thryonomys* cf. *T. swinderianus* indicates a well-watered grassy wetland habitat, and primate ecomorphology suggests the presence of tree cover. Correspondence analysis based on adaptations of the whole faunal community indicates a habitat that is wetter and more closed than other Lower Awash Valley sites. We interpret the habitat of Markaytoli as a riverine forest adjacent to more open habitats.

Grant Information
Research supported by the National Science Foundation (BCS 1460493/1460502) and the John Templeton Foundation.

Romer Prize Session (Thursday, October 27, 2016, 11:15 AM)

MOUNTAINS AND MAMMALS: LINKING LANDSCAPE AND CLIMATE CHANGE TO DIVERSIFICATION IN NEOGENE RODENTS

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A central question linking geological and biological processes is the influence of landscape and climate history on diversification. For mammals today, mountains are among the most diverse ecosystems globally, yet the strong relationship between species richness and topographic complexity is not a persistent feature of the fossil record. To understand the origin and dynamic history of the topographic diversity gradient (TDG), I investigated the Neogene rodent record in western North America in relation to landscape

change. To evaluate the biogeographic processes—speciation, extinction and immigration—driving the TDG, I compiled species-occurrence records from the NeoMap database and calculated diversification rates for 1-myr time intervals in the Basin and Range Province. Diversification rates in the montane west varied significantly through time, peaking during the middle Miocene interval of global warming and regional intensification of tectonic activity.

Two factors—temporal and geographic variation in the distribution of the rock record and origination due to speciation or immigration—potentially limit our ability to interpret this diversification history and thus the origin of the TDG. Because heteromyid rodents represent a large contribution to present and past species richness in the tectonically active west, I evaluated diversification patterns in their fossil record against predicted patterns from models in which variation is simulated for preservation, speciation and extinction rates over space and through time. Preservation bias related to sparse early Miocene formations in the Basin and Range Province may contribute to the initial pattern of low heteromyid diversity in this region. In contrast, a significant pulse of origination is supported during the middle Miocene interval of extension and warming and underlies the appearance of a third of fossil heteromyid species, half of which occur in the Basin and Range Province. Utilizing a modified Jaccard Similarity Index, I found exceptionally low faunal similarity across the province during this time, implying that origination is driven by in-situ speciation. In the Mojave, both high beta diversity among basins and high alpha diversity within faunal assemblages contribute to regional species richness. Finally, a modest increase in faunal similarity during global warming also provides evidence for immigration elevating diversity during this time of pronounced landscape change. Thus, multiple biogeographic processes contribute to the TDG when it is present.

Grant Information
Supported by the NSF Graduate Research Fellowship, SVP Patterson Memorial Grant, and University of Michigan Turner Award and Rackham Graduate Fellowships.

Technical Session XVIII (Saturday, October 29, 2016, 2:45 PM)

BASICRANIAL AND VERTEBRAL PNEUMATICITY IN THERIZINOSAURS: IMPLICATIONS FOR DEVELOPMENT AND FUNCTION

SMITH, David K., Northland Pioneer College, Holbrook, AZ, United States of America; SANDERS, R. Kent, North Canyon Medical Center, Gooding, ID, United States of America; WEDEL, Mathew J., Western University of Health Sciences, Pomona, CA, United States of America; WOLFE, Douglas G., White Mountain Dinosaur Exploration Center, Greer, AZ, United States of America

Axial pneumaticity in theropods extends throughout the presacral vertebrae and the basicranium. The basicranial pneumatic system of the therizinosaur *Nothronychus mckinleyi* was recently presented. Presacral vertebrae were CT-scanned, with the goal of describing the internal structure and ultimately modeling the pneumatic system in therizinosaurs.

The basicranial pneumatics of theropods have been subdivided into the median pharyngeal, subcondylar, and tympanic systems. Therizinosaurs were described as exaggerating all basicranial pneumatic chambers. Recent study of the *Nothronychus* basicranium, however, neglects the link with vertebral pneumatization patterns.

The median pharyngeal and subcondylar systems are surrounded by an ossified epithelium surrounding a complex chamber. This development may be regulated by the same genes that control cervical vertebral embryology. As the basicranium is derived from rostral elements of the spine, it is likely that regional skeletal growth and pneumatization are similarly controlled. Therefore, the pneumatization of the basicranium mirrors that of the cervical vertebrae in typical theropods.

The tympanic recess is the only enlarged chamber in *Nothronychus*. Size increase of this chamber is associated with increased sensitivity to low frequency sound by relaxing impedance on the stapes. This mechanism has been observed in extant archosaurs.

The extensive vertebral pneumaticity of *Nothronychus* is compared to the avian condition. Pneumatic diverticulae invaded the presacral vertebrae of *Nothronychus* through foraminae. In birds, connections also occur in the vertebral canal, intervertebral foramina, and outside the skeleton in the lateral and dorsal air sacs. Anastomosing cervical and thoracic paravertebral air sacs, both lacking gas exchange parenchyma, were likely present in *Nothronychus*.

Thoracic and abdominal air sacs alone have not proven indicative of endothermy, as most reptiles have nonvascular air sac equivalents and unidirectional pulmonary air flow. A more consistent link is in the skeletal hyperpneumatization of birds, which, when seen in dinosaurs, implies the presence of elaborate air sacs and diverticulae. The thoracic air sacs arise from the apical lung and abdominal sacs from the caudal lung. Both supply diverticulae to the dorsal vertebrae, but only the thoracic to the cervicals, and only the abdominals to the sacral/caudal. In birds, a supramedullary diverticulum in the spinal canal connects the systems. This system is here used as a model for *Nothronychus*.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

UNUSUAL EXHIBIT PROPOSALS FOR THE CARNEGIE QUARRY AT DINOSAUR NATIONAL MONUMENT

SMITH, Elliott A., University of Utah, Salt Lake City, UT, United States of America; KINYON BOODHOO, Thea A., Drexel University, San Francisco, CA, United States of America; CHURE, Daniel J., Dinosaur National Monument, Jensen, UT, United States of America

The Carnegie Quarry (CQ) at Dinosaur National Monument is the first site where large scale in situ preservation and exhibition of fossil vertebrate remains was undertaken. The present CQ, housed within the all-glass Quarry Exhibit Hall, contains some 1500 bones belonging to 13 species of dinosaurs, crocodilians, and turtles. Recent research in the DINO paleo archives has revealed past plans for quarry development that, while quite peculiar, were serious proposals. If adopted, the CQ exhibit would have been radically different and unsuccessful both scientifically and educationally. Fortunately these proposals were not implemented.

(I) The Plywood Quarry: An exhibit development plan for Dinosaur National Monument in 1943 laid out the plans for the development of a permanent museum over the quarry. The author of the report, hired within the National Park Service, developed a vision for the bones in the CQ to be excavated, prepared free of matrix, and then re-assembled into articulated skeletons and attached to wooden panels that would overlay the original quarry face. Several detailed drawings show what this display would look like. C.W. Gilmore (USNM) was so alarmed that he wrote directly to the Director of the Park Service to decry this plan as a scientific travesty.

(II) Luminous Bones: In 1944, an NPS employee and an outside geologist/paleontologist made the recommendation to the National Park Service that all the exposed bones be painted with glow-in-the-dark paint. The building enclosing the quarry would have no windows and thus when the lights in the museum were turned off; visitors would be awed and overwhelmed by a large wall full of glowing bones.

(III) The Windowless Visitor Center. The architectural design for the 1958 Quarry Visitor Center envisioned a glass building that allowed for maximum use of ambient light and visually link the CQ to the tilted formations in the quarry area. Park Service officials initially balked at the idea, preferring instead a windowless facility which would allow them to highlight specific bones by spotlights. The original design prevailed.

While these ideas seem unusual today, they reflect the unique conceptual challenges presented to those planning for the development of the first in situ fossil vertebrate exhibit. Fortunately they are just footnotes to history. We will have blue prints and simulations for these proposals for those interested.

Grant Information
Geoscientists-In-The-Parks (GIP) Program—Geological Society of America
Mosaics-In-Science Program—Geological Society of America
National Park Service

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

THE YELLOWSTONE HOT SPOT AND WESTERN FRESHWATER FISH EVOLUTION

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The Yellowstone Hot Spot Track extends from the Nevada-Oregon-Idaho border area northeastward to Yellowstone, Wyoming. It is a sequence of Neogene calderas beginning 16.2 Ma, marking the progression of the North American Plate southwestward over a mantle plume. The Continental Divide has been interpreted to be the current manifestation of thermal uplift in response to the mantle plume. The thermal uplift phenomenon implies a sequence of ancient high paleoelevations on the caldera sites progressing northeastward across southeast Oregon, southwest Idaho, and the Eastern Snake River Plain. This also implies rivers radiating away from uplifted sites, similar to that seen in the Yellowstone area. Regional biogeographic distributions indicate that the area's fishes colonized from the southwest and west: first, to the Barstovian Sucker Creek Formation in the Oregon-Idaho Graben (six spp.), then the Clarendonian Juntura Formation (nine spp.) and Drewsey Formation (14 spp.) in the Juntura-Drewsey Graben. Next, the Clarendonian Poison Creek Formation (10 spp.), the Hemphillian Chalk Hills Formation (19 spp.), and the Blancan Glenns Ferry Formation (32 spp.) are in the Western Snake River Plain, Idaho and Oregon. We test the migrating Continental Divide hypothesis with fish distributions, which are negatively correlated with stream elevation and slope, providing a method for estimating paleoelevation and drainage direction. Two patterns support the predicted change in diversity attributable to high elevations on the hotspot track: (1) fish colonization from the west implies middle Miocene drainage beginning 16.2 Ma and connecting to Pacific tributaries, also connecting the Oregon-Idaho Graben; and (2) the divergence of species between the Chalk Hills and Cache Valley formations coincides with a barrier at the Twin Falls Calderas, consistent with different detrital zircon ages on the eastern vs. western plain. Fish species differences in the Chalk Hills, Idaho, and Cache Valley, Utah, imply a prior connection followed by isolation at about 10 Ma. Cutthroat and Redband trouts are also separated between the Eastern and Western Snake River Plains. However, there are no Neogene Atlantic drainage fishes west of the Neogene Continental Divide near Yellowstone. Many of these lineages have modern descendants, allowing DNA molecular clock tests of divergence and connection ages. Finally, volcanic ash and lava are seen to depress fish diversity, initially, but their dissolution causes later increases in primary productivity and aquatic diversity.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

PROBOSCIDEAN DIETARY VARIABILITY IN NORTH AMERICA AND THE COMPETITIVE EXCLUSION PRINCIPLE

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Proboscideans, currently represented by only three extant species of elephant (*Loxodonta africana*, *L. cyclotis*, and *Elephas maximus*), were once a highly diverse group of megaherbivores that played a large role in shaping past ecosystems. Three proboscidean taxa inhabited Plio-Pleistocene North America, each exploiting a unique dietary niche: mammoths (grazing specialists), mastodons (browsing specialists), and gomphotheres (potential mixed-feeding generalists). Mammoth and mastodon dietary inferences arise from an understanding of molar morphology and have been tested via stable isotope analysis and dental microwear. Gomphothere diets are less understood and more variable; populations from different times and different locations often return varying dietary preferences. Most paleoecological analyses on gomphotheres come from South America, where they survived later and were the only resident proboscideans. We know little, therefore, about how gomphotheres may have altered their diet when in contact with mammoths and mastodons.

To highlight dietary variability among the three North American proboscideans through time, we compiled isotopic data on each taxon reported from the literature and supplemented with new data. We find that gomphothere $\delta^{13}C$ values in tooth enamel shift through time from C_3 consumers during the Miocene (mean $\delta^{13}C$ = -10.4 ‰) to mixed C_3/C_4 consumers in the Pleistocene (mean $\delta^{13}C$ = -4.9 ‰) prior to and after C_4 grass expansion. Mammoths from the late Pleistocene display a wide range of $\delta^{13}C$ values (-14.4 ‰ to 0.5 ‰). Individuals with low $\delta^{13}C$ values occurred in the Yukon, California and the Great Lakes region, while those with higher $\delta^{13}C$ values occurred in Florida, Texas and the Southern Great Plains, suggesting a C_3 and C_4 grass dominated diet,

respectively. In contrast, mastodons retain a predominantly C_3 dietary signal, likely consisting of browse (all $\delta^{13}C \leq -8.4$ ‰), throughout their range and through time.

Spatially and isotopically, gomphotheres and mastodons rarely overlap. This may reflect disparate dietary preferences and explain why the two taxa were able to co-occur in North America since the mid-Miocene. On the other hand, mammoths are cosmopolitan taxa and often overlap both spatially and isotopically with coeval proboscideans. This overlap of diets suggests that mammoths may have competitively excluded gomphotheres and led to their early extirpation from North America; however, more work is needed to test competitive exclusion hypotheses within the Proboscidea.

Grant Information
GSA Research Grant

Poster Symposium I (Wednesday–Thursday, October 26–27, 2016, 4:15–6:15 PM)

NEWLY DISCOVERED CRANIAL, POSTCRANIAL, AND SHELL SPECIMENS OF *BAENA ARENOSA* AND *CHISTERNON UNDATUM* FROM THE UINTA FORMATION, UINTA BASIN, UTAH, USA: INSIGHTS INTO MORPHOLOGICAL VARIATION AT THE END OF THE BAENID RADIATION

SMITH, Heather F., Midwestern University, Glendale, AZ, United States of America; HUTCHISON, J. Howard, Escalante, UT, United States of America; JAGER, Daniel M., Midwestern University, Glendale, AZ, United States of America; ADRIAN, Brent, Midwestern University, Glendale, AZ, United States of America; TOWNSEND, K.E. Beth, Midwestern University, Glendale, AZ, United States of America

The Baenidae were an extinct clade of North American river turtles with an extensive radiation that spanned from the Early Cretaceous to the middle Eocene, and included over 30 species. The last known occurrence of this abundant family falls during the Uintan North American Land Mammal Age (46.2-42 Ma). A partial skull, previously undescribed postcranial elements, and numerous well-preserved shells of baenid turtles *Baena arenosa* and *Chisternon undatum* were recently discovered from the Uinta Formation, Uinta Basin. These fossils represent among the youngest known specimens of the baenid clade, and provide insight into the morphology, evolution, and development of this diverse family just prior to its extinction.

A newly recovered partial baenid cranium, including portions of the basicranium, neurocranium, face, and lower jaw from Uinta B is consistent with a diagnosis of *B. arenosa*, although several intriguing differences were observed. In particular, the condylus occipitalis is crescent-shaped and concave dorsally, the tuberculum basioccipitale flare out laterally, and there is a distinct frontal-nasal suture. The current sample also considerably expands the documented variation in shell morphology in the hypodigms of *B. arenosa* and *C. undatum*. Several novel shell characters not previously observed in these taxa are identified, such as sigmoidal extragular-humeral sulci and small, subtriangular gular scutes. Included among the recently discovered specimens are subadult individuals of both species, which permit a detailed study of discrete bony elements prior to fusion, reveal ontogenetic processes in these taxa, and demonstrate that diagnostic morphological differences between these two sympatric taxa were present from an early developmental age.

These newly discovered Uintan baenid specimens provide valuable insight into the morphology and evolution of this diverse and speciose family at the end of its radiation. They greatly increase the known variation in these late-surviving taxa, and indicate that several characters thought to delineate the species should be redefined.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

LARGE TETRADACTYL FOOTPRINTS IN THE UPPER CRETACEOUS HUNTER CANYON FORMATION OF WESTERN COLORADO: ICHNOLOGICAL EVIDENCE FOR THERIZINOSAURIDS IN THE CAMPANIAN OF NORTH AMERICA?

SMITH, Joshua A., Dominguez Anthropological Research Group, Grand Junction, CO, United States of America; ZANNO, Lindsay E., North Carolina Museum of Natural Sciences, Raleigh, NC, United States of America; LOCKLEY, Martin, University of Colorado Denver, Denver, CO, United States of America

A large landslide in the Upper Cretaceous (Campanian/Maastrichtian) Hunter Canyon Formation of western Colorado reveals abundant vertebrate and invertebrate ichnofossils, along with plant fossils including *in situ* tree boles. Here, the Hunter Canyon Formation is the stratigraphically highest formation in the Mesaverde Group, and preserves fluvio-deltaic sediments deposited in the Western Interior Basin in various coastal plain and marginal marine environments during the terminal regression of the Western Interior Seaway. Among the vertebrate ichnofossils exposed in this landslide are large, tetradactyl footprints of an unidentified animal in multiple trackways, preserved as sand infillings in convex hyporelief on the underside of a single large talus block that is now laying on its side. These tracks show broad, rounded metapodial pes impressions with four pointed phalanges that can vary in degrees of divarication on each print in a single trackway, and they appear to have been made by a bipedal animal as there are no obvious associated manus impressions. The trackways are interspersed among occasional impressions of *in situ* tree boles also preserved as sand infillings in convex hyporelief, with one of the tracks nearly touching one of the boles.

Skeletal remains of large, tetradactyl bipeds are unknown in Campanian/Maastrichtian sediments of North America, making it difficult to readily identify this trackmaker; however, therizinosaurid dinosaurs are known to have a functionally tetradactyl pes, and are also known to have inhabited Late Cretaceous ecosystems of the Western Interior Basin. Therizinosaurids are a unique, enigmatic clade of herbivorous, maniraptoran theropod dinosaurs known from the Late Cretaceous of Asia and North America, with the youngest documented occurrence in the Western Interior Basin being the large-bodied taxon *Nothronychus mckinleyi* from the Middle Turonian Moreno Hill Formation of New Mexico. If the Hunter Canyon ichnofossils can unequivocally be demonstrated to have been made by a therizinosaurid dinosaur, an approximately 20-million-year temporal gap in the skeletal record is shown for this clade in North America, indicating that therizinosaurids survived in coastal plain and marginal marine environments in the Western Interior Basin throughout much of the Late Cretaceous. Alternatively, Campanian/Maastrichtian therizinosaurs in North America could have been immigrants from Asia, further supporting the hypothesis of faunal interchange between these continents during the Late Cretaceous.

Preparator's Session (Thursday, October 27, 2016, 9:15 AM)

CUTTING BONE—A CREATIVE USE OF CYCLODODECANE (CDD) IN HISTOLOGIC SECTIONING OF FOSSIL SPECIMENS

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Histology is a growing field in vertebrate paleontology and it is being incorporated into many fossil preparation labs. Since the kind of sectioning equipment varies among institutions, there is often a period of trial and error in establishing in-house protocols for histology practices, especially for the first step of removing a sample of fossil bone. The portion of the bone must be removed from the rest of the specimen and embedded in a resin block that is subsequently cut, sectioned, and polished. This first step was one of the largest hurdles faced in the lab at Petrified Forest National Park (PEFO). Breaking the bone along preexisting fractures is easily carried out by weakening the fracture with acetone, water, or other means. If a fracture was not already present, the best option is to use a precision saw. The goal is to minimize damage to the remaining fossil and to maximize the number of viable sections to be taken from the resin block.

As a solution, PEFO developed a technique for sawing through fragile Triassic specimens while maintaining their integrity without cracking or splintering unstable or oddly-shaped fossil bones. After consolidation with Acryloid B-72, a specimen was coated in a layer of Carbowax™ 4000 polyethylene glycol (PEG) to stabilize the bone. The resulting globular shape did not fit the saw at PEFO, which lacks a chuck for holding the specimen. Instead, placing the coated fossil in a square block of plaster allowed the swing arm of the saw to hold the specimen and maintain a rigid base to stabilize the specimen during the cut. Liquid plaster contains water, therefore hydrophobic CDD was utilized as the coating instead of hydrophilic PEG. Major cuts for histological sectioning are typically made perpendicular to the length of a long bone. Although the stabilizing technique of CDD and plaster proved to be an effective way to safely cut the specimen, error in the angle of the cut was introduced because a thick layer of CDD prevents the preparator from seeing the actual fossil; it was difficult to judge the exact angle when placing the specimen in the plaster. The result is that by using a thinner layer of CDD (no more than 1.5 mm thick), observing anatomical features not embedded in the plaster, and photos of the entire bone, preparators are now able to consistently orient and cut fossils at the proper angle for histologic analysis while introducing a minimum of incompatible chemicals to the fossil itself.

Technical Session XIV (Friday, October 28, 2016, 3:15 PM)

TAPHONOMY AND SEDIMENTARY ENVIRONMENTS OF MID-TRIASSIC VERTEBRATE ACCUMULATIONS, LIFUA MEMBER (MANDA BEDS), RUHUHU BASIN, TANZANIA

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Four recent expeditions to southwestern Tanzania investigated strata of the Ruhuhu Basin as part of a project aimed at understanding the biogeographic structure of vertebrate communities across southern Pangea during the Permian and Triassic. New data relating to the climate, sedimentary environments, and burial history of tetrapod fossils in the mid-Triassic Lifua Member of the Manda beds are reported here. Two bone-bearing intervals have been defined—one in the lower-most Lifua containing rare multitaxa bonebed-type occurrences, and the second midway through the succession containing multiple skeletons of the same taxon. Both bone-bearing levels are in overbank redbed facies deposited on the flanks of low-sinuosity rivers that flowed from the Ruhuhu rift scarps into a series of subsiding basins under warm, seasonally-wet climate.

The lower bonebed-type occurrence, only discovered in 2014, contains large dicynodonts (*Angonisaurus* and *Dolichuranus*), large cynodonts (*Cynognathus*), and a number of small archosauromorphs. It is associated with massive pedogenically-mottled sandy siltstone overlying a 2m-thick medium-grained, trough-cross bedded channel sandstone. At the top of this interval a chaotic melange of semi-articulated, disarticulated, and reworked bones occurs at the base of a laminated sandstone interpreted as a distal crevasse splay. Similar floodplain-hosted multitaxa bonebeds have been reported from age-equivalent *Cynognathus* AZ (subzone B) strata in the South African Karoo Basin.

Most vertebrate collections from Manda beds derive from mid-Lifua bone accumulations associated with floodplain scour troughs and deflation hollows that, at times, held standing water. Outcropping as isolated patches of calcified overbank mudrocks, they contain multiple articulated and semi-articulated archosauromorph (*Asilisaurus*) and herbivorous cynodont (*Scalenodon*) skeletons. We propose that increased mean annual rainfall raised the watertables resulting in vegetated semi-permanent water bodies in all the floodplain depressions and the preferred habitat for herbivorous dicynodont, cynodont, and archosauromorph populations. The distinctive change in faunal assemblage and taphonomic style between lower and mid-Lifua strata suggests increasingly wetter climatic conditions in this part of Pangea from early to mid-Triassic similar to the *Cynognathus* AZ of the main Karoo Basin of South Africa.

Grant Information
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Technical Session XIII (Friday, October 28, 2016, 2:00 PM)

QUANTITATIVE DENTAL ECOMORPHOLOGY REVEALS A WIDE RANGE OF MAMMALIAN DIETARY ECOLOGIES IN THE FIRST 1.2 MILLION YEARS FOLLOWING THE CRETACEOUS–PALEOGENE MASS EXTINCTION

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Dental surface data can be used to understand dietary ecology in extinct mammals using information from only one or a few teeth. We used dental surface data to characterize dietary ecology in mammals following the Cretaceous–Paleogene (K–Pg) mass extinction, aiming to understand the tempo and mode of change in dietary ecologies during the transition from species-poor disaster faunas to species-rich, ecologically even recovery faunas. Although previous work has investigated change in mammalian dietary ecology at the K–Pg boundary, it has not extended later than the earliest Pg (within 80,000 years of the extinction) and, consequently, has not captured changes during the period of main faunal recovery.

We collected quantitative three-dimensional (3D) dental surface data (via µCT scans) of lower molars from an ecologically and phylogenetically diverse group of 21 species of extant mammals with known diets, representing 17 families and eight orders. Our comparative sample includes mammals with relatively conservative tribosphenic tooth morphologies, for maximum similarity to early Pg mammals, but wide dietary breadth. We characterized the diets of our extant species from both trophic (e.g., herbivore) and material properties (e.g., hard object feeding) perspectives to obtain a nuanced picture of correlation between tooth morphology and diet. We also collected surface data on 12 species of extinct mammals from the earliest Pg of northeastern Montana. We then measured relief index (RFI), Dirichlet normal energy (DNE), and 3D orientation patch count rotated (3D-OPCR) on all specimens. Using these metrics, we conducted discriminant function analysis to determine dietary ecology in the early Pg mammals and, subsequently, tracked changes in mammalian dietary ecology from the Puercan 1 (Pu) through Torrejonian 1 (To1) North American Land Mammal 'Ages' (NALMAs) up to approximately 1.2 Ma after the extinction. Our results suggest a variety of dietary ecologies were present in the early Pg with higher RFI and DNE values but relatively low 3D-OPCR values (indicative of insectivory) in the Pu1 NALMA and an expansion into lower RFI and DNE values (indicative of the emergence of omnivory and frugivory) by the To1 NALMA. Our data show that diversification of mammalian feeding ecologies was underway soon after the K–Pg mass extinction and was in step with increases in mammalian species richness in northeastern Montana.

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Technical Session XIII (Friday, October 28, 2016, 3:30 PM)

NEW EARLIEST EOCENE MAMMAL FAUNA FROM CLAIROIX, FRANCE: FIRST DEFINITIVE DORMAAL (REFERENCE LEVEL MP7) EQUIVALENT OUTSIDE OF BELGIUM

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The rich earliest Eocene mammal assemblage of Dormaal in northeast Belgium has yielded most of the earliest modern mammals of Europe and is the the reference-level for MP7 in the Mammalian Biochronological Scale of the European Paleogene. Despite the fact that several other localities in Europe, such as Silveirinha in Portugal, Le Quesnoy, Pourcy, Sotteville-sur-Mer, Rians, Palette, and Fordones in France, and the Suffolk Pebble Beds in England, contain faunas that have been correlated to Dormaal, none of them preserve the same fauna as Dormaal with the exception of Erquelinnes in southwest Belgium.

Here we describe the new vertebrate site of Clairoix, located only 13 km from Le Quesnoy in the Paris Basin, France, but 225 km southwest of Dormaal. About 150 kilograms of sandy matrix has produced a collection of about 400 vertebrate specimens including 118 isolated mammal teeth. The fauna is composed of the following typical MP7 species: the herpetotheriid marsupial *Peratherium constans*, the amphilemurid erinaceomorph *Macrocranion vandebroeki*, the hyaenodonts *Arfia gingerichi* and *Prototomus minimus*, the carnivoraforms *Dormaalocyon latouri* and *Gracilocyon solei*, and the omomyid primate *Teilhardina belgica*. Besides these index taxa, the arctocyonid *Landenodon woutersi*, the louisinid "condylarths" *Paschatherium dolloi* and *Paschatherium yvetteae*, a perissodactyl, and several rodents also are present at Clairoix. As in Dormaal, the relative abundance analysis of the species from Clairoix indicates that *P. dolloi* and *P. yvetteae* are the most abundant species, followed by *M. vandebroeki* and *T. belgica,* respectively. In term of number of specimens, *Paschatherium* represents more than 50% of the fauna, which corresponds to the acme of *Paschatherium* defined across the Paleocene–Eocene boundary in continental Europe.

The composition and relative abundance of the mammal fauna of Clairoix are very similar to those of Dormaal and Erquelinnes and suggest a similar or very close age. The results of this work also suggest that the mammal assemblage of these three localities does not only correspond to a different paleoenvironment than that of other MP7 correlated faunas but also to an older age closer to the Paleocene–Eocene Thermal Maximum. Fish, frog, lizard, crocodilomorph, and snake remains were also collected and support a fluvial paleoenvironment at Clairoix.

Grant Information
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Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

FOOT STRESS SCALING CONSTRAINS ESTIMATES OF MASS FOR ISOLATED, LARGE SAURISCHIAN DINOSAUR SPECIMENS

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Tracks and autopodial specimens of sauropod and theropod dinosaurs are occasionally cited as representing exceptionally large individuals. These specimens include sauropod tracks of the Broome Sandstone of Western Australia and Plagne in Southern France, the biggest measuring 1.5 m or more in their largest linear dimension. Among particularly large fossils of theropods, a *Tyrannosaurus rex* phalanx (UCMP 137538) is substantially larger than the homologous bone in the next largest specimen. A common method of first approximating mass of large fossil animals is to cube ratios of linear size between isolated elements and their homologs from more complete specimens, and multiply the ratio by a mass estimate for the smaller individual. However, in humans and elephants body mass scales linearly with surface area of the feet, which maintains foot stress overall and/or stress from mass distribution between fore and hind limbs. Squaring ratios of linear dimensions of foot fossils may be a better method of mass extrapolation than cubing these dimensions.

The large Broome sauropod tracks have been precisely measurable, as clear surface imprints with discrete anatomical features. Squaring ratios of their digital span to those of other titanosauriform sauropods yields much lower estimate of body volume than cubing the ratios, approaching but not exceeding current volumetric estimates of very large sauropods based on body fossils. Squared-ratio and surface area estimates for the *T. rex* phalanx suggest a mass between 11.5 and 14 tonnes, depending on conservative mass estimates for other specimens.

Although foot areas correlate linearly and precisely with mass in humans, the squared-ratio/stress-based methods must be part of a larger range of mass estimates methods for morphologically diverse fossil taxa, especially based on isolated elements.

Technical Session XI (Friday, October 28, 2016, 8:00 AM)

MULTIPLE TECHNIQUES YIELD COMPLEMENTARY DATA ON GYRACANTH ANATOMY

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The gyracanthids are a group of early gnathostomes, traditionally classified within the "Acanthodii". The most recent cladistic analyses show "Acanthodii" plus Chondrichthyes as a sister group to osteichthyans, with *Gyracanthides* possibly the sister group to Chondrichthyes within this clade. In light of this, new information on the composition of gyracanthid dermal structures could help refine our understanding of their relationships. Here, we describe the internal structure of a fin spine and scales of a gyracanth gnathostome from the Mississippian of Delta, Iowa USA.

The clay-rich matrix caused some distortion and crushing, but we visualized and reconstructed the distal end of a left pectoral fin spine with micro-computed topography (µCT). Maximum resolution was approximately 20 µm—too coarse to visualize individual dentine tubules but sufficient to reconstruct much of the internal vascular canal network. As with most gyracanthids, the Delta gyracanth's spine has a central pulp cavity and a separate enlarged subcostal canal. Both are infilled distally, probably an effect of aging, as seen in *Gyracanthides hawkinsi*. Smaller vascular canals run subparallel, though somewhat irregularly, to the central vascular cavity. Several perpendicular canals for blood vessels connect the vascular cavity to the posteromedial groove, indicating a fin web as has been observed in articulated *Gyracanthides murrayi*. In addition to the ornamented gyrating ridges characteristic of gyracanthids, the fin spine has a posteromedial ridge with enlarged hooked denticles. Among European and North American gyracanthids, and in particular the Delta gyracanth, this latter character was variably known and originally thought to have systematic value (e.g., distinguishing *Gyracanthus formosus* from *Gyracanthus denticulatus*). We now know that the variation also may be a preservational artifact.

The flat-based scales of the Delta gyracanth resemble "*Mitrodus*" scales known from other gyracanthids. Instead of the "onion-skin" superpositional growth of most acanthodians, the scales grew by areal addition of spiny odontodes. Thin sectioning shows that the odontodes have wide pulp cavities and are composed of orthodentine, while the thin base is of acellular bone. Some scales are as wide as high with pronounced necks, whereas others are wider but stouter, indicating variation over the gyracanth body. Future work will entail µCT study of gyracanthid scales, especially comparative material from other taxa.

Technical Session XII (Friday, October 28, 2016, 1:45 PM)

THE EVOLUTION OF THE ARCHOSAUR EAR: NEW INSIGHTS FROM THE INNER EAR ANATOMY OF RHYNCHOSAURS (DIAPSIDA, ARCHOSAUROMORPHA)

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Rhynchosaurs were abundant herbivorous archosauromorphs in Triassic terrestrial ecosystems. Recent studies on their anatomy have helped shed light on the phylogenetic relationships and early evolution of the clade, but their braincase anatomy has so far remained largely unknown. Here we present for the first time a detailed analysis of the braincase and inner ear morphology of the basal taxa *Mesosuchus* and *Eohyosaurus* based on high-resolution micro-computed tomography, integrating this information with a more comprehensive analysis of archosaur evolution. In comparison to the non-saurian diapsid *Youngina*, the semicircular canals of rhynchosaurs have longer radii of curvature, with a substantial elongation of the posterior canal in relation to the overall size of the vestibule. Likewise, the floccular fossa of *Mesosuchus* on the medial side of the prootic is a deep and protrudes through the loop of the anterior canal. Since these structures are

responsible for ensuring balance control and coordination of eye and neck movements, their enlargement is indicative of an upright posture and locomotion through a structurally complex three-dimensional environment. The borders of the small fenestra ovalis and of the metotic foramen are also better defined than in *Youngina*. Also, the thickened ventral ramus of the opisthotic of *Mesosuchus* more effectively separates these structures, resulting in the avoidance of sound transmission along routes without the sound-detecting epithelia, and thus in an enhanced sense of hearing. This structural separation also increases the pressure-relief function of the metotic foramen. In comparison to the more derived archosauriform *Euparkeria*, rhynchosaurs show fewer modifications to the inner ear such as a smaller metotic foramen and a less elongate cochea and semicircular canals. In archosauromorphs, the stapes in only known for *Prolacerta*. The one of *Mesosuchus*, however, is more similar to that of *Youngina*. Our analysis places the braincase and inner ear morphology of rhynchosaurs as intermediate between stem-diapsids and stem-archosaurs, pointing to a gradual, not straightforward, acquisition of derived hearing characters.

Technical Session XIII (Friday, October 28, 2016, 2:45 PM)

A NEW HAPALODECTID (MESONYCHIA, MAMMALIA) FROM THE LATE PALEOCENE OF THE QIANSHAN BASIN (ANHUI PROVINCE, CHINA): NEW DATA ON THE RADIATION OF THE HAPALODECTIDS

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Mesonychians are an extinct group of primitive hoofed mammals. They have been found all over Laurasia and were well diversified: more than 20 genera are presently recorded. Mesonychia are divided into two families: Hapalodectidae and Mesonychidae. Hapalodectidae are recorded from the late Paleocene to the middle Eocene in Asia (Gashatan to Irdinmanhan), and in the early Eocene in North America (from Wasatchian to early Bridgerian). Hapalodectids remained small: the species of *Hapalodectes*, the type genus of the family, weighed between 500 g and 1 kg. Because the hapalodectids are relatively rare mammals, the discovery of new specimens, especially in the Paleocene, is crucial for understanding the evolution of these peculiar mammals.

Field work in Qianshan Basin (Anhui Province, China) led to the discovery of a new lower jaw of the mesonychian *Hapalodectes* in Gashatan (late Paleocene) sediments. It is worth noting that the fragmentary mandible is only the third specimen of Hapalodectidae discovered in the Paleocene, and the first in southeast China. The premolars and molars of the new fossil are morphologically similar to *Hapalodectes dux*, the most primitive hapalodectid, but their relative proportions recall *H. paleocenus* and the Eocene *Hapalodectes* species. As a result, the fossil described herein appears to be different from the other previously described species of *Hapalodectes* in being morphologically intermediate between *H. dux* and the other *Hapalodectes* species; it is thus identified as a new species. Its discovery is important because it sheds light on the initial radiation of the hapalodectids. The presence of the most primitive hapalodectids in Mongolia (e.g., *H. dux*) suggests that the Mongolian area is the center of origination of this carnivorous family. The differences between the new species and the Eocene hapalodectids from China, *H. huanghaiensis* and *H. hetangensis*, imply that these species do not derive from the newly described species. Therefore, the new Chinese hapalodectid allows reconstructing the existence of two dispersals from the Mongolian area to the southeast of China, before and shortly after the Paleocene–Eocene boundary. At that latter time, *Hapalodectes* also dispersed from Asia to North America; this event was part of the 'East of Eden' dispersals. The Paleocene/Eocene transition thus appears as a crucial event for the distribution and radiation of the hapalodectids with the establishment of two distinct groups, respectively in North America and in the southeast of China.

Grant Information
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Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

MAMMALIAN TAPHONOMIC ENVIRONMENT OF PLEISTOCENE FOSSIL LAKE, OREGON

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Taphonomic studies of fossil assemblages are essential for interpreting the paleobiology and paleoecology of extinct vertebrates and can help us decipher depositional environments for paleo-environmental reconstructions. The purpose of this study was to characterize the depositional environment of Pleistocene Fossil Lake, Oregon through a taphonomic study of its mammalian fossils. Fossil Lake is a former pluvial playa lake basin in south-central Oregon. Its sediments comprise eight rhythmitic fining-upward conglomeratic to clayey packages in which our study samples were discovered. These sample taxa include Felidae, *Canis* spp., *Paramylodon* sp., *Mammuthus* sp., *Camelops* sp., and *Equus* spp. Although no *Bison* sp.—a Rancholabrean biostratigraphic indicator—have been described from Fossil Lake, all specimens in this study (n = 748) are constrained by tephra layers as Rancholabrean in biochronologic age (210 to 14 ka).

For each sample, we measured the presence/absence of root traces on bones as indicative of chemical weathering by plant roots or fungal hyphae, presence/absence of tooth marks due to rodent or carnivore gnawing, presence/absence of carbonate precipitates, degree of physical weathering stages to estimate the extent to which each element has been exposed, and breakage patterns to measure pre- vs. post-mortem bone fracturing. To estimate assemblage specimen structure, we calculated standard taphonomic metrics for numbers of identified specimens, minimum number of individuals (MNI), minimum number of elements, minimum animal units (MAU) as a measure of individual skeletal completeness, and %MAU as a measure of individual skeletal completeness relative to the most complete skeletal sample. We found that *Equus* spp. were represented more (MNI = 31) than any other taxon present in our study (second most abundant was *Camelops* sp., MNI = 6). We also found evidence of pervasive chemical weathering by roots/hyphae (51.4% of all sample elements) and carbonate precipitation, especially in taxa represented by less than 30 elements, and generally complete bones with little evidence for post-mortem destruction (38.57% of all sample elements showed signs of post-mortem breakage). All of these findings suggest that these specimens represent a shoreline steppe habitat around Fossil Lake.

Technical Session XIX (Saturday, October 29, 2016, 3:30 PM)

EXAMINING THE ORIGIN OF PLACENTAL MAMMALS VIA 'PSEUDO-FOSSILIZATION'

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In reconstructing the evolutionary history of placental mammals, a general topology has emerged: four major supraordinal clades, recovered in both molecular only and 'total evidence' (DNA and morphology) phylogenetic analyses. While there is overall a consensus amongst topologies, there is still a deeply entrenched conflict regarding the timing of the placental radiation. Molecular clock analyses consistently recover the base of the crown Placentalia radiation within the Mesozoic, occurring by at least the mid-Cretaceous. However, no morphological study has yet to place known Mesozoic eutherian fossils within this crown group. There are two main explanations for this conflict: 1) the known fossil diversity does not include any crown placental mammals and these specimens are correctly placed in phylogenetic analyses, or 2) the known fossil taxa do represent crown placental mammals within the Mesozoic but due to the lack of genomic data these specimens are being incorrectly placed. The latter explanation calls into question the utility of morphological data. To evaluate this explanation, the resolving power of morphology has been put to the test.

The recent Assembling the Tree of Life: Mammals data set was used as the base of this study, with its over 4,500 morphological characters and large amount of DNA sequences representing every modern order of mammals and several key fossil taxa. For each extant taxon in turn, all DNA data were eliminated and the analyses were re-run to determine where morphological data alone would place each individual species; without the DNA data, these extant taxa become the equivalent of fossils. Results overwhelmingly supported the resolving power of morphology to resolve higher level phylogenetic questions—in no case were extant mammals found to fall outside of crown Placentalia when their genetic data were eliminated from the analysis. There was a change in the topology in several instances, most notably in the former members of 'Lipotyphla'—these taxa were found to cluster together once more in the absence of genomic data. However, even though taxa would move within, or between, supraordinal groups, the position of each species as either crown placental mammals or basal eutherians remained solid. This supports the placement of the Mesozoic fossil eutherians as truly non-placental forms, not misidentified members of the crown group due to lack of genomic data. This in turn strengthens the 'explosive radiation' model of placental mammal evolution rather than a Mesozoic origination for the group.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

ESTIMATING THE ANCESTRAL MORPHOLOGY OF MAJOR ORNITHISCHIAN CLADES IN A SPATIOTEMPORAL CONTEXT

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Global ornithischian phylogeny has undergone a major revision in how we view relationships within it due to the addition of new taxa and characters, with some of the traditional clades drastically repositioned or limited in taxonomic scope. As such, some phylogenetic hypotheses have been thoroughly corroborated, yet others remain unresolved. Recent analyses have attempted to widen the taxonomic and geographic scope, but questions regarding the placement of putative basal taxa in larger clades such as Genasauria and Neornithischia still remain. Here, using a global phylogenetic analysis of basal ornithischians, I estimate the ancestral morphology of Ornithischia and several major clades within it. The phylogeny is fairly well resolved, with the exception of some basal cerapodans and ornithopods. Moreover, the patterns illuminated from the phylogeny can help polarize character optimizations, allowing inferences of ancestral morphologies among major clades. A detailed event-based biogeographic analysis was also used to place each estimated ancestral ornithischian body plan in a geographic context in the Mesozoic. The estimated ancestral ornithischian was bipedal with a generalized skull and relatively long forelimbs more akin to basal saurischians from the Middle Jurassic of southern Gondwana. Genasauria, the most inclusive clade within Ornithischia, likely arose in Africa in the earliest Jurassic, with dispersals into North America shortly thereafter. The ancestral genasaurian demonstrated a shorter forelimb, yet with a generalized *Lesothosaurus*-like skull. Thyreophora was initially a North American clade of generalized, bipedal species from the Early Jurassic that spread throughout Laurasia; whereas, ancestral cerapodans were a Middle Jurassic Laurasian clade that exhibited markedly shorter forelimbs than more basal ornithischians, as well as a lengthened preorbital skull. The lack of phylogenetic resolution for ornithopods precluded an estimate of its ancestral morphology; however, its sister taxon, Marginocephalia, was initially a Late Jurassic Asian clade that dispersed into North America. A trend is evident in ornithischian phylogeny, beginning with a generalized bipedal body plan in southern Gondwana, as the larger clades evolved, lengthening the skull – and subsequently evolving more elaborate cranial morphologies – and dispersing into Laurasia. This analysis provides an outline for character state polarity and a framework upon which future phylogenetic and biogeographic analyses can build.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

HOMOLOGY-FREE DENTAL TOPOGRAPHY MEASURES CAN DISTINGUISH DIETARY CATEGORIES IN MARSUPIALS

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For much of the Cenozoic, South American marsupials represented a larger proportion of the terrestrial mammalian biota than is the case today. Evidently, they inhabited a variety of ecological niches not found among the surviving South American marsupial fauna but analogous to that seen today in Australia (Au) and New Guinea (NG) with arboreal and terrestrial insectivorous, carnivorous, folivorous and frugivorous forms. To reconstruct the autecology of Miocene South American marsupials, we examine the molar surface topography of extant Au-NG marsupials and its relationship to dietary behavior.

So far, these relationships are little studied and the available studies have relied on measurements of homologous crests and cusps. Here, we extend these comparisons with the application of three homology-free measures of dental surface topography (Dirichlet Normal Energy [DNE], Orientation Patch Count Rotated [OPCR], and Relief Index [RFI]) assembled from 3D reconstructions of mandibular second molars obtained from µCT scans of a broad sample of both South American and Au-NG marsupials. Dietary behavior for all living species was obtained from MammalDIET, a comprehensive global dataset of mammalian diet preferences. Results from ANOVA tests suggest that DNE is most successful in distinguishing among dietary groups ($p<0.01$) with a post-hoc Tukey's HSD test suggesting that marsupial insectivores have significantly higher values of DNE than any other dietary group included in this study ($p<0.05$) and that frugivores have significantly lower DNE values ($p<0.05$). These findings are in general concordance with similar studies of other placental groups. Interestingly, ANOVA tests of OPCR and RFI do not show significant differences among dietary groups ($p>0.1$).

On the basis of our finding, it now is possible to use Au-NG dental ecomorphology as a model for understanding the niche structure of Miocene South American marsupials. An ancillary goal is to extend our model to understanding the niche structure of early primates and other archontans.

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Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

THE EVOLUTION OF FORELIMB ARCHITECTURE IN EARLY SAUROPODOMORPHS

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The evolutionary history of Sauropodomorpha is currently hypothesized to record a change from small-bodied, bipedal animals to large-bodied quadrupedal animals. Such major changes in locomotory strategy must necessitate shifts in morphology. We investigated the shape changes that occur in the humerus bone of various sauropodomorphs at key muscle insertion points, as a proxy for understanding the changing role of the forelimb in locomotion. To do this, we made 3D models of a variety of sauropodomorph humeri using photogrammetry and analyzed the shift in positions of landmarks using geometric morphometric techniques. We find distinct changes in the morphology of the humerus from more basal to more derived Sauropdomorpha. This is particularly noticeably around the deltopectoral crest and the internal tuberosity which become much less pronounced in the more derived sauropodomorphs. The olecranon fossa on the distal end of the humerus becomes much shallower. There are many numerous smaller changes as well throughout the morphology of the humerus from basal to more derived Sauropodomorpha. These changes likely result from a shift in gait from bipedal in the more basal animals to quadrupedal in the more derived animals as well as the limb architecture being constrained due to an increase in the size of these animals overtime.

Grant Information
DST-NRF Centre of Excellence in Palaeosciences bursary

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

THE EVOLUTION OF ARCHOSAURIAN BODY SIZE: AN ANALYSIS OF THE INTERVERTEBRAL ARTICULATIONS OF STEM CROCODYLIANS FROM THE TRIASSIC

STEFANIC, Candice M., Virginia Tech, Blacksburg, VA, United States of America; NESBITT, Sterling J., Virginia Tech, Blacksburg, VA, United States of America

Understanding the interplay between skeletal morphology and function is a fundamental goal in biology. To make predictions about body size evolution in extinct animals it is critical to study the central support system, the vertebral column, especially within clades that reached enormous body sizes such as Archosauria. This clade contains the largest animals to live on land (80-ton sauropods and 20-ton theropods) as well as living crocodylians, and some members developed accessory intervertebral articulations to further support the trunk region of the axial column. These accessory articulation structures, the hyposphene-hypantrum complex, consist of a positive structure (hyposphene) and corresponding space (hypantrum) on the posterior and anterior ends of vertebrae, respectively. These structures are well known in saurischian dinosaurs, and although briefly reported, these articulations are also present in some crocodile-line archosaurs (i.e., pseudosuchians, aetosaurs), but are absent in living crocodylians.

To understand the evolution of body size in stem crocodylians, we examined the axial column of the large pseudosuchian, *Poposaurus langstoni* (length of ~4–5 m; estimated mass of 100 kg) from the Upper Triassic (Otis Chalk Quarries) of Texas. Four vertebrae (eighth cervical, fused ninth cervical and first trunk, third trunk) associated with the holotype were previously described, but we located new material (four cervical, four trunk vertebrae) likely from the holotype individual. These trunk vertebrae possess well-developed hyposphene-hypantrum complexes and these are similar to those of other paracrocodylomorphs (e.g. *Postosuchus*, *Effigia*, *Batrachotomus*), but these structures in *P. langstoni* appear more complex than those in their close relatives. The presence of these structures in large paracrocodylomorphs and absence in smaller stem crocodylians supports the hypothesis that they are correlated with larger body size. Furthermore, we examined members of another stem crocodylian clade, Aetosauria. The hyposphene-hypantrum complex is found only in large aetosaurs (e.g. *Desmatosuchus*; length of ~5 m), but is absent in the smaller, more basal members of the clade (e.g. *Aetosaurus*; length of ~1–2 m) meaning the articulation may have been selected for in tandem with increased body size. As crocodile-line archosaurs have undergone miniaturization from suchians to crocodyliforms and have subsequently lost the hyposphene-hypantrum complex, we hypothesize that the loss of these structures occurred during miniaturization.

Grant Information
Welles Fund (UC Berkeley), Graduate Research Development Program (Virginia Tech)

Technical Session XVI (Saturday, October 29, 2016, 11:45 AM)

FLUCTUATION IN SMALL MAMMAL COMMUNITY STRUCTURE DURING THE LATE HOLOCENE IN SOUTHEASTERN UTAH

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Biological conservation on our rapidly changing planet will rely on understanding and separating the effects of recent decadal- and centennial-scale dynamics from the millennial-scale dynamics recorded in the fossil record. Of primary importance is whether the ecological fluctuations that have taken place over the past century fall beyond the range of variation expected in the absence of recent human impacts, such as land conversion. Here, I describe late Holocene small mammal diversity fluctuations in two fossil localities from southeastern Utah—East Canyon Rims 2 and Rone Bailey Alcove—then compare fossil to modern diversity sampled via mark-recapture surveys. These localities span ~4.4 kyr to the present and elucidate pre-industrial faunal dynamics during a period of recent climate change from cool-wet to warm-dry conditions. Localities with comparable levels of small mammal diversity have not previously been reported from this region, so these sites provide novel insight into Holocene mammalian diversity in southeastern Utah. Using temporal cross-correlation, I tested for a relationship between regional temperature and relative abundance, rank abundance, species richness, and evenness. I used Fisher's exact tests to test for changes in the overall taxon abundance distribution. None of the measures of diversity tested here were correlated with temperature change through these, except for relative abundance of leporids.

Most of the small mammal taxa preserved in these fossil deposits are still present in the region today, yet abundance and community structure are significantly different. Modern evenness is lower than in the fossil record from ~4.5–0.7 ka. The observed drop in evenness occurred prior to the onset of high-impact, post-European human land uses in the southeastern United States and is coincident with the precipitous decline in human populations in southeastern Utah that may have resulted from long-term periodic droughts. Low modern evenness is also spatially consistent: modern evenness at survey sites across the study region is lower than it is for all fossil time bins ~0.7 ka and older, suggesting that a landscape-level decline in diversity took place. This study emphasizes the utility of the fossil record in understanding the extent of ecological fluctuations that can be considered 'normal' through long periods of time, information which is essential as we struggle to conserve biodiversity in a rapidly changing world.

Grant Information
Canyonlands Natural History Association; UC Berkeley GRAC; IB Department; Sigma Xi; Paleontological Society; GSA; UCMP; MVZ; K. Wells & the TIDES Foundation

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

PRELIMINARY RESULTS ON THE BONE HISTOLOGY OF HADROSAURS FROM THE LATEST CRETACEOUS OF FAR EASTERN RUSSIA

STEIN, Koen H., Vrije Universiteit Brussel, FWO, Brussels, Belgium; BOLOTSKI, Yuri, Russian Academy of Science, Blagoveschensk, Russia; BOLOTSKI, Ivan, Russian Academy of Science, Blagoveschensk, Russia; SNOECK, Christophe, Vrije Universiteit Brussel, Brussels, Belgium; DEWINTER, Niels, Vrije Universiteit Brussel, Brussels, Belgium; TSOGTBAATAR, Khishigjav, Mongolian Academy of Sciences, Ulaanbaatar, Mongolia; BARSBOLD, Rinchen, Mongolian Academy of Sciences, Ulaanbaatar, Mongolia; HAYASHI, Shoji, Osaka Museum of Natural History, Osaka, Japan; GODEFROIT, Pascal, Royal Belgian Institute of Natural Sciences, Brussels, Belgium; CLAEYS, Philippe, Vrije Universiteit Brussel, Brussels, Belgium

Hadrosaurs, such as *Olorotitan* and *Edmontosaurus,* were among the most abundant and successful Cretaceous dinosaurs. They spread to all continents and some reached body masses rivaling those of the giant sauropods. However, some hadrosaur groups disappeared from the North American continent 5 to 6 million years before the extinction event, whereas the same groups thrived in Asia until the event. The Maastrichtian hadrosaur communities from Far Eastern Russia are a prime example to study the biology of late surviving lambeosaurine hadrosaurs. The bonebeds from which these taxa were excavated show a high species diversity and a high abundance of various skeletal elements, most notably long bones. We sampled long bones from different size classes of the lambeosaurines *Olorotitan* and *Amurosaurus*. Both taxa show highly vascularized cortical bone consisting mainly of a woven-parallel fibered complex with plexiform to laminar vascularization, indicative of high growth rates. Only few lines of arrested growth (LAG) could be observed in even the biggest specimens (femur length ~1 m). It remains unclear if this indicates an uninterrupted juvenile growth phase, or if mass increase was extremely high in the first years, but the high average growth rate is in accordance with high growth rates reported for North American hadrosaurs (e.g. *Maiasaura*). We also sampled the tibia of a large tyrannosaurid theropod (corresponding femur length ~ 0.92 m) which was recovered from the same layers as *Olorotitan*; however, its growth is in sharp contrast with that of the hadrosaurs. The thin section taken from the shaft of the proximal tibia shows a woven-parallel fibred complex with plexiform to laminar vascularization, however, it also shows numerous (>15) LAGs, indicating a much slower average growth and higher chance of survivorship than for hadrosaurs. These data add to a more global perspective on diversity and ecology of Latest Cretaceous dinosaur faunas.

Grant Information
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Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

A DIVERSE NEW FOSSIL LOCALITY IN THE LATE OLIGOCENE NSUNGWE FORMATION, SOUTHWESTERN TANZANIA

STEVENS, Nancy J., Ohio Univ, Athens, OH, United States of America; ROBERTS, Eric M., James Cook University, Townsville, Australia; O'CONNOR, Patrick M., Ohio Univ, Athens, OH, United States of America

The Rukwa Rift Basin (RRB), located in southwestern Tanzania, is a key segment of the western Branch of the East African Rift System. Field reconnaissance in Cenozoic deposits in the RRB documents an extensive late Oligocene continental fauna dated at ~26–24 Ma via high-precision U-Pb and Ar/Ar geochronology of intercalated volcanic tuffs. These localities in the Nsungwe Formation sample proximal alluvial fan systems that transitioned into a complex, volcanically-influenced landscape of fluvial, alluvial and lacustrine depositional environments. Paleoenvironmental reconstructions derived from Nsungwe faunal composition and sedimentological analysis generally reflect seasonally drier habitats preserving perennial availability of water.

Recent field work has revealed the highly productive Nsungwe 3 locality, containing a diverse sample of vertebrate and invertebrate specimens. Mammals are particularly well represented in this locality, comprising ~40% of the Nsungwe 3 fauna. At least four rodent taxa have been recorded based on craniodental specimens, along with associated and beautifully preserved anthracothere postcranial materials. Non-mammalian vertebrates are rich and diverse, including a handful of birds, lizards, snakes and anurans, and a wealth of turtles and fish specimens. Invertebrates are common in the fauna, and include gastropods, ostracods and crabs. Specimens range in size from less than 1 mm to over 10 cm. One of the more striking finds is an associated small crocodylian preserving numerous craniomandibular and postcranial elements. Crocodylid affinities are inferred based in part on a large protuberance on the dorsal surface of the maxilla immediately posterior to the fifth tooth. A transverse frontoparietal suture is present, similar to that observed in the osteolaemin *Brochuchus*; additional materials are necessary to further refine the phylogenetic affinities of this specimen.

These discoveries offer a glimpse at the evolutionary history of late Oligocene terrestrial and freshwater habitats in eastern Africa. Finds from this and other Nsungwe Formation localities help to refine interpretations about the sequence and timing of events in the Paleogene–Neogene transition on continental Africa, offering insights into biogeographic patterns and paleobiological trends in diversity through time.

Grant Information

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Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

A NEW SANDCOLEID (AVES, COLIIFORMES) FROM THE EARLY EOCENE OF WYOMING AND ITS IMPLICATIONS FOR PALEOBIOLOGY, INTRASPECIFIC VARIATION, AND EVOLUTION IN EARLY MOUSEBIRDS

STIDHAM, Thomas A., Institute of Vertebrate Paleontology & Paleoanthropology, Chinese Academy of Sciences, Beijing, China; ROSE, Kenneth D., Johns Hopkins University, Baltimore, MD, United States of America

Most Paleogene mousebird species are known from only one or a few specimens, and many of those are flattened skeletons. A new species of basal mousebird (Sandcoleidae) is represented by nearly 100 three-dimensionally preserved skeletal specimens derived from a minimum of 11 individuals, including one juvenile (two limb bone fragments). Most regions of the skeleton are preserved, from part of the jaw to the pygostyle, including all major limb bones. The fossils derive from a vertebrate locality within the Willwood Formation, Bighorn Basin, Wyoming and are early Eocene in age (Wa-6, ~53 Ma). The holotype fossil locality covers less than 2 square meters and is dominated by bird bones, with the only non-avian specimens including a few mammal teeth, and a lizard specimen. None of the bird bones display gastric etching, bite marks, or any other modifications that would suggest accumulation by a predator, and with a single species dominating the assemblage, it would seem that some aspect of the biology of the bird influenced the taphonomy of this accumulation. The occurrence of multiple osteologically adult individuals, along with at least one juvenile individual, within such a small area may be the result of either cooperative breeding behavior or the formation of groups (of ~5 to 20 individuals) for foraging and nocturnal roosting (similar to the behaviors expressed by extant mousebirds). The large number of individuals in the fossil collection is more consistent with that of a nocturnal roosting cluster (versus a small cooperatively nesting group) and suggests that basal mousebirds formed groups in order to maintain their body temperatures and avoid torpor during cooler nights, as do their extant African relatives.

The new species exhibits typical primitive features of basal mousebirds (e.g., absence of an expanded disc on the pygostyle and absence of a tubercle on the humeral shaft distal to the pneumotricipital fossa), and has a unique (autapomorphic) flattened scapular cotyle on the coracoid in all specimens. The size variation among the specimens is low (~10% or less in linear measurements), and this species is close in size to *Anneavis*. Phylogenetic analysis places the new taxon as the sister to all published sandcoleid taxa and specimens. Based on that relationship, the lineage leading to this new species originated in the Paleocene and survived multiple hyperthermal events (i.e., PETM, ETM2, and H2). Furthermore, that evolutionary tree suggests that sandcoleids (and perhaps all Coliiformes) originated in North America.

Grant Information

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Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

***LIMUSAURUS* AND THE EVOLUTION AND BIOGEOGRAPHY OF CERATOSAURS**

STIEGLER, Josef B., The George Washington University, Washington, DC, United States of America; WANG, Shuo, Chinese of Academy of Sciences, Beijing, China; XU, Xing, Institute of Vertebrate Paleontology & Paleoanthropology, Beijing, China; CLARK, James M., George Washington Univ, Washington, DC, United States of America

A diverse theropod fauna is known from the early Late Jurassic Upper Shishugou Formation of Northwest China including the first-recognized ceratosaur from Asia, the edentulous herbivore *Limusaurus inextricabilis*. The often unusual anatomy of *Limusaurus* reveals interesting convergences with other toothless theropod lineages seemingly unrelated to feeding, including the proportions of vertebrae and the location and style of pneumatized vertebral structures.

Young juvenile ceratosaur skeletons from the *Limusaurus* bonebeds share autapomorphies with *Limusaurus* but possess carnivorous morphotype teeth, suggesting either an additional case of convergence or radical postnatal ontogenetic change. Several parsimony analyses using various ontogenetic stages or individual specimens of *Limusaurus* confirm the referral of the juvenile theropods to *Limusaurus*. Juvenile specimens were not recovered in artificially early-diverging positions, suggesting that ontogenetic size disparity may influence phylogenetic hypotheses for juvenile vs. adult dinosaur taxa more so than intensity of postnatal ontogenetic change.

The phylogenetic study of *Limusaurus* was expanded to examine ceratosaur evolution more broadly, and revealed an Early Jurassic divergence into two major abelisauroid lineages, the large-bodied Abelisauridae and gracile Noasauridae. In addition to their traditional content, the Abelisauridae and Noasauridae contain Jurassic taxa previously thought to represent non-abelisauroid theropods, and numerous fragmentary occurences can now be referred to one of these major lineages.

Biogeographic analysis of Ceratosauria was conducted on a global theropod phylogeny so that patterns of non-ceratosaur divergences would inform model selection. A Dispersal-Extinction-Cladogenesis model incorporating founder event speciation and stratified according to continental fragmentation and global sea-level changes was developed using a pseudo-Bayesian approach. Ancestral range estimation predicts that the Central Atlantic Magmatic Province may have acted as a barrier to dispersal near the Triassic–Jurassic boundary; the Central Gondwanan Desert did not restrict a global Jurassic distribution of ceratosaurs; and, that a Late Cretaceous biotic interchange event occured between Madagascar and mainland Africa, possibly associated with the global Turonian regression event.

Grant Information

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Technical Session XI (Friday, October 28, 2016, 8:45 AM)

NEW CHONDROCRANIUM FROM *TANAODUS WEISI* ADDS TO PETALODONT DIVERSITY

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Tanaodus wisei is a lower Carboniferous (Viséan) petalodont that has important implications for the phylogenetic resolution of early chondrichthyans, in particular the Holocephali. *Tanaodus wisei* has previously been recognized only from a single fossil, NMS (National Museum of Scotland) 1892.24: an articulated dentition with possible placoid scales. We CT scanned the specimen and revealed the anterior part of the neurocranium and mandible, which have never been observed before. The ethmoid region is elongate and expanded anterolaterally; there also appears to be a dermo-skeletal cranial shield. The oral cavity is ventral and anterior to the orbit, indicating a likely shift in the jaw adductor musculature and resembling conditions in modern holocephalans. The multi-element dentition consists of laterally placed, low-crowned, asymmetric teeth with imbricated ridges, and medial symmetric, interlocking teeth. All teeth have a concave baso-lingual portion and teeth appear to be added rostrocaudally. *Tanaodus wisei* notably does not exhibit any acuminate or serrated teeth, and the roots are shallow. We propose that *Tanaodus wisei* was a mid-sized durophagous chondrichthyan and was perhaps adapted a niche similar to that of the extant sheepshead wrasse (*Archosargus probatocephalus*). *Tanaodus wisei* adds to the diversity of early chimaeroid-like fishes and highlights likely homoplasy in early history of tooth plate dentitions. The global distribution of petalodont teeth makes detailed descriptions of the very few articulated specimens available essential if we are to understand the ancient oceanic biodiversity. *Tanaodus weisi* is only the sixth petalodont of which articulated remains are known, the first to be CT scanned, and the first to yield three dimensional endocranial data.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

MACROEVOLUTION OF THE CROCODYLOMORPHA

STOCKDALE, Max, University of Bristol, Bristol, United Kingdom; BRONZATI, Mario, Munich, Germany; ANDRADE, Marco, Porto Alegre, Brazil; BENTON, Michael J., University of Bristol, Bristol, United Kingdom

Extant crocodilians might be considered something of a failure. Since the emergence of the Crocodylomorpha in the Late Triassic their diversity has declined to just 23 species, compared to over 10,000 species in their sister clade, the birds. The extant crocodilians also show low morphological disparity, with all species being semi-aquatic ambush predators with a similar body plan. This low diversity and long fossil range has led to the crocodilians being described as 'living fossils', but is this justified? The Crocodylomorpha in the fossil record show great morphological diversity, including terrestrial, cursorial, fossorial, and marine forms, insectivores, omnivores, herbivores, and durophages. In this study we present a new super tree phylogeny of the Crocodylomorpha and evaluate the tempo and mode of crocodylomorph evolution using morphology. We find extreme conservatism of in the evolution of body size in the Crocodylomorpha and a number of its subclades. Rates of evolution are predominantly stable, but punctuated by environmental changes with rate-shifts in the crown-group associated with mass

extinctions. Time-series modelling of Crocodylomorph diversity and morphological disparity compared with environmental variables finds evolution to be driven and constrained by temperature and the diversity of competing clades such as dinosaurs. We conclude that the Crocodylomorpha adhere strongly to the punctuated equilibrium and Court-Jester models of evolution. Therefore the limited diversity and disparity of the extant Crocodylomorpha is likely a reflection of their rather narrow range of ecological tolerances when compared to birds, and massively changed global environmental conditions that restrict the potential diversity of the group today.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

MOSAIC EVOLUTION IN PHYTOSAURIA: THE ORIGIN OF LONG-SNOUTED MORPHOLOGIES BASED ON A COMPLETE SKELETON OF A PHYTOSAUR FROM THE MIDDLE TRIASSIC OF CHINA

STOCKER, Michelle R., Virginia Polytechnic Institute and State University, Blacksburg, VA, United States of America; NESBITT, Sterling J., Virginia Tech, Blacksburg, VA, United States of America; ZHAO, Li-Jun, Zhejiang Museum of Natural History, Hangzhou, China; WU, Xiao-chun, Canadian Museum of Nature, Ottawa, ON, Canada; LI, Chun, Institute of Vertebrate Paleontology and Paleoanthropology, Beijing, China

The Late Triassic vertebrate faunal assemblage is composed of multiple well-known archosauriform clades, many of which have a near global distribution at both low and high latitudes. These clades possess distinctive morphologies, but in many cases early-branching members are either unknown or currently unrecognized. Progress in recognizing early members of both archosaurian lineages (Pseudosuchia and Ornithodira) has allowed incorporation of those taxa into time-calibrated phylogenetic analyses and predicted an early Middle or Early Triassic divergence for all clades within Archosauria as well as its current sister-taxon, Phytosauria. Phytosaurs are well known from a near-global distribution in the Late Triassic, with the earliest recognized taxa (*Wannia*, *Parasuchus*) from the latest Carnian–earliest Norian. Derived features of phytosaur crania (elongate rostrum, non-terminal nares) and postcrania (hooked coracoid, broad and elongate interclavicle, backswept scapula) are unique compared with all other Triassic archosauriforms, but the relative order and magnitude of phytosaur character state acquisition remains unclear. A recently described taxon from the Ladinian of China, *Diandongosuchus*, was proposed as a poposauroid largely because of similarities (e.g., premaxillary elongation) to the basal form *Qianosuchus*. We reassessed the systematics of *Diandongosuchus* within an extensive analysis of archosauriform phylogenetic relationships and show that *Diandongosuchus* is not a poposauroid, but is the sister taxon to all phytosaurs. First-hand evaluation of *Diandongosuchus* reveals an interdigitated premaxilla-maxilla suture, wide distal end of the quadrate, broad postorbital-squamosal bar, hooked coracoid, broad interclavicle, and backswept scapula, all apomorphies of Late Triassic phytosaurs. Our reinterpretation of *Diandongosuchus* as a phytosaur indicates that the postcranial modifications of phytosaurs occurred well prior to rostral elongation, supports that the clade was located across Pangea, and hypothesizes salt-water tolerance. Continued discovery of early members of these archosauriform clades help resolve character optimizations at the base of Archosauria during Triassic recovery from the end-Permian mass extinction.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

WEST VIRGINIA SCIENCE ADVENTURES: A MODEL FOR SERVICE LEARNING AND STEAM OUTREACH FOR RURAL COMMUNITIES

STRAIT, Suzanne G., Marshall Univ, Huntington, WV, United States of America

Recent studies have shown that fewer than 5% of an individual's lifetime science education comes from formal education (K–12 and college), highlighting the importance of informal learning opportunities like those provided by museums and science centers. However, in many rural and underserved areas, science enrichment is limited or unavailable because communities lack these major components of the learning ecosystem. Additionally, some readily accessible and vetted online programming is not regionally appropriate for more rural K–12 student audiences. In order for STEAM activities to enhance learning and promote continuing interest, they need to be locally and culturally appropriate.

I have designed a program in which local college students, many of whose roots are in these communities, are the principal designers of K–12 STEAM outreach elements for our program's offerings of weekend, home schooler, and summer camp events. Our program integrates service learning in courses with STEAM program development. The students are first directed to write reflective assignments on what made them get interested in science in the first place, including their experiences with both school and informal learning venues. Students then research the state science standards for their chosen age group and sit through classes to familiarize themselves with learning levels and interests. Next, they are assigned articles that address issues of STEAM education equality to make them appreciate the larger problem in their communities. They work with the instructor to design a teaching kit in a topic of their own interest. Having outreach materials designed by a wide variety of people that represent a diversity of ethnic backgrounds, genders, socioeconomic levels, geographic origins and that are nearer in age to K–12 than is typical is a strong advantage of the program. They do the activity with a local group or school to playtest their activity and then return with a full description of the activity, the background needed to teach it, a kit supply check list and a protocol for the activity. The ultimate goal of this project is to engage rural communities in science to promoted STEAM careers and general scientific literacy. Furthermore, by engaging college students in this process they learn that they have the potential to give back to their community and to introduce the concept that they can be community STEAM partners throughout their lives.

Technical Session II (Wednesday, October 26, 2016, 10:30 AM)

A SYSTEMATIC AND TAXONOMIC REVISION OF *MOSASAURUS* AND A GLOBAL MOSASAURINI

STREET, Hallie P., University of Alberta, Edmonton, AB, Canada

Mosasaurus hoffmannii, the namesake of the giant marine lizard clade Mosasauridae, was first discovered in the Cretaceous phosphatic chalks at Maastricht, Netherlands. The famous fossil known as the 'Grand Animal de Maestricht' was described before the first dinosaur and long before the scientific conception of extinction and evolution. Though *M. hoffmannii* is an important taxon in mosasaur systematics, it has been imprecisely diagnosed for more than 200 years, and has not been completely reviewed in terms of the numerous species (~50) assigned to the genus. I present here emended diagnoses for *Mosasaurus* and its type species *M. hoffmannii*, compare the morphology of thirteen species of *Mosasaurus* in current usage from around the world, conduct phylogenetic analyses including these species of *Mosasaurus*, and combine the results of the morphological and phylogenetic analyses to revise the systematics and taxonomy of *Mosasaurs* and its closest relatives. Each of the specimens of *Mosasaurus* included in this study was observed firsthand. Many of the species currently assigned to *Mosasaurus* exhibit morphologies that differ notably from the *Mosasaurus* paradigm, as diagnosed by *Mosasaurus hoffmannii*. The phylogenetic analyses supported the morphological interpretations and recovered a monophyletic *Mosasaurus* composed of *M. hoffmannii, M. missouriensis*, and *M. lemonnieri*. A specimen from Belgium, which had previously been assigned to *M. hoffmannii*, but whose morphology differs slightly from both *M. hoffmannii* and *M. lemonnieri*, is found to be a separate species. Restricted to only four species, *Mosasaurus* is nested in a monophyletic Mosasaurini with two other clades of related taxa. The highly derived mosasaur *Plotosaurus* and its closest relatives were found to be the sister group to *Mosasaurus*. A taxon previously only known from New Zealand, *Moanasaurus*, is shown to be more diverse than previously understood, with specimens from Japan and Belgium sharing similarities with the type species *Moanasaurus mangahouangae*. Even as *Mosasaurus* itself is found to be less diverse than in previous interpretations, the larger Mosasaurini clade is shown to be more diverse than previously understood. This clade rapidly achieved worldwide distribution during the late Campanian and went on to dominate the worlds' oceans until their sudden demise in the End-Cretaceous mass extinction.

Grant Information

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Poster Symposium I (Wednesday–Thursday, October 26–27, 2016, 4:15–6:15 PM)

THE EVOLUTION OF ECOLOGICAL NICHE STRUCTURE IN NORTH AMERICAN MIDDLE EOCENE UNGULATES

STROIK, Laura K., Grand Valley State University, Allendale, MI, United States of America; TOWNSEND, K.E. Beth, Midwestern University, Glendale, AZ, United States of America

Previous research has examined the potential association between changes in middle Eocene ungulate ecomorphologies and concurrent environmental shifts. However, none of these studies have quantified the ecological niche space occupied by specific ungulate groups or statistically evaluated the extent of overlap among ungulate niches. An analysis of niche overlap is required to identify both significant shifts in niches over time and competition among taxa.

Dietary ecological niches were reconstructed for sixteen families, representing six orders of Bridgerian and Uintan ungulates from North America (N = 450). Linear dental measurements identified as those that best predict dietary regime and body mass in related extant taxa (e.g., maxillary second molar height at the protocone and molar length [related to hypsodonty index]) were collected. Statistical overlap between each pair of dietary niches was determined using a modified MANOVA, where the F-statistic was calculated using Euclidean distances in multi-dimensional principal component space. In addition, the absolute 'hypervolumetric size' and relative 'volume' of the multi-dimensional 'space' occupied by each niche were calculated.

Results indicated that there was little to no overlap among the niches of ungulate orders within each land mammal age. Notably, there was no significant change between the Bridgerian and Uintan NALMAs in either the artiodactyl ($P = 0.435$) or perissodactyl ($P = 0.170$) niche within the overall ungulate niche space; however, both niches did increase in size. These changes were more pronounced in perissodactyls than artiodactyls and signal an expansion in body size and the inclusion of more browsing diets. This indicates that an increase in dietary variability characterized a significant number of North American ungulates during the middle Eocene.

Technical Session III (Wednesday, October 26, 2016, 2:45 PM)

CONVERGENT EVOLUTION AND BIOMECHANICS OF THE RAPTORIAL FOOT

STRUBLE, Mikayla, Bozeman, MT, United States of America; ORGAN, Chris, Bozeman, MT, United States of America

The birds of prey are a unique polyphyletic group composed of three unrelated lineages of birds that have each arrived at very similar body plans stemming in part from a distinctive footing behavior, characterized by the use of feet as the primarily tool of interaction with the environment. In modern birds, we find that non-raptorial, non-perching birds have relatively longer proximal phalanges, while we see mild proximal shortening in digit 4 in perching birds and extreme shortening in digits 2-4 in raptors. This proximal abbreviation is highly characteristic of raptorial groups and the patterns of abbreviation we see indicate several complex trends. We explore these patterns with four distinct sets of hypotheses, distinguishing trends which are common to all raptors and appear necessary to increase grasping capabilities, trends which are unique to each true clade of raptor, trends which stem from diet and the stresses associated with distinct hunting styles, and with the aid of fossil data, the stages in which such foot morphologies originated. Raptorial convergent evolution has been difficult to study because of the long standing uncertainty in avian phylogeny, but genetic analysis in the last decade has reorganized the avian phylogenetic tree and offers scientists for the first time a well-supported view into the history of avian, and raptorial, diversity. Using measurements of phalanges from a diverse set of modern and fossil birds, we estimate the degree of abbreviation for proximal phalanges by comparison with penultimate phalanges in each respective toe. Using these values, we use Baysian methods to support an association between proximal shortening and increasing grasping behavior (which suggests raptors display an extreme development of perching biomechanics), estimate rates of evolution in each element, and find associations with raptorial clade and diet. We then regress

abbreviation trends back into the avian phylogenetic tree to shed light on the evolution of predatory behavior in Aves. We find similar patterns of proximal abbreviation in several non-avian groups, including some Enantiornithines such as *Rapaxavis*, and several genera of Late Cretaceous oviraptorids, such as *Elmisaurus*. Here we offer a tentative suggestion some oviraptorids, the diet of which has often been debated, displayed increased grasping ability which might have been used in cursorial raptorial behavior. This evidence would support previous publications suggesting a combination of stability flapping and raptorial grasping behavior to subdue prey.

Grant Information
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Technical Session XVII (Saturday, October 29, 2016, 10:15 AM)

MORPHOLOGICAL DIVERSIFICATION DRIVES ADAPTIVE RADIATION IN SAUROPTERYGIAN MARINE REPTILES

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The Triassic was a key interval in the diversification of life, as the biosphere recovered following the devastating Permo-Triassic mass extinction event. Sauropterygian marine reptiles were major components of this recovery, and diversified spectacularly in the Early-Middle Triassic. Four sauropterygian subgroups, the placodonts, pachypleurosaurs, nothosaurs and pistosaurs, drove the burst of marine tetrapod diversity in the first 10-20 million years of the Triassic. In the Late Triassic, however, species diversity crashed, culminating in the extinction of all basal lineages. The success of sauropterygians in the Middle-early Late Triassic has been attributed to rapid partitioning of morphologies and body plans, leading to exploration of divergent non-overlapping adaptive zones. However, this has never been considered in a numerical framework. Here, I test this hypothesis by constructing empirical morphospaces incorporating Triassic sauropterygians and early plesiosaurs, based on a new discrete skeletal character data set, overall body proportions and geometric skull shape disparity. High morphological disparity was seen early in sauropterygian evolution, peaking in the Anisian and remaining stable until the Carnian. Morphospaces illustrate partitioning by sauropterygian subclades, with major groupings forming distinct clusters and statistical tests confirming separations. The aberrant durophagous placodonts had the most divergent morphologies, showing major innovations in skull shape, dental characters and the postcranial skeleton. When analyses are performed with basal plesiosaurs included, they fall close in morphospace to pistosaurs, suggesting the foundations of their body plan and skull shape were established in the Middle Triassic. Overall, sauropterygians show the hallmarks of adaptive radiation in deep time, and this likely represented a response to new marine trophic opportunities.

Technical Session VI (Thursday, October 27, 2016, 9:00 AM)

A NEW BADGER-LIKE GIANT OTTER (LUTRINAE, MUSTELIDAE) FROM THE LATEST MIOCENE SITE OF SHUITANGBA IN YUNNAN PROVINCE, SOUTHWESTERN CHINA AND A TOTAL EVIDENCE PHYLOGENY SUGGESTING A PREVIOUSLY UNRECOGNIZED CLADE OF OTTERS IN EASTERN ASIA

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Otters have a worldwide distribution but a poor fossil record going back to the middle Miocene. Propensities for a bunodont dentition in multiple lineages, commonly for cracking mollusks or other hard foods, also result in the repeated enlargements of the posterior parts of the dentition, such as in the sea otter. No attempt has been made for a global phylogenetic framework of all fossil taxa, and for existing regional studies or treatments of clades, no consensus has emerged because of these convergences.

A nearly complete skull, mandible, and partial skeleton, representing at least two individuals, of a new species of fossil otter were recovered from the latest Miocene (~6.2 Ma) lignite beds of the Shuitangba Site in northeastern Yunnan Province, southwestern China. This site also produced diverse mammalian and avian faunas of mostly Oriental characteristics (South China and Southeast Asia). CT reconstruction of the crushed skull demonstrates that the Shuitangba otter has a unique combination of cranial and dental characters featuring an otter-like cranium but a badger-like upper molar. This new form belongs within the lutrines because of its possession of a large infraorbital canal and ventral expansion of the mastoid processes, among other traits. A posteriorly expanded M1, however, is badger-like. In overall morphology, the Shuitangba otter is closest to *Siamogale* from the middle Miocene of Mae Moh in northern Thailand. A previously described jaw ("*Lutra*" *aonychoides*) from the early Pliocene of Yushe Basin in north China appears to represent the same taxon as the new giant otter from Yunnan, which shares an expanded posterior crest of the m1 metaconid.

We present the first attempt at combining morphological and molecular (nuclear and mitochondrial DNAs) character matrices of five extant (*Pteronura*, *Lontra*, *Enhydra*, *Aonyx*, *Lutra*) and eight extinct genera (*Tyrrhenolutra*, *Paralutra*, *Paludolutra*, *Enhydritherium*, *Siamogale*, *Vishnuonyx*, *Sivaonyx*, *Enhydriodon*), plus two outgroups (*Martes* and *Galictis*). Parsimony and Bayesian analyses consistently recover an eastern Asian clade based on characters of upper and lower molars that includes forms from Shuitangba, Yushe, and Mae Moh.

Grant Information
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Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

IDENTIFYING THE END TRIASSIC EXTINCTION IN THE MOENAVE FORMATION, UTAH USING C-ISOTOPE CHEMOSTRATIGRAPHY, DETRITAL ZIRCON GEOCHRONOLOGY, AND BIOSTRATIGRAPHY.

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The Late Triassic to Early Jurassic-aged Moenave Formation of southwestern Utah and northwestern Arizona preserves an array of dinosaur ichnofossils, from the exquisite shoreline tracks at the St. George Dinosaur Discovery Site at Johnson Farm in St. George, Utah to the surrounding cliffs such as Olsen Canyon, Utah and the Whitmore Point Reference Section, Arizona. The age of the Moenave Formation and location of the end Triassic extinction (ETE) have been speculated and investigated for the past decade using biostratigraphy and magnetostratigraphy. Here we bring together C-isotope chemostratigraphy, archosaur ichnotaxa biostratigraphy, and new detrital zircon U-Pb dates. C-isotope data reveal a distinct negative C-isotope excursion (NCIE) just above the contact between the lower member of the Moenave, the Dinosaur Canyon Member (DCM) and the upper member, the Whitmore Point Member at the Whitmore Point Reference Section in northern Arizona and Black Canyon, Zion National Park, Utah. A distinct NCIE has been linked to an influx of CO_2 and methane caused by the eruption of the Central Atlantic Magmatic Province (CAMP) and has been suggested to indicate the ETE. However, a recent discovery of *Eubrontes* and *Anomoepus* tracks from the DCM in Olsen Canyon suggests the ETE occurs in the DCM because their first occurrences are biostratigraphic indicators of post-ETE time. Detrital zircon from sandstone in the upper Dinosaur Canyon Member ~3 m below the distinct NCIE in the Whitmore Point Reference Section yields a maximum depositional age of 201.32 ± 0.07 Ma. This age is the same as one previously determined from an ash from a marine section in New York Canyon, Nevada (201.33 ± 0.13 Ma), perhaps indicating the sources are related. U-Pb geochronology dates the ETE to 201.56 ± 0.22 Ma, suggesting that the depositional age of this sandstone from the DCM is younger than the ETE. This maximum depositional age for the Moenave corroborates the ichnotaxa data and suggests that either the NCIE from the Whitmore Point Member is not at the ETE or there is a lag in the C-isotope record distal to the CAMP *versus* proximal to the CAMP, such as in the Newark Basin of northeast North America where they are approximately coincident.

Grant Information
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Technical Session XII (Friday, October 28, 2016, 2:30 PM)

STRUCTURE, FUNCTION, AND EVOLUTIONARY HISTORY OF UNCINATE PROCESSES IN EXTANT CROCODILIANS AND OTHER ARCHOSAURS

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Uncinate processes (UPs) are flanges extending from the posterior margins of the vertebral ribs of some reptiles. Among living taxa, UPs are best known in birds, in which they are typically narrow, well ossified structures that anchor ventilatory muscles and may also play a role in bracing the trunk. Narrow (partially) ossified UPs are present in *Sphenodon* and broad cartilaginous UPs occur in crocodilians, yet these structures are poorly known. Furthermore, the distribution of UPs among fossil archosaurs is unclear because cartilage is rarely preserved. Some oviraptorosaurs and dromaeosaurids have bird-like UPs, while some basal neornithischians have mineralized UPs remarkably similar in shape to those of crocodilians. Outside Dinosauria, we have noted detached, partially ossified UPs in an undescribed Jurassic basal crocodylomorph. Furthermore, our observations of *Crocodylus* and *Alligator* indicate that crocodilian UPs have an osteological correlate, namely a scar on the edge of the rib, and a corresponding scar is present in the Miocene tomistomine *Penghusuchus*. Searching for the correlate may confirm the presence of UPs in additional extinct taxa.

We investigated crocodilian UPs by dissecting a subadult farm-raised *Crocodylus* specimen. Thoracic vertebral ribs 1–5 bear tab-like UPs, some wider than the corresponding intercostal spaces. Muscles attaching to the UPs include M. serratus, M. iliocostalis, M. obliquus abdominus externus, and M. intercostalis externus. Some slips of M. intercostalis externus arise from the intermediate ribs and extend anterodorsally to the UPs, resembling the M. appendicocostalis associated with avian UPs. Although crocodilian UPs easily bend, their resistance to stretching may allow them to increase the leverage of inclined fibres of M. intercostalis externus during inspiration, just as avian UPs increase the leverage of M. appendicocostalis. However, the diversity of the musculature attaching to the UPs in crocodilians raises the possibility of additional functions.

The similarity between crocodilian and ornithischian UPs suggests plate-like UPs may be ancestral for archosaurs. Dissection of a domestic Chinese Goose confirms descriptions of avian UPs as embedded in triangular sheets of membranous tissue, which we hypothesize may represent a portion of a broad, plesiomorphic UP that only partially ossifies in birds. This scenario would imply that UPs are homologous, yet morphologically and histologically variable, across Archosauria and perhaps even Sauropsida.

Grant Information
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Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

A CRITIQUE OF LATE CRETACEOUS DINOSAUR BIOGEOGRAPHY AND ENDEMISM IN THE WESTERN INTERIOR BASIN, NORTH AMERICA

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North–south faunal provinciality among Campanian and/or Maastrichtian vertebrates, especially dinosaurs, in the Western Interior Basin (WIB; Laramida) of North America has been accepted by many vertebrate paleontologists for about 30 years. However, a detailed review of the data on the biostratigraphic and paleogeographic distribution of non-dinosaurian vertebrates indicates little to no evidence of north–south provinciality. The case based on dinosaur distribution is also very problematic, resting solely on a few taxa of dinosaurs, most notably chasmosaurine ceratopsids, which have also been used to identify extreme dinosaur endemism. Identification of north–south dinosaur provinces can be rejected because of: (1) problems and biases in sampling; (2) the lack of topographic barriers in the WIB that would divide provinces; (3) the lack of climatic or vegetational differences and/or gradients that would serve to provincialize vertebrates; (4) oversplit taxonomic (largely cladotaxonomic) decisions that have driven the perception of endemism and provinciality; (5) the demonstrable diachroneity of most fossil assemblages, which undermines the ability to include them in biogeographic analyses; and (6) the non-uniformitarian conclusions that are integral to the perception of dinosaur provinciality and endemism. Thus, not only can we demonstrate the biological and geological implausibility of dinosaur-based biogeographic provinces and high degrees of endemism in the WIB, but we conclude that the arguments and analyses that have been conducted to support such concepts are highly questionable. Consequently, there is no persuasive evidence that there was any discrete biogeographic separation of the Campanian (or Maastrichtian) dinosaur-dominated vertebrate assemblages from north to south in the WIB. Rather, such "provincial divisions" are largely due to temporal differences between vertebrate assemblages and cladotaxonomy.

Technical Session IV (Wednesday, October 26, 2016, 3:45 PM)

TESTING COMPETING MORPHOLOGICAL AND MOLECULAR PHYLOGENIES OF CHIROPTERA WITH MORPHOLOGICAL FEATURES OF THE INNER EAR COCHLEA

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Competing phylogenies of chiropterans offer contrasting scenarios of evolution of echolocation in bats. The traditional phylogeny of Megachiropterans and Microchiropterans suggests a single origination of echolocation in Microchiropterans. Molecular estimates of chiropteran relationships proposed two alternative clades of Yinpterochiroptera and Yangochiroptera, each including echolocating taxa. This suggests a dual origin of echolocation in bats. To test these competing hypotheses, we used Computed Tomography (PaleoCT facility of UChicago) to examine the Rosenthal's canal for the spiral cochlear ganglion, a crucial neural structure for hearing and known to show variation among bats with different hearing capabilities, for 10 echolocating and non-echolocating bats, plus other mammalian outgroups. The 3D structure of the Rosenthal's canals were reconstructed using Mimics and 3-matic softwares and were compared with published histological sections of the inner ears. In all Yinpterochiropteran bats, the spiral ganglion is enclosed entirely in the Rosenthal's Canal embedded in the primary bony lamina, a plesiomorphy of therian mammals. For Yangochiropteran bats, the spiral ganglion is only enclosed in Rosenthal's canal in the basal-most cochlear turn, but most of the cochlear ganglion is not enclosed by bone and is exposed in the internal auditory meatus. This extra-otic position of the ganglion corresponds to a shift of the ganglion relative to the cartilaginous otic capsule during the ontogeny in Yangochiropteran bats. It is a highly derived feature, as compared to the intro-otic position of this ganglion of other mammals. This egression of cochlear ganglion and corresponding reduction of bony enclosure of the ganglion provide morphological support for the molecular phylogenetic hypothesis for the Yangochiropteran clade. It also sheds light on contrasting development of the bat inner ear and shows different ontogenetic transformations of the spiral ganglion to accommodate different cochlear innervation for echolocation, respectively for Yinpterochiropterans and Yangochiropterans, in support of dual origination of echolocation.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

VERTEBRATE PALEONTOLOGY IS THE IDEAL GATEWAY SCIENCE FOR BOTH STEM AND "STEAM" EDUCATION: STRATEGIES USING THE HISTORY OF ANIMATION, FILM, AND DIGITAL SPECIAL EFFECTS

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Vertebrate paleontology derives science education utility and importance from the fact that it spans both life and physical science categories in K-12 education. There is near universal consensus that science-technology-engineering-mathematics (aka STEM) education is critical to modern educational strategies and future economic development worldwide. The addition of art to STEM (aka STEAM) not only brings a balance to STEM education, but it broadens its appeal, particularly to students who might think they are uninterested in STEM disciplines. Astronomy, marine biology, and paleontology are amongst the most popular of gateway scientific specialties, but vertebrate paleontology is unique in its historical and current relationship to art, animation, and motion pictures - disciplines that are generally very popular with students who favor the arts and humanities. Vertebrate paleontology's role in the history of animation and film is not only dramatic, but critical. By drawing a dinosaur and thus proving he could not have rotoscoped from film, Winsor McKay's *Gertie the Dinosaur* signaled the birth of character animation. Barely 25 years later the dinosaurs of Disney's Right of Spring sequence in *Fantasia* remains one of the most iconic sequences in the history of animation and film in general. Barely more than 50 years later, *Jurassic Park* was the film that set the stage for inclusion of digital effects for virtually every motion picture since. Thus, more than any single discipline, vertebrate paleontology's key role in the history of art, animation and film facilitates an integrative appreciation of life, earth and physical sciences, animation, digital modeling for film, and video game design. Freely available resources from 2-D and 3-D animation and film, and scientific visualization for use of these examples in K-12 STEM/STEAM presentations are provided. Strategies to adapt traditional paleontological research to encourage students toward combining science and art are offered.

Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

MIDDLE MIOCENE SYMPATRIC TRAGULIDS IN C3-DOMINATED GRASSLANDS OF MAE MOH (LAMPANG PROVINCE, NORTHERN THAILAND): THE FIRST RECORD OF THE GENUS *DORCATHERIUM* FROM SOUTHEAST ASIA

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Fossil tragulids are poorly known in Southeast Asia, only the Asian mouse-deer *Siamotragulus*, containing two previously described species (*S. sanyathanai* Thomas et al., 1990, and *S. haripounchai* Mein and Ginsburg, 1997), has been reported from the middle Miocene of Li Basin, in the northern part of Thailand. The nearby locality of Mae Moh has yielded the richest middle Miocene mammalian fauna of Thailand with more than 18 taxa including primates, carnivores, rodents, proboscideans, a rhinocerotid, a suid, bovids, and cervids. Most fossils have been collected from two coal layers, Q and K, dated between 13.4–13.2 ka according to a well-calibrated magnetostratigraphy.

Here we describe a relatively complete flattened skull in association with its mandible of *Dorcatherium* recovered from these layers of the Mae Moh locality, and we also report the occurrence of two smaller-sized tragulid species, referred to *S. sanyathanai* and *S. haripounchai*. The *Dorcatherium* skull, which is a juvenile, bears complete tooth rows (upper cheek teeth: DP3, DP4, and M1–M3 and lower cheek teeth: p1?, dp2–dp4, and m1) and is possibly attributed to a new species of *Dorcatherium* because it differs from Asian *D. minus* in having distinctly larger DP4 and from *D. majus* in being smaller in size. This material represents the first record of *Dorcatherium* in Thailand, therefore, extending the geographic distribution of this genus into Southeast Asia during the middle Miocene.

An analysis of stable carbon isotopes extracted from the enamel of *Dorcatherium* and *S. haripounchai* has indicated that their niche occupation corresponded to exclusive C3 grasslands. These two tragulids also shared their habitat with the cervid *Lagomeryx manai*, unlike their European relatives. On the other hand, several other ungulates from the same stratigraphic layers show more negative $d^{13}C$ values in their dietary intake, indicating that the Mae Moh landscape also included the forest-woodland ecotone. The sympatric occurrence of at least three different-sized ruminants that have low-crowned molars suggests abundant available food resources in an open canopy around the Mae Moh area. The grazing adaptation of Mae Moh tragulids as well as that of associated lagomerycids contrasts with the conventional view that low tooth crowns always indicate leaf-eating and suggests that paleodietary specialization on leaves or grass might have occurred independently in several ruminant lineages.

Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

BONE HISTOLOGY OF ADOCUSIAN TURTLES FROM ASIA AND NORTH AMERICA

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Adocusia (Adocidae + Nanhsiungchelyidae) are one of the most abundant groups of turtles in Asia and North America, which are known since the Late Jurassic to the Late Paleogene. Previously only preliminary histological results of the adocid and nanhsiungchelyid shell bones from North America have been reported. Here we provide histological data on shell bones of both adocids (*Adocus, Ferganemys, Shachemys*) and nanhsiungchelyids (*Basilemys, Hanbogdemys*, *Kharakhutulia*) from Asia and North America. All studied specimens show a well-developed diploe and external and internal compact cortices. Adocids are characterized by extensive and well developed reticular systems of primary vascular canals (PVC) of the external cortex. Nanhsiungchelyids show simple or branching PVC, but extensive reticular patterns such as indicated for adocids, were not encountered in the nanhsiungchelyids from Central Asia and Mongolia, except in specimens of *Kharakhutulia*. Growth marks are wavy in both families, but extending sub-parallel to the external bone surface in adocids and not parallel in nanhsiungchelyids. A highly organized "spindle-shape pattern" of ornamentation is restricted to *Basilemys* from the Late Cretaceous of North America. The wavy character of the growth marks depicts the typical 'pock-mark' surface sculpturing. The cancellous bone is dominated by short and thick trabeculae in adocids but usually more slender in nanhsiungchelyids, likely reflecting varying shell thickness. The internal cortical bone consists of parallel-fibered bone (PFB) which grades locally into lamellar bone (except in North American samples of *Adocus*, showing only PFB). Secondary bone remodeling is more frequent in nanhsiungchelyids. Sharpey's fibers that extend perpendicular to the bone margins are well developed in adocids, but not observed in nanhsiungchelyids. On the whole, adocusians shared characters (e.g., morphogenesis of a regular ornamentation pattern; zonation of external cortex with rather homogeneous fine fibered interwoven structural fibers in the more internal zone and a dominance of vertically oriented fibers in this tissue and the presence of growth marks in the more external zone), corroborate the close relation of both groups within the stem-trionychian taxon Adocusia.

Grant Information

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Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

OSTEOHISTOLOGICAL ONTOGENETIC ASSESSMENT AND PHYLOGENETIC ANALYSIS OF *NIPPONOSAURUS SACHALINENSIS* (DINOSAURIA, HADROSAURIDAE)

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The hadrosaurid *Nipponosaurus sachalinensis* from the upper part of the Yezo Group (upper Santonian to early Campanian) of Sakhalin Island, Russia, was originally described as an adult individual. Later studies suggested that the holotype is sub-adult based on some anatomical features (e.g., neurocentral suture and dentition), and argued its specific-level validity and phylogenetic position. Most of the previous studies placed *Nipponosaurus* within the clade of Lambeosaurini (derived lambeosaurines) but do not agree its phylogenetic status (e.g., a basal Lambeosaurini or a sister taxon to *Hypacrosaurus*). In this study, we revisit its ontogenetic stage through osteohistological ontogenetic assessment and test its phylogenetic analyses with a new data matrix based on a consideration of ontogenetic variation.Thin sections of the femur exhibit 1) woven bone with a gradual transition from longitudinal to laminar vascularity towards the outer cortex, 2) no lines of arrested growth, 3) secondary remodeling mainly limited within the inner cortex. The combination of these microstructural features resembles that of the late juvenile stage of *Maiasasaura*, suggesting (as previously suggested) *Nipponosaurus* had not reached skeletal maturity at the time of death. The femur size of *Nipponosaurus* (535 mm) is slightly larger than a large juvenile stage *Maiasaura* (500 mm), which may indicate similar growth rates.

Our phylogenetic analysis recovered *Nipponosaurus* basal to the clade Lambeosaurini, and three unambiguous synapomorphies (overlapping posterior margins of the coronoid process and the dentary dental battery, strongly concave posteroventral margin of the posterior process of the jugal, and angular tip of the ventral flange of the jugal) suggest it is monophyletic with *Arenysaurus* and *Blasisaurus*. Re-evaluation of morphological characters indicates that *Nipponosaurus* is diagnosed by the following ontogenetically non-variable characters: large lateral shelf of dentary, strong deflection of the lateral margin of the first phalanx on digit IV, and significantly long ulna compared to femur. Our results suggest that *Nipponosaurus* is a valid taxon as a non-lambeosaurini lambeosaurine, contrary to the previous studies.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

A NEW SKULL OF *NUMATAPHOCOENA YAMASHITAI*, A FOSSIL PORPOISE FROM THE LOWER PLIOCENE, THE UPPER PART OF THE HOROKAOSHIRARIKA FORMATION, NUMATA, HOKKAIDO, JAPAN, AND PHYLOGENY OF THE PHOCOENIDAE

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The early Pliocene porpoise *Numataphocoena yamashitai* from Numata Town, Hokkaido, Japan is known from the holotype, a fairly well preserved skeleton with an incomplete skull and a referred isolated periotic. We study a new referred skull of *N. yamashitai* from almost the same locality as the holotype. The skull preserves the premaxillae, left posterior maxilla, left frontal, left lacrimojugal, left palatine and left parietal. The new skull probably belongs to a younger individual because it is about 80% of the size of that of the holotype and shows distinct sutures. The specimen provides information about skull morphology, which adds diagnostic characters of the species. *Numataphocoena yamashitai* differs from other phocoenids in having a shallow wide groove on the dorsal face of the maxilla into which the posterior dorsal infraorbital foramen opens, a narrower and sharper anterior part of the internal acoustic meatus, and a robust anterior process of the periotic. Using TNT, we analyzed a new data matrix with 22 taxa and 122 characters to examine the phylogenetic relationships among the Phocoenidae. The results support the close relationships between *N. yamashitai* and the fossil phocoenids from Haboro Town, Hokkaido, Japan. The new material helps to understand the interspecies variation of the extinct species *Numataphocoena yamashitai* and its phylogenetic position.

Technical Session XX (Saturday, October 29, 2016, 3:15 PM)

TEMNOSPONDYL ECOMORPHOLOGICAL DIVERSITY ACROSS THE PERMIAN–TRIASSIC BOUNDARY IN THE KAROO BASIN, SOUTH AFRICA

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Stereospondylomorpha is a clade of typically large, semi-aquatic temnospondyl amphibians that flourished in the wake of the end-Permian mass extinction. Their taxonomic diversity greatly increased at both basinal and global scales following the extinction event, but the reasons for this are uncertain. Much of the morphological diversity seen among temnospondyls is in skull shape, which is associated with feeding ecology. If the observed increase in temnospondyl diversity was facilitated by an increase in ecological breadth among sympatric species then we should expect to see a dramatic increase in cranial morphological diversity in the Early Triassic. To test if this is the case, a series of geometric morphometric analyses on the skull shape of temnospondyls from the Karoo Basin sequence, which crosses the P–T boundary, was performed.

Following the end-Permian mass extinction the taxonomic diversity of Karoo temnospondyls roughly triples, while their cranial disparity increases only by about 60–100%, depending on how inclusive one makes the analysis with incomplete specimens. This suggests that although temnospondyl diversity greatly increased following the P–T extinction, the corresponding increase in ecological diversity may have been modest. Cranial disparity further increases by 200% later in the Early Triassic, between the *Lystrosaurus* to the *Cynognathus* assemblage zones, even though taxonomic diversity actually decreases during this interval. Cranial shape was found to be very closely tied to phylogeny, and so changes in the degree of relatedness between sympatric temnospondyls has a strong influence on morphological diversity. Intermediate morphologies are dominated by Permian to earliest Triassic rhinesuchids and lydekkerinids, while most of the more extreme morphologies are represented by later *Cynognathus* assemblage zone taxa.

Symposium III (Saturday, October 29, 2016, 9:45 AM)

FACULTATIVE THERMOGENESIS IN TEGU LIZARDS PROVIDES METABOLIC SUPPORT FOR THE PARENTAL CARE MODEL OF ENDOTHERMY

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The origins of vertebrate endothermy occurred at least twice in ancestral lineages to mammals and birds. Lepidosauria, as a sister taxa to Archosauria, are primarily ectothermic, but provide for comparative assessment of the ongoing evolution of thermoregulatory strategies. Most lepidosaurs rely on behaviour, with mild or negligible physiological contributions toward thermoregulatory control. The ancestral state of endothermy, however, most likely resembled that of many extant lepidosaurs, suggesting that insights into the selection pressures that led to the protoendothermic rise in metabolism may be observed in select taxa within the lepidosauria. A number of hypotheses have been proposed to explain the origins of vertebrate endothermy, including locomotory, thermoregulatory, reproductive activity, and parental care as the putative selective forces that contributed to sustained and elevated metabolic rates and body temperatures. Extant lepidosaurs lack the requisite insulation required for sustained endothermy, however the oldest direct evidence of parental care dates to Middle Permian synapsids, whereas insulating fur evolved by the Triassic in the synapsid lineage. Many non-avian dinosaurs are proposed to have exhibited parental care and nest brooding, thus the possible selective pressures for reproductive endothermy were likely in place between the Middle Permian through the Triassic. Here, I discuss our recent discovery of facultative endothermy in an extant squamate, the tegu lizard, *Salvator merianae* (Duméril & Bibron, 1839). Both male and female tegu lizards exhibit a profound rise in body temperature and heart rate in the wild during the reproductive season that cannot be explained by thermal inertia or behavioural thermoregulation. Tegus spend much time underground and maintain an insulated nest following egg-laying. As a result, their seasonal change in metabolism is estimated at ~3 fold higher than normal, leading to body temperatures up to 10°C above their burrow temperatures. Understanding how this novel form of endothermy evolved and is related to fitness remains to be determined, but will shed valuable light on the compatibility of paleobiological hypotheses for the origins of endothermy in tetrapods.

Technical Session IV (Wednesday, October 26, 2016, 4:00 PM)

MYLODONTID SLOTHS OF THE MIDDLE MIOCENE PEBAS MEGA-WETLANDS SYSTEM (WESTERN AMAZONIA, NORTHEASTERN PERU)

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Current knowledge suggests that Mylodontidae (Xenarthra, Pilosa, Folivora) is the basal-most sloth clade, after the divergence of extant *Bradypus*, within crown Folivora (the crown excludes the stem sloth *Pseudoglyptodon*). To date, most of what is known about the early history of Mylodontidae comes from the fossil record of Deseadan (late Oligocene) and Santacrucian (early Miocene) localities from southern South America (SA). The fossil record of pre-Quaternary sloths in tropical SA has been elusive generally, but recent discoveries from the tropics (e.g., *Baraguatherium*) provide alternative hypotheses concerning the origin, early diversification, and biogeography of Mylodontidae.

Here, we report two middle Miocene mylodontids from new vertebrate-bearing faunas near Iquitos (northeastern Peru, western Amazonia), discovered in localities belonging to the proto-Amazonian Pebas Mega-Wetlands system. Three mandibles are assigned to *Pseudoprepotherium* cf. *confusum*, initially described from the potentially coeval La Venta Fauna (Laventan SALMA) of Colombia. The Iquitos material of *P.* cf. *confusum* appears to document two morphotypes, consistent with possible sexual dimorphism. The second mylodontid taxon consists of mandibular and cranial material of a new species of orophodontine-like sloth. Preliminary phylogenetic analysis places this latter taxon in a polytomy with basal mylodontid taxa, such as *Octodontotherium* (late Oligocene) and *Nematherium* (early Miocene), which suggests that this new taxon represents an early-diverging lineage of mylodontid sloths, relictually surviving in the lowland tropics. This basal phylogenetic position within mylodontids also has implications for enhancing understanding of the ancestral morphological conditions of sloths, especially dental morphology, since the mylodontids are the nearest relatives to all other sloths. New recovered mylodontids from Miocene localities in tropical SA, such as these Iquitos specimens, will permit refined evaluation of biogeographical patterns on both regional and continental scales. The loss of mega-wetland habitats following the onset of the Amazon River system, around ~10 Ma, greatly affected other vertebrate communities but the degree to which it influenced xenarthran evolution has not been possible to evaluate previously.

Romer Prize Session (Thursday, October 27, 2016, 8:15 AM)

A HIDDEN EXTINCTION IN TETRAPODS AT THE JURASSIC–CRETACEOUS BOUNDARY

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Reconstructing deep time trends in diversity remains a central goal for palaeobiologists, but our understanding of the magnitude and tempo of extinctions and radiations is confounded by uneven sampling of the fossil record. In particular, the Jurassic–Cretaceous (J–K) transition, around 145 million years ago, remains a poorly understood interval, despite a minor apparent extinction and radiation of numerous important clades. Here, a rigorous subsampling approach, shareholder quorum subsampling (SQS) is applied to a comprehensive tetrapod fossil occurrence dataset to assess the group's macroevolutionary dynamics across the J–K transition. Almost every higher tetrapod group was affected by a significant decline across the boundary (up to 75% diversity loss, in theropods), culminating in the extinction of many basal taxa, such as rhamphorhynchid pterosaurs and non-neosauropods. This is coupled with ecological release and radiation of numerous modern lineages, including lepidosaurian sub-groups, eusuchians, sharks, and marine turtles. The timing of this extinction varies, with some

groups (e.g., sauropods) in decline prior to the boundary, and others (e.g., turtles) suffering their greatest diversity drop in the earliest Cretaceous. This is coupled with extremely high and widespread extinction rates at the J–K boundary, at up to eight times background rates in thalattosuchians, and suppressed origination rates in all groups throughout the earliest part of the Cretaceous, culminating in an overall wave of diversity decline and gradual ecological turnover. These patterns are independent of global and regional sampling proxies, except in North America, where there is strong evidence for a common cause explanation, with sea level driving both sampling and diversity patterns. Subsampling appears to alleviate the issue of geological heterogeneity in sampling intensity due to the intrinsic relationship between macrostratigraphic architecture and the effect this has on the availability to sample from the fossil record. Maximum-likelihood modelling demonstrates that eustatic sea level was the primary mechanism regulating diversity changes for most tetrapod clades through the availability of near-shore environments and shallow marine basins. Much of this apparently global pattern derives from the European fossil record, were eurybathic changes around the J–K boundary were driven by a major regression and the closure of shallow marine basins, and highlights the importance of distinguishing between regional and global signals.

Grant Information
National Environmental Research Council (NERC)

Poster Symposium I (Wednesday–Thursday, October 26–27, 2016, 4:15–6:15 PM)

UPDATE ON THE CYPRESS HILLS FORMATION FAUNAS OF SASKATCHEWAN (EOCENE–OLIGOCENE): NEW LOCALITIES AND NEW FOSSILS

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From 1935–1980, mammalian faunas from the Cypress Hills Formation (CHF) of southwest Saskatchewan have been collected mainly by parties under McCorquodale, Russell, and Storer. The oldest local fauna from the CHF, the Swift Current Creek Local Fauna, was primarily collected from a single locality: Swift Current Creek (SCC), a series of interbedded, calcareously cemented, sandstones and conglomerates that has yielded a Uintan-age fossil assemblage. SCC is the only Uintan fauna known from the Great Plains, and collecting efforts during the 20th Century resulted in the recovery of >50 species of mammal, representing >35 families in 17 orders including primates and bats. Most SCC specimens were recovered through a combination of traditional surface collecting and power dry-screening.

Since 2014, a joint field party from the University of Calgary and the Johns Hopkins University has re-initiated collecting efforts in the CHF, focusing on the SCC locality. To date, quarrying, acid preparation, and sorting of power dry-screen concentrate collected by previous workers has yielded a large sample of mammalian fossils that partially overlaps that published by Storer and others. In the past, power screening likely damaged some fossils, but the use of acid preparation promises to yield specimens of a more intact character. New specimens recovered since 2014 include the first record of *Protoreodon* cf. *P. parvus* (a partial jaw), the first record of *Macrocranion* from the CHF (an upper molar), a larger species of *Metanoiamys*, approximately twice as large as the specimens of *M. fugitivus* from SCC, as well as a molar with possible primate affinities. A nearly-complete ulna of a brontotheriid represents the largest element recovered from the site. New exploratory efforts in the area have yielded a new Uintan locality in addition to a new Chadronian locality.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

DOES COMPUTED TOMOGRAPHY IMPROVE THE ACCURACY OF THE MANDIBULAR FORCE PROFILE METHOD FOR BITE FORCE ESTIMATION AND FEEDING BEHAVIOR RECONSTRUCTION IN EXTANT AND EXTINCT CARNIVORANS?

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In recent years, several methods that employ biomechanical principles have been developed to investigate the craniomandibular adaptations of extinct predators to gain insight into their paleoecology. Most methods are complex, time-consuming, and require specialized computer software, but the mandibular force profile method uses the simpler principle of beam theory to identify mandibular biomechanical adaptations that reflect the bite force and feeding strategies of predators. While this method uses external dimensions of the mandibular corpus to determine its biomechanical properties, in effect assuming it consists of solid bone ('solid mandible model'), more accurate results could potentially be obtained by quantifying the internal distribution of cortical bone as the mandible is partly hollow ('hollow mandible model'). To test this possibility, mandibles of four extant carnivorans (gray wolf *Canis lupus*, spotted hyena *Crocuta crocuta*, lion *Panthera leo*, and clouded leopard *Neofelis nebulosa*) and of the extinct dire wolf (*Canis dirus*) were CT scanned, mandibular biomechanical properties were calculated at each interdental gap using the Moment macro in the software ImageJ and resultant values were compared to those obtained from the solid mandible model. Results reveal that the solid mandible model overestimates biomechanical properties by 2%–40% depending on species and location on the mandible, but the pattern of change in biomechanical properties along the mandible remains the same. As such, feeding behavior reconstructions are consistent between the hollow and solid mandible methods and are not affected or improved by the use of CT scans. Bite force estimates produced by the two methods are very similar (within 4%), except for *Crocuta*, where the solid mandible model underestimates bite force by 10%–14%. This discrepancy is due to the more solid nature of the *Crocuta* mandible (up to 92% cortical bone) relative to the mandible of other carnivorans (70%–86% cortical bone), an adaptation for bone cracking. Therefore, use of CT scans improves bite force estimation accuracy for taxa with bone-cracking adaptations, but not significantly so otherwise. Bite force estimates derived from mandibular force profiles are closer to empirically-measured bite force values (within 15%) than those inferred from jaw musculature dimension (Thomason's 'dry skull method'), which are 49%–58% lower. As such, the mandibular force profile approach provides reliable bite force estimates that can be used to calibrate finite-element analysis models.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

USE OF MORPHOMETRIC ANALYSIS ON ASTRAGALI TO DIFFERENTIATE BISON SPECIES

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Species-level taxonomic studies generally include detailed morphological descriptions of taxa. These descriptions have been based on non-metric, subjective, visual comparisons of morphological traits regardless of whether diagnostic characters between species are quantitative or qualitative in nature. Currently, bison species in the fossil record are determined by morphologic characteristics of the cranium and horn cores. This material is often fragmentary at sites which have yielded a wealth of postcranial elements that can be ascribed to the genus *Bison*. Species-level determination on postcranial material is often decided based on size when more than one species is present. This study explored the potential of using the astragalus in a geometric morphometric analysis to differentiate bison species. We gathered 13 3D landmarks from 160 astragali from Pleistocene and Holocene sites in Idaho. Landmark data was treated with Procrustes superimposition to remove all non-shape differences and then subjected to principal component analysis and linear discriminant function analysis. In addition, eight standard measurements were taken and subjected to the same analysis. This study demonstrated that the astragalus can be used to differentiate large Pleistocene artiodactyls (bison and camels) and bison to the species-level.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

A PRELIMINARY INVESTIGATION OF ALLOMETRY IN THE TIBIA AND PEDAL DIGIT II UNGUAL OF THE LARGE DROMAEOSAURID *UTAHRAPTOR* (DINOSAURIA, THEROPODA)

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Little is known about the growth trends of dromaeosaurid taxa due to the lack of unambiguous ontogenetic series like those available for other theropods (e.g., *Allosaurus*). However, ongoing preparation of a nine-ton field jacket excavated by the Utah Geological Survey (UGS) has produced skeletal material from at least seven *Utahraptor* individuals representing multiple ontogenetic stages. Juvenile elements thus far recovered from this field jacket allow for a preliminary investigation of growth trends in this large-bodied dromaeosaurid. We investigated growth trends in the tibia and the pedal digit II ungual by comparing the adult holotype from the Utah State University Eastern Prehistoric Museum (CEUM) with juvenile material currently housed at the UGS. Measurements from each element were log transformed to improve normality then plotted on bivariate plots and the slopes checked for allometry. A measure of claw curvature was obtained by fitting a circle to its outer edge and recording the degrees of arc scribed by the claw. The proximal width, diaphyseal circumference, and distal width of the tibia show positive allometry when compared to overall length with line slope values of 1.85, 2.33, and 2.80, respectively. These slopes reflect a relative increase in tibia robustness through ontogeny. General increases in hind limb robustness associated with relative shortening of the limb through ontogeny have been observed in the other theropods and is well-documented in *Allosaurus*. In contrast, the pedal digit II ungual of *Utahraptor* displays more isometric-like growth. Articular surface height, total claw height, and flexor tubercle width all have line slope values closer to 1 (1.22, 1.17, and 0.92, respectively) when compared to claw length. Interestingly, the flexor tubercle width/articular surface height ratio is higher in the juvenile (0.41) than it is in the adult (0.29) suggesting that juveniles may have had a relatively enlarged flexor tubercle compared to adults. Claw curvature is smaller in the juvenile (118 degrees) compared to the adult (127 degrees). The growth trends reported here are only preliminary. As preparation of the UGS field jacket continues, more elements and ontogenetic stages will be sampled and additional methods (e.g., histology) will be employed to analyze growth trends. However, the initial trends reported here incite intriguing questions for ongoing research such as how much allometry may be ascribed to body size increase and how much may be explained by functional differences between juvenile and adult Utahraptors.

Technical Session III (Wednesday, October 26, 2016, 3:45 PM)

AUSTRALIAN ISLAND EMUS ARE HOLOCENE DWARFS

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At least six taxa of emus (flightless birds) inhabited Australia in the past: *Dromaius gidju* n. sp. from the Miocene; *D. ocypus* from the Pliocene; *D. ater*, *D. baudinianus*, and *D. novaehollandiae diemenensis* from the Holocene; as well as *D. novaehollandiae*, which is currently extant. Fossil evidence and reports from early European explorers suggest that at least three island emus, including the two dwarfed emus, were hunted to extinction only recently in the 19th century (*D. ater, D. baudinianus,* and *D. novaehollandiae diemenensis* from southern Australian offshore islands: King island, Kangaroo Island, and Tasmania, respectively). Although a previous study of the King Island emu found their genetic diversity fell within that of the mainland emu, little is known about how the Kangaroo Island emu or the Tasmanian emu relate to either of these forms, or even whether the Tasmanian emu was diminutive in size at all. By sequencing a short fragment of the mitochondrial control region from sub-fossil specimens of the King Island emu (n=8), Kangaroo Island emu (n=11) and Tasmanian emu (n=4), we were able to establish they all share the same or similar DNA markers with the extant mainland emu (n=81). Short damaged fragments of DNA are usually all that remain in sub-fossil and fossil bone remains, particularly from hot or wet regions of the world such as Australia.

Measurements were also taken of the femur and tarsometatarsi bones of the King Island emu (n=16 and n=12), Kangaroo Island emu (n=13 and n=12), and mainland emu (n=8 for both) for length, proximal width, proximal depth, distal width, distal depth, shaft width, and shaft depth. Preliminary analyses of pairwise linear measurements show the Kangaroo Island emu were smaller than the mainland emu, with the King Island emu even smaller than the Kangaroo Island emu. By generating Mosimann shape variables for each individual, we were able to remove a substantial part of the isometric scaling. Principal component analyses of the Mosimann shape variables show some overlap of all three emu taxa, suggesting even though isometric size is largely removed some size-related shape (allometric) variability remains. Furthermore, the degree of dwarfism for each island emu appears to correlate with island size. By analyzing both genetic and morphological diversity of congeneric island/mainland taxa pairs, this work on the Australian emu provides a case study for examining island dwarfism as an evolutionary mechanism.

Poster Symposium I (Wednesday–Thursday, October 26–27, 2016, 4:15–6:15 PM)

DIVERSITY AND TURNOVER OF MAMMALIAN CARNIVORES FROM THE MIDDLE EOCENE WASHAKIE FORMATION, WYOMING, U.S.A.

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Vertebrate fossils from the middle Eocene (ca. 49–45 Ma) Washakie Formation of southcentral Wyoming, U.S.A., provide a rare window into the faunal reorganization across the Bridgerian and Uintan North American land mammal 'ages' within a single depositional basin. Documentation and interpretation of faunal dynamics in the Rocky Mountain region during this time, which experienced substantial changes in climate and landscapes, will help us better understand the post-warming trajectories of vertebrate diversity. Here, based on recently cataloged as well as previously described specimens, we report a revised list of mammalian carnivores from the late-Bridgerian lower unit (Twka1) and the early-Uintan middle unit (Twka2) of the Adobe Town Member. A minimum of 16 species of carnivores occur in Twka1, including two mesonychians, one oxyaenid, six hyaenodontids, and seven carnivoramorphans. Fragmentary materials from Twka2 represent at least 11 distinct forms, including two mesonychians, one oxyaenid, three hyaenodontids, and five carnivoramorphans. That few of the taxa from Twka2 can be confidently assigned to known carnivore species reflects in part the still very limited knowledge of early-Uintan mammals in the region, but it also implies the high potential for additional collecting in the Washakie Basin to help fill in this knowledge gap. Notably few taxa from Twka2 occur, or appear to have immediate ancestors, in Twka1, suggesting high taxonomic turnover between the Br3 and Ui1b subchrons. The carnivoramorphan component of the Washakie fauna differs from earlier Bridgerian assemblages of the Rocky Mountain region in the absence of arboreal hypocarnivores/frugivores (despite abundance of primates in Twka1) and from later Uintan assemblages in the absence of hypercarnivores (whereas small to large hypercarnivorous “creodonts” are present in Twka1), though interestingly enough some of the taxa here appear to show the beginning of 'face shortening.' Taken together, the temporal and ecological diversity patterns of mammalian carnivores within the Washakie Basin are consistent with: (1) the previously proposed rapid biomic shift in the region from forest-dominant to woodland/savanna-dominant, and (2) synecological constraint on diversification. Greater knowledge of the paleobiology of fossil taxa may reveal mammalian carnivores to be more sensitive to environmental changes than have been recognized.

Grant Information

Curation of a pertinent fossil collection at the Field Museum was supported by the NSF Collections in Support of Biological Research program (DBI-1203530 to K.D. Angielczyk).

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

NEW SKELETAL MATERIAL OF THE EXTINCT MIOCENE PINNIPED *ALLODESMUS* FROM JAPAN INDICATES THEIR NEW SYSTEMATICS AND LOCOMOTORY ADAPTATION

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Allodesmus is an extinct pinniped that is known only from the middle and late Miocene of the North Pacific and belongs in the family Desmatophocidae. According to the previous studies, *Allodesmus* includes at least five species and is divided into three subgroups: 'Basal,' 'Broad head' and 'Long head.' However, the phylogenetic study of *Allodesmus* has been inadequate, and their evolutionary history is still controversial. Moreover, studies of the postcranial bones of *Allodesmus,* or the Desmatophocidae, is almost non-existent because of insufficient skeletal material for those taxa.

A nearly complete skeleton of *Allodesmus* (AMP25) collected in 1991 from the middle Miocene Okoppezawa Formation (ca. 16.5–11 Ma), Hokkaido, northern Japan, consisting of a skull, forelimbs, hind limbs, ribs and vertebrae, demonstrates not only its phylogenetic but paleobiological importance, and we investigated this enigmatic taxon by inclusion of this new specimen among the Pinnipedia in the phylogenetic framework.

As for the result of our phylogenetic analysis among species of *Allodesmus* within the Desmatophocidae, the 'Long head' subgroup including the type species was confirmed as a clade. However, the 'Broad head' subgroup including AMP25 was not supported as a monophyletic group, instead they were recognized as unresolved polytomy with the 'Long head' subgroup. Among them, AMP25 has an autoapomorphy in which the supraorbital process is located at the anterior portion of the interorbital bar. From the above and additional observations, we have concluded that AMP25 belongs to a distinct species. Importantly, in spite of the supposed close relationship of the Desmatophocidae to the Phocidae, appendicular bones of AMP25 and some other *Allodesmus* species show very different and distinctive character combinations among the pinnipeds. In particular, the morphology of the ankle bones of AMP25 is remarkably distinguishable from those of phocids, which means that some postcranial characters other than those we used for the phylogenetic analyses have potential problems in their homologies. In other words, the evolutionary process of their functional adaptation in water and on land must be reconstructed independently from characters that are used for the phylogenetic analyses.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

NEW APATEMYIDS FROM THE CHADRONIAN OF SIOUX COUNTY, NEBRASKA WITH REASSESSMENT OF SPECIMENS FROM RABEN RANCH

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The Apatemyidae is a unique radiation of insectivorous mammals known from the Paleogene of Europe, India, and North America. Although geographically widespread, apatemyids comprise small percentages of faunal assemblages. Efforts to understand within-taxon variation, produce differential diagnoses, and apply formal taxonomy to apatemyids are confounded by the small samples currently known from geographically and temporally disparate localities. Despite some disagreement regarding the number of apatemyid genera and species, there is widespread agreement that two genera exist sequentially during the Eocene in North America. The genus *Apatemys* appears first, persisting from the earliest Wasatchian through the Duchesnean and the genus *Sinclairella* follows, persisting from the Duchesnean until the end of the Oligocene.

The genus *Sinclairella* is well documented from two Chadronian localities of northwestern Nebraska—an anthill locality and the Raben Ranch locality—whereas specimens from the anthill locality are consistent with descriptions of the type specimen for *Sinclairella dakotensis*, an M_1 specimen from Raben Ranch is considerably smaller than specimens currently assigned to the hypodigm.

Here, we describe apatemyid specimens collected from three additional sites in Sioux County, Nebraska during field seasons from 2011–2015. All three localities include specimens of *Sinclairella dakotensis* and one, the Whitehead Creek locality, includes two upper molars of a second apatemyid taxon that we assign to the genus *Apatemys*. Reevaluation of the apatemyid sample from the contemporaneous Raben Ranch locality suggests that the small M_1 from Raben Ranch represents the same species of *Apatemys* as the teeth from Whitehead Creek. In addition to sharing morphological features with *Apatemys* to the exclusion of *Sinclairella*, the Raben Ranch M_1 is consistent with an equivalent-sized mammal as that represented by the upper molars from Whitehead Creek. Recovery of these specimens both extends the distribution of *Apatemys* to the middle Chadronian of Nebraska and expands the apatemyid sample of this region permitting a better analysis of within-taxon variation.

Grant Information

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Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

NEUROANATOMICAL EVOLUTION OF PALAEOGNATHS: INSIGHT FROM NEW CRANIAL ENDOCASTS OF ELEPHANT BIRDS (AEPYORNITHIFORMES)

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The evolutionary history of palaeognathous birds is marked by repeated evolution of island endemism, gigantism, nocturnality and flight loss. Understanding whether and how the neuroanatomy of palaeognaths tracks these patterns could shed light on the processes by which these patterns occurred. In particular, the endocranial morphology of extinct Malagasy elephant birds, the largest birds that ever lived, represents a crucial gap in our understanding of the neuroanatomical evolution of these birds. Here, we report new digital reconstructions of the endocasts and endosseous labyrinths of adult elephant birds, a moa, and a cassowary, and compare them with other palaeognaths and representatives from across Aves. The resulting 3D digital models were analyzed in a comparative framework taking into account phylogeny and used to infer ancestral head posture and identify evolutionarily shifts in neuroanatomy.

Many neuroanatomical traits show variation across Palaeognathae, including the size and shape of the olfactory bulbs and development of the telencephalon, Wulst, optic lobe and cerebellum. In particular, the optic lobe of the elephant bird is highly reduced. Only the nocturnal kiwi shows more midbrain reduction, and we suggest the elephant bird may have had a similar nocturnal activity pattern. The elephant bird and kiwi, recovered as sister taxa by molecular phylogenetic analyses, also display many endocranial differences, for example, in the size and shape of the telencephalon and pneumaticity of the skull roof. The endosseous labyrinth has been mostly overlooked in investigations of palaeognath neuroanatomy; our study reveals striking differences in the shape and orientation of semicircular canals among palaeognaths, even among elephant birds. These neuroanatomical shifts, as well as others reported here, indicate trends in brain shape evolution among palaeognaths that likely correspond to changes in locomotor mode and activity patterns.

Technical Session V (Wednesday, October 26, 2016, 3:45 PM)

STABILITY OF EMPIRICAL MAMMAL CO-OCCURRENCE NETWORKS OVER PALEONTOLOGICAL TIMESCALES

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The study of biological interaction networks among species has experienced a surge in recent years, but this approach is still uncommon in paleontology. Co-occurrence networks have received increasing attention from ecologists because they may be able to

reveal mechanistic processes governing community assembly. One topic of particular interest is the stability of community networks over time, which has potential application over paleontological as well as ecological time scales. Although theoretical and empirical studies of spatially explicit networks abound, so far most temporal network research has been simulated due to lack of adequate temporal data. These simulations and the theory behind them have suggested various network characteristics such as low connectance (proportion of links realized) and diversity of interaction types that may impart stability to co-occurrence networks through time. To examine empirical support for existing hypotheses, we use large-scale paleontological time series data from the New and Old Worlds (NOW) database of fossil mammals. For each European Land Mammal Age (MN zones), we use the Pairs algorithm to identify significant co-occurrence patterns between pairs of mammal genera across space then classify the resulting links as either aggregations or segregations, forming the basis for co-occurrence networks. We examine the effects of distribution of interaction types (proportion of aggregated to segregated pairs), network connectance, and degree of compartmentalization on stability, measured as persistence of interacting mammal genera (nodes) and significant interactions between mammal genera (links) over successive MN zones. Our results show increased node persistence when aggregations and segregations each account for at least 40% of significant interactions. All networks with a node persistence greater than 29% have a connectance between 0.05 and 0.125. Highly connected networks have fewer random interactions, suggesting clusters of genera that are more constrained by biotic interactions or dispersal parameters are less likely to persist in their roles. We conclude that a balance of interactions in co-occurrence networks may play a role in stabilizing co-occurrence network structure across long timescales.

Grant Information
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Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

FUNCTIONAL ANALYSIS OF HAND AND FOOT METAPODIALS AND PHALANGES OF *PLESIADAPIS TRICUSPIDENS* (PLESIADAPIFORMES, PLESIADAPOIDEA; PALEOCENE, FRANCE)

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Besides living euarchontan mammals (Euprimates, Scandentia, Dermoptera), Plesiadapiformes constitute an important Paleocene–Eocene group. They play a pivotal role in the debate concerning primate origins. The reconstruction of the locomotor and postural diversity of plesiadapiforms is thus essential for establishing robust phylogenetic relationships within euarchontans. To this end, autopodial elements, being in direct contact to the substrate, are good indicators of positional behaviors and substrate preferences. In this study, we investigated the functional morphology of fossil metacarpals, metatarsals, proximal, intermediate, and distal phalanges of *Plesiadapis tricuspidens* from late Paleocene localities of the Paris Basin, France. We compared these fossil elements to those of extant euarchontans and other mammals of various positional behaviors. We found that *P. tricuspidens* exhibited a mosaic morphology. Many characters are similar to those of arboreal medium-sized mammals (e.g., squirrels). Some others are comparable to those of more terrestrial forms, and some are unique and distinguished the fossils from the functional-behavioral groups. The functional interpretation of its autopodial elements provided evidence of a manus associated with claw clinging and climbing capacities on large vertical substrates, as well as clambering and grasping upon smaller branches. In a different manner, the pes appeared less efficient in climbing and clambering but able to accomplish claw clinging and climbing as well as walking on larger substrates of various orientations. These features suggest that *P. tricuspidens* was a scansorial mammal engaging in claw clinging and climbing on steeply inclined and vertical substrates, capable of quadrupedal activities as well, and of climbing and clambering on smaller fragile branches to a lesser extent. As *Plesiadapis* appears to be among the least specialized plesiadapiforms in terms of morphology, it is possible that this positional behavior may represent the ancestral archontan one.

Grant Information
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Poster Symposium I (Wednesday–Thursday, October 26–27, 2016, 4:15–6:15 PM)

NEW SPECIMENS OF *HARPAGOLESTES* (MESONYCHIA, MESONYCHIDAE) FROM THE UINTA FORMATION, UINTA BASIN, UTAH

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The mesonychid *Harpagolestes* was one of the largest carnivorous mammals of the middle Eocene and likely filled a top predator or scavenger role in these ecosystems; however, their sparse fossil record has been understudied. *Harpagolestes* was initially recognized from the early middle Eocene (Bridgerian North American Land Mammal Age, NALMA) of Wyoming and has subsequently been listed in faunas from middle Eocene deposits in southern California, Texas, Washakie Basin (Wyoming), and Utah, as well as Eocene deposits in Asia. A comprehensive data set, including two new specimens, an incomplete skull and a pair of mandibles, from stratigraphically controlled localities in the Uinta Formation, Uinta Basin, Utah, now allows us to begin to characterize the craniodental diversity of *Harpagolestes* during the middle Eocene.

Although five species of *Harpagolestes* from the middle Eocene (Bridgerian through Duchesnean NALMAs) are considered valid, a lack of understanding about the variation and taxonomic utility of craniodental characters for this genus has historically led to most specimens being assigned to new species. Much of the problem relates to the extreme tooth wear expressed in most specimens that precludes a comprehensive analysis of occlusal morphology. Using dental dimensions as a proxy for size and comparing mandibular depth at the first molar, we analyzed 17 *Harpagolestes* and 11 other middle Eocene mesonychid specimens. Our results indicate diagnostic patterns of variation for *Harpagolestes* both within the Uinta Formation and between it and other North American *Harpagolestes* localities. The new mandibular specimens have smaller dental dimensions for the second molar that are similar in size to the mesonychid *Mesonyx*. These mandibles were recovered higher in the Uinta Formation than specimens from the stratigraphically lower White River Pocket locality that have larger dental dimensions. Although the mandibular specimens from the Washakie Basin have much deeper mandibular corpi, their dental dimensions are similar to specimens from Utah, perhaps indicating that they represent the same species. Similarly, the Texas specimens also have deeper mandibular corpi, but exhibit slightly larger dental dimensions, particularly in the maxillary cheek teeth, than those found in Utah or Wyoming. These results suggest that *Harpagolestes* had fewer and less wide-ranging species than previously reported.

Grant Information
Funding for this project was provided by Midwestern University and the UC Museum of Paleontology with permission from the Bureau of Land Management.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

REDESCRIPTION OF A TELEOSAURID SKULL (CROCODYLOMORPHA, THALATTOSUCHIA) FROM THE LIASSIC OF HOLZMADEN, GERMANY

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In 1894, Bernard Hauff Sr. discovered an excellently preserved teleosaurid skull (Crocodylomorpha, Thalattosuchia) in Lower Jurassic sediments (Posidonia Shale Formation) of his quarry, located in Holzmaden, southern Germany. The specimen was purchased in 1894 for the palaeontological collection of Utrecht University by proffersor C.E.A. Wichmann, and listed as *Teleosaurus* sp. (collection number G337-1894). A thorough morphological description of the skull morphology and analysis of morphometric data of this specimen allows me to assign the specimen to a species by comparison of the morphological characters and morphometric data with previously described teleosaurid species from the Early Jurassic of south Germany. On the basis of the size, shape and proportion of the skull and its individual elements, it can be concluded that G337-1894 belongs to *Steneosaurus bollensis*, the most common teleosaurid species in Lower Jurassic sediments of southern Germany. Determination of the ontogenetic stage of the specimen is complicated by the lack of postcranial material. Nonetheless, the size and proportions of the cranium suggests that this individual was in a relatively late ontogenetic stage. A higher resolution of the ontogeny in the genus *Steneosaurus* however, requires more cranial and postcranial material and histological data of particularly early ontogenetic stages.

Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

ENAMEL MATURATION IS INDEPENDENT OF APPOSITIONAL GEOMETRY

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Isotopic zoning within mammalian tooth enamel encodes a sub-annual time series of isotopic variations of an animal's body water composition, with a damping factor that depends mainly on the geometry of enamel mineralization. Enamel mineralizes in two stages. First, an appositional matrix is seeded with crystallites along a front that forms a low angle relative to the enamel-dentine junction (EDJ). This matrix is mineral poor, containing only ~25% of total mineral content. After apposition, enamel undergoes a prolonged maturation stage that precipitates the remaining ~75% of total mineral. Because maturation precipitates the majority of enamel, understanding the geometry of this stage is crucial for accurately interpreting chemical and isotopic zoning profiles.

We used an electron probe microanalyzer to collect X-ray maps of Ca, P, Na and Mg from several disparate ungulate (*Odocoileus*, *Bos*, *Ovis*, *Lama*, *Equus*) teeth across the transition from immature to mature enamel, i.e., across the maturational front. Pixel size was 15 µm and area images were typically ~2 mm x ~2 cm. Many imaged areas also encompassed large regions of enamel in its appositional stage. These compositional maps show that while appositional enamel mineralizes at a low angle relative to the EDJ, the majority of enamel (inner and middle layers) mineralizes heavily at a high angle to the external tooth surface and the EDJ over length scales of 2–4 mm. The outer enamel surface mineralizes more slowly and later than the inner and middle enamel layers. These data suggest that isotopic sampling strategies should parallel the geometry of maturation, not apposition, and focus on interior enamel to improve data fidelity. In principle, because the length-scale of maturation is also smaller than previous estimates, the magnitude of isotopic damping is also reduced, so enamel zoning more closely reflects original body water isotopic variations.

Grant Information
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Poster Symposium II (Friday–Saturday, October 28–29, 2016, 4:29 PM)

TYING IT ALL TOGETHER: USING RADIOMETRIC AGES TO CORRELATE FOSSIL LOCALITIES ACROSS THE UPPER JURASSIC MORRISON FORMATION, WESTERN INTERIOR, USA

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The Morrison Formation (Upper Jurassic) of the western United States is one of the most prolific fossil-bearing rock units in the world. Placing these fossils into a temporal context is necessary in order to make paleoecological and evolutionary comparisons of the fauna across the formation as well as with similarly aged faunas worldwide.

In the past, researchers have used several different methods to attempt long-distance correlations of vertebrate fossil localities across the Morrison Formation. These methods include lithostratigraphy using clay mineralogy and biostratigraphy using pollen, ostracods, charophytes, and dinosaurs. While each of these methods has useful qualities and may be valuable in local areas, overall they fail to provide reliable correlations across the vast depositional area of the Morrison Formation. Radiometric ages are the best tool for correlations across this widespread rock unit, and current work is providing these ages.

Using new U/Pb ages from ashfall zircons as well as recalibrated legacy $^{40}Ar/^{39}Ar$ ages, we can now begin to construct a radiometrically-based stratigraphic framework for

the Morrison Formation. This new work utilizes each dated locality's own stratigraphic section, and includes only those nearby localities that can be directly correlated. Data are now available to correlate fossil localities in southeastern Wyoming including the numerous localities at Como Bluff, Bone Cabin Quarry, and Sheep Creek, as well as localities at Garden Park in south-central Colorado, Mygatt-Moore and Curecanti in western Colorado, and Dinosaur National Monument in northeastern Utah.

These correlations based on radiometric ages demonstrate that the stratigraphic relationships within the Morrison Formation are complex, with more variations in thickness and age of various members and the formation as a whole than previously were appreciated. This is important when evaluating prior correlations of fossil localities; for example, assumptions that localities near the top of the formation are temporally equivalent are not supported when radiometric ages are used as the main datum. Future work will include more ages in order to place additional fossil localities into this temporal framework.

Technical Session XII (Friday, October 28, 2016, 2:00 PM)

THE CARTILAGE CONE OF ARCHOSAUROMORPHS: IMPLICATIONS OF CHONDRO-OSSEOUS JUNCTION ON HIP JOINT LOADING AND FEMORAL OSSIFICATION

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Fossil archosauromorphs evolved a rich spectrum of chondro-osseous morphology beyond the diversity exhibited by extant archosaurs. The cartilage cone is a convex extension of the epiphyseal hyaline cartilage that inserts into the concave metaphyseal growth plate of long bones. Among extant archosaurs, the cartilage cone results from delayed endochondral ossification relative to perichondral ossification during embryological development, and is absent in post-hatching neonates. In contrast, the proximal femora of many post-neonatal fossil archosauromorphs retain uncalcified cartilage cones, as evident from the concave metaphyseal growth plates. This study investigated the evolutionary transitions, functional roles, and ontogenetic significance of the cartilage cone in archosauromorphs. Femora of 140 taxa were studied and digitized. Key phylogenetic transitions in cartilage morphology were estimated using likelihood ancestral state reconstruction on the osteological correlates, and analyzed using phylogenetically corrected correlation to reveal trends in body size evolution. The cartilage cone arose independently in multiple lineages, including dinosauriformes and paracrocodylomorphs, but was secondarily reduced and subsequently lost in sauropods, theropods, ornithischians, crocodylomorphs, and phytosaurs. Although adult body size does not predict the presence of the cartilage cone, it is often absent in large adults but persist in locomotor patent conspecific juveniles. The cartilage cone likely provided mechanical support to the thick epiphyseal hyaline cartilage against tensile and shear strain by increasing metaphyseal surface contact. In sauropods and phytosaurs, reduction of the cone coincides with highly rugose growth plates; whereas reduction of the cone in theropods coincides with smooth growth plates. These divergent adaptations are hypothesized to associate with transitions in cartilage thickness and locomotor-induced loading regimes across the chondro-osseous junction. Overall this study indicates that multiple lineages of basal archosauromorphs used uncalcified hyaline cartilage as load bearing tissues on par with subchondral bones, illustrating a key innovation in locomotor tissues.

Poster Symposium II (Friday–Saturday, October 28–29, 2016, 4:24 PM)

TEMPORAL DISTRIBUTION OF DIPLODOCID SAUROPODS ACROSS THE UPPER JURASSIC MORRISON FORMATION (USA)

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Diplodocid sauropods include nearly 20 species from the Late Jurassic to Early Cretaceous of North and South America, Europe and Africa. Peak diversity of Diplodocidae is reported from the Upper Jurassic Morrison Formation, from which 15 species are known. However, no detailed long-distance correlation across fossil sites was possible until recently. Herein, we analyze an updated phylogenetic matrix of diplodocid specimens, and correlate it with new stratigraphic data from the sites where they were collected. The phylogenetic matrix includes 53 diplodocid specimens (47 from the Morrison Formation), and 485 characters. Two specimens are scored for the first time, and the scoring of six operational taxonomic units was revised. Detailed character analysis resulted in the splitting of several multistate characters into their neomorphic and transformational components. The analysis was run with the software TNT using an extended implied weighting approach, which reduces the influence of missing data on the downweighting of homoplasies. The Morrison Formation was split into six stratigraphic systems tracts, of which only systems tracts 3-6 are currently known to produce diplodocid skeletons. The consensus tree recovers the specimens of *Apatosaurus louisae* as more closely related to *Brontosaurus excelsus* than to *A. ajax*. *Amphicoelias altus* and the Portuguese specimen ML 418 are successively more basal diplodocids than Apatosaurinae + Diplodocinae. The Stratigraphic Consistency Index of the consensus tree was calculated in R using the strap package, and is significantly better than expected by chance. Diversity increases throughout the system tracts from 3 to 8 co-occurring species. The high diversity can be explained by environmental or geographical segregation, or too little temporal resolution in the system tracts. Within *Diplodocus*, our results indicate that *D. longus* could be the ancestral species of *D. carnegii* and *D. hallorum*. These two species occur later and are geographically segregated. The study shows that a combination of detailed phylogenetic studies and stratigraphic information can help to detect evolutionary transitions and possible speciation events.

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Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

TWO RARE ARTIODACTYL MAMMALS FROM THE UPPER MIOCENE NAKALI FORMATION OF KENYA, EAST AFRICA

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The upper Miocene Nakali Formation (ca. 10 Ma) of central Kenya is an important fossil locality, particularly in anthropology and primatology, because the formation has yielded several taxa of colobine, small non-cercopithecoid catarrhine, and hominoid primates. However, the Nakali fossil mammal fauna has not been well documented. Since 2002, a joint research team from Kyoto University and National Museums of Kenya has been conducting geological and paleontological field research in the Nakali Formation.

Here, we report two rare artiodactyls from the Nakali Formation, a listriodontine suid and a tragulid ruminant, collected by the joint research team. These two artiodactyl taxa are rare in terms of collection size in the formation and are important for clarifying the Nakali fossil mammal fauna. The listriodontine suid 'cf. *Listriodon* sp.' is represented by a talonid of a lower molar that has a strongly lophodont hypolophid. Although the material is fragmentary, it seems to be phyletically related to *Listriodon splendens*, which has never been recorded in Africa and is the most derived species among the genus. If the Nakali specimen proves to be phyletically closely related to to this species, it indicates that the lineage of *L. splendens* had immigrated from Europe/Turkey to East Africa by ca. 10 Ma. The tragulid *Dorcatherium* sp. cf. *D. pigotti* is represented by M1 (or DP4) and a mandible with p3–m3, which are comparable in size to those of *Dorcatherium pigotti* among the African species of the genus. Although the genus *Dorcatherium* and species *D. pigotti* are common taxa in the early to middle Miocene of Africa, they are rarely found in the late Miocene. This is the second record of the genus in the late Miocene of Africa, reinforcing that *Dorcatherium* had existed until the early late Miocene in East Africa.

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Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

A NEW SPECIMEN OF *MONONYKUS OLECRANUS* (DINOSAURIA: THEROPODA) FROM BUGIN TSAV, WESTERN GOBI DESERT, MONGOLIA, WITH NEW INFORMATION ON THE VERTEBRAL AND SKULL MORPHOLOGY

TSUIHIJI, Takanobu, University of Tokyo, Tokyo, Japan; WATABE, Mahito, Osaka City University, Osaka, Japan; WITMER, Lawrence M., Ohio Univ, Athens, OH, United States of America; TSOGTBAATAR, Khishigjav, Institute of Paleontology and Geology, Mongolian Academy of Sciences, Ulaanbaatar, Mongolia; BARSBOLD, Rinchen, Institute of Paleontology and Geology, Mongolian Academy of Sciences, Ulaanbaatar, Mongolia

A disarticulated but associated partial skeleton of *Mononykus olecranus* was found at the type locality of this taxon, Bugin Tsav, in the western Gobi region of Mongolia by a field party of the Mongolian–Japanese joint expedition in 2006. The specimen can be referred to *M. olecranus* based on the presence of putative autapomorphies of this taxon such as strongly compressed anterior dorsal vertebrae, the supracetabular crest developed only in the anterior part of the acetabulum, and the base of the ascending process deeply excavated medially. The specimen provides new information on the morphology of this taxon, especially on the vertebrae and skull, unavailable in the holotype specimen.

At least eight vertebrae are incorporated in the sacrum. The centra of the four posterior sacral vertebrae are compressed mediolaterally, forming a ventral keel. On the anterior-most caudal vertebrae, the transverse process is triangular in profile, expanding anteriorly. In the skull, the frontal is anteroposteriorly elongated. The left and right parietals are fused with each other. The dorsal surface of the parietal is flat and anteriorly bears a well-demarcated slot for articulation with the frontal. As in *Shuvuuia,* the foramen magnum is very large, especially compared with a small occipital condyle. The basal tubera are small and are widely separated from each other. Two hypoglossal foramina and a larger vagus foramen are present ventrolateral to the occipital condyle. The quadrate is anteroposteriorly flattened. The proximal end forms a condyle with a flange expanding laterally. These structures may correspond to the medial and lateral heads of the quadrate observed in other parvicursorines. The laterosphenoid bears a prominent capitate process. CT scan data revealed delicate structures preserved within associated matrix. The basipterygoid process is long and flattened, extending nearly vertically as it is preserved. The presence of extensive pneumatization in the basicranial region is revealed for the first time among alvarezsaurids. The rostral tympanic recess, demarcated dorsally by the laterally-expanding preotic pendant, is anteriorly continuous with a large, mostly open space surrounded by the basiphenoid. This condition apparently represents an extreme degree of pneumatization of the basisphenoid, similar to the swollen or bulbous parasphenoidal rostrum present in some maniraptorans.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

CRANIAL OSTEOLOGY OF A NEW SPECIMEN OF *LYCAENOPS* (THERAPSIDA: GORGONOPSIA)

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Recent systematic revision of gorgonopsians has resulted in major changes to the group; however, many taxa remain obscure. *Lycaenops ornatus* is one of the best-known gorgonopsians, and yet the alpha taxonomy of its genus is poorly understood, impeding more in-depth study. Here we describe ROM 47470, a new, well-preserved gorgonopsian partial cranium with affinities to *Lycaenops angusticeps* from the *Cistecephalus* Assemblage Zone in the South African Karoo Basin. The specimen comprises most of the posterior portion of the skull and some of the snout. Several features distinguish ROM

47470 from *L. ornatus* and ally it with *L. angusticeps* including increased pachyostosis of the orbit and post orbital bar regions, horn-shaped elongate postfrontals, an expanded ventrally curved subtemporal bar, an enlarged squamosal sulcus that extends onto the subtemporal bar, decreased contribution of the frontal to the orbit, and the inferred presence of an elongated snout. A detailed description of the well-preserved temporal and braincase regions reveals new data on the narrow morphology of the braincase, a moderately pachyostosed and deflected subtemporal bar, a pachyostosed orbital region forming a raised ring around the orbit, and the presence of a distinctive large preparietal.

We included ROM 47470 in a phylogenetic analysis using a recently published matrix, amending the coding based on observation of this and other specimens currently assigned to *L. angusticeps*. A single most parsimonious tree was recovered with ROM 47470 a sister taxon to *L. ornatus*, supporting its placement within a monophyletic *Lycaenops*. This sister taxon relationship is supported by the following synapomorphies: the presence of a preparietal and the expansion of the postorbital bar. In addition, we recover *Lycaenops* as sister to a monophyletic Rubidgeinae. However, many specimens of *Lycaenops* and closely related taxa remain undescribed, and some are only provisionally taxonomically assigned. A more comprehensive study of *Lycaenops* including specimens FMNH UC 1513, UCMP 47470, AMNH 5535, and AMNH FARB 5537 is essential for further deciphering the systematics of the genus.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

POMPEII–LIKE FLORAL FOSSILS IN THE KRUGER NATIONAL PARK: PALAEOENVIRONMENTAL AND STRATIGRAPHIC CONTEXT FOR NEWLY DISCOVERED ASSEMBLAGES ALONG THE LETABA RIVER, SOUTH AFRICA

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Atypical, potentially fossiliferous, surficial features occur within volcanic rocks of the Karoo Large Igneous Province (LIP), more specifically preserved on several lava flow tops in the upper part of the Sabie River Basalt Formation (Kruger National Park, South Africa). One particularly well-preserved lava surface along the banks of the Letaba River is locally faulted into Platform 1 (Helms Deep) and Platform 2 (Hippo Shangri La). Stratigraphically, this assemblage is located ~4700 m above the base of a basaltic lava pile, together with interbedded rhyodacitic flows. On the other hand, this assemblage is ~200 m below the main base of a >6500 m thick rhyodacitic Jozini Formation; much of which was arguably emplaced within <1 million years. We first determined that its flow top structures are not just volcanically derived and abiotic, but represent preserved imprints of biotic material. Grid-base maps and detailed photographs convincingly identify these as 3D preserved palaeo-floral macro- and microfossils, classified according to morphological aspects as shoots, leaves, and bark, along with fragmentary branches and trunks. Morphologies of identified structures strongly resemble those of Cheirolepidiaceae conifers, also reported from near-synchronously deposited Elliot and Clarens formations of the Northeaster Upper Karoo sedimentary rock strata. These occurrences provide the earliest known floral record of the Cheirolepid family.

Bulk rock geochemistry of four underlying basaltic and rhyodacitic units, as well as a capping basaltic ash fall, together with LA-ICPMS zircon age dating, help to contextualize fossil emplacement and preservation history. Firstly, the surface distribution of plant material suggests that it was transported and deposited on a rhyodacitic breccia, together with some unconsolidated and cooled rhyodacitic ash. This surface was subsequently covered by a decimeter-thick basaltic ash layer, which consolidated as a very fine-grained mold across the floral bed. It is still questionable how the organic matter was then meticulously replaced by the unconsolidated rhyodacitic ash and ultimately forming a hardened cast that currently constitutes the fossils. Even if this preservation event was perhaps not as dramatic as at Pompeii, evidence of forests growth near such a highly active volcanic center still challenges our concepts of environmental hostility that, e.g., the Karoo LIP's correlation to the Pleinsbachian–Toarcian mass extinction.

Grant Information
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Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

THE LAST ANKYLOSAURID FROM ASIA: *TARCHIA* OR *SAICHANIA*?

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The taxonomic status of specimens referred to *Tarchia* and *Minotaurasaurus* has been contested. Palaeontological Institute-Moscow (PIN) 3142/250, a well preserved skull from the Upper Campanian-lower Maastrichtian Nemegt Formation at Hermiin Tsav, Mongolia, was long considered *Tarchia gigantea*. The name is a recombination of *T. kielanae*, based on Zaklad (Institute of) Paleobiologii-Polish Academy of Sciences (ZPAL) MgD I/111, a partial skull from the Upper Campanian Baruungoyot Formation at Khulsan, and "*Dyoplosaurus giganteus*", based on PIN 551/29 from the Nemegt Formation at Nemegt. The latter consists of a partial tail, pes, and osteoderms but is now considered non-diagnostic. The holotype of *Saichania chulsanensis*, Mongolian Academy of Sciences (MPC) 100/151, consists of a well preserved skull and postcrania also from the Baruungoyot Formation at Khulsan.

At issue is whether PIN 3142/250 represents *Tarchia* or *Saichania*. Comparisons have been problematic because for many years, only black and white photographs of ZPAL MgD I/111, holotype of *T. kielanae*, were available for comparison. Reexamination of that holotype confirms that it preserves several diagnostic features, most of which are present in PIN 3142/250 but not in the holotype of *M. ramachandrani*, which is from the Djadokhta Formation.

Some of these Asian specimens have a small depression or 'postorbital fossa' just anterior to the squamosal horn in which sits a secondary ossification, the 'accessory postorbital osteoderm'. This has been considered a unique autapomorphy of *T. kielanae*—as redefined to include *M. ramachandrani* but not PIN 3142/250. However, the ossification is separated from the skull roof by matrix in both known *Minotaurasaurus* specimens. Thus, the absence of this ossification in PIN 3142/250 could simply be due to the general lack of fusion. Importantly, PIN 3142/250 does have postorbital fossae. The odd rostral truncation of both squamosal horns in PIN 3142/250 also suggests the former presence of unfused accessory osteoderms.

PIN 3142/250 has some similarities to MPC 100/151, e.g. in cranial caputegulae arrangement, narial morphology, and overall size. However, these two specimens differ in many other characters, including position of the orbits, exoccipital shape, mode of quadrate-exoccipital contact, inclination of the occiput, and braincase morphology. Given these differences and the lack of diagnostic features in PIN 551/29, PIN 3142/250 is referred to *Tarchia* sp., with *Minotaurasaurus* recognized as a separate and valid genus.

Technical Sesssion X (Friday, October 28, 2016, 10:30 AM)

PHYLOGENETIC SYSTEMATICS OF NEOSUCHIA BASED ON EXPANDED TAXONOMIC AND CHARACTER SAMPLING: IMPLICATIONS FOR CROCODYLIFORM HISTORICAL BIOGEOGRAPHY, BASAL NEOSUCHIAN DIVERSITY, AND THE ORIGIN OF CROCODYLIA

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Neosuchian crocodyliforms can provide key insights into biogeography, climate change, and survivorship during the Mesozoic and early Cenozoic, but a poor understanding of their phylogeny limits these efforts. Until recently basal (non-crown group) neosuchians were represented by a few exemplar taxa, partly due to limited fossil sampling during the Mesozoic and Paleogene, and in contrast to the comparably better sampled and species-rich Gondwanan notosuchian radiation. New discoveries and overlooked collections are filling gaps in neosuchian diversity, but phylogenetic resolution has not kept pace. We have undertaken a large-scale taxon-sampling rich revision of the clade. Results reveal insights into problematic taxa. *Acynodon* is not a basal alligatoroid but a nested member of Hylaeochampsidae and specimens from France referred to *A. iberoccitanus* are not conspecific with the *A. iberoccitanus* holotype. Consistent with recent analyses, *Allodaposuchus* is not an alligatoroid and *Arenysuchus* is not a crocodyloid; both are members of a diverse allodaposuchid clade closely related to Crocodylia. A close relationship among *Paralligator*, *Shamosuchus* and *Theriosuchus* is recovered, but first hand re-examination of the Late Jurassic *Batrachomimus* from Brazil reveals it to be unrelated to the Laurasian Paralligatoridae and instead to be a basal notosuchian or perhaps even outside Mesoeucrocodylia. Goniopholidid relationships remain poorly resolved. *Isisfordia*, originally considered a eusuchian, remains recovered in a more basal position within Neosuchia. *Pachycheilosuchus*, previously considered an atoposaurid or a hylaeochampsid with close affinities to *Pietraroiasuchus*, is now recovered with *Pietraroiasuchus* and the enigmatic *Unasuchus* in a novel clade Unasuchidae. Unasuchids may be related to hylaeochampsids. The biogeography of mesoeucrocodylians still strongly supports a Laurasian/Gondwanan dichotomy between advanced neosuchians and notosuchians, but the basal placement of *Isisfordia* and *Susisuchus* suggests early diverging members of advanced neosuchian clades may have been more cosmopolitan than currently appreciated. Improved taxonomic sampling among advanced neosuchians suggests that the ancestral condition of Crocodylia was much more superficially "alligator"-like than previously appreciated. This bears on how we root Crocodylia and may help resolve ongoing conflicts over the taxonomic content of Crocodylia and the position of *Gavialis*.

Grant Information
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Technical Session VI (Thursday, October 27, 2016, 11:45 AM)

THE MORPHOLOGY OF MOTION IN SUB-SURFACE FOOT TRAJECTORIES AND FOSSIL DINOSAUR TRACKS

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Dinosaur footprints are an extremely common and highly disparate component of the Mesozoic fossil record. The morphological diversity of tracks, relative to pedal disparity, is inflated by two key factors. First, variation in substrate depth and consistency can cause animals to sink and move differently from step to step. Second, track surfaces can be exposed on bedding planes at any depth within the disturbed volume. To understand how these factors impact fossil track variation, we need to know more about movement below the original surface. Even in living animals, however, documenting foot motion within the substrate is difficult because the distal limb is hidden by opaque sediment.

We used X-ray Reconstruction of Moving Morphology (XROMM) to visualize and measure sub-surface 3-D kinematics in Helmeted Guineafowl (*Numida meleagris*). In order to image the feet, we walked birds through radiolucent artificial substrates created to mimic dry sand (poppy seeds) and wet, cohesive muds (glass bubbles, clay, water). Undistorted and calibrated biplanar x-ray videos (250 Hz) synchronized with two standard light videos imaged the feet both above and below ground. Our initial efforts have focused on tracing the tip of digit III, a highly identifiable landmark in many dinosaur tracks.

Guineafowl display a surprisingly wide range of toe trajectories, even within a single individual. Comparison among and within substrates is hampered by a lack of obvious landmarks. Unlike the discrete stance-swing phases of strides on solid ground, birds on deformable materials appear to transition from air to substrate and back again more gradually. We have identified a number of kinematic events that may be homologous across all substrates and thereby allow paths to be aligned and compared quantitatively. Initial results suggest that the downward and upward components of a single track are decoupled. Entry angle is related to the length of the previous step, whereas exit angle

correlates with the length of the subsequent step. We are developing novel, low-dimensional, visual representations to explore variation and to better understand the relationship between toe trajectories and fossils. By incrementally sectioning our data, we can predict digit III path geometries on virtual slabs of varying depth and thickness. Understanding how substrate consistency affects guineafowl toe trajectories provides context for fossil track specimens so that we can begin to reconstruct the ancient locomotion preserved within them.

Grant Information
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Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

CALCIUM ISOTOPE ANALYSIS OF FOSSIL BONES: THE PALEOGENE GIANT FLIGHTLESS BIRD *GASTORNIS* WAS A HERBIVORE

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Gastornis was a giant flightless bird that was one of the largest tetrapods in Paleocene-Eocene terrestrial ecosystems in both Eurasia and North America. Based upon its huge skull and ferocious beak, capable of exerting a bite forceful enough to crush bone, it has mostly been reconstructed as a fearsome predator. However, its diet is controversial, and plant-feeding has also been suggested. Calcium isotopes are a proxy for trophic level and decrease systematically along the food chain. Consumption of bone rich in light calcium isotopes as well as the fractionation of calcium isotopes during bone biomineralization results in low bone $^{44}Ca/^{42}Ca$ in carnivores.

Here, we assess whether *Gastornis* ingested bone by analyzing calcium isotope compositions of its bones, comparing them with those of sympatric carnivorous and herbivorous mammals and crocodiles as well as modern-day birds. The fossil remains are from the richest *Gastornis* locality in Europe, the Middle Eocene Geiseltal, the near-contemporaneous Messel site, along with the oldest *Gastornis* specimen from the Middle Paleocene of Walbeck, all from Germany. We find that *Gastornis* has bone $^{44}Ca/^{42}Ca$ similar to those of herbivorous ground birds, such as extant ratites and the extinct moa, but much higher than modern-day carnivorous raptors, indicating that it did not ingest a significant amount of bone. Clearly, *Gastornis* was a herbivore and not the carnivorous apex predator often-portrayed in Paleocene-Eocene terrestrial food webs. Thus, *Gastornis* did not replace theropod dinosaurs as a hypercarnivore in Paleogene terrestrial ecosystems, requiring a rethinking of the structure of Paleogene vertebrate food webs and the paleobiology of *Gastornis*.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

ASCENDANCY OF THE ECOLOGICAL NICHE: COMPARATIVE FORELIMB MORPHOLOGY AND FUNCTION IN BODY FORM ECOMORPHS, THE HIPPOPOTAMIDS, PECCARIES, AND SUIDS

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Hippopotamus forelimb bones and girdles were compared with those of suoids. Although no longer considered to be closely related phylogenetically, these taxa are still ecomorphs, because they share body shapes and ecological niches that partially overlap. Despite differing habits (hippos are semiaquatic, using an underwater 'walking' pattern of locomotor movements; pigs and peccaries are terrestrial but capable of swimming in the same manner as do most mammals), similar selective forces predicate cranial morphological accommodations for large, robust canines for combat and/or self-defense in each group. *Hippopotamus amphibius,* especially, has a large head and huge, self-sharpening canines. Forelimb proportions also differ between hippos, and among suids and tayassuids. *Hippopotamus amphibius* is largest in body size but has the relatively shortest legs. Pigs and peccaries weigh from less than $1/10^{th}$ the mass of *H. amphibius* to approximate pygmy hippos in body size. Hippo scapular glenoid fossae are rounded, with rounded, convex humeral heads. Suoid glenoids are more elongate, although all show some degree of humeral circumduction. Hippopotamid supraspinous fossae are relatively larger than those of suoids; the latter show more gracile scapulae with prominent spines. The hippo's large, sharp lateral projection recurves distally, with a greatly ventrally expanded acromion. Peccary scapular spines arise anteriorly; although the degree of lateral projection is progressively farther posteriorly in larger-bodied taxa (*P. porcus, S. scrofa, P. aethiopicus*) until the greatest expansion, halfway anteroposteriorly, in *H. meinerzhageni*. Suoid scapular spines slope gently and project laterally, without an acromion, except in *H. meinerzhageni,* wherein the process extends slightly farther laterally halfway to the distal-most point. Hippos show a wide, thickened midspinal bulge that does not reach the posterior border, as would most metacromion processes. Suoids have prominent, triangular, rounded, thickened, rugose posteriorly pointing metacromions. This feature is more prominent in pigs. The diversity of these morphological characters emphasize that different muscle groups perform forelimb anteroposterior and circumduction movements in each group. We anticipate that identifying the anatomical correlates of limb function in these ecomorphs will permit greater accuracy in the interpretation of life habits of extinct taxa that show comparably diversified osteological features.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

NEW BIRD FOSSILS FROM THE WOODBINE FORMATION (LOWER MIDDLE CENOMANIAN) OF TEXAS

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The Cenomanian record of bird fossils in North America is sparse. Here we report on newly discovered material that contributes to the growing collection of avialan elements from the coastal marine deposits of the Woodbine Formation (lower middle Cenomanian) of northern Texas. Most of the new specimens come from a public road-cut exposure only a few hundred meters from and at approximately the same stratigraphic level as the type locality for *Flexomornis howei*, an enantiornithine taxon diagnosed by a dorsoventrally broad and distinctly 'kinked' scapular blade. The new specimens were collected from 2009 to 2015 by an avocational fossil enthusiast and donated to the Perot Museum. The elements include a partial scapula that can be assigned to *F. howei*, an almost complete enantiornithine coracoid, two partial synsacra, and a mostly complete but poorly preserved ulna. An additional element collected from the Grapevine Dam Spillway, the same area as the type of *Flexomornis*, may be a heavily crushed but otherwise complete avialan humerus, albeit from a taxon with a larger body size than the other avialan body fossils currently known from the unit. The ichnotaxon *Magnoavipes lowei*, footprints hypothesized to have been made by a large crane-like bird, was first described from the Woodbine Formation nearby. It should be expected then that fossils of relatively large avialan species might be found in the formation. Collectively, the bird fossils from the Woodbine Formation of northern Texas show that the southwestern shoreline environments of Appalachia supported an abundant, diverse avifauna by the early middle Cenomanian.

Symposium I (Wednesday, October 26, 2016, 11:30 AM)

EVALUATING THE UTILITY OF RARE EARTH ELEMENT PROFILES AS A PROXY FOR SOFT TISSUE AND BIOMOLECULAR PRESERVATION POTENTIAL IN FOSSIL BONE

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Despite decades of research, taphonomic and geochemical factors correlating to and controlling preservation of original organics remain enigmatic. Actualistic experiments have demonstrated rapid trace element uptake by bone hydroxyapatite, and previous researchers have used these data to hypothesize that bone rare earth element (REE) profiles may provide a proxy for potential biomolecular preservation. Trace element-depth profiles exhibiting a simple, steep decline reflect a single, brief phase of REE uptake and are thought to characterize bones that experienced minimal interaction with groundwater, a quality thought to greatly increase potential for preservation of endogenous organics. To test this hypothesis, we obtained REE profiles of nine bones from a hadrosaur bonebed in the Cretaceous Hell Creek Formation of South Dakota and correlated these with the presence of soft tissues in the same specimens after demineralization with ethylenediaminetetraacetic acid. Additionally, for one sample we also conducted multiple assays for endogenous organics, including collagen I; these included polyacrylamide gel electrophoresis with silver-staining, immunofluorescence, and enzyme-linked immunosorbant assay (ELISA). Every bone tested exhibited steeply declining REE concentrations with increasing cortical depth, consistent with the type of profiles hypothesized to favor retention of endogenous biomolecules. Similarly, every bone yielded demineralization products morphologically consistent with vertebrate osteocytes and fragments of fibrous matrix, regardless of cortical or cancellous tissue structure. These qualitative data were supported by electrophoresis, in which extraction products stained with silver at molecular weights different from those obtained from co-extracted sediment. Furthermore, immunofluorescence and ELISA results support the preservation of endogenous collagen I epitopes in the same fossil specimen, but not in sediment or laboratory reagents. Thus, we provide the first fossil evidence that steeply declining REE profiles can correlate to preservation of original soft tissues and biomolecules. We suggest that this correlation may arise because both REE uptake and soft tissue degradation are influenced by pore fluid interactions; further testing is needed. REE composition of fossil bone is a valuable measure of extent of diagenetic alteration, regardless of duration of REE uptake, and may provide a valuable proxy for identifying fossils with potential biomolecular preservation.

Grant Information
National Science Foundation Graduate Research Fellowship (DGE Award 1002809) and the Jurassic Foundation

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

MORPHOLOGICAL VARIATIONS IN MOLARS OF PALEOPARADOXIID FROM THE MIDDLE MIOCENE TONOKITA FORMATION IN AKAN, HOKKAIDO, JAPAN

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A large number of molars of paleoparadoxiid were excavated from the middle Miocene Tonokita Formation in Akan, Kushiro City, western part of Hokkaido, Japan. In the lower molars, two morphological types were distinctly acknowledged. They were comparable to lower molars of the lost syntype (Sawane specimen) and the neotype (Izumi specimen) of *Paleoparadoxia tabatai*, respectively. The Izumi-type molar has five main cusps, developed cingulum on the buccal side and a single root, while the Sawane-type molar has four main cusps with large tubercles attached to the distal end and slightly developed cingulum and a single or bifurcated root. However, Sawane- and Izumi-type molars overlap considerably in crown size with each other. In addition, the horizon containing these molars is a transgressive lag deposition, possibly including secondary fossils from the lower horizon, and bone specimens accompanied with molars have not yet been known in this locality. Thus, it is uncertain whether the morphological difference between Izumi- and Sawane-type molars shows two distinct species or some intraspecific variation within a single species. In either case, molar size difference could not provide a feature to identify species.

Technical Session XV (Saturday, October 29, 2016, 11:15 AM)

MAXIMUM LIKELIHOOD ESTIMATION OF TITANOSAURIFORM SAUROPOD BIOGEOGRAPHIC HISTORY IN THE LATE CRETACEOUS

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Titanosauriform sauropods were globally distributed in the Late Cretaceous. The extent to which their distributions reflect dispersal, vicariance, regional extinction or just sampling failure, remains poorly understood. In order to examine these issues generally, and evaluate competing hypotheses for the appearance of *Alamosaurus* in North America in particular, we constructed a new phylogeny for Titanosauriformes and subjected it to biogeographic analysis. The phylogenetic data set comprises 387 characters for 68 taxa. Analysis in TNT yields 12 most parsimonious trees, which form the basis for a time-calibrated agreement subtree. The ancestral ranges for each node were estimated using the Maximum Likelihood approach in BioGeoBEARS, with and without paleogeographic constraints.

Alamosaurus is placed within an Asian clade, with *Jiangshanosaurus* and *Opisthocoelicaudia* as successively more distant sister-taxa. In unconstrained analyses, most geographic distributions are explained as the result of founder-event speciation. However, when paleogeographic data are added, regional extinction and vicariance are more significant (with the former dominating when constraints are most restrictive on dispersal). Constrained analyses suggest that the clade represented by *Isisaurus*+Saltasauridae was widespread across Pangaean fragments during the Aptian, with subsequent range contraction resulting from regional extinction and/or vicariance. In all results, *Alamosaurus* is interpreted as deriving from a lineage that was present in Asia during the Early Cretaceous and then dispersed to North America later. This runs counter to many previous studies that have favored the 'Austral immigrant' hypothesis in which *Alamosaurus* dispersed into North America from South America. The timing of the dispersal from Asia to North America is uncertain, but all results suggest that it occurred during or after the Albian. Thus, the ancestral lineage of *Alamosaurus* could have taken part in dispersals across Beringia either during the Albian, or the Campanian, as has been proposed for numerous other dinosaurian clades. However, the restriction of Alamosaurus to southwestern North America, combined with the complete absence of sauropods from the otherwise well sampled northern Laramidian faunas, supports a pre-Campanian date for the putative dispersal from Asia.

Symposium II (Friday, October 28, 2016, 8:30 AM)

AN EARFUL OF JAW, THEN AND NOW: USING MARSUPIAL EVO-DEVO TO SHED LIGHT ON A MAJOR EVOLUTIONARY TRANSITION IN THE PALEONTOLOGICAL RECORD

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During synapsid evolution, postdentary elements in the reptilian jaw transitioned into the middle ear of mammals. Though this astounding change is well documented in the fossil record, questions regarding the developmental sequence that drove the ossicular transition still remain. At birth, modern marsupials possess a very reptilian jaw joint with functional articulation between the articular and quadrate. These elements will later become the malleus and incus, respectively, of the middle ear. This entire transition occurs postnatally and represents a natural system for comparison with the fossil record. We utilized *Monodelphis domestica* as a model organism and traced the development of ossicular structures as they separate from the jaw and fully incorporate into the middle ear. Micro-CT scans throughout development and three-dimensional reconstructions were used to compare marsupial developmental stages with the known fossil record of early mammals exhibiting transitional forms of the definitive mammalian middle ear (DMME), demonstrating an instance of ontogeny recapitulating phylogeny. The apparent ossicle size decrease in marsupials is revealed to be merely an artifact of negative allometry triggered by Meckel's cartilage breakdown and facilitated by continued growth of the surrounding skull elements. Cryosections and immunohistochemistry (IHC) show separation of Meckel's cartilage from the malleus occurs at postnatal day 20 and is facilitated by apoptosis, unlike the process in placental mammals. Additionally, laser capture microscopy and RNA sequencing were used to identify genes whose expression changes during the time of Meckel's cartilage breakdown. These assays identified many key genes with roles in apoptosis and bone breakdown, including Tgfbr2 (part of the TGFB signaling pathway). We verified the differences in gene expression of key genes using fluorescent in situ hybridization (FISH) and functionally tested the role of TGFB signaling in Meckel's cartilage development in vivo. When we blocked TGFB signaling in vivo, we repressed the breakdown of the Meckel's cartilage and the associated cell death and retained the connection between the Meckel's cartilage and the middle ear ossicles. Therefore, by changing the levels of only a single signaling pathway in opossums, we were able to phenocopy the Meckel's cartilage of mammals that lived 150 million years ago. Furthermore, the seeming ease of this developmental mechanism might explain the parallel evolution of the middle ear in multiple mammalian lineages.

Grant Information
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Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

NEW LIGHT ON VERTEBRATE FOSSILS: HOW SYNCHROTRONS CAN CONTRIBUTE

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Recent developments in experimental and methodological approaches have greatly improved our understanding of the life and behaviors of animals now long extinct. They have also enabled the recovery of original biomolecular components from vertebrate remains that are tens to hundreds of millions of years old. Various experimental methods have been applied, including synchrotron radiation-based techniques, to identify and characterize these ancient biomolecules. These analytical tools were once primarily in the realm of physics, but are now also widely employed by scholars from the fields of life and material sciences. Synchrotron radiation-based techniques can provide detailed information on structure and composition, as well as the spatial distribution of elements and molecules at micrometer resolution.

We used a suite of synchrotron radiation-based techniques, including micro-Fourier transform infrared microspectroscopy (μFTIR), X-ray absorption near edge structure (XANES), and extended X-ray absorption fine structure (EXAFS), to analyze the molecular content of microbodies obtained from an orbital pigmentation in a bony fish fossil from the Eocene Fur Formation of Denmark. Our measurements revealed that the minute bodies are dominated by organic compounds that are remarkably similar to modern eumelanic pigments. In the light of this finding, the strengths and limitations of some synchrotron radiation-based techniques for biomolecular identification and characterization in fossils are discussed.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

FACTORS INFLUENCING MACROSCOPIC AND BIOMOLECULAR FEATHER PRESERVATION ON A SPECIMEN OF *ORNITHOMIMUS* (DINOSAURIA, THEROPODA) FROM DINOSAUR PROVINCIAL PARK, ALBERTA

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The recent discovery of *Ornithomimus* with preserved feathers from the lower Dinosaur Park Formation of Southern Alberta sheds light on potential factors that regulate soft tissue preservation. UALVP 52531 was preserved in a complex depositional setting, in which each of the trunk of the body, the pelvic region, and hind limbs + tail are encased in different matrices: ironstone, mudstone, and sandstone, respectively. Modes of feather preservation vary accordingly across these regions of the animal. The trunk, which is encased in hard and well- cemented coarse sandstone, preserves a highly compressed single layer of feathers that form a sheet-like covering over the body, with little separation between individual filamentous structures. The pelvic area, encased in a much finer matrix, preserves individual feathers with exceptional detail; individual feather elements, including branching, can readily be discerned. The majority of tail feathers are encased in fine to medium sand, with poor detail limited to thin carbonized lineations, as seen in other specimens of *Ornithomimus* recovered from the Horseshoe Canyon Formation. Water surrounding the specimen, preventing acceleration of decay but crushes and obscures feather details. On the other hand, thinly-bedded muds prevented both homogenization of filaments on the body and subsequent crushing of pith-filled individual filaments. Feather samples from each facies can be compared with combinations of SEM, FTIR, and ToF-SIMS. These observations suggest that the animal did not move from its original burial position, and that anoxia was localized in the region of finest texture and most detailed preservation. As a consequence, primary keratinous and melanosomal structures are preserved in exquisite detail.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

BRIDGING THE GAP: THE BIOSTRATIGRAPHIC RECORD OF THE GENUS *BELONOSTOMUS* WITH NOTES ON NEW OCCURENCES IN TEXAS AND MEXICO

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*Belonostomus*is a small, rare, andunique teleosteomorphfish found within marine paleocommunities of the later parts of theMesozoic; however, these fish are often unnoticed in collections.*Belonostomus*is a member within thefamily Aspidorhynchyidae. The fossil material has been extremelylimited but sufficient for assessing the temporal range of*Belonostomus*.The records consist of complete to nearly complete skeletons from theTithonian-aged Jurassic Solnhofen Lagerstätten, and fragmentaryremains such as partial skulls and presymphyseals that can be found in thevarious Cretaceous systems ranging from the middle Coniacian and thegenus persists until after the K–Pg boundary in the Paleocene in theThanetian Tongue River Formation before their extinction.Biostratigraphic assessment for this genus still remains unclear,which in turn has various implications such as biogeographicdistribution. In this report we will help clarify the two bigimplications such as species diagnosis for North American finds andproperly assess the biostratigraphic understanding of the genus. Wereport new occurrences of *Belonostomus*from the middle Cenomanian of the Del Rio Formation in Texas and theConiacian–Turonian boundary of the lowest parts of the Austin Group.These, along with occurrences in lowerTuronian Agua Nueva Formation innorthern Mexico, which all appeared in their coeval communities andare based off of new fossil sites. This will help bridge the gapfrom the Early–Late Cretaceous and Paleocene to those of the LateJurassic and Late–Early Cretaceous in North America.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

QUANTITATIVE DENTAL MICROWEAR SUPPORTS CLINOLINEAL MASTICATION IN *PSITTACOSAURUS* (ORNITHISCHIA, CERATOPSIA)

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With its relatively primitive dental anatomy and basal phylogenetic position, *Psittacosaurus* is important for understanding the evolution of chewing in ceratopsians. Clinolineal chewing was recently proposed for *Psittacosaurus*, contrasting with the circumpalinal and orthopalinal models proposed as the derived condition in neoceratopsians. Clinolineal motion involves the simultaneous elevation and retraction of the mandibles, moving the jaw along an oblique trajectory relative to the transverse plane. In *Psittacosaurus*, caudally divergent tooth rows with obliquely inclined occlusal facets sustain equidistant spacing of the upper and lower dentition, maintaining occlusal

contact through the entire power stroke. This mechanism was not possible in more derived ceratopsians, which have vertical facets that would cause dental disengagement. Clinolineal chewing also requires precise, stereotyped motions for proper dental occlusion, which should manifest in dental microwear.

To test this, microwear orientation was quantified in five individuals from four species of *Psittacosaurus*. Rao's spacing test rejects the null hypothesis ($p < 0.01$) of uniform dispersion of striation angles about a unit circle in all teeth examined, indicating a preferred orientation. Mean orientation ranged from 38° to 68°, measured in a 180° arc from apical to basal in the distal hemisphere and these values are consistent with striation orientations observed by other workers. When orientations were plotted on rose diagrams, multiple classes could not be distinguished in most samples, and neither could they be distinguished reliably using discriminant function analysis.

Parallelism of striations was also explored by calculating length of the mean vector (r), a measure of dispersion ranging from zero (low parallelism) to one (high). Values in the examined psittacosaurs ranged from r = 0.88 to 0.94, indicating an exceptional degree of parallelism consistent with a single direction of microwear striations.

The above evidence supports a stereotyped jaw action in *Psittacosaurus*. Furthermore, the exceptionally high r-values indicate that chewing was a precise action meant to align the dentition for optimal maintenance of occlusion. Demonstration of a stereotyped and precise behavior is consistent with the clinolineal model of mastication for *Psittacosaurus*. Furthermore, the exclusion of this model for more derived ceratopsians is also consistent with their microwear patterns.

Technical Session III (Wednesday, October 26, 2016, 2:15 PM)

EVOLUTIONARY TRANSITIONS IN REPRODUCTION FROM NON-AVIAN THEROPODS TO NEORNITHINE BIRDS: THE ENANTIORNITHINE RECORD

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Enantiornithes represents the most diverse and widespread clade of Mesozoic birds with >60 species and a worldwide distribution, yet they failed to survive the end Cretaceous (K-Pg) extinction. We review their fossil record, documenting the evolution of reproductive traits from non-avian theropods like oviraptors and troodontids through to neornithine birds. Enantiornithine eggs, clutches embryos, and nesting grounds are known from Argentina, Romania, Mongolia, and China. The slightly asymmetric and elongate eggs of enantiornithines range in size from 26 to 70 mm, with an elongation index (length/diameter) of 1.6-2.2. Eggshell microstructure includes straight, narrow pores, a mammillary layer, a second prismatic layer with at least some squamatic ultrastructure, and the potential for a third, external layer. Eggs consistently occur upright either tightly arranged in clutches with associated adults in a manner similar to that of troodontids or scattered singularly within sandstone units. Embryonic bones of both wings and legs exhibit well formed articular surfaces suggesting superprecocial hatchlings. Reproduction in enantiornithine birds included sequential ovulation from a single ovary and oviduct, eggs planted upright within sediments, and incubation by a combination of sediment and attendant adult or eggs fully buried with perhaps no parental care.

Reproduction passed through five stages from basal theropods to neornithines: 1) pre-maniraptoran theropods, 2) oviraptor-grade maniraptorans, 3) troodontid-grade paravians, 4) Enantiornithes, and 5) basal Neornithes. Major changes occurred incrementally in egg size, shape and microstructure; nest form; incubation method; and parental care. Reproduction in troodontid theropods is consistent with this clade representing the sister taxon to birds. The few changes between derived non-avian theropods and enantiornithines includes the loss of function in one reproductive tract and an increase in relative egg size. Neornithines differ from enantironithines in possessing still relatively larger but less elongate and more variably shaped eggs and incubation free of sediment, permitting greater adult-egg contact. Associated changes also likely included egg turning and chalazae, the albumin chords that maintain proper embryo posture during egg rotation. Neornithes are the only Mesozoic clade of Dinosauria to nest completely free of sediment, and this, as well as improved incubation efficiency, may have played a crucial role in their surviving the K-Pg mass extinction event.

Grant Information
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Technical Session V (Wednesday, October 26, 2016, 2:00 PM)

THE MESOZOIC BREAKUP OF PANGAEA AND TERRESTRIAL VERTEBRATE BIODIVERSITY

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The relationship between species diversity and area has been widely studied in modern ecosystems, and the strong, consistent correlation between the two has been referred to as one of the few "laws" of ecology. Although biodiversity dynamics in response to Anthropogenic effects on available terrestrial area—both in size and connectivity—have been previously modeled, similar changes in biodiversity due to natural changes in geography have never been quantified. During the Mesozoic, terrestrial regions went through enormous changes in both their number, size, and connectivity. At the beginning of the era, Earth's landmasses were largely gathered into a single, enormous supercontinent called Pangaea. However, by the end of the era, total terrestrial area was reduced by almost a quarter, with the remaining exposed land area highly fragmented by both changes in continental position due to plate tectonism as well as flooding due to large scale sea level rise. In order to understand the potential effects of this massive shift in terrestrial geography, I modelled expected biodiversity through time using the Species-Area Relationship. Through the Mesozoic terrestrial vertebrate biodiversity would be expected to nearly double due to the fragmentation of terrestrial regions, despite an overall decline in total terrestrial area. Previous studies of Mesozoic terrestrial vertebrate biodiversity have generally found increases in diversity through this time period as well, though this increase is often attributed to climactic or intrinsic biological factors. Instead, this model suggests that geography alone may explain some or all of the observed increase in biodiversity. The results of this study emphasize the importance of geography in studies of past biodiversity.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

MORPHOLOGICAL OBSERVATIONS AND BODY SIZE ESTIMATES BASED ON LAMNOID SHARK VERTEBRAL CENTRA FROM THE LATE CRETACEOUS OF SEYMOUR ISLAND, ANTARCTICA

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The fossil record of neoselachian sharks is heavily biased towards their teeth, which occur in high numbers, are frequently shed and replaced, and are covered in enameloid that has a relatively high potential to be preserved. Along with teeth, shark vertebral centra, which may be structurally reinforced by calcified cartilage, also preserve fairly regularly and can provide an additional source of complementary data for analyzing the shark fossil record. We examined two well-preserved Late Cretaceous shark vertebral centra from the Lopez de Bertodano Formation of Seymour Island, western Antarctica, which dates to ca. 65–70 million years ago. Along with an assemblage of sharks, the remains of dinosaurs, birds, marine reptiles, and ammonoid cephalopods and other invertebrates have been recovered from the Lopez de Bertodano Formation, which preserves a fauna indicating relatively mild conditions during the Late Cretaceous at this high southern latitude site. The two shark vertebral centra (catalogued in the collections of the Field Museum of Natural History as PF 11920 and 11921) measure (respectively) 135.4 mm in maximum width and 40.3 mm in length (PF 11920), and 55.8 mm in maximum width and 18.9 mm in length (PF 11921). The overall proportions of the centra, constricted notochordal canals, smooth external walls, and internal calcification structure as revealed by CT-scans and conventional radiography all suggest that both centra are from large lamnoid sharks, which are known from other Antarctic Late Cretaceous records. Within lamnoids, the calcification pattern along with the external morphology of the centra points to their likely assignment to the Family Cretoxyrhinidae and (provisionally) the genus *Cretoxyrhina*. We incorporated measurements from the larger centrum into a regression relating maximum vertebral width to body length in the extant Great White Shark *Carcharodon megalodon*; assuming similar proportions, we estimate a maximum total length of 7.2 meters for the Lopez de Bertodano shark with this large centrum, a size that would exceed the maximum recorded for extant white sharks.

Technical Sesssion X (Friday, October 28, 2016, 12:00 PM)

THE EFFECTS OF POST GLACIAL CLIMATE CHANGE ON THE EVOLUTION OF MEMBERS OF THE *CHRYSEMYS* COMPLEX

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Godfrey Hewitt (1996, 1999) made several predictions concerning the post-glacial expansion/re-colonization of species' geographic ranges and the effects this has on genetics, speciation, and morphology among related taxa. Primarily this consists of the idea that geographic ranges contract during ice ages and the subsequent interglacial geographic range expansion is primarily the result of members in the periphery of the ranges. This results in the expanding populations becoming genetically and morphologically differentiated from the populations in the core, whilst having little genetic or morphological variation within the expansion area. Over multiple iterations of this pattern, and/or long enough times of isolation, speciation should occur in the "peripheral" populations while the "core" species should be the one that is still present in the ancestral geographic range.

Using geometric morphometric (GMM) analyses, species distribution modelling (SDM), and previous genetic work from the literature, I tested these hypotheses within the *Chrysemys* complex (*Chrysemys picta picta, Chrysemys picta marginata, Chrysemys picta bellii,* and *Chrysemys dorsalis*). The *Chrysemys* complex contains one of the most ubiquitous and cold-tolerant of all North American turtle species (*Chrysemys picta*) and all members of the complex have shown post-glaciation range expansions; both of these factors cause it to be an ideal candidate for testing Hewitt's hypotheses. Plastrons from a total of 62 individual specimens were used in the GMM analyses (7 *C. dorsalis*; 15 *C. p. bellii*; 21 *C. p. marginata*; 11 *C. p. picta*; and 8 *Trachemys scripta*specimens). SDMs were created using Maxent and point occurrence data collected from the literature. The SDMs were tested using fossil occurrences.

Hewitt's hypotheses are not well supported within the *Chrysemys* complex. Genetic data suggests that *C. dorsalis* should be treated as the core population. The GMM results are contradictory. When analyzing the entire complex, *C. picta* subspecies are morphologically differentiated from *C. dorsalis* (MANOVA $p<0.05$), thus supporting Hewitt's hypotheses. However, when *Trachemys scripta* is used to polarize the morphometric differences, it is shown that *C. dorsalis* has a more derived plastral shape than *C. picta,* which does not support Hewitt's hypotheses. The SDMs show that *C. p. marginata* has the smallest range expansion since the LGM (94% expansion). According to genetic data, under Hewitt's hypotheses, *C. dorsalis* would be predicted to have the smallest range expansion.

Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

MOSASAUROID PHYLOGENY UNDER MULTIPLE PHYLOGENETIC METHODS

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Mosasauroids (Mosasauridae + Aigialosauridae) are one of the extinct lineages of reptiles secondarily adapted to a fully aquatic lifestyle. Despite a long history of studies on this group, it is still uncertain whether mosasauroids acquired aquatic adaptations only once or multiple times. The most recent phylogenetic analyses support multiple origins of fully aquatic mosasauroids; however, mosasauroid interrelationships have only been

tested so far using traditional (unweighted) maximum parsimony (TMP) method. Maximum likelihood (ML) and Bayesian inference provide alternative approaches, which, unlike TMP, account for the varying branch lengths and evolutionary rates.

In this study, we present the first mosasauroid phylogeny performed under different phylogenetic methods, including ML, Bayesian inference, and implied weighting maximum parsimony (IWMP), in addition to TMP using contingent and multistate coding schemes. Contingent TMP, as used in most recently published datasets, recovers a monophyletic Mosasaurinae, with halisaurines and*Dallasaurus* at their stem, as well as a monophyletic 'Russellosaurina'. Multistate TMP finds halisaurines in a polytomy with Mosasaurinae and 'Russellosaurina'. IWMP recovers similar overall topology to both TMP analyses, but with halisaurines basal to 'Russellosaurina'. ML results are similar to those of contingent TMP, with halisaurines and *Dallasaurus* at the stem of Mosasaurinae. The Bayesian estimate deviates the most from all other results: 'Russellosaurina' is not monophyletic; and *Clidastes* forms a monophyletic group with *Globidens*.

The alternative topologies were tested for incongruence using parsimony-based Templeton test and likelihood-based Shimodaira-Hasegawa (SH) test. Results indicate a high degree of similarity between the TMP, IWMP, and ML phylogenies (Templeton and SH P>>0.05), and a significant difference between the Bayesian estimate and all alternative topologies (Templeton and SH P<0.0001). Such strong divergence of Bayesian results may be attributed to the difference in parameter estimation, which is greatly emphasized for a simple Mk-model and data set with a strong phylogenetic signal.

The hypotheses derived under different search criteria should be evaluated based on the set of assumptions behind each method, biological meaning of the topologies, and quality of the data set. We address these problems of interpreting different phylogenies to propose an alternative hypothesis of multiple acquisitions of derived aquatic conditions in mosasauroids.

Technical Session XIV (Friday, October 28, 2016, 3:00 PM)

THE LOPINGIAN *DAPTOCEPHALUS* ASSEMBLAGE ZONE (KAROO BASIN, SOUTH AFRICA): A REVISED BIOSTRATIGRAPHY SUPPORTS A PHASED PERMO–TRIASSIC MASS EXTINCTION EVENT

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South Africa's Karoo Basin is famous for preserving a terrestrial counterpart to the marine biotic crisis documented globally during the catastrophic Permo-Triassic mass extinction (PTME). Currently, the terrestrial PTME in the Karoo Basin is considered to be a phased extinction spanning the boundary of the *Dicynodon* (DiAZ) and *Lystrosaurus* (LAZ) Assemblage Zones. Recently, high precision dates from a silicified ash layer 60 m below the current Permo-Triassic boundary (PTB), and assumptions about sedimentation rates, have been used to argue that the real PTB is higher in the section than previously recognized, and that faunal turnover in the Karoo was not coeval with the marine event. I present an updated Karoo biostratigraphy that replaces the DiAZ with the *Daptocephalus* Assemblage Zone (DaAZ) and provides further evidence for phased faunal and climatic changes beginning below the newly dated horizon. The DaAZ has been reinstated to reflect that the dicynodont *Daptocephalus leoniceps* is a more suitable index fossil for this interval because updated ranges of prior index taxa (*Dicynodon lacerticeps*, *Theriognathus microps*, *Procynosuchus delaharpeae*) show that they disappeared well below the inferred PTB at the top of the revised DaAZ. Coinciding with these disappearances is the appearance of *Lystrosaurus maccaigi* in association with large changes in relative abundances as well as changes in palaeoclimate that indicate drying of the floodplain environments. The same patterns of disappearance are observed at the same stratigraphic interval throughout the basin, despite the thinning of strata northward. Sedimentation rates varied greatly in the Karoo Basin making their use as indicators of timing problematic. These data indicate significant faunal and climatic changes were already occurring below the dated horizon and support a phased terrestrial PTME in the Karoo Basin. Determining whether the Karoo PTME was synchronous with the marine event will require dated strata closer to the inferred PTB and a full consideration of the complexities of the geological and fossil records in the basin.

Grant Information
National Research Foundation (NRF) ((AOGR)UID=826103)

Technical Session XVI (Saturday, October 29, 2016, 9:15 AM)

SPATIAL VARIATION IN PLIOCENE PALEOHABITATS IN THE TURKANA BASIN, KENYA: IMPLICATIONS FOR LARGE-MAMMAL PALEOCOMMUNITY ASSEMBLY

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Though paleontologists have long posited links between variation in paleoenvironments and mammalian evolution, clear, causal relationships between the two remain elusive. Ecological theory connects environment to mammalian responses at landscape scales by linking mechanisms such as competition resulting from variation in habitat types (habitat diversity) to variation in mammalian biodiversity across regions. These concepts provide a conceptual framework for examining the mid-Pliocene, when hominin diversity was high and the dietary niches of the hominins *Australopithecus afarensis* and *Kenyanthropus platyops* show a shift toward incorporating resources from open (grassland) habitats. This study analyzed the local to regional-scale vegetation patterns that influence large mammal paleo-niche space within East Turkana, Kenya using extant ecosystems in Kenya as a baseline. Extant vegetation was measured within 16 ecologically-variable parks in Kenya using a global land cover map. Fossil vegetation data were derived from carbon isotopic signals, compiled from a database of published values (n = 49) as well as from samples collected using strategic lateral sampling of contemporaneous paleosols from multiple sites in three regions across East Turkana (northern, intermediate, and southern) (n = 143). Heterogeneity for both fossil and modern samples was measured as the α diversity of plant cover for each habitat using Shannon's diversity index (H). In extant sites, linear regression was used to establish a relationship between land cover diversity and temperature (R^2= 0.226, p = 0.015) and precipitation (R^2= 0.203, p = 0.02). Analyses show that habitat diversity in East Turkana varies across sites. Intermediate lacustrine deposits show higher levels of habitat diversity (H = 1.34) similar to modern Kenyan sites with higher precipitation and lower temperature. Alternately, northern fluvial and southern deltaic environments show substantially lower diversity (H = 0.98 and 1.02, respectively). Across 70 km in East Turkana, southern sites demonstrate more closed (wooded) habitats with slightly greater habitat diversity as compared to northern sites. This study thus suggests a spatial gradient in East Turkana, where a greater range of species, including hominins, occupied habitats in southern and intermediate East Turkana sites, and sets a baseline for exploring habitat diversity in fossil sites.

Grant Information
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Technical Session XIII (Friday, October 28, 2016, 3:00 PM)

MULTIVARIATE CHANGE IN THE DENTAL MORPHOLOGY OF THE SMALL-BODIED INSECTIVOROUS MAMMAL *MACROCRANION* (EULIPOTYPHLA, ERINACEOMORPHA) ACROSS THE PALEOCENE–EOCENE THERMAL MAXIMUM

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The Paleocene–Eocene Thermal Maximum (PETM) at ~56 Ma is marked by the rapid onset of a negative carbon isotope excursion that lasted ~175 kyr with an associated shift towards warmer global mean annual temperatures (MAT) by ~5–10 °C, followed by a return to pre-excursion MAT. At least 40% of measured mammalian genera recovered from the Bighorn Basin, Wyoming, are smaller during the PETM compared to adjacent intervals, but previous high-resolution studies addressing the timing and magnitude of shifts in body size relative to climate change were mostly limited to relatively large-bodied taxa with little focus on changes in tooth shape. To help fill that knowledge gap, we calculated the relief index (RFI: a ratio of 3D area to 2D planimetric area) and collected 3D geometric morphometric, linear, and angular measurements from lower second molars (M_2; n = 36) of *Macrocranion*, a putative lineage of ancestral (*M. junnei*)-descendant (*M. nitens*) small-bodied (~24 g) erinaceomorph insectivores that first appeared at the beginning of the PETM and persisted through the early Eocene in North America.

Two measures of size (centroid size and ln[length x width]) provide congruent results. Body size was not static during and after the PETM. Unlike the trend observed in equids, changes in body size in *Macrocranion* were not closely correlated with shifts in isotopically reconstructed MAT. Shape, when measured in unworn specimens, was also not static through and after the PETM. Several morphological trends were observed: the degree of lingual canting progressively and significantly decreased, the height of the talonid notch relative to the trigonid basin significantly increased from the beginning to the middle of the PETM, and the difference between the height of the trigonid and talonid notch further decreased from the middle of the PETM into the post-PETM interval. We hypothesize that these trends explain the observed changes in RFI of unworn teeth, which were lowest during the middle of the PETM, then returned to early-PETM levels after the PETM. RFI of worn teeth were scaled by RFI of unworn specimens from the same time bin. That scaled-RFI was used as a measure of relative degree of wear. Relative wear decreased through the study interval in concert with the observed changes in shape. This pattern may be related to change in sampled population structure, diet, or environmental factors. Its potential causes and presence in other small-bodied PETM mammal lineages have yet to be explored.

Grant Information
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Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

PRELIMINARY ANALYSIS OF *PROTOSTEGA GIGAS* OSTEOHISTOLOGY

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Protostega gigas was a large sea turtle that lived in the Late Cretaceous Western Interior Seaway of North America. Despite being a well-documented member of its ecosystem, little is known about how *Protostega* grew and aged. In fact, little research has been undertaken on sea turtle bone histology, and none has been done on *Protostega*. The purpose of this study is to expand the knowledge of sea turtles osteohistology in general, and to study *Protostega* growth specifically; this includes determining the ontogenetic stage of the specimen at the time of death.

The femur of the *Protostega gigas* specimen analyzed (FHSM VP-17979) is spongiose, with large networks of vascular canals and little or no open medullary cavity. The bone is composed of woven and parallel-fibered tissue. Vascular canal orientation is dominated by longitudinal and circumferential canals organized in concentric layers. Vascular canals increase in circumferential organization towards the outer cortex. Three lines of arrested growth were also observed. Because there are vascular canals open to the periosteal surface of the bone, three widely spaced lines of arrested growth, and no indications of reduced vascularity and cessation in bone growth, this specimen is interpreted to have been a juvenile between three and four years old at the time of death. Overall, the *Protostega* bone analyzed in this study has a similar microstructure to that that described in the leatherback sea turtle, but it is unclear whether the lack of an open medullary cavity is characteristic of the taxon or a juvenile feature. This research provides and important data point for studying sea turtle paleobiology, and future research will include sectioning additional *P. gigas* bones to learn about growth in an individual and comparing *P. gigas* to other sea turtle taxa.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

MYOLOGICAL RECONSTRUCTIONS FROM WELL-DEFINED APPENDICULAR MUSCLE SCARS IN *DREADNOUGHTUS SCHRANI*, A GIGANTIC TITANOSAURIAN SAUROPOD FROM PATAGONIA, ARGENTINA

VOEGELE, Kristyn, Drexel University, Philadelphia, PA, United States of America; ULLMANN, Paul, Rowan University, Glassboro, NJ, United States of America; LAMANNA, Matthew C., Carnegie Museum of Natural History, Pittsburgh, PA, United States of America; LACOVARA, Kenneth J., Rowan University, Glassboro, NJ, United States of America

We reconstructed the limb and girdle musculature of the giant titanosaurian sauropod *Dreadnoughtus schrani* from the Cretaceous of Argentina based on observations of osteological correlates and dissections of taxa comprising the Extant Phylogenetic Bracket of non-avian dinosaurs (crocodylians and birds). *Dreadnoughtus* is less derived and significantly larger-bodied than any titanosaurian for which myology has previously been reconstructed. Furthermore, these fossils display extensive, well-developed, and well-preserved muscle scars, making them ideal for myological study. Titanosauriforms evolved a unique posture, termed wide-gauge, in which the limbs were not held directly underneath the body. Identifying titanosauriform muscle origins and insertions and how these may have changed through the evolutionary history of these sauropods is an important step in deciphering the acquisition of this posture. We compared the reconstructed musculature of *Dreadnoughtus* with those of other titanosaurian species to explore myological variation within the group. *Dreadnoughtus* shares a textured, raised knob on the medial side of the scapula for attachment of the M. subscapularis with several derived titanosaurians (e.g., *Aeolosaurus*, *Lirainosaurus*, *Neuquensaurus*, *Paralititan*, *Pitekunsaurus*, *Saltasaurus*) and the diplodocoid *Suuwassea*, suggesting a potential increase in stress applied by this muscle in these taxa. Also, the M. coracobrachialis is reconstructed as inserting in a fossa on the proximomedial portion of the anterior surface of the humerus in *Opisthocoelicaudia*, *Notocolossus*, *Saltasaurus*, and *Dreadnoughtus*. A proximolaterally–distomedially-oriented shelf within this fossa is also present in *Paralititan*, but only *Dreadnoughtus* and *Opisthocoelicaudia* have been reported to possess discernible muscle scars at this location. The insertion sites of the M. gastrocnemius and the Mm. flexor tibialis externus and internus show no scarring in *Opisthocoelicaudia*, whereas *Dreadnoughtus* has visible scarring here, suggesting that in the latter these sites were under greater stress when the muscles were activated and more bone remodeling took place as a result. Comparisons among titanosaurians suggest widespread myological variation, and few phylogenetic patterns can currently be elucidated, necessitating the study of additional taxa. By identifying such myological variations, we can begin to address specific evolutionary and biomechanical questions related to the unique wide-gauge posture of titanosaurians.

Grant Information
NSF DGE Award 1002809

Technical Session I (Wednesday, October 26, 2016, 8:00 AM)

SPECIALIZED WEAR FACETS IN MAMMALIAN DENTITIONS

VON KOENIGSWALD, Wighart, Institut Fuer Palaeontologie, Bonn, Germany

Withdrawn

Dental wear is regarded as part of the life history of teeth. An early ontogeny during which the teeth are formed is separated from a late ontogeny during which the teeth are consumed by wear. A survey of various dentitions reveals a general difference between the wear of primary and secondary occlusal surfaces.

Teeth with a primary occlusal surface that functions well with the initial surface are worn down gradually. Most tribosphenic teeth and all bunodont molars belo[illegible] to this category. The exposed dentine may be regarded as a measure of wear [illegible]ng the late ontogeny of these teeth.

In contrast, teeth with a secondary occ[illegible]al su[illegible] to [illegible]ecome fully functional. By exposing th[illegible] dentine [illegible] sectio[illegible] of [illegible] e used either as blades or [illegible] fo[illegible] the [illegible] th[illegible] food [illegible] t[illegible]es of specialized facets ar[illegible] fo[illegible]ed. The [illegible] fa[illegible] s [illegible]ccu[illegible] [illegible]arious mammalian groups independ[illegible] to [illegible] specialized [illegible] [illegible]f th[illegible] teeth, such facets can function uniformly [illegible] long ti[illegible] d[illegible]ensive wear.

From [illegible] div[illegible]sit[illegible] [illegible]mmalian dentitions, four different types of facets were selected. [illegible] a[illegible]ll w[illegible]ely distributed. Their construction and function is discussed and compared [illegible]h [illegible]chanical tools. Comparable to scissors, a pair of symmetrical blades that slide past each other characterize carnassials, but occur in herbivores as well as bilophodont-scissors. Single blades with a differently shaped antagonist form ectoloph-guillotines in an asymmetrical arrangement. In these teeth only part of the dentine is exposed. Serial crests that are formed by the cross-section of vertical enamel bands are found in rasp-facets. The large dentine field is structured by enamel-islets or lateral infolds. Finally nipper-facets, found in rodent and lagomorph incisors, have only a small but sharp edge formed by the one-sided enamel and a very large area of exposed dentine.

If the exposure of the dentine is used as a measure for stages during the late ontogeny, all these different types of facets represent different phases. Dentine teeth, e.g., those of xenarthrans, can be added as a very late stage. In each of these specialized facets the relevant section of the ontogeny is relatively elongated, whereas other phases are reduced. Thus the different types of specialized facets represent different heterochronic modifications of the late ontogeny of teeth.

Grant Information
Deutsche Forschungsgemeinschaft FOR 771

Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

ONTOGENETIC HETERODONTY IN *RETICULODUS SYNERGUS* (HYBODONTIDAE, ACRODONTINAE), A FRESHWATER SHARK FROM THE UPPER TRIASSIC OF THE AMERICAN SOUTHWEST

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Isolated teeth from the extinct hybodontid shark *Reticulodus synergus* have been documented throughout the Upper Triassic Chinle Group and Bull Canyon Formations of the American southwest. In this study, we extend the stratigraphic range of *R. synergus* into the Redonda Formation and provide evidence for ontogenetic heterodonty in the species based on a reappraisal of the type and newly discovered material. We examined ~4000 specimens of the type series from the Museum of Northern Arizona (MNA) and recorded measurements of representative teeth for foreaft base length, crown width, and crown height. In total, we measured more than 50 teeth. *Reticulodus* exhibits moderate monognathic heterodonty, wherein the shapes of the teeth vary by position in the jaw. We thus assign all teeth to one of three morphotypes. Morphotype I is characterized by a high crown width (CW) to fore aft base length (FABL) (~0.75), morphotype II by a moderate CW:FABL ratio (~0.59), and morphotype III by a low CW:FABL ratio (~0.37). Adult teeth measure 1–10 mm FABL with occlusal surfaces ornamented with numerous reticulations, crenulations, and pits. Shapes of the adult teeth are dependent on morphotype and vary between rounded, ovoid, rectangular, and hexagonal in occlusal view. The occlusal surface of adult teeth is planar and exhibits a crushing-type dentition, indicating that the diets of adults likely consisted primarily of hard-shelled organisms. Juvenile teeth measure approximately 0.7–2 mm FABL and exhibit greater monognathic heterodonty than do adults. Juvenile teeth lack the indentations obvious in adult teeth, but possess a coronal apex in morphotype I. In morphotypes I and II, juvenile teeth possess a serrated labial peg which is connected to the body of the crown by a "bridge" which divides the labial edge of the crown into two laterolabial sulci. Teeth of morphotype III are rarely found with FABL measurements of < 2 mm, suggesting these tooth families may be absent in juveniles. The teeth of juveniles exhibit a clutching-type dentition which would facilitate the capture and consumption of softer bodied organisms. As the shark aged, the occlusal surface would begin to develop the crenulations and reticulations adorning the crown. The teeth would transition from a clutching-type to a crushing-type dentition to allow the organism to shift prey species. The ontogenetic changes in tooth structure would allow both adults and juveniles to occupy the same habitat and ameliorate intraspecific competition between the two age groups.

Grant Information
Appalachian State University Office of Student Research Undergraduate Research Assistantship

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

SEA COWS IN THE STREET—HOW FOSSIL REMAINS IN THE PEDESTRIAN ZONE OF GIRONA (SPAIN) EXTEND OUR KNOWLEDGE ON EOCENE SIRENIANS (MAMMALIA, TETHYTHERIA)

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Sirenians, or sea cows, are a group of marine mammals with an evolutionary history dating back over some 50 Ma into the early Eocene. The Dugongidae, represented by the single species *Dugong dugon* today, have a long and rich fossil record. However, their phylogenetic interrelationships, especially those of Eocene dugongid taxa, are the subject of controversial debates and in need of revision.

In 2015, sirenian remains, mainly including cranial elements and some ribs, were identified in the pavement of the city Girona in northern Spain. The paving is composed of Eocene limestones and presumably middle Eocene in age. First investigations reveal that the fossil materials most likely represent a single specimen, which is preserved in a series of different sections comparable to section planes of a CT. The preservation of the find is excellent and allows the identification of diagnostic skull elements, such as the rostrum, the maxilla, and the frontal. Preliminary data referring to the dental formula are of particular importance, because the preserved alveoli in the maxilla indicate plesiomorphic conditions. Although not all molars are preserved, at least M3 is missing, the antemolar dentition includes the alveoli of four single-rooted premolars, one canine, and one pair of upper incisor tusks. With less certainty, two further alveoli are identified that may have housed a second and third upper incisor.

Only few Eocene dugongids from Europe are known and include four species: *Halitherium taulannense* Sagne, 2001, from the late Eocene of France; and three species of the genus *Prototherium*, *P. veronense* De Zigno, 1875 and *P. intermedium* Bizzotto, 1983, both from the late Eocene of Italy, and the recently described *P. ausetanum* Balaguer and Alba, 2016, from the middle Eocene of Spain. Based on the first morphological results, comparisons of the new find from Girona with these species argue for a closer relationship with *Prototherium*, and, according to our present knowledge on the palaeobiogeographic and stratigraphic distribution of Eocene sirenians, most likely with *P. ausetanum*.

Ongoing CT scanning and 3-D-reconstruction of the Girona sea cow will enhance the potential of its morphological and taxonomic interpretation and will also provide new insights into the evolutionary history and diversity of Eocene dugongids and Eocene sirenians in general.

Technical Session I (Wednesday, October 26, 2016, 11:00 AM)

THE PALEOPATHOLOGY OF CHRONIC LAMINITIS: GROSS LESIONS AND CT-BASED EVIDENCE FROM THE FOSSIL RECORD OF *EQUUS*

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All ungulate species are potentially susceptible to the disease laminitis, which affects the major support structures of the hoof; documented cases include cattle, giraffes, rhinoceroses, and zebra, but it is most widely studied in the horse. Previous thought maintained that the conditions necessary to trigger equine laminitis nutritionally would not exist without human intervention. Recently, however, this assumption has been called into question.

Chronic laminitis results in a constellation of pathognomonic lesions to the ungual phalanx, including calcification of tendinous and laminar attachment sites, neovascularization, cortical bone thinning, and progressive osteolysis. These lesions are retained in fossil specimens. The rich fossil record of *Equus* allows investigation into the appearance and frequency of chronic laminitis pre-dating equine domestication. An examination of North American vertebrate paleontology collections yielded 1,119 disarticulated ungual phalanges of *Equus* spp. for study, including populations from Blancan, Irvingtonian, and Rancholabrean Land Mammal Ages.

As assessed via multifactorial gross pathological survey and computed tomographic measurements, more than three quarters of specimens studied exhibited chronic laminitic pathology, a number consistent with documented disease prevalence in modern feral horses. The most frequent pathology observed was attachment site calcification paired with abnormal vascular enlargement and proliferation, but nearly one third of phalanges studied also displayed considerable bone remodeling. This evidence of laminitis in the history of horses millions of years pre-domestication places its origins far earlier than previously documented and firmly in the realm of taphonomic concerns among paleontologists. Chronic laminitis additionally presents multiple potential population dynamic influences, which should be examined in future studies.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

NEW INFORMATION ON SOCIAL BEHAVIOR IN *KEICHOUSAURUS HUI*, A PACHYPLEUROSAUR FROM THE MIDDLE TRIASSIC OF GUIZHOU, SOUTH CHINA

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Extant reptiles, such as *Egernia*, and also some dinosaurs such as the Cretaceous psittacosaurs present social behavior including parental care and gregarious behaviors. However, social behavior has not been sufficiently proven in the Middle Triassic marine reptile *Keichousaurus hui* Yong, 1958, from Guizhou, China, represented by thousands articulated skeletons. Many well-preserved specimens were found in one slab, showing sexual dimorphism and ontogeny, thus making it ideal for social behavior research.

Here, we present two associations with an implication of social behavior in *Keichousaurus*. One consists of two juveniles and a neonate preserved together with an adult, labeled as BGPDB-R0002, the other one is a gravid *Keichousaurus* fossil consisting of embryos preserved within the adult, labeled as BGPDB-R0003. The adult of BGPDB-R0002 is preserved in dorsal view, and the snout-vent length is 181.0 mm, while the ratio of its humerus length relative to femur length is 1.304. According to previous studies on sexual dimorphism and ontogeny, we conclude that this is a male *Keichousaurus* which has already reached sexual maturity. A neonate is preserved on the left side of the adult's 4^{th}-6^{th} ribs, with a skull length of 9.0 mm, while its body is partly overlaid by the adult. There are also two juveniles preserved next to the adult's pelvis on the right side, both of which are under one year old. Specimen BGPDB-R0003 is a gravid *Keichousaurus* preserved in dorsal view. Though the embryos are poorly preserved, we can still discern at least 7 embryos within the adult according to their rib orientation. There is also a neonate *Keichousaurus* next to the adult's pelvis. It is not clear if the adult died during labor.

The specimen BGPDB-R0002 showed the possibility of gregarious behavior or parental care in *Keichousaurus*. The specimen BGPDB-R0003 indicates that *Keichousaurus* has a large brood size and a small offspring size, thus are unlikely to perform parental care. In contrast with K-selected plesiosaurs (Eosauropterygia, Reptilia) that gave birth to large, probably single progeny, *Keichousaurus* resembles the r-selected strategy of investing little parental care in progeny. Our findings not only show that social behavior in reptiles may have already emerged in Middle Triassic, but also indicates how studies on marine reptiles can contribute to our understanding of the evolution of vertebrate social behavior.

Technical Session III (Wednesday, October 26, 2016, 3:00 PM)

THE OLDEST KNOWN AVIAN GASTRIC PELLET FROM A FISH-EATING ENANTIORNITHINE, WITH IMPLICATIONS FOR THE DIGESTIVE SYSTEM IN EARLY BIRDS

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Enantiornithes is the most speciose Mesozoic avian clades, and constitutes the sister group to Ornithuromorpha—the clade unites all living birds and their close Mesozoic relatives. Due to the lack of fossil evidence, little is known about the feeding habits of enantiornithines. In contrast, there are fossilized stomachs with the derived features of the digestive system of crown birds in other stem-group birds. We report a fish-eating enantiornithine bird from the early Cretaceous Jehol biota of China. This specimen preserves a gastric pellet that includes fish bones. This bird, like many modern piscivores and raptors, seems to have swallowed whole prey and regurgitated indigestible materials such as bones, invertebrate exoskeletons, scales and feathers. Because pellets from Mesozoic sites that can be unambiguously attributed to birds are absent, our finding represents the oldest record of an avian gastric pellet. The pellet points to a piscivorous diet and suggests that the alimentary tract of the new enantiornithine resembled those of extant birds in having efficient antiperistalsis and a two-chambered stomach with a muscular gizzard capable of compacting indigestible matter into a cohesive pellet. Thus, these distinctive features of modern birds appear to have been present in some Early Cretaceous enantiornithines. Along with recent discoveries, it shows that trophic partitioning took place early in bird history, contributing to their enormous diversification since the Early Cretaceous.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

A NEW CONFUCIUSORNITHID SPECIMEN FROM THE LOWER CRETACEOUS OF WESTERN LIAONING, CHINA

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Confuciusornithidae is a basal avian group from the Early Cetaceous Jehol Biota of northeastern China. As the most primitive beaked birds presently known, they exceeds all other avian groups in the Jehol Biota in fossil quantity and duration. The fossils are discovered from the Dabeigou Formation (about 131 Ma), the Yixian Formation to the Jiufotang Formation (about 120 Ma) of northern Hebei and western Liaoning. Here we report on a new confuciusornithid specimen, PMOL-AB00178. The specimen is a nearly complete and mostly articulated skeleton from the Lower Cretaceous Yixian Formation (about 125 Ma) in Yixian, western Liaoning. It is an adult individual, as indicated by the complete fusion of the composite bones. It exhibits many derived features not seen in other known confuciusornithid birds: relatively small body size and slender limb bones, narrow centra of synsacrum to form a longitudinal ridge, a pygostyle with foramen, developed extensor process of alular metacarpal, pubis strongly curved caudally. The features indicate that the group is more derived and possesses stronger flight capability than our previous understanding. A single manual digit, which is judged to belong to a small enantiornithine bird, is preserved in the abdomen of the specimen. This find provides new evidence on the diet of confuciusornithid birds.

Technical Session XVIII (Saturday, October 29, 2016, 2:30 PM)

CRANIAL ONTOGENETIC VARIATION IN THE LATE JURASSIC CHINESE CERATOSAUR *LIMUSAURUS INEXTRICABILIS*

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Limusaurus inextricabilis is a ceratosaur theropod from the early Late Jurassic (Oxfordian) upper part of the Shishugou Formation of northwestern China, which represents the only known Jurassic theropod with a fully developed rhamphotheca and gastric mill. The original description of *Limusaurus inextricabilis*, based on a subadult specimen, revealed a suite of autapomorphies unique to this taxon. Recent study of 18 specimens including several young juveniles yielded 47 cranial ontogenetic variable features of *Limusaurus inextricabilis*; for example, compared to the juveniles, the subadults and adults have a proportionally shallower head, the quadrate shaft is relatively straighter in adults than in juveniles, and the anterior end of the dentary is much more downturned than in juvenile specimens. Meanwhile, several previously suggested autapomorphies proved to be correlated with ontogeny, such as the relatively short skull that is half as long as the femur, toothless skull and mandible, premaxilla with a convex buccal edge, and the relative size of the external mandibular fenestra.

Among 47 cranial ontogenetic changes we identified in these specimens, the most unexpected one is the change from a fully-toothed jaw in the hatching and juvenile individuals to a completely-toothless beaked jaw in the more mature individuals, representing the first fossil record of ontogenetic edentulism among the jawed vertebrates. Data derived from Mi-CT and SR-μCT reveal dental vestiges such as enclosed hollow alveoli inside the dentary of subadult and adult *Limusaurus inextricabilis*. This radical change suggests a diet shift probably from ominvory for juvenile *Limusaurus* to herbivory for adult *Limusaurus*, which is also supported by geochemical data and the presence of gastroliths only in larger specimens. Comparisons of stable oxygen and carbon isotopes in *Limusuaurus* and Shishugou taxa of presumed dietary habits also supports a shift from omnivorous to herbivorous diet. The present evidence suggest that the ontogenetic tooth-loss of *Limusaurus* is a gradual, complex process. Specimen level phylogenetic analyses recover all ontogenetic stages of *Limusaurus* as monophyletic within Ceratosauria, and this result is robustly supported by character jackknifing analysis.

Grant Information
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Technical Session XVII (Saturday, October 29, 2016, 10:30 AM)

AN ADULT SPECIMEN OF *SINOCYAMODUS XINPUENSIS* (SAUROPTERYGIA: PLACODONTIA), WITH NEW INFORMATION ON CYAMODONTOID ONTOGENY

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Cyamodontoidea is an armored group of Placodontia (the basal-most clade of marine Sauropterygia). It was mainly known from the western Tethys Fauna (modern Europe and Middle East) until *Sinocyamodus xinpuensis*, the first Chinese placodontian, was reported in 2000. The holotype of *S. xinpuensis* (IVPP V 11872) was described as a juvenile individual. Here we report the only adult specimen of this taxon. The new specimen is a nearly complete skeleton, exposed in dorsal view. It is a large-sized cyamodontoid with a total length of at least 105 cm, over twice the length of the holotype (49.3 cm). The new specimen can be readily referred to *S. xinpuensis* on the basis of the presence of following characters: 1) orbit relatively elongated; 2) nasal-frontal contact, nasals not separated by posterior processes of premaxillae; 3) parietal with an anterolateral process inserting between frontal and postfrontal; 4) humerus with a distally notched ectepicondylar groove; and 5) carapace composed of three types of osteoderms with rows of meridional ridges and vaulted zones on both sides. Compared with the holotype, three evident differences are present in the skull and armor of the new specimen, which are interpreted as ontogenetic variations. 1) The length ratio of the upper temporal fenestra to the orbit remarkably increases (from 1.23 in the holotype to 1.86 in new specimen); this reflects a cranial growth allometry, indicating that the posterior portion of the skull grew faster than the anterior portion with age. 2) The new specimen has a relatively elongated carapace compared with the holotype; the ratio between length and width of the carapace is 0.89, compared with 0.66 in the holotype. 3) The new specimen shows a carapace pattern that is morphologically more complicated than that of the holotype. Our ontogenetic study of *S. xinpuensis* not only enriches our knowledge of the morphological changes in single placodontian species with age but also suggests that those differences have to be used with caution in the taxonomical identification of the relevant taxa.

Romer Prize Session (Thursday, October 27, 2016, 9:00 AM)

MODULAR DEVELOPMENT AND EVOLUTION OF THE THEROPOD BRAIN

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How do large, complex brains evolve? Shifts in the timing and rate of development are thought to be proponents of major evolutionary transformations in the brain, and, by association, the enclosing skull. While most studies on brain evolution have proceeded on mammals, birds also exhibit highly encephalized brains, analogous neural cytoarchitecture, and incredible neuroanatomical variation. In addition, well-preserved fossils of theropod dinosaurs provide critical paleontological data on brain morphology through endocasts, making birds an excellent comparative system to study brain evolution. Avian craniofacial form has been argued to be the result of paedomorphosis, which explains larger brain sizes in birds. However, whether similar heterochronic events account for the specialized shape of the avian brain has not been tested. If heterochrony underpins avian brain evolution, then ontogenetic trajectories of brain shape changes should predict interspecific neuroanatomical variation. To address this hypothesis, I used a 3-D geometric morphometric approach to densely characterize the neuroanatomical shape of a broad taxonomic sampling of coelurosaurs, including key non-avian theropod taxa. I integrated these evolutionary data with a robust, developmental sampling of modern chicken and alligator endocasts and brains—a first for analyses of this kind on archosaurian brains. Unexpectedly, parallel ontogenetic trajectories of chicken and alligator brains are largely orthogonal to the evolutionary transformations of theropod brains, indicating that overall brain evolution was decoupled from the heterochronic processes argued to have driven their craniofacial evolution. Results show that brain evolution along bird-line archosaurs is modular, suggesting that major functional subdivisions of the brain have evolved independently. Evolutionary allometry partially accounts for general brain shape evolution in coelurosaurs with only the cerebrum showing a strong link between evolutionary and ontogenetic shape trajectories that implies peramorphosis within Aves—a pattern inverted from that of the skull. These results, therefore, point to piecemeal assembly of the avian brain through allometric constraints, followed by elevated neurogenesis in the cerebrum. Intriguingly, the evolution of the theropod head appears to be defined, in part, by discordant developmental patterns, which together, have contributed to the evolution of mammal-like encephalization in living birds.

Grant Information

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Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

THE FIRST POSTCRANIAL SKELETON OF *CIMEXOMYS JUDITHAE* AND IMPLICATIONS FOR LOCOMOTOR DIVERSITY IN LATE CRETACEOUS CIMOLODONTAN MULTITUBERCULATES

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Cimolodontan multituberculates were abundant and species rich in Late Cretaceous terrestrial ecosystems of the Northern Hemisphere. In North America, they are known almost exclusively from isolated teeth and jaws; whereas the few associated postcranial skeletons of cimolodontans are known from Mongolia and China. Here, we report on new specimens of the basal cimolodontan *Cimexomys judithae*, including an articulated hind limb and distal forelimb, that were recovered from the late Campanian-aged (ca. 75.5 Ma) Egg Mountain locality of the Two Medicine Formation in western Montana. The femur of *C. judithae* preserves diagnostic features of multituberculates, including 1) a greater than hemispherical articular head, 2) a greater trochanter, extending proximally well beyond the head, aligned with the shaft, 3) a posteriorly located lesser trochanter elliptical in cross-section and convex proximolaterally, 4) a broad intercondylar notch on the distal epiphysis, and 5) a lateral condyle and epicondyle larger than the medial condyle and epicondyle. The distal humerus of *C. judithae* preserves additional diagnostic features of multituberculates, including 1) a mediolaterally broad distal epiphysis, 2) a large, spherical radial condyle with a lateral capitular tail, and 3) a broad, dorsoventrally compressed entepicondyle that is much larger than the ectepicondyle. Postcranial features also provide insight into the locomotor behavior of *C. judithae*. Specifically, the ulna exhibits a large olecranon process that extends well beyond the semilunar notch and curves medially toward the enlarged entepicondyle, and the hind limb is robust and has a very broad distal femoral epiphysis. From these observations, we infer that *C. judithae* was semifossorial. As such, the preservation of multiple associated or articulated postcranial elements of *C. judithae* at Egg Mountain could be explained by the fact that burrowing animals are more likely to be buried rapidly and avoid subaerial disturbance postmortem. Taken together, these new postcranial data indicate that Late Cretaceous cimolodontans had a greater diversity of locomotor modes than previously recognized.

Grant Information

NSF #1325365 (EAR) to D.J. Varricchio, G.P. Wilson, and J. Conrad

Technical Session XIX (Saturday, October 29, 2016, 4:00 PM)

TAKING IT A STEP FURTHER: THE ASSESSMENT OF STRIDING BIPEDALISM IN EXTINCT KANGAROOS

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The pelvis is an informative region for inferring locomotor behavior as it anchors several important muscle groups that facilitate movement and direct posture. Recent work contends that based on pelvic features, sthenurine kangaroos (subfamily: Sthenurinae) were too large to have engaged in saltatorial locomotion at slower speeds, consequently adopting a bipedal striding gait. *Sthenurus tindalei* (AMNH 11749) is a large-bodied Pleistocene specimen (~110–144 kg) with an associated, well-preserved right innominate. To complement the existing literature and previous linear measurement-based assessment of this group, this study uses a combination of 3D geometric morphometrics and trabecular analyses to evaluate the locomotor capabilities of *Sthenurus tindalei.*

A principal component analysis performed on 24 homologous 3D landmarks taken on the pelvis of extant diprotodonts (n = 75) shows clear separation between arboreal, quadrupedal and saltatorial taxa. On PC1 (30%) vs. PC2 (18%), *Sthenurus tindalei* shares a morphospace with *Dendrolagus lumholtzi*, a tree kangaroo with several primitive pelvic adaptations secondarily acquired for arboreality. On all other PCs, *Sthenurus* occupies a unique position, though placing near *Vombatus ursinus* on PC2 vs. PC3 (13.8%) due to shared iliac flaring. A discriminant function analysis performed on the Procrustes coordinates correctly classifies extant taxa by locomotor category with high cross validation support. *Sthenurus* groups as a saltatorial biped. Size contributions are minimal across PCs (r^2<0.20).

30 digitally segmented samples were extracted from designated, load bearing regions of the pelvis using high-resolution micro-CT scans. A linear regression tested the relationship between the degree of anisotropy, calculated as mean-intercept length (MIL), and locomotor behavior; however, only saltatorial bipeds were distinguishable by MIL (P<0 .05). Although the *Sthenurus* MIL is encompassed within the range of variation exhibited by quadrupeds, it falls closer to the mean of the bipedal saltators.

Findings support previous interpretations but cannot effectively rule out substantial hopping capabilities or even an increased reliance on a quadrupedal gait. Given the resemblance to *Dendrolagus*, if S*thenurus* is capable of striding bipedalism, it implies that a pelvic configuration inherited from an arboreal ancestor could have enabled this rare form of locomotion in both marsupials, and possibly in primates, as both converge in aspects of their pelvic morphology.

Grant Information

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Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

A NEW HIGHLY PRODUCTIVE BONEBED OF THE LATE TRIASSIC AETOSAUR *TYPOTHORAX*

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Typothorax is a genus of typothoracisine aetosaur that is currently known primarily from osteoderms and other postcranial elements, but only a handful of relatively complete skeletons, most of which are isolated specimens that are currently undescribed. Here we describe a new bonebed from the conglomeratic base of a channel sandstone within the Martha's Butte Beds of the upper Sonsela Member of the Chinle Formation in northeastern Arizona. The bonebed contains osteoderms and skeletal elements of *Typothorax*, including a relatively complete, articulated subadult skeleton with skull collected during the 2015 field season that includes a partial skull and the most complete pedes known from any aetosaur. Blocks removed from the locality also contain parts of at least two additional skeletons, including one with a complete, articulated hindlimb and tail.

Preliminary analysis of the bonebed indicates the presence of multiple individuals of *Typothorax*, possibly varying in age. Although the bonebed has so far yielded articulated skeletal material only of *Typothorax*, several theropod dorsal vertebrae have also been collected, as well as teeth of rauisuchids, crocodylomorphs, phytosaurs, theropods and fish. This site offers an unprecedented opportunity to further describe the osteology of *Typothorax* and potentially understand ontogenetic change in the animal, as well as the paleoecology of the area during this time.

Grant Information

Supported in part by a Connecticut State University Grant and a grant from Southern Connecticut State University.

Symposium II (Friday, October 28, 2016, 8:15 AM)

EVO-DEVO OF MAMMALIAN BRAIN PROPORTIONS: TESTING PARADIGMS OF CONSERVED GROWTH AND EVOLUTIONARY SCALING IN THE GROWING MARSUPIAL BRAIN

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The genetic patterning of mammalian brain development dates back to the earliest beginnings of vertebrate life. However, the fossil record shows that the size and structure of the mammalian brain have been modified extensively from the tube-like, relatively small brain of cynodonts to the relatively large brain of mammals. Nevertheless, it has been argued that the scaling of the main partitions of the brain (e.g., cerebrum, cerebellum, medulla) with total brain size is tightly constrained by developmental regularities governing neurogenesis. In particular, it has been suggested that brain partitions whose peak neurogenesis is later in development will evolve into larger structures, because they produce larger numbers of neurons. The conservative scaling across different brain sizes was explained with an equally conserved scaling of neurogenetic timetabling with total brain sizes. This "late equals large" hypothesis is debated and not congruent with the fossil record. Its core predictions—that developmental brain proportion scaling should be uniform across mammals, and that evolutionary and developmental proportion scaling should resemble each other—have never been tested. In this study, we provide the first quantitative evaluation of these predictions, using micro-CT reconstructions of hydrogel-stabilized, iodine-stained growth series of three marsupials (*Macropus eugenii*, n = 11; *Trichosurus vulpecula*, n = 10; *Monodelphis domestica*, n = 12). ANOVAs of scaling slopes and intercepts contradict several predictions arising from "late equals large", including that mammalian brain

partition development has a uniform slope and intercept and scales similar to cross-species adult brain scaling. We also found that the suggestion that brain proportion scaling contains little phylogenetic signal is masked by coalescing large cross-species datasets. The developmental diversity of brain partition scaling suggests that brain proportion evolution is not constrained by neurogenetic patterns, that developmental scaling patterns are diverse even in the small, three-species sample we had, and that this developmental flexibility may well have made the origins and evolution of the exceedingly specialized mammalian brain possible.

Grant Information
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Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

PHYLOGENY OF SABERTOOTH FELIDS (CARNIVORA, FELIDAE, MACHAIRODONTINAE)

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For this study, a matrix of 48 morphological characters from skull and dentition were coded for 22 taxa of carnivorans, including 17 species of Machairodontinae, two Felinae, one felid of uncertain systematic position (*Nimravides*), and the outgroup taxa *Cryptoprocta ferox* and *Canis lupus*. Of the characters, 25 were binary and the remainder multistate. They were analysed as unordered. Analyses were carried out in TNT 1.5beta using implicit enumeration. Two analyses were carried out: one using unweighted characters, the other employing the implied weights function in TNT. The first analysis yielded two trees of 125 steps; CI 0.608; RI 0.767. The clade (*Smilodon Megantereon*) was recovered as a monophyletic group, as was (*Amphimachairodus*(*Homotherium Xenosmilus*)). The two trees differed in the specific topology of the species of *Homotherium* vs *Xenosmilus*. *Rhizosmilodon* was the sister taxon to (Smilodontini Homotheriini), followed rootwards by a paraphyletic *Dinofelis*. Sister to that was a monophyletic clade (*Metailurus*(*Promegantereon Machairodus*)). The second analysis also yielded two trees of 129 steps; CI = 0.589; RI = 0.748; Weight = 9.163. The same two crown clades were recovered. Sister to these was (unresolved) *Rhizosmilodon* + *Machairodus*, followed rootwards by a monophyletic *Dinofelis*. The next clade was composed of (*Nimravides*(*Promegantereon Metailurus*), followed by Felinae and the outgroup taxa. All trees had low stability values. Clearly, the results presented are strongly influenced by factors such as geological age, size and ecology, rather than phylogeny. However, these factors appear somewhat mitigated here as compared with previous machairodont phylogenies in the recovery of a distinct (if restricted) Smilodontini and Homotheriini. The second analysis points to some interesting possibilities for future research in the recovery of a monophyletic *Dinofelis*, the position of *Nimravides* within Machairodontinae rather than outside crown group Felidae as in the first analysis, and in the recovery of *Machairodus* closer to the Homotheriinae, where some traditional hypotheses place it. On the other hand, a monophyletic Metailurini, as traditionally conceived, is not recovered in either analysis. Future work involves adding further taxa and characters, especially characters of the postcranium, to further stabilize the tree and establish a reliable phylogeny of the Machairodontinae.

Grant Information
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Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

LEARNERS AS RESEARCHERS: TEACHING CONCEPTS OF STABILITY AND CHANGE IN NATURAL SYSTEMS THROUGH PROJECT-BASED EXPLORATION OF PALEONTOLOGY

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A Crosscutting Concept in the K–12 Next Generation Science Standards is "stability and change" in natural systems. Paleontology provides opportunity to examine stability and change: the study of evolutionary rates, processes of fossilization and the rock cycle, and patterns of extinction rates and mass extinctions. In a four week course for K–12 teachers, we explored this concept in a variety of ways: observing rocks in the field, simulating evolutionary processes, examining specimens, and using techniques to record change over time in these systems. Through these activities, teachers gained knowledge of change and stability in terms of history of life on Earth. We framed the course with the questions: when, where, why, and how? This structure showed how the intersections between stratigraphy, geochronology, climatology, and evolutionary biology allow paleontologists to describe a fossil organism. These questions were revisited often as teachers connected their understanding of concepts with enactment of activities. To approach the question of "when?" for example, we made a paper geologic timescale, and used it with frequency as a backbone for the concepts of phylogenetics, extinction, and plate tectonics. Teachers emphasized the value of the timescale, saying that it helped them understand the scale of Earth history. They also felt the timeline allowed them to conceptualize how incrementally slow or intermittent processes (e.g., natural selection, plate tectonics) have wrought immense changes and biotic diversity observed in the present day.

A hallmark of the course was consistent reconnection to actual research. The integration of research tied foundational content to learning how to generate and investigate new research questions. Complex research ideas and methods became accessible as participants gained or enhanced their understanding of concepts like "stability and change" over time. By using effective pedagogical strategies and offering interesting and recent content, we offered teachers tools for use with their own students. Emphasizing "stability and change" instilled a deep understanding of critical concepts in paleontology. Interestingly, in addition to supporting teacher learning of paleontology, teachers also developed a deep empathy for their own students; one teacher noted how easy it is to forget, as an adult, the feeling of struggling in class. Simultaneously, we found that, in teaching the course, we honed our science communication skills by gaining familiarity with the background and interests of our audience.

Poster Symposium I (Wednesday–Thursday, October 26–27, 2016, 4:15–6:15 PM)

A COMPARISON OF TWO LATE UINTAN (LATE MIDDLE EOCENE) MICRO-MAMMAL FAUNAS FROM THE CENTRAL ROCKY MOUNTAINS AND TEXAS COASTAL PLAIN AND THEIR PALEOECOLOGIC IMPLICATIONS

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The WU-26 fossil locality has yielded the first micro-mammal fauna from the late Uintan (late middle Eocene), Uinta C Member of the Uinta Formation in the Uinta Basin of northeastern Utah. The formation outcrops comprise the type locality for species that define the Uintan North American Land Mammal Age. Our field crews have processed more than 28 tons of bulk sample from WU-26 and recovered more than 600 micro-mammal specimens identifiable to at least the genus level. The fossil-bearing horizon is a 15-cm thick, green, pond or oxbow lake(?) claystone, which lies 40 m below thick channel sands at the base of the Duchesne River Formation's basal Brennan Basin Member. WU-26 provides a unique glimpse into the micro-mammal community that inhabited the Uinta Basin near the end of deposition of the Uinta Formation. The virtual absence of paleobotanical specimens in the Uinta Formation makes paleoclimatic reconstructions problematic. A tiny palynologic flora recovered from WU-26 is currently understudy.

More than 1000 micro-mammal specimens were collected at Texas Memorial Museum locality 42486 from the parallic, late middle Eocene, Laredo Formation, at Laredo, Texas. Micro- and macro-floral remains along with fish and reptilian species indicate the Casa Blanca community lived in a lowland tropical rain forest and coastal mangrove setting. The WU-26 sample size is now large enough to make meaningful comparisons with the Ui3-age Casa Blanca micro-mammal community. *Protoreodon parvus* is present in both faunas. Several other genera are present in both faunas including *Herpetotherium*, *Mytonius*, *Epihippus*, *?Amynodon*, *Mytonomys*, *Microparamys*, and *Pauromys*, indicating that both environments shared habitats compatible for these taxa. That fact and the presence of crocodilians including "Allognathosuchus," the carettochelyid turtle, *Pseudanosteira pulchra*, along with the tortoise *Hadrianus*, and at least four species of Omomyid primates, suggest that the paleoclimatic regime at WU-26 was subtropical or warmer. It is significant that the earliest known North American lagomorph, *Mytonolagus petersoni*, as well as *Janimus*, *Pareumys*, *Sciuravis* and *Talpavus* are present at WU-26 but absent from TMM 42486, indicating that paleoecological differences also existed. Small mammals in the Casa Blanca fauna not yet discovered at WU-26 include *Mahgarita*, *Laredomys* and *Microeutypomys*.

Grant Information
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Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

VIRTUAL ENDOCAST OF LATE PALEOCENE *NIPTOMOMYS* (MICROSYOPIDAE, PRIMATES) AND EARLY PRIMATE BRAIN EVOLUTION

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Understanding the timing of brain size changes early in primate evolution is critical for evaluating adaptive hypotheses surrounding the evolution of their relatively large average brain size among mammals. As the stem Primates closest to the base of the tree for which we have endocasts, microsyopids are of particular importance for understanding this question. Cranial endocasts have been reported for a few of the larger microsyopine microsyopids, but this study documents the first for the more diminutive Uintasoricinae. Since overall brain size can influence aspects of cerebral scaling, the smaller uintasoricines may provide new insights into the evolution of the brain in early primates, which are inferred to also have been of small body mass.

Here we report the first partial cranium of a uintasoricine, *Niptomomys* cf. *thelmae* (USNM 530198), from late Paleocene (Clarkforkian NALMA) of Wyoming. Due to the telescoped nature of the specimen, multiple bone fragments had to be independently isolated, repositioned, and merged. From this newly reconstructed cranium, the endocranial anatomy was extracted to produce a virtual endocast.

Estimates of body mass for the specimen range from 22.8 g (cranial length) to 71.8 (upper molar area), and the volume of the virtual endocast is 4.8 cm^3. Like some other plesiadapiforms (*Plesiadapis*, *Ignacius graybullianus*, some specimens of *Microsyops*), the *Niptomomys* virtual endocast has visible caudal colliculi, suggesting less caudal expansion of the cerebrum compared to that of Euprimates. When compared to overall endocast volume, the olfactory bulbs of *Niptomomys* are larger than in other known plesiadapiforms or euprimates, at 8.61% of total brain volume, compared to ~5% for both *Microsyops annectens* and *Ignacius graybullianus*. This suggests that reductions in the relative size of the olfactory bulbs may have occurred independently in microsyopids and in more derived primates, or could reflect adaptive specializations particular to uintasoricines. Interestingly, when compared to later known microsyopids, the encephalization quotient (EQ) of *Niptomomys* is relatively high (EQ range is 0.35–0.83; using Eisenberg's equation). Although the lower end of the range is relatively low, the whole range is shifted up relative to estimates for *Microsyops* based on the same body mass estimators (0.32–0.52). In all, *Niptomomys* provides new insight into early primate brain morphology, with larger olfactory bulbs, but a higher EQ, than inferred from the study of other plesiadapiform endocasts.

Grant Information
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Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

DIGITAL COLLECTIONS AND WEB MODULES AT THE UC MUSEUM OF PALEONTOLOGY: BRINGING MUSEUM COLLECTIONS TO EDUCATORS AND PUBLIC AUDIENCES

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Our science is becoming increasingly digital, and the move to web-mobilize paleontological collections metadata and create digital representations of specimens in a variety of formats - from photographs to CT to laser scanning - is a high priority for museums. However, integrating that growing body of content into K–6 education materials and presenting it to the public in meaningful ways continues to be a challenge. As the University of California Museum of Paleontology (UCMP) continues to grow its digital specimen records and capture taxonomic and contextual data as part of rehousing and collection curation projects, online educational modules are being developed to help users formulate questions, test ideas, and interpret Earth history from collections-based research.

As the outreach component of a current rehousing and digitizing project of a Holocene to Pleistocene collection from the McKittrick and Maricopa seeps (Kern County, California), we have developed a new style of module that incorporates digital content from the collections with original graphic art and content to highlight unique communities of fossil vertebrates, plants, and insects preserved at the site. Graphical representations of Pleistocene ecosystems in the Central Valley of California are backdrops for module storyboards guided by questions on changing climate and shifting environments and their impact on food webs, biotic interactions, and ultimately extinction. Drawing this information from the McKittrick fossil collection with supporting digitized materials and photographs will guide users in reconstructing the fauna, visualizing measurable changes in the fauna and the landscape through time, while exploring the causes of change within Pleistocene ecosystems of California. These modules can also be readily integrated within existing content on UCMP's suite of web sites, *Understanding Evolution*, *Understanding Science,* and *Understanding Global Change*. This cross-pollination among sites provides multiple options to discover museum research across a variety of platforms easily accessible by the public.

Grant Information
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Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

PEDAL SOFT TISSUE AND BIOLOGICAL RESTORATION OF *AUSTRALOVENATOR WINTONENSIS* (THEROPODA, MEGARAPTORIDAE) TO DETERMINE THE EFFECTS SOFT TISSUE HAS ON RANGE OF MOTION

WHITE, Matt A., University of Newcastle, Newcastle, Australia

Skeletal range of motion analysis of dinosaur specimens has generally focused on bone on bone articulation without the allowance of soft tissue. Herein is an attempt to interpret the effect soft tissue would have on the pedal range of motion of *Austraovenator wintonensis*. The pedal range of motion of *Dromaius novahollandiae* (commonly known as an emu) was used to determine the variation in pedal movement with and without soft tissue. This was achieved with computed tomography by scanning the *Dromaius* pes in fully flexed and extended positions with the soft tissue intact. The soft tissue was then removed and the *Dromaius* bones were re-scanned individually. This enabled the pedal elements to be both manually and digitally manipulated to determine the bone range of motion.

A comparison revealed that there was a reduction in pedal range of motion with the presence of soft tissue. The variation was used as a guide to determine the pedal range of motion of *Australovenator* with the allowance of soft tissue. Additionally, the soft tissue of the *Australovenator* pes was reconstructed based on the *Dromaius* dissection to describe how the soft tissue influenced movement.

Poster Symposium II (Friday–Saturday, October 28–29, 2016, 4:28 PM)

USING BIPARTITE NETWORKS TO EXAMINE MORRISON FORMATION DINOSAUR COMMUNITY STRUCTURE

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The Upper Jurassic Morrison Formation is both geographically extensive and well-sampled, making it an ideal candidate for biogeographic analysis at both course and finer scales. Here, we examine the Morrison Formation for species richness and diversity indices, and using bipartite network-based techniques, transform these data into metrics for per-locality endemism, average occurrence, and biogeographic connectivity. These values were compared between four discrete regions based roughly on latitude and lithology – Northeast (Montana, South Dakota, and northern Wyoming), West Central (Utah and western Colorado), East Central (central and eastern Colorado and southern Wyoming), and South (New Mexico and Oklahoma).

Biogeographic connectivity is nearly identical in both East and West Central regions, and is noticeably lower than in either the Northeastern or South regions; connectivity is highest in the South region, with substantial overlap between it and the Northeast region. Despite the lower connectivity scores, endemism is essentially zero in the central regions and slightly higher in the Northeast and South regions. This suggests the possibility of additional clines within the central regions that are producing taxonomic variation along a gradient rather than an outright balkanization of localities and basins.

Here this is tentatively interpreted as greater habitat homogeneity in the South and Northeastern Morrison regions, and greater fractionation in the central regions. This is consistent with observations highlighting the central regions as consisting of multiple individual basins as 'environmental outliers' in a more continuous background. The greater fractionation likely resulted in substantial edge habitats, leading to the observed gradient in taxonomic composition. This is consistent with taxonomic assemblages, which have the more classically "open" adapted taxa (diplodocids, large theropods) present across the Morrison and more "closed" adapted taxa (small theropods, woody browse or high browse feeders) generally restricted to the central regions. Further avenues of research include examination of changes in community composition and connectivity across the Salt Wash-Brushy Basin transition in western parts of the depositional area, and correlations between this area and localities further to the east and north where these members are not recognized.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

HISTOPATHOLOGY OF A POTENTIALLY CANCEROUS MASS IN A LATE PERMIAN GORGONOPSID CANINE

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Bone pathologies have been noted in a variety of extinct taxa, including Mesozoic mosasaurs, ornithiscian and saurischian dinosaurs, as well as Pleistocene mammals, and can elucidate behavioral, physiological, and ecological dynamics of extinct species. Diseases that present internally with little external manifestation, however, have received comparatively little attention. Here we present a dental pathology that was recognized only after producing histological sections of a gorgonopsid right dentary from the Late Permian of Tanzania. Embedded in the anterior portion of the dentary, alongside the functional canine root, are up to seven small tooth-like structures. Similar to the functional tooth, these lesions display dentine with distinct periodic lines of von Ebner as well as a pulp cavity. Unlike the functional canine, however, these ectopic teeth appear to be surrounded by enamel instead of cementum, despite being embedded entirely within alveolar bone. The lesions change shape and location relative to the functional canine along the apical-occlusal axis. Beginning towards the apical end of the canine, the pathological teeth are circular, with an average diameter of 1.6 mm, and wrap around the mesial border of the functional tooth root (diameter of 15 mm). Moving towards the occlusal end, the circular lesions amass closely together and appear to have eroded into the mesiolabial edge of the functional root. In the occlusal direction, the pathological teeth are rounded, but no longer form perfect circles, and appear to merge and/or bud from each other, at one point forming a considerably large lesion with a significant pulp cavity. In this position, there is still evidence of erosion on the functional canine root. At the most occlusal end, the ectopic teeth revert to their circular shape, reduce in abundance and show no evidence of erosion or resorption of the functional canine.

Diagnoses are difficult to make for fossil pathologies. However, based on a survey of modern dental pathologies, we tentatively conclude that our sample presents an instance of odontoma. Odontoma is a broad term referring to developmental anomalies resulting in growth that gives rise to fully differentiated dental tissues. More specifically, based on the organized tooth-like structure of these lesions, we suggest that this may be an instance of compound odontoma. While we leave our diagnosis open for further refinement, our current assessment is that we have described a cancerous pathology in a Permian tetrapod and its earliest instance among synapsids.

Grant Information
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Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

CRETACEOUS MAGNETOSTRATIGRAPHY IN SOUTHWESTERN TANZANIA AND IMPLICATIONS FOR VERTEBRATE PALEOBIOGEOGRAPHY

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The Galula Formation of the Rukwa Rift Basin (Tanzania) preserves an important Cretaceous vertebrate fauna, including saurischian dinosaurs, a gondwanatherian mammal, and notosuchian crocodyliforms, that helps fill a gap in our understanding of vertebrate evolution in Africa. Despite continental Africa's limited vertebrate record during this time, it is considered an important key in understanding evolution during the breakup of Gondwana. One idea suggests Africa separated from other Gondwanan continents in the Early Cretaceous, with increasing levels of faunal endemism through the end of the Mesozoic. Another hypothesis argues that continental Africa remained intermittently connected to South America into the Late Cretaceous, allowing continued faunal exchange. In order to test these hypotheses and understand the significance of the Galula Fm, it is necessary to establish rigorous age constraint for the formation, which has been largely hindered by a lack of primary volcanic material for radiometric dating.

Here, we use magnetostratigraphy to constrain the age of the Galula Fm Oriented samples were collected from the upper Namba and lower Mtuka members and underwent stepwise demagnetization to determine polarity. Given relatively limited existing age constraint, one interpretation correlates the Namba Mbr, a unit dominated by normal polarity with short reversed intervals, to Chron C32. An alternative correlation assigns reversals in the Namba Mbr to recently proposed short reversals near the end of Chron C34, a time that is traditionally interpreted as having stable normal polarity. The Namba Mbr fauna is generally consistent with either correlation based on comparisons with other regions of Gondwana at this time. The Mtuka Mbr lacks clear magnetic reversals, suggesting an age within Chron C34. These data minimally allow the Namba Mbr to be interpreted as mid-Late Cretaceous (Turonian–Campanian), with the Mtuka Mbr less well constrained to the middle Cretaceous (Aptian–Cenomanian). The reliability of these results is supported by the fold test, indicating magnetization of the Galula Fm occurred prior to tectonic deformation in the region. Moreover, the paleomagnetic pole closely matches the apparent polar wander path for Africa during the Late Cretaceous. This significantly decreases potentially long ghost lineages for certain groups (e.g., gondwanatherians, notosuchians) present in the Namba Mbr, and likely reflects the general diversification of these clades in western Gondwana during the mid-Late Cretaceous.

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Symposium I (Wednesday, October 26, 2016, 9:30 AM)

FROM WHITE TO BLACK: MAILLARD REACTION PRODUCTS AND ENDOGENOUS PORPHYRINS STAIN FOSSIL HARD TISSUES

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Many recent studies using next generation technologies to unravel exceptional molecular preservation have changed our view on the limits of biomolecular stability during fossilization. Nevertheless, common hard tissues have not attracted much attention. Thus, the color change of vertebrate hard tissues from *in vivo* white to blackish-brown in many fossils is generally considered to be based on colored minerals. However, our results show that Maillard reaction products and porphyrins are the main staining agents in vertebrate hard tissues such as bones, eggshells, teeth, and fish scales. These hard tissue matrices yield structural proteins and glycosaminglycans extracellularly, which give rise to Maillard reaction products; intracellularly they represent a source of hemes. We analyzed samples of dinosaur, crocodile, mammal, and paleonisciform hard tissues covering a broad range of age, locality, and chemotaphonomic environments. Using Raman and UV/Vis spectrophotometry, ToF SIMS, EMPA and Powder XRD for demineralized fossil hard tissues, we identified a broad range of Maillard-based modifications in preserved oligopeptides with secondary structures derived from the extracellular matrix (ECM), and protein-cleaved, heme-derived porphyrins from within fossil osteocytes. All analyzed samples contained no brownish-staining crystalline minerals. This demonstrates that diagenetic staining is based on two different preservation phenomena: Firstly, Maillard-staining produces a brownish to blackish hue of the preserved ECM resulting from demineralization of bones, eggshells, teeth, and scales. Secondly, hemes clustering alongside osteocyte inner structures contribute to the diagenetic staining of bones by superimposing layers of dark orange- to reddish-brown osteocyte centers. The color of fossilized hard tissues is mainly determined by the type of amino acids reacting with the reducing sugar and their exposure time, as well as the character of post-Maillard modifications due to pH, Eh, and the water content of the surrounding sediment. This study not only rectifies a common misconception regarding the origin of diagenetic color in hard tissues, it also offers an explanation for the fossilization of peptide secondary structures: Intra-peptide Maillard-crosslinks between amino acids which are adjacent in a folded conformation may contribute to their preservation. The possibility that Maillard-crosslinks are the key to the fossilization of proteinaceous biomolecules suggests a new avenue for investigation.

Grant Information

We would like to thank the support by SVP via the Stephen Cohen Award for Student Research 2015.

Technical Session VII (Thursday, October 27, 2016, 3:45 PM)

THE BIOGEOGRAPHY OF LATE CRETACEOUS ANKYLOSAURID DINOSAURS: IMPLICATIONS FOR ANKYLOSAURID DIVERSITY IN WESTERN NORTH AMERICA

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Global and regional fluctuations in sea level and climate during the Late Cretaceous strongly influenced the biogeographic distribution of non-marine faunas from Asia to western North America (Laramidia), including ankylosaurid dinosaurs. These dispersal events may have been triggered by short-lived regressions, producing an ephemeral Beringian land bridge that allowed for intercontinental dispersal to take place. Repeated episodes of sea level rise (transgressions) repeatedly inundated this Beringian land bridge and prevented continuous faunal dispersal.

Fossil evidence from the Early Cretaceous of Asia yields some of the earliest ankylosaurid dinosaurs (e.g., *Shamosaurus*), suggesting an Asian origin for the clade Ankylosauridae, with one or more dispersal events to North America. Currently, two distinct clades of Late Cretaceous ankylosaurid dinosaurs are known from western North America. The oldest occurrences of northern Laramidian ankylosaurids (*Scolosaurus*, *Dyoplosaurus*) are recorded from the middle Campanian stage (~77 Ma) of the Dinosaur Park Formation of Canada, whereas the younger, southern Laramidian clade first appears at ~76 Ma in the upper Campanian Kaiparowits Formation of Utah. To investigate how the biogeography of these clades relates to sea level change during the Late Cretaceous, I utilized temporal calibrated phylogenies in combination with biogeographic modeling, and the most recent eustatic sea level data, to reconstruct dispersal, extinction, and vicariance events for the clade Ankylosauridae. These data suggest at least two intercontinental, three intracontinental, and a single vicariance event during Santonian and Campanian times (~86-77 Ma). These results support the hypothesis of distinct northern and southern biogeographic provinces for ankylosaurid dinosaurs during the upper Campanian in Laramidia, and this hypothesis is congruent with that for other Laramidian non-marine tetrapod clades. Late Cretaceous global eustatic sea level data in combination with the biogeographic models suggest that the intercontinental dispersal events were contemporaneous during periods of relative sea level fall. The earliest dispersal event occurred within a falling stage systems tract, while the latter dispersal event coincides with the terminal stage of a highstand systems tract. A single vicariance event occurred during a time of relative sea level rise, triggering the onset of a lowstand systems tract, which submerged the Beringian land bridge, and resulted in cladogenesis driven vicariance.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

TESTING HYPOTHESES OF SKELETAL UNITY IN SAUROPOD REMAINS FROM THE HOWE-STEPHENS QUARRY (MORRISON FORMATION, WYOMING, USA) USING LONG BONE HISTOLOGY

WIERSMA, Kayleigh, University of Bonn, Bonn, Germany; CANOVILLE, Aurore, University of Bonn, Bonn, Germany; SIBER, Hans-Jakob, Sauriermuseum Aathal, Aathal, Switzerland; TSCHOPP, Emanuel, Università di Torino, Torino, Italy; SANDER, Martin P., University of Bonn, Bonn, Germany

Sauropod bone histology has emerged as the major source of information on life history of these giant extinct animals. It provides an insight into the growth record and ontogenetic age of an individual. Sauropod fossils from the Upper Jurassic Morrison Formation of the Western Interior of the USA, e.g., from the famous Carnegie Quarry at Dinosaur National Monument, are commonly found as mass accumulations of partially articulated skeletons or isolated bones. In such mass accumulations, assignment of specific bones to particular individuals is difficult, and incorrect assignment may have far-reaching taxonomic consequences. In this study, we provide a detailed assessment of skeletal unity by means of paleohistology for sauropod partial skeletons and isolated long bones in a typical Morrison Formation dinosaur quarry, the Howe-Stephens Quarry (Bighorn Basin, Wyoming). Using histological features such as histological ontogenetic stages, growth marks, annual cyclicity, remodeling rate, and the number of generations of secondary osteons, an assignment of long bones to individuals was made and compared with assignments based on field observations. In the case of the Howe-Stephens Quarry, histology allowed assignment of isolated bones to an existing individual, matching of isolated bones to reveal a new individual, and to test whether a specific bone really belongs to the individual it was assigned to in the field. Thus, a new method for testing skeletal unity in fossil tetrapod skeletons is established. However, the histological evidences should be combined with other characters such as morphology and taphonomy to provide the most reliable hypotheses of skeletal unity.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

EXPLORING THE EVOLUTIONARY STRUCTURE AND TIMING OF MAJOR HABITAT SHIFTS IN CROCODYLOMORPHA

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Modern crocodylomorphs are semiaquatic ambush predators largely restricted to freshwater or estuarine environments, but the group is ancestrally terrestrial and was prevalent in nonaquatic and shallow marine ecosystems in the past. Previous work suggested a single shift from a terrestrial to an aquatic mode of life with the emergence of Neosuchia in the Jurassic, but a new phylogenetic analysis with increased ingroup and outgroup sampling suggests at least three independent aquatic transitions. Neosuchians first invade freshwater habitats in the Jurassic, with up to three independent shifts into the marine realm in the Late Cretaceous and at least one more in the Cenozoic. Thalattosuchians first appear in marine habitats in the Early Jurassic. The only known thalattosuchians from freshwater deposits nest well within Teleosauridae, suggesting either that thalattosuchians are ancestrally marine or that specimens preserving an early freshwater/semiaquatic ancestry are yet to be recovered. Recent work also puts the semiaquatic Cretaceous mahajangasuchids within an otherwise terrestrial clade (Notosuchia).

Within most marine groups, some species return to freshwater environments. This includes the two living gharials, *Gavialis gangeticus* and *Tomistoma schlegelii*. Although found only in freshwater settings today, both are derived independently from ancestors found in marginal marine deposits. All living non-alligatorid crocodylians, including the gharials, have a keratinized tongue with salt-excreting glands. Alligatorid historical biogeography suggests a much smaller number of dispersal events across marine barriers than for other crocodylian groups, which is consistent with the diminished salinity tolerance observed in living forms. That close outgroups to Crocodylia tend to be endemic suggests that the alligatorid condition is plesiomorphic.

Only twice have crocodylomorphs reverted from an aquatic to a highly terrestrial habit, both occurring within the crown group - the planocraniids and the mekosuchine *Quinkana*. The planocraniid excursion to the terrestrial realm occurs in the early Cenozoic, possibly in response to open niches provided by the end-Cretaceous mass extinction. Terrestriality of the highly aberrant notosuchians is most parsimoniously reconstructed as plesiomorphically retained from their last common ancestor with predominantly aquatic neosuchians.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

AN IMPORTANT PLESIOSAUR DISCOVERY FROM THE OXFORD CLAY: HOW COOPERATION BETWEEN SCIENCE AND INDUSTRY IS BENEFITTING PALAEONTOLOGY

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The Peterborough Member of the Oxford Clay Formation in the United Kingdom is renowned for its well preserved marine reptile fossils. This Middle Jurassic *lagerstätten* has produced abundant sauropterygians, thalattosuchians and ichthyosaurs, and has also yielded, but perhaps not so commonly known, various dinosaurian taxa and pterosaur remains. In recent years, however, the primary source of these fossils, the brick making industry, has gone into serious decline – so much so that there is now only one remaining working quarry in the Lower Oxford Clay. With the future of UK brick manufacturing unclear, the importance of this quarry to vertebrate palaeontology should not be

underestimated.The Oxford Clay Working Group (OCWG) was set up in 2011, in collaboration with the quarry landowners, to collect, protect and document vertebrate fossils from this very important resource. Despite collecting disassociated vertebrate remains, efforts to secure articulated or disarticulated skeletons have been hampered by modern quarrying techniques and a change of practice by not excavating to the most productive levels. Here we report on a newly recovered, partially articulated plesiosaur skeleton representing an ontogentically advanced individual. The skeleton consists of a largely complete skull preserved three dimensionally and multiple post cranial elements including cervical, dorsal and caudal vertebrae, pectoral and pelvic elements, an ilium, both humeri and numerous bones and digits from both front and rear paddles. There are also multiple ribs and gastralia present, but both femora are absent. The skull block has twice been subjected to high resolution computed tomography (CT), providing preliminary results that are undergoing further noise reduction to filter out sedimentary distortion. However, early indications have already suggested a number of characteristics which may help, together with other skeletal elements, to solve anatomical and taxonomic problems within Cryptoclididae and, perhaps, Elasmosauridae. The specimen has been successfully transferred to the Oxford University Museum of Natural History and so made available for scientific study and eventual public display. The museum has instigated a not insignificant plan for the specimen, which includes not only preparation, conservation and research but, of equal importance, a number of outreach and educational programmes with the focus on public interaction through organised meetings, visits and workshops designed to involve people of all ages on a number of levels.

Technical Session IX (Thursday, October 27, 2016, 3:30 PM)

EXAMINATION OF CHANGES TO THE PECTORAL MUSCULATURE ACROSS THE FIN-LIMB TRANSITION USING EXTANT FISHES

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The fin-limb transition is a major macro-evolutionary event where vertebrates transitioned from aquatic to terrestrial locomotion. The fossil record demonstrates changes occurring to the pectoral skeletal system over this transition, but those to the pectoral musculature are not preserved. The evolution of pectoral musculature can be examined by looking at extant taxa on both sides of the transition, but this has been complicated in the past by a lack of anatomical descriptions focused on musculature for key actinopterygian and sarcopterygian fishes. Using micro CT scanning and serial histological sections, the pectoral anatomy of the bichir, *Polypterus senegalus*, and the marbled lungfish, *Protopterus aethiopicus*, was investigated. These taxa occupy key positions in the phylogeny of fishes, allowing the basal condition for pectoral musculature in Osteichthyan and Sarcopterygian fishes to be determined. New information from these extant taxa demonstrates a complex pectoral musculature, with multiple muscles crossing the glenoid-fin joint, as well as muscles arising entirely within the fin. Similar musculature can be found in fossil taxa such as *Eusthenopteron* and *Ichthyostega* by looking at osteological correlates of musculature. However, this study suggests that this complexity in the musculature arose prior to stem tetrapods. Thus, major changes to the pectoral musculature occurring exclusively across the fin-limb transition were limited to divisions of the distal musculature within the fin/limb.

Grant Information
NSERC DG and Canada Research Chair (awarded to supervisor)

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

THE MCINTOSH PALEONTOLOGICAL ARCHIVE: MAKING A LIFETIME OF RESEARCH AVAILABLE TO THE WORLD ONLINE.

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John Stanton "Jack" McIntosh (1923-2016) was a theoretical physicist who was also the world's authority on sauropod dinosaurs. First writing to R.S. Lull in 1938 at the age of 13 about the synonymy of *Cardiodon* and *Cetiosaurus*, Jack spent the next 70 years investigating sauropod anatomy and systematics around the world as well as conducting extensive archival research unravelling the complex and sometimes bewildering history of collections. Through publications and personal interactions, he influenced generations of sauropod and other dinosaur researchers.

In the course of his paleontological career Jack amassed an immense collection of books, publications, copies of quarry maps, and historic photos. He had over 190 notebooks which recorded his observations and notes, along with massive and extensive measurements of sauropod bones. His personally taken photographic collection of sauropod and other dinosaur bone photos exceeds 40,000 images. There is also extensive correspondence with paleontologists around the world.

Jack was deeply concerned about maintaining the integrity of his archive and that it always be available for use by the scientific community. He chose not to donate it to an institution because he was afraid it would end up locked up and unused in an institutional archive.

The McIntosh Archive Working Group is dedicated to achieving Jack's dream. The archive is presently stored in the Museum of Paleontology at Brigham Young University. We are currently inventorying and organizing the archive, assessing the condition of the materials, identifying conservation needs, and developing a strategy for it. Our goal is to digitize his research data (notebooks, photos, etc.) with the ultimate goal of making it freely available on-line through a website, accessible to anyone at any time. Although we already have some commitments, the working group is looking for partners, individual and institutional, who can assist in this large and important effort for one of the great dinosaur archives.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

A HIGH-RESOLUTION RECORD OF EARLY PALEOCENE FAUNAL DYNAMICS IN THE SAN JUAN BASIN, NEW MEXICO

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The Nacimiento Formation (PgN) of the San Juan Basin, New Mexico, contains a four million year record of vertebrate faunal succession through most of the lower Paleocene, arguably the best such record in the world. This record spans the critical interval in which mammals rise to dominance and begin an adaptive radiation following the end-Cretaceous mass extinction. In addition, the biota was impacted by a hot house climate punctuated by episodic hyperthermal events. The New Mexico Museum of Natural History and Science, Albuquerque (NMMNHS), houses a collection of over 15,000 vertebrate specimens that were collected from the PgN over the past 40 years. Most of these specimens are associated with relatively precise locality and stratigraphic information. The PgN stratigraphic framework is precisely correlated to the Paleocene global time scale using magnetostratigraphy coupled with radiometric dates from volcanic ashes. Together, this record provides a unique high-resolution record of faunal dynamics through the lower Paleocene.

Rarefied mammal richness and turnover estimates as well as various diversity indices (e.g., Dominance, Simpson, Shannon) are based primarily on NMMNHS specimen data (both total number of specimen [TNS] and minimum number of individuals [MNI]) distributed among seven faunal horizons (2 Puercan [Pc1–2], 6 Torrejonian [Tj1–6]). Temporal placement of bin boundaries are based on sediment accumulation rates calculated using both linear and cubic spline interpolation between tie points (e.g., magnetic reversals correlated to the GPTS). We considered only specimens collected through surface collecting to reduce collecting biases.

Important conclusions from our analyses are: (1) maximum richness is reached early in the Torrejonian (in Tj2); (2) turnover rates are highly dependent on estimates of bin duration, nevertheless our PgN age models based on either linear or cubic spline interpolation of tie points indicate similar elevated rates (compared to background) of disappearance between Pc1–2, Tj3–4, and Tj5–6 and appearance between Tj4–Tj5 and Tj5–Tj6; and (3) compound diversity measures fluctuate through the early Paleocene with the lowest evenness values found in Pc1, Tj4, and Tj6.

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Technical Session VI (Thursday, October 27, 2016, 10:15 AM)

PREDICTION OF POTENTIAL FOSSIL-BEARING LOCALITIES IN THE ELLIOT FORMATION (UPPER TRIASSIC–LOWER JURASSIC), SOUTH AFRICA

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Identification of candidate fossil-bearing localities is traditionally based on a mixture of historical knowledge, local contacts, geologic mapping, and literature searches. This is then followed by time-consuming and expensive field work, visiting sites in turn to evaluate their potential. The increasingly widespread availability of digital spatial data, plus advances in geospatial technology, now opens the possibility of developing data-driven computer models to predict potentially productive fossil sites. Here, we develop a model that identifies potential fossil localities at the reconnaissance stage of prospecting using a criterion of present day environmental suitability for fossil discovery. This model employs techniques from analytical biology, Geographical Information Systems (GIS), and remote sensing. The model is designed to be flexible with no limit on the number of variables and can use a variety of data types (both continuous and categorical) by means of a principle coordinate analysis (PCO). In addition it allows the use of either simple occurrence data or a combination of presence/absence data. In the current study, the environmental factors chosen were determined by their likely impact on the potential to find a fossil site and on the availability of data in the study area. We used six environmental variables; slope, aspect, elevation, drainage density, land cover, and vegetation density derived from topographic base data and Landsat 8 imagery processed in GIS. Occurrence data obtained from the Evolutionary Studies Institute, University of the Witwatersrand, South Africa was combined with field data. Absence data was simulated by a grid of background points at 250 m intervals across the study area. We undertook a PCO to explore the data and define the principle coordinate space equating to occurrences. PCO scores were input into a linear discriminant analysis (LDA) to allow us to predict if absence data fell within the PCO space occupied by known sites. Results were exported back to GIS to identify significant spatial clustering of candidate sites. We tested the model on outcrops of the Elliot Formation (Upper Triassic–Lower Jurassic) in the Free State, South Africa. The total available outcrop area of the Elliot Formation in the study area is approximately 2,300 km^2; the LDA correctly predicted 95% of the known occurrences and reduced the potential prospective area to 438 km^2. Initial field testing in 2015 identified two new sites based on the model output.

Technical Session VIII (Thursday, October 27, 2016, 1:45 PM)

NEW MAMMALIAN FOSSILS FROM THE INTERTRAPPEAN BEDS OF THE SOUTHERN PART OF THE DECCAN VOLCANIC PROVINCE AND THE CRETACEOUS–PALEOGENE TRANSITION IN INDIA

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Our understanding of Cretaceous–Paleogene (K/Pg) dynamics in terrestrial ecosystems is largely based on paleontological and geological data from a single geographic region, western North America (NA). As important as these data are for extinction and recovery studies in terrestrial ecosystems, they represent a mostly coastal lowland paleoenvironment from a single geographic region situated relatively close to the bolide impact site (Yucatán Peninsula, México). Accordingly, the Deccan Volcanic Province (DVP) of central and western India provides a much-needed, geographically disparate counterpoint to NA. Its fossil-bearing infra- and intertrappean deposits span the interval of both peak volcanism and the bolide impact (ca. 67–64 Ma). Importantly, this region is near antipodal from the impact crater and represents 'ground zero' for Deccan Trap volcanism, a proposed causal factor in the K/Pg mass extinction.

Here, we report on 24 new mammalian fossils from the intertrappean beds in the southern part of the DVP. These fossils provide new dental and mandibular data for the genus *Deccanolestes* and evidence of at least three new eutherian taxa. These data add to the emerging picture of DVP mammals, consisting of mostly small-bodied eutherians, an endemic gondwanatherian, and a relictual haramiyidan. An improved geochemical and geochronological framework for the DVP also provides us the opportunity to refine the ages and stratigraphic relationships of the individual mammalian local faunas. Geochemical analysis of basalt samples that bracket the Naskal locality and the Gokak locality stratigraphically correlate to the upper Ambenali Formation and the transition between the Ambenali and Mahabaleshwar formations, respectively—and all lie within chron 29R. Although intertrappean fossil localities have mostly been considered latest Cretaceous in age, these geochemical data imply that the Naskal and Gokak local faunas are both earliest Paleogene in age, if the geochemical formations are isochronous throughout the DVP. Accordingly, we infer that *Deccanolestes* and the gondwanatherian *Bharattherium* survived the K/Pg boundary in India. As sample sizes and age determinations from these and other DVP localities improve, we will have our first robust view of K/Pg dynamics in terrestrial ecosystems outside of NA and at 'ground zero' for volcanism.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

COMPARATIVE CRANIAL OSTEOLOGY OF SUBADULT CENTROSAURINE DINOSAURS FROM THE TWO MEDICINE FORMATION, MONTANA

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Throughout growth, centrosaurine dinosaurs (Ornithischia; Ceratopsidae) typically progressed from a more generalized juvenile cranial morphology to distinct mature morphologies, developing diagnostic cranial ornamentations relatively late in ontogeny. At least three stratigraphically separated taxa of centrosaurines are currently recognized from the upper Two Medicine Formation of Montana: *Rubeosaurus ovatus*, *Einiosaurus procurvicornis*, and *Achelousaurus horneri*. *E. procurvicornis* is primarily known from two bonebed sites (Canyon Bonebed [CBB] and Dino Ridge Quarry [DRQ]) preserving a total of at least 15 individuals, while *A. horneri* is known from three partial to near-complete skulls. Recent reassessment of this material reveals transitory ontogenetic features in some large *E. procurvicornis* specimens which verge on the morphologies used to diagnose *A. horneri*, thus obscuring the distinction between the most mature individuals of these taxa. This is consistent with the hypothesis that these ceratopsians represent an anagenetic lineage, with morphological overlap occurring as a result of peramorphosis of cranial ornamentation. Here we assess a previously undescribed small subadult specimen of *E. procurvicornis* (MOR 456 8-8-87-1) from the CBB and compare its cranial osteology to a nearly-identically sized immature specimen of *A. horneri* (MOR 591). Whereas these individuals are of comparable size (basal skull length ~ 60 cm), MOR 456 8-8-87-1 exhibits more mature cranial surface textures, a rugose overgrowth at the margin of the parietosquamosal contact, and a possible partially fused epijugal. The nasal horn morphology of these specimens is nearly identical, yet the supraorbital ornamentation differs noticeably, with MOR 456 8-8-87-1 expressing broader, more rugose supraorbital ornamentation whereas MOR 591 exhibits a sharp, ridge-like horncore above the orbit. Comparisons with other specimens from the CBB and DRQ reveal the ontogenetic development of supraorbital ornamentation in *E. procurvicornis*, providing insight into the utility of this feature for determining relative maturity. Further, the young *E. procurvicornis* expresses a more elongate facial region compared to the similarly sized *A. horneri*. Our survey indicates that *E. procurvicornis* and *A. horneri* exhibit very similar morphology both early and late in ontogeny, with subtly detectable differences occurring as a result of the complex heterochronic development of these features through this evolutionary lineage.

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

A BIRD'S EYE VIEW OF THE WESTERN INTERIOR SEAWAY: THE ROLE OF SEABIRDS IN UNDERSTANDING LATE CRETACEOUS MARINE ECOSYSTEMS

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In modern marine ecosystems, seabirds are often indicators of ecological hotspots, as their geographic distribution is correlated with physical, chemical, and biological oceanographic factors. Pursuit diving seabirds – those that actively pursue prey underwater using wing or foot propulsion – are even more limited in distribution and closely tied to oceanographic factors because diving ability is often gained at the expense of flight capabilities. Limited or loss of flight makes long distance searches for food, long travel distances between breeding and foraging areas, and predator evasion more energetically demanding and difficult. Today, pursuit diving seabird populations are restricted to waters cooler than 15°C.

Late Cretaceous marine environments were characterized by greenhouse climate and high sea levels, resulting in paleoenvironments with no modern analogs. However, these marine environments were also home to pursuit diving seabirds called hesperornithiforms – flightless seabirds found in Northern Hemisphere Late Cretaceous marine sediments, and particularly well-represented from North American Western Interior Seaway (WIS) deposits. As the presence of hesperornithiforms in waters warmer that 15°C indicates that ecosystems were structured differently than today, the goal of this project is to explore how fossil seabird populations can be used to better understand Late Cretaceous marine ecosystems.

Biotic factors like predator-prey relationships and competitor interactions are hypothesized to have affected fossil penguin diversity in the Cenozoic, and have also been suggested to influence modern pursuit-diving seabird distributions (along the 15°C isotherm). However, the spatio-temporal overlap between hesperornithiforms, marine reptiles, and large predatory fishes does not support the same type of competition or predator-prey relationships as a biogeographic driver. Rather, it seems likely that abiotic factors significantly affected WIS seabird populations. The distribution of Late Cretaceous pursuit-diving seabird populations, together with inferred physical, chemical, and biological conditions along the Seaway, support the hypothesis that hesperornithiform distributions are more strongly influenced by abiotic than biotic factors. The unique oceanographic factors characterizing epicontinental seas likely explain why pursuit diving seabird distribution was so different in the Late Cretaceous compared to today.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

THE TERRESTRIAL VERTEBRATE ASSEMBLAGE OF LANGENBERG QUARRY (LOWER SAXONY, NORTHERN GERMANY): A GLIMPSE OF A LATE JURASSIC ISLAND ECOSYSTEM

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The Langenberg Quarry near Goslar is a classic outcrop of late Oxfordian to late Kimmeridgian shallow marine strata at the northern rim of the Harz Mountains in northern Germany. Paleogeographically located in the Lower Saxony Basin, it was surrounded by paleo-islands in the Jurassic. The terrestrial fauna and flora of these islands has been investigated by the *Europasaurus*-Project since 2012.

Land plants from the Langenberg include conifer cones and twigs with well-preserved cuticles. The quarry is the type locality for the dwarfed basal macronarian sauropod dinosaur *Europasaurus* but also yielded remains of other dinosaurs such as three bones of a diplodocid sauropod, a stegosaur tooth, very few theropod bones with possible affinities to Ceratosauridae, and several theropod teeth. Based on discriminant function analysis and cladistic analysis of these teeth, a variety of theropod groups was present including basal Tyrannosauroidea, Allosauroidea, Megalosauroidea cf. *Marshosaurus*, Megalosauridae cf. *Torvosaurus*, and probably Ceratosauria.

Non-dinosaurian terrestrial vertebrates include several 3D-preserved remains of pterosaurs, a paramacellodid lizard, and a new genus of atoposaurid crocodilians. Microvertebrate remains recovered by screen-washing are dominated by teeth of fish and crocodyliforms but also included an astonishing variety of mammal teeth. Multituberculata are represented by several isolated molariform teeth. One molar represents a new taxon with affinities to *Proalbionbaatar*. Docodonts, as typical elements of Jurassic mammal faunas, are represented by indeterminate fragments of molars. Dryolestids, as stem therians, are a dominant element of Jurassic mammalian faunas of the western hemisphere but are very rare in Asia. Three dryolestid molars from Langenberg show a close relationship to the English Purbeck. The Langenberg docodonts and dryolestids are the easternmost European representatives of these groups. Triconodonta are represented by a eutriconodont molariform with a distinct cingulum. Unlike in the more basal amphilestids, all three main cusps of the Langenberg eutriconodont are of almost the same height.

The Langenberg findings provide unique insights into a Jurassic European insular ecosystem and close a significant gap in our knowledge of early mammal evolution. Paleobiogeographically, close relationships to the contemporaneous Guimarota (Portugal) vertebrates are evident not only from the mammals but also from the atoposaurids and the paramacellodid.

Grant Information
The Volkswagen Foundation generously funded the *Europasaurus*-Project (grant no. 85 882) and OW in the grant initiative 'Research in Museums'.

Technical Session I (Wednesday, October 26, 2016, 9:00 AM)

FUNCTIONAL MORPHOLOGY OF MOLARS IN UNGULATES: CONSTRAINTS AND COMMON FEATURES

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High energetic demands in large mammal herbivores require breaking ingested plant matter down mechanically before the cell walls are degraded by symbiotic microorganisms. The comminution of food through mastication is hence essential for efficient energy intake. The agents of mastication are the postcanine teeth, premolars and molars. Premolars mostly puncture-crush the food, and molars, with their longer enamel ridges, reduce food particle size further. Thus, molar morphology has been studied in detail regarding masticatory efficiency and dietary specialisations. However, most studies focused on the second (upper) molar as a representative tooth position, hereby implying a homogenous function for all molars.

To fill the gap, I investigate the functional morphology of all molars in herbivorous ungulates based on microtomographic images of 22 extant Perissodactyla and Cetartiodactyla. I assess relative enamel content per tooth and distribution of enamel within the tooth crown as integral characteristics of dental morphology, as enamel is the hardest dental tissue and forms the shearing ridges. The orientation of enamel ridges

towards the chewing direction has been discussed to influence chewing efficiency and is thus assessed as a functional trait. The following hypotheses are tested:

1. The spatial distribution of dental tissues along the molar tooth row and within each molar is not homogenous due to specific adaptations towards force distribution and eruption time per tooth position.

2. The orientation of enamel ridges towards the chewing direction is adaptive and changes during ontogeny.

Relative enamel content varies between tooth positions and is consistently highest in third molars. Its distribution within the tooth crown is uneven with the lowest relative content at the top of the crown. The orientation of enamel ridges shows tooth position specific patterns with third molars having the highest angles and least dispersion in angle orientation. During the hypothetical ontogenetic stage 2, which resembles the prime reproductive age, orientation of enamel ridges of all molars is homogenous. This suggests a homogenous function of molars is only achieved during the prime age. During later wear stages the third molar (M3) compensates for functional loss in the anterior molars. As M3 has the highest enamel content and maintains a consistent enamel ridge orientation over its whole crown height, it can withstand high masticatory forces close to the temporomandibular joint and provide efficient shear-cutting function when the M1 is worn down.

Technical Session XVII (Saturday, October 29, 2016, 11:30 AM)

THE FUNCTION OF THE PLESIOSAUR NECK—A SMART INVENTION FOR THE AQUATIC ENVIRONMENT

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Most plesiosaurs have long necks, reaching extreme lengths in the derived Elasmosauridae. However, plesiosaur neck function and evolution has been little studied.

We investigated the functional morphology of the cervical vertebrae based on personal observation of the first Triassic plesiosaur skeleton, isolated Triassic plesiosaur vertebrae, and an articulated *Cryptoclidus* neck, but also incorporated literature data for Elasmosauridae. Based on the comparison with extant reptiles and mammals, the analysis of the shape and angle of the zygapophyses, of the intercentral articulation, and of the neural spines indicates that plesiosaurs had a remarkably inflexible neck because of the medially inclined zygapophyses and the thin (less than 3 mm) intervertebral discs combined with platycoelous centra. Elasmosaurs have the longest neck, with over 70 cervical vertebrae, but our model calculations indicate that the head could be moved laterally by just 170 degrees, while the Triassic plesiosaur had a maximal lateral neck excursion of 90 degrees. Dorsal flexion was limited to 1 degrees per intervertebral joint because of the tall neural spines, and ventral flexion was limited to less than 2 degrees, again because of the thin intervertebral discs.

Together with its elongation, the limited flexibility of the neck is one of the most interesting features that evolved in plesiosaurs. During the evolution from the basal plesiosaurs to the Elasmosauridae, the neck became relatively longer, thereby increasingly setting the head off from the rest of the body. Based on their dentition, plesiosaurs were hunting fish because they have the typical pointed and slender teeth and larger fangs of piscivores. In the comparison with recent marine vertebrates preying on schooling fish, we hypothesize that plesiosaurs employed one of two hunting strategies, ambushing or fast attack. The wide separation of the head from the rest of the body probably provided a strong camouflage effect in ambush predation, explaining the evolution of the long plesiosaur neck. In fact, there may have been a double camouflage effect, visually and hydrodynamically, because the small head on the long neck meant that the bulk of the predator was not recognized by the prey. Stiffness made the neck resistant to the strong forces acting on it during attack. Nonetheless, the long neck presents a conundrum in terms of lung volume: to solve the respiratory dead space problem, a large lung volume is necessary, but to avoid decompression syndrome, small collapsible lungs were required.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

TRACKWAY EVIDENCE FOR A THEROPOD GROUP ATTACK UPON A POSSIBLE CERATOPSIAN DINOSAUR FROM THE MORENO HILL FORMATION (TURONIAN) NEW MEXICO

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Track impressions upon a fallen sandstone block reveal multiple three-toed (theropod) dinosaur tracks; associated with a large, shallowly-impressed, circular track exhibiting the pedal architecture of a quadrupedal, possibly ceratopsian, ornithischian. The track site lies near, and stratigraphically slightly above, the Moreno Hill Formation (Turonian) dinosaur type localities (the Zuni Fauna), including *Zuniceratops, Nothronychus, Jeyawati* and a new theropod dinosaur currently under study. The track surface is a silty-muddy interval atop the lower of two prominent and widely persistent channel sandstones; the track surface now lies perpendicular to horizontal. The theropod tracks are "muddy"; deeply impressed into a water-rich substrate which slumped into the impressions, while also preserving features such as claw impressions. Mapping the three-toed tracks reveals at least three sizes (up to 33.5 cm wide) of tri-dactyl tracks (including a matched stride-pair) exhibiting a wide inter-digit angle and morphology comparable with theropods such as tyrannosauroids. Several of the theropod tracks are oriented toward, and then away from, the posterior margin of the circular track. The ungual impressions of the circular (approximately 34 cm) track suggest rapid movement away from the oncoming three-toed tracks. The circular track is less impressed into the substrate than the three-toed tracks, apparently more buoyant on the muddy substrate. The assemblage of tracks appears a rare example of positive evidence for a co-operative and active pursuit by a group of theropod predators, (possibly tyrannosauroid), upon an equally large four-legged (possibly ceratopsian) dinosaur.

The sandstone surface nearby preserves swimming tail/track impressions interpreted as crocodilian, in-situ tree stumps are documented in nearby finer-grained facies, the *Zuniceratops* holotype coracoid contains D-shaped bite penetrations with surface checking of the elements suggesting inundation-desiccation, and the *Zuniceratops* bone-bed was deposited within a "log-jam" channel deposit. Together these data demonstrate a close association between submerged and emergent environments with predator and prey elements interacting at the margins. *Zuniceratops* (or other quadrupedal ornithischian) probably sought shelter from more land-bound predators by risking danger within crocodile-inhabited wetlands, as do many modern terrestrial herbivores.

Technical Session XVII (Saturday, October 29, 2016, 9:00 AM)

A LARGE MACROPREDATORY ICHTHYOSAUR FROM THE LATE TRIASSIC OF WILLISTON LAKE (BRITISH COLUMBIA, CANADA) INDICATES HIGH ECOLOGICAL DIVERSITY OF BASAL PARVIPELVIA

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Ichthyosaurs were a successful clade of secondarily aquatic tetrapods which were important in Mesozoic marine faunas from the Early Triassic (ca. 248 mya) until the early Late Cretaceous (ca. 94 mya). A key episode in their evolutionary history was the emergence of the clade Parvipelvia, characterised by a reduced pelvic girdle. This is thought to have been a key anatomical innovation related to the evolution of an oscillatory mode of swimming, which enabled parvipelvians to adapt to life in the pelagic realm. This transition is well documented at Williston Lake, British Columbia, Canada, where rocks spanning the Norian (Late Triassic) have yielded fossils of the earliest known parvipelvians, as well as shastasaurids, basal euichthyosaurs and other marine reptiles. Here, we present a new ichthyosaur from Williston Lake, collected by Royal Ontario Museum crews in 1991. Conodont analysis confirms a Late Norian age of the specimen, making it the most complete ichthyosaur known from this time interval. The specimen consists of a partial rostrum with numerous teeth, partial forefins, a partial pelvic girdle and partial hindfin. The size of the available material indicates a large animal, exceeding all other marine reptiles known from Williston Lake, except for some shastasaurids, in body size. The teeth are set in a dental groove, without distinct alveoli and have large, labiolingually flattened, bicarinate crowns. This indicates the new ichthyosaur was a macropredatory form, feeding on large-bodied prey items. The forefin of the new ichthyosaur has four primary digits (II-V) and a reduced accessory digit, with notching occurring along the entire anterior margin of the forefin, and a round foramen enclosed by the contiguous shafts of the epipodials. The ischium and pubis are more rod-like than plate-like and fused proximally. There are only two proximal tarsals in the hindfin, similar to the condition in more basal ichthyosaurs such as *Mixosaurus* and in contrast to euichthyosaurs where the number of elements in the distal tarsal row increases to three. A phylogenetic analysis places the new taxon in a grade of basal parvipelvians together with *Macgowania* and *Hudsonelpidia*, indicating that parvipelvians were already ecologically diverse at the very beginning of their evolutionary history. It also confirms a complex marine ecosystem of the Williston Lake area in the Late Norian, with ichthyosaurs being apex predators.

Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

DESCRIPTION, TAPHONOMY, AND PALEOECOLOGY OF THE LATE PLEISTOCENE PECCARIES (ARTIODACTYLA, TAYASSUIDAE) FROM BAT CAVE, PULASKI COUNTY, MISSOURI

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The late Pleistocene fauna from Bat Cave, central Ozarks, Missouri provides an opportunity to assess specific aspects of behavior, ecology, and ontogeny of the Rancholabrean species *Platygonus compressus*. All identifiable elements referable to this taxon were catalogued and examined, and a minimum number of individuals of 70 was determined for the sample. Maturation of individuals was assessed using the tooth eruption sequence and occlusal wear patterns for all tooth-bearing mandibular elements and isolated lower dentition. Approximate ages were established through comparison with extant peccary taxa. The presence of distinct, developmentally non-overlapping age groups indicates that *P. compressus* was cyclically deposited in the Bat Cave locality, and we suggest that the cave functioned as a seasonal shelter in which individuals would occasionally die. The study also leads us to surmise that the peccaries engaged in synchronous, seasonal breeding behaviors; a characteristic typical of temperate climates. Demographic assessment of the Bat Cave peccary population suggests that younger individuals formed the bulk of the population at a given time with progressively older individuals becoming scarcer until the age of 10 years, which matches the typical demographic patterns and life expectancy of extant peccaries. A predator-prey relationship between *P. compressus* and *Canis dirus*, the second most abundant vertebrate from the Bat Cave site, is also described in this study. Morphology of the tooth impressions visible on many of the peccary bones from Bat Cave were diagnostic of that of a large canid, which are attributed to *C. dirus*. Degree to which different skeletal elements were modified by predators was assessed and categorized and compared to the bones of extant white-tailed deer (*Odocoileus virginianus*), which were consumed by gray wolves (*C. lupus*). Damage patterns suggest that the feeding patterns of *C. dirus* at Bat Cave were consistent with its extant relative, and that these predators would periodically enter the cave to hunt and/or scavenge peccaries. Presence of less frequent smaller bite impressions suggests that smaller carnivorans occasionally scavenged from the peccary carcasses and potentially utilized the cave site when the peccaries were absent.

Poster Symposium II (Friday–Saturday, October 28–29, 2016, 4:22 PM)

WHAT FACTORS INFLUENCE OUR RECONSTRUCTIONS OF MORRISON FORMATION SAUROPOD DIVERSITY?

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The Upper Jurassic Morrison Formation classically represents the "Golden Age" of sauropods, and the numerous genera and species within this formation appears distinct

within the North American Mesozoic record. As reported, the Morrison may have sustained 14 genera and 23 species of sauropods. Subsequently, this incredibly specious diversity has produced numerous theories to explain accommodation of such large and copious co-occurring taxa. Previously, a similar specious diversity was recorded in the Hell Creek Formation of North America—where seven genera and nearly two dozen species of tyrannosaurs, ceratopsians, and pachycephalosaurs were thought to co-occur. Yet revised examinations into this specious formation have revealed that stratigraphy and ontogeny greatly effect and alter our perceptions of diversity richness—this rich assemblage was conversely represented by potentially three genera and four species. Using the Hell Creek Formation as a model, we should apply these principles to other formations that have seemingly high diversity (i.e., the Morrison Formation). While the idea of a homogenized Morrison Formation exists, stratigraphic distribution of these sauropods demarcate into distinct biozones. New dating techniques are resulting in finer temporal resolution, and are changing the temporal position of previously established quarries. Similarly, biologic processes are altering diversity perceptions. Plotting body size stratigraphically, it initially appears that larger specimens occur higher in section. Yet while increasing average body size may be a legitimate trend, there are several specimens that counter this "rule" for many genera. Likewise, dramatic allometric ontogenetic trajectories had led to the erection of at least three diplodocid genera—*Amphicoelias*, *Seismosaurus*, and *Suuwassea*—and we strongly suspect that many more Morrison "species" could alternatively be explained as ontogimorphs. We have a long way to go to revealing the true nature of Morrison Formation sauropod diversity. Undoubtedly species level (i.e., *Brachiosaurus* and *Diplodocus*) and ontogenetic dietary partitioning did exist, but the notion of a base of 23 levels of co-occurring divisions seems outside the realm of parsimony. The Morrison Formation may have indeed exhibited a sauropod rich assemblage unlike any other in North America, and the implications of stratigraphy and ontogeny may be minor; yet these factors do alter "diversity", and true diversity will not be fully revealed until we take these factors into consideration.

Technical Session VII (Thursday, October 27, 2016, 3:00 PM)

A NESTLING-SIZED SKELETON OF *EDMONTOSAURUS* (ORNITHISCHIA, HADROSAURIDAE) WITH AN ANALYSIS OF ONTOGENETIC LIMB ALLOMETRY IN RELATION TO MAJOR GAIT SHIFTS

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Unlike the skull, the ontogeny of the postcranial skeleton has not been studied intensely in hadrosaurid dinosaurs. Based on a study of disarticulated *Maiasaura* bonebed limb bones, it has been suggested that a major gait shift from bipedal juveniles to quadrupedal adults occurred early in ontogeny. This gait shift has been assumed to have occurred across all hadrosaurs. Ontogenetic changes in limb length proportions (e.g. forelimb vs. hindlimb) used to document ontogenetic gait shifts in *Massospondylus* and *Psittacosaurus* could not be calculated for *Maiasaura* since few associated skeletons are available. The relative length and characteristic morphology of hadrosaurid limbs differ between clades, suggesting possible variability in hadrosaurid locomotor dynamics.

The hadrosaurid *Edmontosaurus* is well known from an ontogenetic series of associated individual skeletons (N>20). Currently, the smallest described articulated specimen (LACM 23504) has a femur length of 57 cm, approximately 40% of adult size, and is potentially beyond the point when the hypothesized gait shift may have occurred. Here, we describe a very small (~70 cm body length; 15 cm femur length) articulated hadrosaurid skeleton, UCMP 128181, discovered by Harley Garbani in Garfield County, Montana. It represents the earliest ontogimorph of *Edmontosaurus* and is recognized as a late nestling based, in part, on comparisons of femur length with other hadrosaurid nestlings. UCMP 128181 preserves a partial scapula, rib cage, vertebral series from the shoulder to mid-tail, a large portion of the pelvic girdle, and both hind limbs through a combination of bone and natural impressions in the concretion. The prepubic process of the pubis is shallow with a relatively long proximal constriction and a paddle-like, asymmetrical and subellipsoidal anterior end, which supports our generic assignment.

UCMP 128181 greatly expands the known ontogenetic range for *Edmontosaurus* as a new end-member and contributes to a sample of associated skeletons well suited for allometrically testing the gait shift hypothesis. Morphometric comparisons reveal that the proportions of the major hind limb elements remain isometrically conservative throughout growth in *Edmontosaurus*. Although UCMP 128181 does not preserve forelimbs, ordinary least squares regressions based on other *Edmontosaurus* skeletons (N=7) reveal isometry of the forelimb relative to the hindlimb. This suggests that the proposed gait shift, if it occurred, did so before the late juvenile stage (LACM 23504) in *Edmontosaurus*.

Grant Information
Doris O. and Samuel P. Welles Research Fund

Technical Session XI (Friday, October 28, 2016, 11:00 AM)

THE DISCOVERY OF A FOSSIL ANABANTID FISH (PERCIFORMES, ANABANTIDAE) FROM THE UPPER OLIGOCENE OF CENTRAL TIBET AND ITS PALEOBIOGEOGRAPHICAL IMPLICATIONS

WU, FEIXIANG, Institute of Vertebrate Paleontology and Paleoanthropology, [illegible]nese Academy of Sciences, BEIJING, China; CHANG, Mee-mann, Insti[illegible]rate Paleontology and Paleoanthropology, Chinese [illegible]cademy [illegible]ci[illegible]ce[illegible] B[illegible]ji[illegible]ina; MIAO, Desui, Biodiversity Institu[illegible] Universit[illegible] of [illegible]s[illegible] [illegible]w[illegible]wr[illegible]ce[illegible] KS, United States of America

Withdrawn

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Grant In[illegible]m[illegible]n
Strategic [illegible]io[illegible] Research Program of the Chinese Academy of Sciences (grant XDB03020104), the National Basic Research Program of China (grant 2012CB821900)

Withdrawn

Colbert Prize (Wednesday–Saturday, October 26–29, 20164:15–6:15 PM)

FIRST OCCURRENCE OF *CYNOGNATHUS* IN TANZANIA AND ZAMBIA, WITH BIOSTRATIGRAPHIC IMPLICATIONS FOR THE AGE OF TRIASSIC STRATA IN SOUTHERN PANGEA.

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The fossil record of the Beaufort Group of South Africa (Karoo Basin) has been divided into six assemblage zones that serve as key benchmarks for continental Permo–Triassic biostratigraphy in southern Pangea. The Burgersdorp Formation, the uppermost formation in the Beaufort, coincides with the *Cynognathus* Assemblage Zone (CAZ) and is typically considered to be Olenekian to Anisian in age (Middle Triassic). In the 1990s, the CAZ was split into three subzones (A, B, and C) based on the presence of distinct capitosauroid temnospondyls and their co-occurrences with amniote taxa. For example, in the Karoo, the cynodonts *Cynognathus* and *Diademodon* range across all three subzones, whereas other taxa are restricted to individual subzones. Nonetheless, it has proven difficult to correlate formations from across southern Pangea to the subzones of the CAZ because of dearth of co-occurring taxa.

Recent fieldwork in the lower section of the Lifua Member of the Manda beds of Tanzania recovered associated pieces of a large cynodont, while related fieldwork in the lower Ntawere Formation of Zambia recovered a large block containing cynodont material. Both of these can be referred to *Cynognathus*. The Tanzanian referral is based on the sectorial nature of the seven most posterior lower postcanines, and a hook-like process on the entepicondyle of the humerus, although an ectepicondylar foramen is uncharacteristically absent. The referral of the Zambian specimen is based on the distinctive shape of two postcanine teeth found in the same block as a partial humerus displaying entepicondylar hooking. These discoveries support the hypothesis that the Ntawere, and now the Lifua Member, each contain two distinct vertebrate-bearing horizons that represent distinct stratigraphic intervals, perhaps separated by millions of years. The lower horizons likely correlate to the CAZ B based on *Kannemeyeria* in the Ntawere and *Dolichuranus* in the Lifua.

These two novel occurrences make *Cynognathus* a wide-ranging biostratigraphic marker; it now occurs in six formations (upper Fremouw, Antarctica; Rio Seco de la Quebrada, Argentina; Omingonde, Namibia; Burgersdorp, South Africa; Lifua Member; Ntawere), many of which are biostratigraphically linked to the CAZ B through other taxa (*Diademodon*, *Kannemeyeria*). Of all *Cynognathus*-bearing strata, only the Rio Seco de la Quebrada has been radiometrically dated and is estimated at 235.8 MA (Carnian). This implies that horizons containing *Cynognathus* are likely Late Triassic in age rather than early Middle Triassic.

Grant Information
This research supported by National Science Foundation EAR-1337569, EAR-1337291, and EAR-1336986

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

A NEW PROTOCOL FOR MORPHOLOGY-BASED SYSTEMATICS: A CASE STUDY OF MICRORAPTORINE THEROPOD PHYLOGENY

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Compared to molecular systematics, morphology-based systematic studies have long suffered from a relatively small number of characters and relatively subjective character formulation. These two problems are partially caused by the traditional way of formulating characters, which emphasizes that characters should be abstracted from relatively distinct variations and be stable within the species level. In this case characters are pre-evaluated, in contrast to characters typically used in molecular systematics, which are minimum molecular variations (single nucleotide polymorphisms) among individual organisms and are in principle without pre-evaluation before they are used in phylogenetic reconstructions. Following molecular systematic strategy, this study proposes a new protocol for morphology-based systematics: using specimens as operational taxonomic units (OTUs) and formulating characters from variation as finely divided as possible.

Under this protocol, a dataset comprising 20 dromaeosaurid specimens and 250 characters was built to explore the poorly resolved phylogenetic relationships of the Microraptorinae, a recently discovered theropod clade that has provided fresh insights into the transition to birds. 180 of these 250 characters are derived from variation among the microraptorines, about 8 times as many characters as used in previously published datasets. The analysis recovers a new stem eudromaeosaurian clade comprising two short-armed Jehol species and a monophyletic Microraptorinae comprising most Jehol dromaeosaurids and the North American *Hesperonychus*. Within the latter, *Microraptor* and *Hesperonychus*, the geologically youngest microraptorine taxa, are placed as the most crownward, and one specimen from a Hauterivian deposit the most stemward.

Based on the resulting phylogeny and character analysis, this study has identified evolutionary trends of improved flight adaptations and reduced carnivorous adaptations within this group; most significantly, two new microraptorine species have been discovered from four specimens previously assigned to two known microraptorine species. This study demonstrates that the new protocol can help to extract strong systematic signals from fine morphological variations and to identify which anatomical region yields a more reliable phylogeny and thus using this new protocol in morphology-based systematics has significant implications in phylogenetic reconstruction, taxonomical work, and understanding character evolution as well.

Grant Information
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Poster Session I (Wednesday, October 26, 2016, 4:15–6:15 PM)

INVESTIGATING VERTEBRATE PALEOECOLOGY OF THE KAIPAROWITS FORMATION VIA STABLE ISOTOPIC COMPOSITION OF SKELETAL REMAINS

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The Campanian (76.6-74.5Ma) Kaiparowits Formation is a highly fossiliferous alluvial deposit and exposed near Escalante, UT. The Kaiparowits fauna is very diverse and include many endemic taxa; however, details of the of the Kaiparowits paleoclimate is not well studied. Because biodiversity and climate are intimately related, understanding paleoclimate of the Kaiparowits Formation will help decipher the paleoecology of the Kaiparowits fauna. We anticipate that the paleoclimate of the Kaiparowits Formation is influenced by the Laramide Orogeny and transgression/regression of the Western Interior Seaway.

In an effort to study paleoclimate of the Kaiparowits Formation, 113 fossil specimens were loaned from the Utah Natural History Museum; loaned fossils include hadrosaur teeth and bones, crocodile teeth and turtle shells. The oxygen stable isotope compositions of phosphate ($\delta^{18}O_p$) were analyzed using isotope ratio mass spectrometer (IRMS) with high temperature conversion elemental analyzer (TC/EA). $\delta^{18}O_p$ are converted to $\delta^{18}O_w$ using equations from previous studies. In order to test the isotopic integrity of the fossil samples, carbonate oxygen isotope composition ($\delta^{18}O_c$) was also analyzed with IRMS with Gas Bench II-IRMS.

Preliminary findings include (1) $\delta^{18}O_p$-$\delta^{18}O_c$ plot shows taxonomic differences in isotopic composition, suggesting biogenic signals are preserved in fossils; (2) calculated mean $\delta^{18}O_w$ are -15.59‰ (n=35, sd=3.03) for hadrosaur (based on tooth $\delta^{18}O_p$ and humidity estimate of 70%), -10.22‰ (n=25, sd=2.11) for turtle and -8.26‰ (n=23, sd=3.76) for crocodile, possibly reflecting niche partitioning; (3) $d^{18}O_w$ in semi-aquatic taxa show enrichment up-section. The $\delta^{18}O_w$ did not reflect the hypothesized transgression in the lower middle unit potentially due to incomplete stratigraphic data.

Technical Session XV (Saturday, October 29, 2016, 11:45 AM)

COMMUNAL NESTING BEHAVIOR OF DINOSAURS REVEALED BY STATISTICAL ANALYSES OF PHOSPHORUS DISTRIBUTION IN, AND EXTERNAL MORPHOLOGY OF, EGGSHELLS

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Animal mating behavior is unlikely to preserve during the fossilization process. In the past, paleobiologists have suggested a plausible scenario including communal nesting and paternal care of non-avian theropod dinosaurs by comparing the ratio of adult mass to clutch volume between birds and non-avian theropod dinosaurs. However, this hypothesis was later refuted, since a subsequent analysis of a larger dataset failed to detect a relationship between mating behavior and the ratio of adult body mass and clutch volume. Here, we combine statistical and chemical approaches to test the communal nesting hypothesis.

Previous ornithological studies have suggested that the discrepancy of phosphorus concentration between the mammillary and prismatic zones of the eggshell varies with maternal age. Therefore, it is hypothesized that the phosphorus discrepancy should be similar between paired eggs, but would differ between pairs, if the pairs were laid by different females. Hence, we measured length and width for the statistical analyses, and used a small piece of eggshell from each egg in a clutch for elemental analysis.

Cluster analysis and principal component analysis of the length and width of eggs from a single clutch showed grouping by pair, which suggests that the egg pairs in a clutch might be laid by different females. Elemental analysis performed on eggshell pieces by means of electron probe micro-analysis (EPMA) indicates that the phosphorus discrepancy varies from pair to pair, but remains relatively constant within pairs, which also suggests that a clutch might be completed by several females. The results hence support the communal nesting hypothesis.

We also analyzed the phosphorus distribution in eggshell fragments taken from each egg of a sauropod clutch, since sauropods were commonly considered to be single-mother nesting animals. The EPMA results confirmed this hypothesis, because phosphorus discrepancy was similar between all eggshells from the same sauropod clutch.

Based on our results, in combination with other previous evidence from egg coloration, porosity, and nesting structure, we directly and unambiguously show communal nesting in non-avian theropod dinosaurs, for the first time. The similarity in phosphorus discrepancy in sauropod and theropod eggshells also implies that these taxa had similar oviduct function and physiology.

Grant Information
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Poster Symposium I (Wednesday–Thursday, October 26–27, 2016, 4:15–6:15 PM)

ECOLOGICAL INFERENCES OF EARLY EUPRIMATES OF THE BRIDGER BASIN: AN EVALUATION OF CRANIODENTAL AND POSTCRANIAL BODY MASS PREDICTORS FROM ASSOCIATED SKELETONS

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Body mass prediction is a frequent goal of paleontologists since body mass covaries with many aspects of a species' ecology. For example, niche partitioning by body mass (as predicted from tooth size) is often invoked in mammalian paleocommunities. However, tooth size can vary independent of body mass, and this variation has important ecological implications. The lack of fossil specimens preserving associated craniodental and postcranial elements has confounded thorough evaluation of hypotheses of niche partitioning by body mass.

Here, we predict body masses of seven sympatric euprimate species from the Bridgerian of Wyoming: *Notharctus tenebrosus*, *Notharctus* cf. *pugnax*, *Notharctus* cf. *robustior*, *Smilodectes gracilis*, *Omomys carteri*, *Washakius insignis*, and *Hemiacodon gracilis*. All specimens include associated dentitions and postcrania except *H. gracilis* (a composite of two specimens). Body masses are predicted using two sets of equations relying on molar area (one based on an 'all-primate' reference sample, the other on an 'all-strepsirrhine' sample), as well as equations based on tarsal facet areas and limb bone cross-sectional areas.

For each species, postcranial variables predict similar body masses, while dental predictors often deviate from each other and postcrania. For *S. gracilis* and *O. carteri*, postcranial predictions are more concordant with values generated by the 'all-primate' equations than the 'all-strepsirrhine' equations. In all other species, postcranial predictions are more similar to predicted values of the 'all-strepsirrhine' equations. These patterns of concordance suggest that *S. gracilis* and *O. carteri* have dental/postcranial proportions that are more similar to non-strepsirrhine taxa of the 'all-primate' sample (i.e., anthropoids), while all other examined taxa have proportions similar to extant strepsirrhines. Since anthropoids often have smaller molars than similarly sized strepsirrhines, *S. gracilis* and *O. carteri* likely have small molars relative to their postcranial dimensions.

Based on postcrania, the body mass range of *S. gracilis* overlaps with *N. tenebrosus* (~2000–3000 g) while *O. carteri* overlaps with *H. gracilis* (~300–400 g), suggesting these pairs of species were similar in size. Our multi-proxy approach to body mass prediction indicates that among Bridgerian notharctine and omomyid species of similar body mass, relative molar size likely reflects exploitation of different dietary resources, as observed among certain similarly sized, sympatric primates today.

Grant Information
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Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

AN ENIGMATIC CROCODYLIFORM FROM THE MIDDLE JURASSIC OF SCOTLAND, UK, AND ITS IMPLICATIONS FOR THE EVOLUTIONARY TRANSITION FROM SMALL-BODIED NEOSUCHIANS TO EUSUCHIA

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The Middle Jurassic represents a relatively poorly-sampled time interval in neosuchian crocodyliform evolution. In particular, fossils of small-bodied non-marine neosuchians are rare, which confounds our understanding of the evolutionary transition leading to Eusuchia, the clade that includes extant crocodylians. Here we report the first crocodyliform from the Middle Jurassic (Bathonian) Duntulm Formation of the Isle of Skye, Scotland, UK, comprising an isolated left dentary and part of the splenial. We used high-resolution CT scanning to reveal dentary characteristics that are otherwise unobservable via mechanical preparation. The dentary measures 28 mm anteroposteriorly with complete anterior ramus and truncated posterior margin at the 13th alveolus. The morphology of the dentary alveoli implies mild heterodonty, and they form a sigmoid tooth row. An extended articulation surface on the dentary suggests that the splenial would have covered most of the medial side of the dentary in life. Morphologically, this new taxon most closely resembles the Cretaceous neosuchians (*Pachycheilosuchus trinquei*, *Unasuchus reginae*, and *Pietraroiasuchus ormezzanoi*) in having shallow dentary alveoli, short mandibular symphysis, and sigmoidal tooth-row. The new taxon differs from other neosuchians in having a Meckelian canal that dorsoventrally expands posterior to the mandibular symphysis and drastically constricts at the 6th tooth position. Furthermore, a labiolingually compressed dentary, lack of dermal ornamentations, and presumed weak heterodont dentition differentiate the Duntulm taxon from other Skye crocodyliforms, including *Theriosuchus* sp. from the Valtos Formation and a possible goniopholidid from the Kilmaluag Formation. Therefore, we suggest that the Duntulm specimen represents a new neosuchian or eusuchian taxon, pending further understanding of the phylogenetic relationships among neosuchian clades that are basal to Eusuchia. The crocodyliform fauna of the Middle Jurassic of Skye expands the taxonomic and ecological diversity of early neosuchians, and it demonstrates that small-bodied neosuchians were broadly present in terrestrial or near-shore environments in the Middle Jurassic (ca. 168–166 Ma) of Laurasia.

Grant Information
H Yi is funded by the Sino-British Fellowship of the Royal Society and University of Edinburgh.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

BURROWS OF SMALL ANIMALS FROM THE MID-CRETACEOUS CEDAR MOUNTAIN FORMATION, UTAH, USA

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Vertebrate burrows from the Mesozoic of North America are scarcely known, and are represented by an unnamed synapsid from the Upper Triassic of Arizona, an unidentified archosaur and synapsid from the Lower Jurassic of Utah, and the small ornithischian dinosaurs *Drinker* from the Upper Jurassic and *Oryctodromeus* from the Lower Cretaceous of Montana. We have found two burrows in the mid-Cretaceous (Albian~Cenomanian) Mussentuchit Member of the Cedar Mountain Formation of Utah, USA. The burrow-bearing bed of the Mussentuchit Member consists of poorly-drained paleosols, and the burrows are infilled with light-colored carbonate probably due to a rise in a regional water table. The estimated mass of the excavators is 2.9-7.17 g and 6.89-15.32 g based on the size of each burrow, indicating that both tracemakers were small animals. Both burrows were found in-situ and inclined downwards in a sinuous pattern to terminate in an expanded distal chamber. The first burrow is 60 cm long, whereas the second is 100 cm long and branched, with some small, expanded chambers in the middle of the tunnel. The tunnels have a width to height ratio of around 1.3. The external walls lack scratch marks, but do show localized, prominent bulges or nodes that are infilled local expansions of the tunnel. These are unlike those reported from Triassic and Jurassic vertebrate burrows. A bulge in the second burrow was possibly left by tip of the excavator's head, as seen in the burrows of modern fossorial squamates. The discovery of a potential squamate burrow from the mid-Cretaceous of Utah is consistent with the oldest body fossils of skink and snake from the mid-Cretaceous. In addition, non-isolated chambers, a single entrance, and a relatively long tunnel of the potential squamate burrow indicate that the oldest squamates might be subterranean and solitary animals.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

ESTIMATION OF BODY MASS AND CENTER OF MASS OF THE TROODONTID *SINOVENATOR CHANGII*

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The basal troodontid *Sinovenator changii* is a key taxon for understanding maniraptoran phylogeny and the evolution of important characters in the transition to birds. However, many aspects of this species remain unknown, including an accurate body mass and the position of its center of mass (CoM), which are fundamental parameters for comprehending its biology. A well preserved skeleton, IVPP V20378 was CT-scanned and digitized. The digital skeleton was then re-articulated and flesh digitally added to reconstruct the fleshy volume of the body. Using custom code, the body mass was estimated to be minimally 512 g and maximally 884 g, a range encompassing the 794 g result from equations for estimating body mass from femur dimensions. *Sinovenator*'s body mass is between those of the 1.2 kg *Microraptor gui* and the 0.1 kg *Archeaopteryx lithographica*. Sensitivity analysis of CoM position showed that it was consistently located below and in front of the hip joint. After linearizing the CoM position by body mass$^{1/3}$, it located somewhat more caudally than in *Microraptor gui*,a four-winged eumaniraptoran thought to be able to fly to some extent. These results compare well with other maniraptorans and follow broad evolutionary trends in Theropoda. We discuss in what manner these results affect our understanding of how body mass, mass proportions, and CoM position changed along the line to modern birds.

Grant Information
This program is funded by the National Natural Science Foundation of China (41120124002) and the National Basic Research Program of China (2012CB821900).

Poster Session II (Thursday, October 27, 2016, 4:15–6:15 PM)

A SMALL FOSSIL PENGUIN (AVES, SPHENISCIFORMES) FROM THE LATE MIOCENE BAHÍA INGLESA FORMATION, ATACAMA DESERT, NORTHERN CHILE

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Penguins (Spheniscidae) are diverse and abundant birds in the Cenozoic assemblages of the Southern Hemisphere. The Bahía Inglesa Formation (middle Miocene – Pliocene) is the most abundant and best studied Neogene fossil vertebrate assemblage in Chile. Penguins are the most abundant birds in this unit, with five different species from two genera, *Spheniscus* and *Pygoscelis*. A small tarsomatatarsus is presented here and recognized as a *Spheniscus* representative. The fossil is characterized by small size, comparable to the smallest extant species of Spheniscidae, the Little Penguin *Eudyptula minor*. The genus *Spheniscus* is characterized by large variation of osteological characters, which make the assignment of isolated fossil materials difficult. Nevertheless, a unique combination of characters is presented for distinguishing the species here described from extant and fossil species of the genus. With the addition of the present record, two important features of *Spheniscus* can be pointed out: it is the penguin genus with the largest latitudinal range distribution, recorded from Antarctica in the Late Miocene to the Galapagos Islands today. A remarkable size spectrum is displayed among the fossil and modern species, with the smallest species recorded described here, to the Late Miocene extinct *Spheniscus urbinai* comparable in size to the King Penguin *Aptenodytes patagonicus*. The addition of a new record to the Miocene penguin fauna of the Bahía Inglesa Formation is consistent with a greater than extant diversity during the Neogene as has been described in other localities; clear examples are the Miocene fauna of southern Argentina, Peru, and South Africa. All these localities share a major diversity of Spheniscidae, and then being reduced to the Plio-Pleistocene limit, showing the current diversity, mostly monospecific. Faunal turnover patterns and impoverishment of diversity is common at the end of the Neogene in marine mammals, which are commonly associated with the penguin fossil record in the Southern Hemisphere.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

NEW POSTCRANIA CLARIFY THE AFFINITIES OF THE UNUSUAL EOCENE MAMMAL *SIMIDECTES*

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Simidectes is an enigmatic faunivorous or omnivorous mammal known from the Uintan and Duchesnean of the western United States. The dentition of *Simidectes* is highly distinctive, and comparisons with other faunivores have not led to confident resolution of the affinities of the genus, with a link to pantolestans, specifically Pantolestidae or Paroxyclaenidae, currently considered most plausible. Assessments of *Simidectes* have been largely based on craniodental morphology, although a partial skeleton attributed to *S. magnus* has provided some insights into possible affinities. Unfortunately, reevaluation of this skeleton indicates that it likely represents a species of the large carnivoramorphan *Miocyon* and not the similarly sized *S. magnus*.

Here we report on new postcranial material of *Simidectes* spp. from the middle Eocene of southern California that greatly clarifies the relationships of the genus. In particular, the tarsus of *Simidectes* demonstrates striking similarities to hyaenodontid "creodonts" and indicates that *Simidectes* is a divergent member of Hyaenodontidae. Notable tarsal features linking *Simidectes* and hyaenodontids to the exclusion of pantolestids include a narrow astragalar tibial facet with the medial ridge longer than the lateral; a proximomedial plantar tuberosity that projects medially, not ventrally; the presence of an astragalar cotylar fossa; a very narrow astragalar ectal facet; an elongate astragalar neck; a calcaneal tuber of moderate length but an elongated body; an elongate calcaneal ectal facet facing medially as much as dorsally; a two part calcaneal fibular facet; a low plantar tubercle; and a cuboid facet that is deeper than wide and inclined medially.

Referral of *Simidectes* substantially expands dental disparity within Hyaenodontidae. Although premolar morphology is quite similar to hyaenodontids, *Simidectes* is unusual in lacking well-developed carnassial shear, and the genus is also the first known hyaenodontid in which m1 is the largest lower molar. The origins of *Simidectes* remain unclear, but the lack of dentally similar hyaenodontids in North American Bridgerian faunas suggests an origin from the still poorly known Asian middle Eocene hyaenodontid fauna.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

A NEW SPECIES OF EARLY DIVERGING ORNITHOPOD INCREASES THE PALEOBIODIVERSITY OF HERBIVOROUS DINOSAURS IN LATE CRETACEOUS ECOSYSTEMS IN NORTH AMERICA

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Strata deposited in western North America between the late Early Cretaceous (Aptian-Albian) and early Late Cretaceous (Cenomanian-Turonian) record a dramatic faunal and floral reorganization that altered terrestrial ecosystems at the highest trophic levels and set the stage for the establishment of iconic Late Cretaceous assemblages. Faunal transitions among dinosaurs are pronounced and include the apparent replacement of megaherbivorous clades such as sauropodans and ankylosaurids with iguanodontians, and extirpation of allosaurians, which had previously dominated megapredatory niches. Much remains to be learned about the pace and drivers of this ecological reassembly including potential correlations with key physiogeographic, climatic, and paleoenvironmental changes in the Western Interior Basin, as well as the apparently pronounced influence of faunal interchange between Laurasian landmasses during this interval. Yet, ultimately, our understanding of this transitional period in North America's biotic history is predicated on the alleviating taxonomic gaps in available fossil record of the "mid-Cretaceous."

We report discovery of a new species of transitional ornithopod from the Cenomanian age (96.7-98.39 ± 0.07 Myr) Mussentuchit Member, Cedar Mountain Formation of Utah, confirming high paleobiodiversity of herbivorous dinosaurs in early Late Cretaceous ecosystems on the continent, as suggested previously by microvertebrate sampling. Multiple elements of the skull including the premaxilla, predentary, dentary, jugal, and braincase, as well as portions of the axial and appendicular skeleton represent the single known specimen of this species (NCSM 29373). Preliminary phylogenetic analysis posits NCSM 29373 as an early diverging iguanodontian, near the origin of Ornithopoda, based largely on a combination of derived and primitive dental traits including three premaxillary teeth, and a reduced number (11) of large, heavily ridged dentary teeth lacking a cingulum and bearing curved roots. Prior to this discovery, neornithischian paleobiodiversity in the Mussentuchit Member included abundant macrovertebrate remains of the hadrosauroid *Eolambia caroljonesa* and a new, recently discovered species of orodromine. Documentation of an early diverging ornithopod in this assemblage confirms that a minimum of three non-ceratopsian neornithischian clades cohabited within early Late Cretaceous terrestrial ecosystems of North America.

Grant Information
This work was funded by the Canyonlands Natural History Association.

Technical Session XVI (Saturday, October 29, 2016, 11:30 AM)

NORTHWARD DISPERSAL OF LARGE MAMMALS INTO THE ARCTIC AND SUBARCTIC DURING THE LAST INTERGLACIATION (SANGAMONIAN)

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Rich radiocarbon records from fossils recovered in Alaska and Yukon document the continuing presence in Eastern Beringia of the cold-adapted "mammoth fauna", an assemblage dominated by woolly mammoths (*Mammuthus primigenius*), bison (*Bison priscus*), and horses (*Equus* spp.). However, much less is known about the composition of faunal communities in Beringia prior to radiocarbon time (>50,000 ^{14}C yr bp). Here we report new dates for mammal species that have been occasionally encountered in high-latitude Late Pleistocene localities, but which do not seem to fit ecologically within the

"mammoth fauna". Relevant taxa include American mastodons (*Mammut americanum*), western camels (*Camelops hesternus*), flat-headed peccaries (*Platygonus compressus*), ground sloths (*Megalonyx jeffersonii*) and giant beavers (*Castoroides ohioensis*). Developing chronologies for these species has been a methodological challenge, but results strongly suggest they only inhabited Eastern Beringia prior to 50,000 ^{14}C yr bp. Given what is known of their Pleistocene mid-continental range, it seems likely that they ranged to the far north only during relatively short warming intervals, particularly the Last or Sangamonian Interglaciation (Marine Isotope Stage 5, ~130–100,000 years ago). Yet if these mammals were well adapted to interglacial conditions, why did they fail to survive the Pleistocene/Holocene transition anywhere in North America? Further, was the high-latitude cold-adapted "mammoth fauna" deleteriously affected during the Sangamonian? Dispersal of warm-adapted species during the Last Interglaciation provides a compelling analog for understanding present-day northward dispersals, which are also generally considered to be facilitated by warming climates.

Poster Session IV (Friday, October 28, 2016, 4:15–6:15 PM)

FOSSIL EGGSHELLS REVEAL PREVIOUSLY UNKNOWN DINOSAUR DIVERSITY OF THE END CRETACEOUS WILLOW CREEK FORMATION IN SOUTHWESTERN ALBERTA

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Fossil eggshell fragments from the uppermost Cretaceous Willow Creek Formation (latest Maastrichtian) in southwestern Alberta provide insight into dinosaur diversity at the end Cretaceous in that region. The Willow Creek Formation, which spans the Cretaceous-Paleogene boundary, bridges a geographic gap between the time-equivalent fossiliferous formations in central Alberta (Scollard Formation) and Montana (Hell Creek Formation), both of which have relatively diverse dinosaur faunas. Although the known dinosaur diversity of the Willow Creek Formation is comparatively low (*Tyrannosaurus rex*, Hadrosauridae indet., Leptoceratopsidae indet.) due to the dearth of skeletal remains, over 300 fragments of fossilized eggshells, yet to be taxonomically identified, have been collected from the formation. Histological analysis of these eggshells reveals that they can be assigned to at least six different dinosaur ootaxa (*Continuoolithus*, *Montanoolithus*, *Porituberoolithus*, *Prismatoolithus* spp., *Spheroolithus*), likely belonging to hadrosaurs and to various small theropods (dromaeosaurids, oviraptorosaurs, troodontids) previously unknown from this formation. All of the theropod eggshells studied are relatively thin (<1 mm) and were laid by animals of small body size (<100 kg). Although large theropods were present at the end Cretaceous in Alberta, their eggshells are not yet known from the Willow Creek or contemporaneous formations. Overall, the Willow Creek eggshell assemblage indicates significantly greater dinosaur diversity than what is known from skeletal remains alone. With respect to small-bodied theropods, this diversity is comparable to the Scollard and Hell Creek formations.

Grant Information
NSERC Discovery Grants

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

A 3D PRELIMINARY RECONSTRUCTION OF THE SKULL OF *LARIOSAURUS HONGGUOENSIS* (REPTILIA, SAUROPTERYGIA) BASED ON MICRO-COMPUTED TOMOGRAPHIC DATA

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Sauropterygia was one of the most diverse and successful Mesozoic marine reptile clades spanned almost the entire Mesozoic and traversed a wide range of habitats. With the wider application of micro-computed tomographic (μCT) scanning in reconstruction of fossil specimens, some species of placodonts has been extensively studied by using this new method on anatomical description and phylogenetic analyses, including a reconstruction of the braincase and inner ear, and an investigation of tooth replacement patterns. However, μCT scanning has been rarely used in study of other Sauropterygia. Herein we for the first time conducted it for nothosaurid sauropterygian *Lariosaurus*.

Lariosaurus hongguoensis, found from the Middle Anisian (Middle Triassic) of southwestern China, is the oldest definite representative of genus *Lariosaurus* known so far. By using μCT scanning, we reconstructed the three-dimensional skull morphology of the holotype of *Lariosaurus hongguoensis*, and present a more accurate osteological description of the specimen's most part of dorsal and ventral sides, and the whole occiput, including supraoccipital, exoccipital, basioccipital and foramen magnum. We thus clarified some indistinct anatomical features from previous research, such as the absence of a jugal. Considering that the relation of jugal to the orbit is a character in the matrix of phylogenetic analysis in sauropterygian, this loss of jugal, which is commonly shared by other Chinese *Lariosaurus*, could be a derived character. This may lead to a modification of the position of *Lariosaurus* in the phylogenetic tree. These results extend our knowledge on *Lariosaurus* cranial anatomy in three-dimensions, and introduce the superiority of Micro-computed tomographic.

Technical Session XVII (Saturday, October 29, 2016, 8:45 AM)

A THREE-DIMENSIONAL SKULL OF *CHAOHUSAURUS* (REPTILIA, ICHTHYOPTERYGIA) FROM THE LOWER TRIASSIC OF ANHUI, CHINA

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Ichthyopterygia is one of the most successful marine tetrapod clades, which lasted from the Early Triassic (Olenekian) to the early Late Cretaceous (Cenomanian) and eventually gave rise to dolphin-like thunnosaurs. *Chaohusaurus* is one of the most basal ichthyopterygians from the Middle and Upper Member of Nanlinghu Formation (Olenekian, Lower Triassic) in Chaohu, Anhui Province, China, and has the oldest definitive stratigraphic record of all Mesozoic marine reptiles. The holotype of *C. geishanensis* is poorly prepared while that of *C. chaoxianensis* had been damaged extensively, so their anatomical details, especially of the skull, are still incompletely known. Recently, over eighty well-preserved skeletons of *Chaohusaurus* have been excavated from Chaohu, and some of them have been prepared in detail. Here, we report a completely articulated skeleton contained in a carbonate nodule with the skull preserved three-dimensionally. This specimen can be attributed to *Chaohusaurus* by two apomorphies: the anterior flange of the humerus is not extensive or uniformly convex; and the distal tarsals 1 and 2 are unossified. It can be identified as *C. chaoxianensis* because its distal tarsal 3 is not ossified. Its three-dimensionally preserved skull, showing the original suture patterns clearly, allows the following inferences to be made in comparison with other Early Triassic Ichthyosauriformes: *Chaohusaurus* was already well-adapted to aquatic life, with the external naris dislocated posteriorly; the prefrontal–postfrontal contact forming an orbital ridge is confirmed to be present in *Chaohusaurus*, which could strengthen the skull roof better, and could be related to the adaption to the aquatic life; the squamosal and postorbital participate in the margin of the upper temporal fenestra unlike in more derived ichthyopterygians where they are eliminated by the margin by the supratemporal and postfrontal, respectively. The new information is critical to improving our knowledge on the cranial morphology of the Early Triassic ichthyopterygians, and helps to understand the origin and early evolution of this group.

Technical Session IX (Thursday, October 27, 2016, 2:00 PM)

SILURIAN PLACODERMS FROM THE XIAOXIANG FAUNA REVEAL HIGH MORPHOLOGICAL DISPARITY CLOSE TO CROWN GNATHOSTOMES

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The past decade has seen inspiring discoveries of early fishes from the Silurian Xiaoxiang Vertebrate Fauna (Late Ludlow, about 423 million years ago), a valuable and rare window to explore the early evolution of jawed vertebrates. As the first maxillate placoderm, *Entelognathus primordialis* bears characters previously restricted to osteichthyans, and helps to establish the emergence of crown gnathostomes (cartilaginous and bony jawed vertebrates) from placoderms—a paraphyletic array of stem gnathostomes. However, the dermal jaw homology cannot be resolved unambiguously from previous phylogenetic analyses, mainly because *Entelognathus* is the only member of the maxillate placoderms.

Recently, in addition to galeaspids and diverse osteichthyans, several new placoderms including *Entelognathus*-like forms have been found from the Xiaoxiang Fauna, revealing high morphological disparity close to crown gnathostomes. Here I report a new antiarch (i.e., a member of the basalmost clade of placoderms), and a new maxillate placoderm close to crown gnathostomes. The new antiarch is distinguishable from the other antiarchs in its anterior median dorsal plate away from the anterior edge of the trunk armour, and provides new data about the upper and lower jaws of the group. The new maxillate placoderm bears an arthrodire-like skull roof and laterally-set eyes. Surprisingly, it resembles antiarchs in possessing additional median dorsal plates in the trunk armour, an opercular (i.e., submarginal) with a ventral lamina, and anterodorsal process of the opercular attaching onto the skull roof, as well as the ventral mouth. This mosaicism of the macromeric dermal skeleton sheds new light on its homology and evolution, and adds to the understanding of the placoderm phylogeny.

Grant Information
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Technical Session IX (Thursday, October 27, 2016, 2:30 PM)

REANALYSIS OF SERIAL GRINDING DATA SHEDS LIGHT ON THE EVOLUTION OF THE NEUROCRANIUM IN PRIMITIVE JAWED VERTEBRATES

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Neurocranium data have played an important role in recent studies that have established a consensus on the relationship between the major gnathostome lineages. However, the neurocrania of placoderms, which are resolved to be a paraphyletic array of stem-group jawed vertebrates, are often not well preserved, resulting in less information extracted when compared with those of chondrichthyans and osteichthyans. During the mid-20th century, Swedish paleontologist and anatomist Erik Stensiö did pioneering work on a number of placoderm neurocrania using a serial grinding technique. These studies yielded large amounts of anatomical data, but the process of reconstruction from slice images via wax models to final drawings was not documented in the publications, leading to lingering uncertainty about the reliability of some of his interpretations. The problem is compounded by the fact that the fossils were destroyed by the grinding process used to study them.

We are attempting to overcome these problems and recover the anatomical information from the specimens, starting as a test case with the arthrodire placoderm *Tapinosteus hertzi*, by scanning, aligning and importing the original drawings of the serial sections into 3D modeling software. We exploit the now more accessible morphologic detail while both enjoying the convenience of digital handling and segementation and preserving the testability of the interpretation. *Tapinosteus hertzi* belongs to the eubrachythoracids, a placoderm group from the Middle Devonian that shows parallel evolution to crown gnathostomes in morphological characters that implying the enhancement of feeding, locomotory and sensory capacities. Incorporating the data into the current phylogenetic framework, which has changed a great deal since Stensiö's time, helps to create a better understanding of character distribution in the early evolution of gnathostomes.

Grant Information
Project Grant 2014-4102 from Vetenskapsrådet; a Wallenberg Scholarship from the Knut and Alice Wallenberg Foundation, both awarded to Per Ahlberg.

Poster Session IV (Saturday, October 29, 2016, 4:15–6:15 PM)

INTRASKELETAL HISTOVARIABILITY IN THE HIND LIMB OF *PSITTACOSAURUS MONGOLIENSIS*

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Since the discovery of the lines of arrested growth in dinosaur bones, skeletochronology has been explored in numerous dinosaur taxa. Various skeletal elements have been used for the relative age assessment of dinosaur individuals. However, each element exhibits a different histological developmental pattern. In the past, the tibia and femur have been sectioned for histologic analyses for many dinosaur taxa. In previous studies of *Psittacosaurus* skeletochronology, the humerus, femur, tibia, and fibula have been utilized. Determining an ideal skeletal element for *Psittacosaurus* skeletochronology and tissue typing is necessary to study the growth strategy of this animal. We sectioned associated femora, tibiae, and fibulae from four individuals reflecting different ontogenetic stages in this study. The femur and tibia show similar vascularization throughout the specimens. The fibulae exhibit mostly longitudinal vascularizations in all individuals. The tibia and fibula present the same numbers of lines of arrested growth whereas the femur appears to have lost its innermost preserved growth lines due to an extensive expansion of the medullary cavity in the bone. Extensively distributed resorption cavities are observed in all elements including the femur, tibia, and fibula from the larger individual. This may reflect a simultaneous effect in all weight-bearing hind limb elements due to a considerable physiologic change such as initiation of skeletal maturity. However, this hypothesis needs to be tested in other hind limb elements including the metatarsals of *Psittacosaurus*.

Technical Session IV (Wednesday, October 26, 2016, 2:00 PM)

NEW SKELETON OF *PLATYOSPHYS AITHAI* (CETACEA) FROM THE LATE MIDDLE EOCENE OF GUERAN IN SOUTHWESTERN MOROCCO

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Gueran is an internally-drained depression in the Sahara located 125 km southeast of the town of Boujdour in southern Morocco. The site was discovered in 2014, and dozens of skulls and partial skeletons of late middle Eocene archaeocetes have been removed by commercial collectors from a bed producing fossils over a distance of some 20 kilometers.

We were successful in recovering a partial skeleton of *Platyosphys aithai* this year, which is much more complete than previously known specimens of the genus. The skull has the upper dental formula 3.1.4.2, typical of basilosaurids, with normally-spaced anterior teeth. Upper canine teeth are small and gracile, indicating that the specimen is female. Upper molars are exceptionally small, narrow, and low-crowned. Cervical vertebrae and anterior-most thoracics were destroyed by weathering before the skeleton was collected. The remainder of the skeleton includes 10 thoracic vertebrae in articulation. These are trapezoidal in dorsal and ventral profile with posterior ends distinctly wider than anterior ends. Associated ribs have anteroposteriorly expanded distal ends. The skeleton is lying on its left side. Ribs of the right side are displaced, suggesting eruption of gasses from the abdominal cavity before burial. The first ten lumbar vertebrae of the skeleton were also recovered enabling construction of a substantial vertebral length profile for the genus and recognition of sexual dimorphism in posterior thoracic and lumbar vertebral size. Cones of cancellous bone in posterior thoracic and lumbar vertebrae are distinctive, which enables vertebrae of *Platyosphys* to be distinguished from those of other genera with elongated vertebrae.

The number of archaeocete species recovered from Gueran now includes three protocetids and five basilosaurids, making the Gueran archaeocete fauna the most diverse known anywhere.

Grant Information

Field work supported by the National Geographic Society; Faculty of Sciences, Université Hassan II, Aïn Chock, Casablanca; and University of Michigan Museum of Paleontology.

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