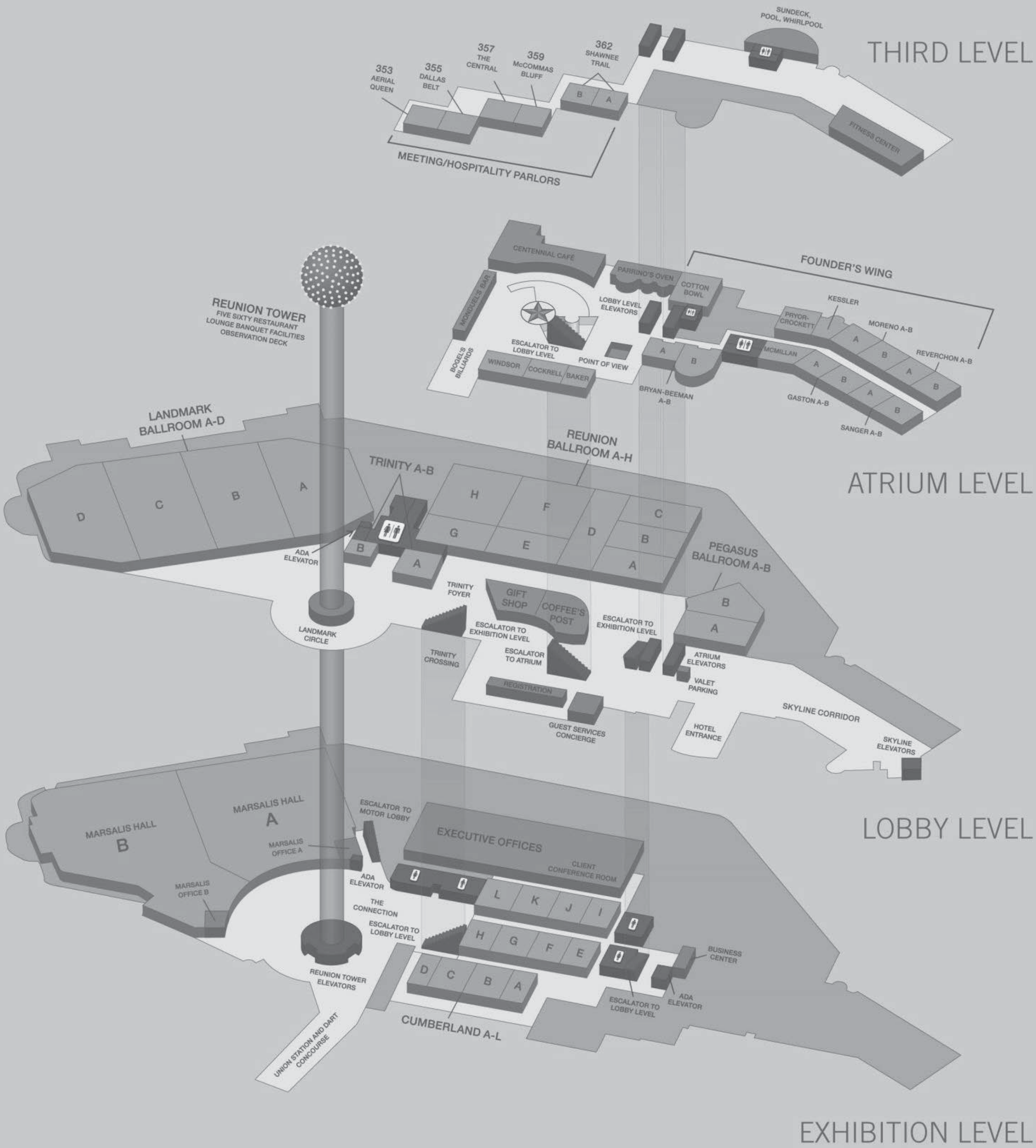
SVP
SOCIETY OF VERTEBRATE PALEONTOLOGY

SVP 75th Annual Meeting

Meeting Program & Abstracts

SOCIETY OF VERTEBRATE PALEONTOLOGY
OCTOBER 2015
ABSTRACTS OF PAPERS
75th ANNUAL MEETING

Hyatt Regency Dallas
Dallas, Texas, USA
October 14 – 17, 2015


THIRD LEVEL
SUNDECK, POOL, WHIRLPOOL
353 AERIAL QUEEN
355 DALLAS BELT
357 THE CENTRAL
359 McCOMMAS BLUFF
362 SHAWNEE TRAIL
B
A
FITNESS CENTER
MEETING/HOSPITALITY PARLORS
CENTENNIAL CAFÉ
PARRINO'S OVEN
COTTON BOWL
FOUNDER'S WING
MONDUEL'S BAR
LOBBY LEVEL ELEVATORS
KESSLER
PRYOR-CROCKETT
MORENO A-B
REVERCHON A-B
MCMILLAN
ESCALATOR TO LOBBY LEVEL
POINT OF VIEW
BOGEL'S BILLIARDS
WINDSOR
COCKRELL
BAKER
BRYAN-BEEMAN A-B
GASTON A-B
SANGER A-B
REUNION TOWER
FIVE SIXTY RESTAURANT
LOUNGE BANQUET FACILITIES
OBSERVATION DECK
LANDMARK BALLROOM A-D
REUNION BALLROOM A-H
TRINITY A-B
ATRIUM LEVEL
D
C
B
A
H
F
G
E
ADA ELEVATOR
PEGASUS BALLROOM A-B
TRINITY FOYER
GIFT SHOP
COFFEE'S POST
ESCALATOR TO EXHIBITION LEVEL
LANDMARK CIRCLE
TRINITY CROSSING
ESCALATOR TO ATRIUM
ATRIUM ELEVATORS
VALET PARKING
REGISTRATION
GUEST SERVICES CONCIERGE
HOTEL ENTRANCE
SKYLINE CORRIDOR
SKYLINE ELEVATORS
LOBBY LEVEL
MARSALIS HALL B
MARSALIS HALL A
ESCALATOR TO MOTOR LOBBY
MARSALIS OFFICE A
MARSALIS OFFICE B
EXECUTIVE OFFICES
CLIENT CONFERENCE ROOM
ADA ELEVATOR
THE CONNECTION
ESCALATOR TO LOBBY LEVEL
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C
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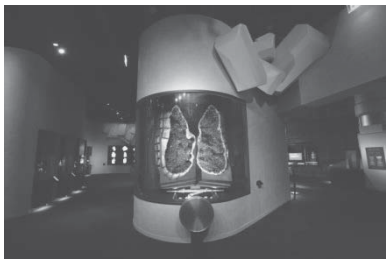
A
BUSINESS CENTER
REUNION TOWER ELEVATORS
ESCALATOR TO LOBBY LEVEL
ADA ELEVATOR
CUMBERLAND A-L
UNION STATION AND DART CONCOURSE
EXHIBITION LEVEL

WELCOME TO DALLAS


Greetings!

On behalf of the Perot Museum of Nature and Science and Southern Methodist University, the Host Committee of the 2015 Annual Meeting of the Society of Vertebrate Paleontology welcomes you to Dallas. This historic meeting, celebrating the 75th anniversary of our Society, will be held at the Hyatt Regency Dallas, one of the most iconic luxury hotels in downtown Dallas.

Within easy walking distance is Dallas' Historic West End, an area once settled by Caddo Indians, and later purchased by Tennessee lawyer John Neely Bryan in the mid-1800s. Bryan went on to found the city of Dallas, and in nearby Dealy Plaza tourists can visit a replica of Bryan's cabin. Dallas' West End is now home to numerous shopping and dining venues.

Leaving the Hyatt Regency Dallas and on the other side of the West End district is the new Perot Museum of Nature and Science. With a history that includes the former Dallas Museum of Natural History, the Perot Museum of Nature and Science opened its new doors in December 2012. The exhibition halls were developed with the help of several partnerships, and much of the content of the museum's T. Boone Pickens Life Then & Now hall is the result of close co-operation and contributions between the Museum and Southern Methodist University. In addition to the dynamic partnership between these two institutions, the professional paleontological community in Dallas works closely with and benefits from an active group of avocational paleontologists, the Dallas Paleontological Society, and the role of avocational paleontologists is also part the story told at the Perot Museum.

Together, we welcome all of you to Dallas for what is sure to be an enlightening assemblage of the world's most engaged vertebrate paleontologists at the 75th Anniversary Meeting of the Society of Vertebrate Paleontology in 2015.

Anthony R. Fiorillo, SVP 7th Annual Meeting Host Committee Co-Chair
Louis Jacobs, SVP 75th 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 audo/videotape professionals to archive sections of the Meeting for the Society's use.)

Editorial policies of Science and Nature magazine: 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 2015 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, 2015, <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. Deamining, 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 #2015SVP. We look forward to seeing your thoughts and discussion online!

2015 SVP Workshops

*For Pre-registered Attendees**

Day					
TUE, October 13	9:00 am – 12:00 pm Iodine-EnhancedSoft-Tissue Imaging:An Introductory Workshop for Vertebrate Paleontologists **Hyatt Regency Dallas, Pegasus A**	9:30 am – 4:30 pm Geomorph: R Package for the Collection and and Analysis of Geometric Morphometric Data **Hyatt Regency Dallas, Gaston AB**	10:00 am – 4:00 pm Morphological Evolution in Deep Time: Calculating Disparity Rates from Discrete Phenotypic Data **Southern Methodist University**	1:00 pm – 4:00 pm Vertebrate Fossil Packing for Shipment by Courier **Hyatt Regency Dallas, Moreno AB**	1:00 pm – 5:00 pm UV and Other Forensic Techniques in Specimen Diagnostics and Documentation **Hyatt Regency Dallas, Sanger AB**
WED, October 14	12:30 pm – 1:30 pm Paleontology and the Media – Communicating Your Research to the Popular Press **Hyatt Regency Dallas, Landmark D** OPEN TO ALL				

**The Paleontology and the Media Workshop is free to attend and open to all.*

2015 SVP Field Trips

For Pre-registered Attendees

Day	
FRI, October 9 –TUE, October 13	Investigating Modern and Eocene Estuarine Environments, Their Biological Communities & Depositional Facies **Time:** Begins Friday, October 9, at 11:00 am. **Pick up Location:** Baggage pick up area of Terminal C at George Bush Intercontinental Airport in Houston, Texas **Drop off Location:** Ends Tuesday, October 13, at the Hyatt Regency Dallas (headquarters hotel)
TUE, October 13	Early- and Mid-Cretaceous Archosaur Localities of North-Central Texas **Time:** 7:00 am – 6:00 pm **Pick up/Drop off Location:** Hyatt Regency Dallas
TUE, October 13	Ocean Dallas: Late Cretaceous Strata and Vertebrate Fossils of North Texas **Time:** 8:00 am – 3:00 pm **Pick up/Drop off Location:** Hyatt Regency Dallas
SUN, October 18 – TUE, October 20	Permian Vertebrate-Bearing Strata of North-Central Texas **Pick up Location:** Begins Sunday, October 18, at 7:30 am at the Hyatt Regency Dallas **Drop off Location:** Ends Tuesday, October 20, at 6:00 pmat the Hyatt Regency Dallas

2015 SVP Schedule of Events (subject to change)

All events are held at the Hyatt Regency Dallas unless otherwise noted with an **

Event/Function	TUE, October 13	WED, October 14	THUR, October 15	FRI, October 16	SAT, October 17
Registration Desk	3:00pm – 7:00pm **MARSALIS HALL FOYER**	7:00am – 5:00pm **MARSALIS HALL FOYER**	7:00am – 5:00pm **MARSALIS HALL FOYER**	7:30am – 4:00pm **MARSALIS HALL FOYER**	7:30am – 4:00pm **MARSALIS HALL FOYER**
Symposium		1:45 pm – 4:15 pm Symposium 1: Advances in Mid-Cretacious Paleoecology **LANDMARK AB**		1:45 pm – 4:30 pm Symposium 2: Conservation Paleobiology **LANDMARK C**	8:00 am – 12:15 pm Symposium 3: Geometric Morphometrics in Vertebrate Paleontology **LANDMARK AB**
Romer Prize Session			8:00am – 12:15pm **LANDMARK AB**		
Preparators' Session			8:00 am – 12:15 pm **LANDMARK D**		
Technical Sessions		8:00am – 12:15pm Technical Session I Ungulates/Dietary Reconstruction **LANDMARK AB**	8:00am – 12:15pm Technical Session VI Fish **LANDMARK C**	8:00am – 12:15pm Technical Session X Dinosauria - Theropods **LANDMARK AB**	8:00am – 12:15pm Technical Session XV Southern Hemisphere Mammals/Extinction **LANDMARK C**
		8:00am – 12:15pm Technical Session II Birds & Pterosaurs **LANDMARK C**	1:45pm – 4:15pm Technical Session VII Dinosauria Ornithischia **LANDMARK AB**	8:00am – 12:15pm Technical Session XI Euarchontoglires **LANDMARK C**	8:00am – 12:15pm Technical Session XVI Early Archosaurs/Crocs **LANDMARK D**
		8:00am – 12:15pm Technical Session III Synapsids and Permian Anapsids **LANDMARK D**	1:45pm – 4:15pm Technical Session VIII Carnivorous Mammals **LANDMARK C**	8:00am – 12:15pm Technical Session XII Turtles/Squamates **LANDMARK D**	1:45pm – 4:15pm Technical Session XVII Dinosauria - Sauropods **LANDMARK AB**
		1:45pm – 4:15pm Technical Session IV Cetacea/Brains **LANDMARK C**	1:45pm – 4:15pm Technical Session IX Mesozoic Mammals and Late Mesozoic Faunas **LANDMARK D**	1:45pm – 4:15pm Technical Session XIII Dinosaur Biology **LANDMARK AB**	1:45pm – 4:15pm Technical Session XVIII Paleoecology **LANDMARK C**
		1:45pm – 4:15pm Technical Session V Histology and Methods **LANDMARK D**		1:45pm – 4:15pm Technical Session XIV Marine Reptiles **LANDMARK D**	1:45pm – 4:15pm Technical Session XIX Early Tetrapods **LANDMARK D**

All events are held at the Hyatt Regency Dallas unless otherwise noted with an **

Event/Function	TUE, October 13	WED, October 14	THUR, October 15	FRI, October 16	SAT, October 17
Poster Sessions Set-up: 7:30am – 9:30 am **Poster Symposium and Colbert Prize Competition posters will be on display Wednesday thru Saturday.*		Poster Viewing: Session I (Regular Session Posters and E&O Poster Session): 9:30am – 6:15pm Exhibit/Poster Mixer: 4:15pm – 6:15pm **Poster Symposium authors will be present at their posters.* **MARSALIS HALL** Posters associated with "Advances in Mid-Cretaceous Paleoecology: Understanding a Major Terrestrial Transition" Symposium: 9:30am – 6:15pm Poster Session: 4:15pm – 6:15pm **LANDMARK CIRCLE**	Poster Viewing: Session II (Regular Session Posters): 9:30am – 6:15pm Exhibit/Poster Mixer: 4:15pm – 6:15pm **Colbert Prize Competition authors will be present at their posters.* **MARSALIS HALL** Posters associated with Preparators' Session: 9:30am – 6:15pm Poster Session: 4:15pm – 6:15pm **LANDMARK CIRCLE**	Poster Viewing: Session III (Regular Session Posters): 9:30am – 6:15pm Exhibit/Poster Mixer: 4:15pm – 6:15pm **MARSALIS HALL** Posters associated with "Conservation Paleobiology: Insights into Modern Ecosystems from Vertebrate Records" Symposium: 9:30am – 6:15pm Poster Session: 4:15pm – 6:15pm **LANDMARK CIRCLE**	Poster Viewing: Session IV (Regular Session Posters): 9:30am – 6:15pm Exhibit/Poster Mixer: 4:15pm – 6:15pm **MARSALIS HALL** Posters associated with "The Shape of things to Come: Geometric Morphometrics in Vertebrate Paleontology" Symposium: 9:30am – 6:15pm Poster Session: 4:15pm – 6:15pm **LANDMARK CIRCLE**
Poster Symposium		Viewing: 9:30am – 6:15pm Exhibit/Poster Mixer (authors will be standing at posters): 4:15pm – 6:15pm **MARSALIS HALL**	Viewing: 9:30am – 6:15pm **MARSALIS HALL**	Viewing: 9:30am – 6:15pm **MARSALIS HALL**	Viewing: 9:30am – 6:15pm **MARSALIS HALL**
Colbert Prize Competition Posters		Viewing: 9:30am – 6:15pm **MARSALIS HALL**	Viewing: 9:30am – 6:15pm Exhibit/Poster Mixer (authors will be standing at posters): 4:15pm – 6:15pm **MARSALIS HALL**	Viewing: 9:30am – 6:15pm **MARSALIS HALL**	Viewing: 9:30am – 6:15pm **MARSALIS HALL**
Exhibit Viewing		9:30am – 6:15pm **MARSALIS HALL**	9:30am – 6:15pm **MARSALIS HALL**	9:30am – 6:15pm **MARSALIS HALL**	9:30am – 6:15pm **MARSALIS HALL**
SVP Business Meeting and Open Forum			12:30pm – 1:30pm **LANDMARK AB**		
Preparators' Meeting			2:00pm – 3:30pm **PEGASUS A**		
Women in SVP Luncheon		12:00pm – 2:00pm **PEGASUS A**			
Social Events	7:30pm – 8:30pm Special Lecture by Dr. William Tsutsui, President of Hendrix College and author of "Godzilla on My Mind" *Chasing Godzilla, Japan's Favorite Sea Monster* **LANDMARK AB**	7:30pm – 10:30pm Welcome Reception ****PEROT MUSEUM OF NATURE AND SCIENCE**	7:30pm – 11:30pm The Round Table Forum and Reprint Exchange **LANDMARK D**	6:30pm – 11:30pm Auction **REUNION EFGH**	7:00pm – 10:00pm Awards Banquet **LANDMARK ABC** 10:00pm – 1:00am After Hours Party **LANDMARK D**

PROGRAM AT A GLANCE

	Landmark AB	Landmark C	Landmark D	Landmark AB	Landmark C	Landmark D
	Technical Session I	**Technical Session II**	**Technical Session III**	**Romer Prize Session**	**Technical Ssession VI**	**Preparators' Session**
	WED	**WED**	**WED**	**THUR**	**THUR**	**THUR**
8:00 am	Racicot	Bhullar	Cisneros	Anné	Randle	Smith
8:15 am	Calamari	Balanoff	Tsuji	Atterholt	Ahlberg	Balcarcel
8:30 am	Zazula	Heers	Reisz	Borths	Zhu	Policelli
8:45 am	Emery	Hall	Macdougall	Bourke	Bronson	Fair
9:00 am	Van Heteren	Wang	Richards	Chen	Gibson	Lee
9:15 am	Bormet	Field	Huttenlocker	Cherney	Maxwell	Cavigelli
9:30 am	O'Brien	Kirchner-Smith	Shelton	Fraser	Liu	Avrahami
9:45 am	Ludtke	Kambic	Knaus	Gold	Claeson	Salazar
10:00 am	COFFEE					
10:15 am	Brown	Ksepka	Bakker	Halliday	Criswell	Herbel
10:30 am	Hoffman	Stidham	Sidor	Kemp	Campione	Davies
10:45 am	Yamada	Proffitt	Whitney	Pineda-Munoz	Peart	Browne
11:00 am	Arman	Smith	Olroyd	Poole	Coates	Sadleir
11:15 am	Mihlbachler	Britt	Hopson	Pritchard	Pruitt	Keillor
11:30 am	Moran	Olin	Kammerer	Stiegler	Underwood	Egberts
11:45 am	Biasatti	Wilson	Rowe	Tsai	Miyashita	Yarborough
12:00 pm	Bernor	Andres	Jones	Urban	Motani	Benton
12:15 pm	**BREAK**					
1:30 pm						
	Landmark AB	**Landmark C**	**Landmark D**	**Landmark AB**	**Landmark C**	**Landmark D**
	Symposium 1: Advances in Mid-Cretacious Paleoecology	**Technical Session IV**	**Technical Session V**	**Technical Session VII**	**Technical Session VIII**	**Technical Session IX**
1:45 pm	Zanno	Weisbecker	Petermann	Burns	Furbish	Smith
2:00 pm	Arbour	Ferreira-Cardoso	Werning	Barta	Hopkins	Hoffmann
2:15 pm	Makovicky	Gingerich	Chiba	Sartin	Hartstone-Rose	Grossnickle
2:30 pm	Noto	Houssaye	Rothschild	Crystal	Smith	Lautenschlager
2:45 pm	Adams	Zouhri	Hill	Leblanc	Manafzadeh	Rankin
3:00 pm	C. Suarez	Boessenecker	Bever	Freedman	Wroe	Varricchio
3:15 pm	M. Suarez	Velez-Juarbe	Gelnaw	Gates	Madern	Cullen
3:30 pm	Fiorillo	Deméré	Zhang	Hedrick	Van Valkenburg	Williams
3:45 pm	Brusatte	Fordyce	Matzke	Evans	Orcutt	Rogers
4:00 pm	Rabi	Lambert	Sansom	Brown	Solé	Gatesy
4:15 pm	*Poster Session I*			*Poster Session II*		
6:15 pm						

	Landmark AB	Landmark C	Landmark D	Landmark AB	Landmark C	Landmark D
	Tehnical Session X	**Technical Session XI**	**Technical Session XII**	**Symposium 3: Geometric Morphometrics in Vertebrate Paleontology**	**Technical Session XV**	**Technical Session XVI**
	FRI	**FRI**	**FRI**	**SAT**	**SAT**	**SAT**
8:00 am	Griffin	Morse	Sues	Watanabe	Nabavizadeh	Chure
8:15 am	Marsh	Prufrock	Lawver	Marugán-Lobón	Gardiner	Sobral
8:30 am	Burch	López-Torres	Vavrek	Head	Macrini	Heckert
8:45 am	Carrano	Silcox	Nicholson	Vitek	McGrath	Parker
9:00 am	Sereno	Boyer	Holroyd	Sherratt	Croft	Nesbitt
9:15 am	Carr	Beard	Vermillion	Savriama	West	Irmis
9:30 am	Van de Reest	Maclatchy	Lively	Tallman	Wood	Drymala
9:45 am	Kobayashi	Ward	Campbell	Goswami	Pian	Sullivan
10:00 am	COFFEE					
10:15 am	Button	Evans	De Mar	Jones	Villavicencio	Morris
10:30 am	Funston	Rook	Simoes	Wilson	Spano	Araujo
10:45 am	Lu	Keller	Conrad	Yi	Lindsey	Larsson
11:00 am	Zelenitsky	Torgeson	Cernansky	Milne	Davis	Figueiredo
11:15 am	Wiemann	Marcy	Folie	Angielczyk	Alroy	Souza
11:30 am	Moyer	Fox	Da Silva	Baab	Mitchell	Hastings
11:45 am	Xu	Lightner	Larson	McNulty	Orzack	Ferguson
12:00 pm	Currie	Flynn	Melstrom	MacLeod	McHugh	Holliday
12:15 pm	**BREAK**					
1:30 pm						
	Landmark AB	**Landmark C**	**Landmark D**	**Landmark AB**	**Landmark C**	**Landmark D**
	Technical Session XIII	**Symposium 2: Conservation Paleobiology**	**Technical Session XIV**	**Technical Session XVII**	**Technical Session XVIII**	**Technical Session XIX**
1:45 pm	Mallon	Lyman	Depolo	Habib	Brocklehurst	Struble
2:00 pm	Moore	Badgley	Lawrence Wujek	Fronimos	Anemone	Marjanovic
2:15 pm	Bailleul	DeSantis	Wolniewicz	Atwood	Birlenbach	Porro
2:30 pm	Gould	Smith	Wintrich	Woodruff	Peppe	Maddin
2:45 pm	Takasaki	Feranec	O'Keefe	Schmitt	Chew	Frobisch
3:00 pm	Bertozzo	Davis	Sander	Mannion	Smiley	Jia
3:15 pm	Lloyd	Louys	Van Buren	Gorscak	Doman	Szostakiwskyj
3:30 pm	White	Behrensmeyer	Polcyn	Kundrat	Du	Pardo
3:45 pm	D'emic	Miller	Connolly	Wilson	Rowan	Tarailo
4:00 pm	Grady	Fox-Dobbs	Konishi	Curry Rogers	Lazagabaster	Tabor
4:15 pm	*Poster Session III*	Koch		*Poster Session IV*		
6:15 pm						

SAVE THE DATE!

August 23 - 26, 2017

SVP 2017

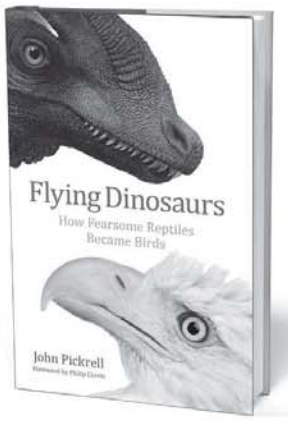
77TH ANNUAL MEETING

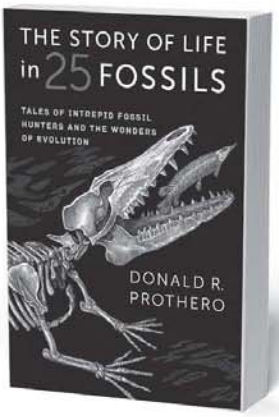
SVP
SOCIETY OF VERTEBRATE PALEONTOLOGY

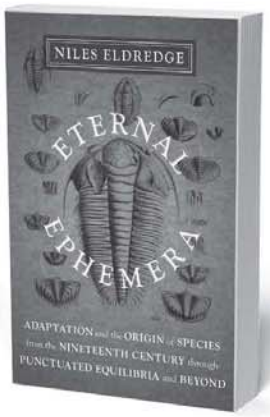
August 23 - 26, 2017

Calgary Telus Convention Centre

Calgary, Alberta, Canada







Aristotle's Ladder, Darwin's Tree

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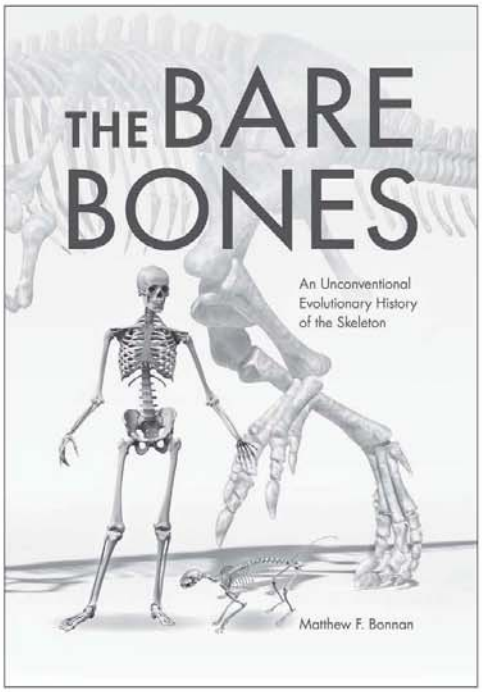

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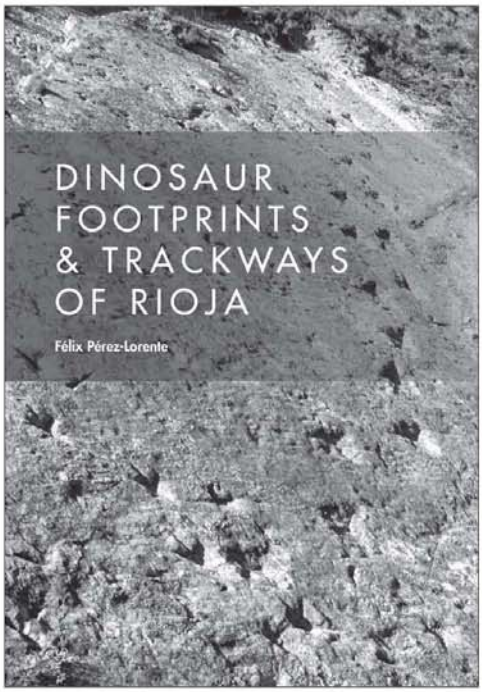

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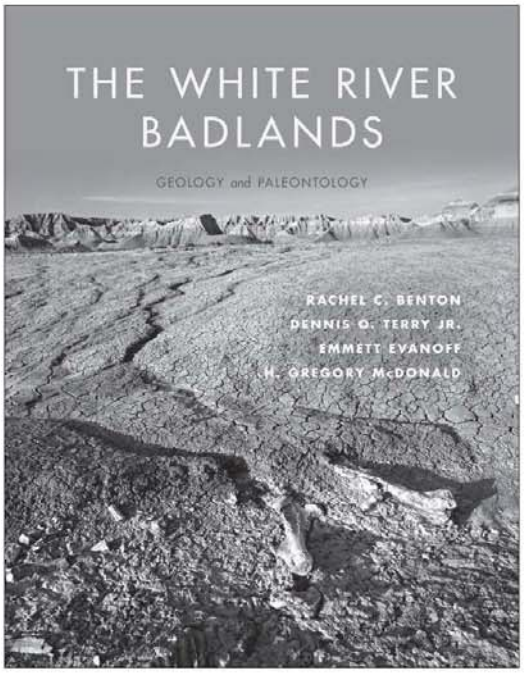

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WEDNESDAY MORNING, OCTOBER 14, 2015

TECHNICAL SESSION I

HYATT REGENCY DALLAS, LANDMARK AB

MODERATORS: Matthew Mihlbachler and Jonathan Hoffman

8:00 **Racicot, R., Ludtke, J., Smith, N.** TESTING FOR PHYLOGENETIC SIGNAL IN MORPHOLOGICAL DATA USING GENOTYPE-BASED PHYLOGENIES

8:15 **Calamari, Z.** NO BONE UNTURNED: DETECTING HARD TISSUE SYNAPOMORPHIES FOR BOVIDS (ARTIODACTYLA, MAMMALIA) THROUGH TOTAL EVIDENCE ANALYSES OF MORPHOLOGY AND MITOCHONDRIAL, NUCLEAR, AND ANCIENT DNA

8:30 **Zazula, G. D., Heintzman, P. D., Cahill, J. A., MacPhee, R. D., Hall, E., Southon, J. R., Nalawade-Chavan, S., Shapiro, B.** ANCIENT DNA AND RADIOCARBON DATES RESOLVE PLEISTOCENE *CAMELOPS* (FAMILY CAMELIDAE) PHYLOGENY AND CHRONOLOGY IN EASTERN BERINGIA

8:45 **Emery, M., Warrick, D., Davis, E.** TRAUMATIC INJURY IN *PROMERYCOCHOERUS* (FAMILY MERYCOCOIDODONTIDAE, ORDER CETARTIODACTYLA)

9:00 **Van Heteren, A. H., Sander, P.** PRE- AND POSTNATAL GROWTH RATES OF INSULAR DWARFED HIPPOPOTAMI FROM THE PLEISTOCENE OF CYPRUS

9:15 **Bormet, A. K., Polly, P.** THE EFFECTS OF SUBSTRATE, BODY POSITION, AND PLASTICITY ON THE MORPHOLOGY OF RUMINANT UNGUALS

9:30 **O'Brien, H. D., Bourke, J.** THE HEMODYNAMICS OF VASCULAR RETIA: TESTING A HYPOTHESIS OF BLOOD PRESSURE REGULATION THROUGH THE ARTIODACTYL CAROTID RETE

9:45 **Ludtke, J. A.** POSTNATAL PETROSAL ONTOGENY WITHIN DOMESTIC SHEEP

10:00 **BREAK**

10:15 **Brown, C., Rinaldi, C., Van Valkenburgh, B.** MACROSCOPIC ENAMEL INDICATORS OF POPULATION-WIDE FOOD STRESS IN MODERN, PLEISTOCENE, AND HOLOCENE UNGULATES

10:30 **Hoffman, J., Clementz, M.** GRAIN SIZE DISTRIBUTION OF INGESTED SILICA BY EXTANT UNGULATES: IMPLICATIONS FOR MASTICATORY PROCESSING AND MICROWEAR

10:45 **Yamada, E., Kubo, M. O., Kubo, T., Kohno, N.** TOOTH ENAMEL SURFACE TEXTURE ANALYSIS FOR THE EXTANT DEER POPULATIONS WITH KNOWN DIET

11:00 **Arman, S., Prideaux, G. J., Ungar, P., Brown, C. A., Desantis, L., Schmidt, C.** INTRA- AND INTER-MICROSCOPE DIFFERENCES IN DENTAL MICROWEAR TEXTURE ANALYSIS

11:15 **Mihlbachler, M. C., Campbell, D., Chen, C., Ayoub, M., Kaur, P.** EFFICACY OF DENTAL MICROWEAR IN TESTING PALEODIETARY HYPOTHESES FOR NON-RUMINANT UNGULATES: A TEST CASE USING NORTH AMERICAN MIOCENE RHINOCEROSES

11:30 **Moran, S. M., MacFadden, B. J.** STABLE ISOTOPE PALEOECOLOGY OF THE EQUID *PARAHIPPUS LEONENSIS* FROM THE EARLY MIOCENE THOMAS FARM SITE (GILCHRIST COUNTY, FLORIDA)

11:45 **Biasatti, D. M., Bernor, R. L., Cooper, L. W.** INSIGHTS ON LATE MIOCENE CLIMATE CHANGE AND REGIONAL UPLIFT IN MARAGHEH BASIN, EASTERN AZERBAIJAN PROVINCE, NORTHWEST IRAN REVEALED BY STABLE CARBON AND OXYGEN ISOTOPE ANALYSES OF FOSSIL HORSE TOOTH ENAMEL

WEDNESDAY MORNING, OCTOBER 14, 2015
TECHNICAL SESSION I (CONTINUED)

12:00 **Bernor, R. L., Ataabadi, M. M., Biasatti, D. M., Meshida, K., Wolf, D.** NEW SYSTEMATIC AND BIOGEOGRAPHIC INTERPRETATIONS OF THE LATE MIOCENE (9–7.4 MA) MARAGHEH HIPPARIONS, NORTHWEST IRAN

WEDNESDAY MORNING, OCTOBER 14, 2015
TECHNICAL SESSION II
HYATT REGENCY DALLAS, LANDMARK C
MODERATORS: Amy Balanoff and Brian Andres

8:00 **Bhullar, B. S., Oliveira, F., Abzhanov, A.** PALEONTOLOGICAL, EMBRYOLOGICAL, AND MOLECULAR INSIGHT INTO THE DEVELOPMENTAL BASIS OF THE DISTINCTIVE MAXILLARY REDUCTION OF BIRDS (REPTILIA, AVES) AND EXPERIMENTAL RESTORATION OF A LARGE MAXILLARY REGION IN CHICKENS

8:15 **Balanoff, A. M., Turner, A. H., Smaers, J. B.** MOSAIC EVOLUTION AND THE INFLUENCE OF FLIGHT ON NEUROANATOMICAL VARIATION WITHIN THEROPODS

8:30 **Heers, A. M., Rankin, J. W., Hutchinson, J. R.** BUILDING A BIRD: ONTOGENETIC AND EVOLUTIONARY CONSTRUCTION OF THE AVIAN BODY PLAN

8:45 **Hall, J. T.** THE FUNCTIONAL SIGNIFICANCE OF PTILOPODY IN EXTANT AND EXTINCT BIRDS

9:00 **Wang, M., Zheng, X., Jingmai, K., Lloyd, G. T., Wang, X., Wang, Y., Zhang, X., Zhou, Z.** THE OLDEST RECORD OF ORNITHUROMORPHA WITH IMPLICATIONS FOR EVOLUTIONARY RATE OF EARLY CRETACEOUS BIRDS

9:15 **Field, D. J., Feo, T. J., Prum, R.** LATE EVOLUTIONARY ORIGIN OF MODERN AVIAN FLIGHT FEATHERS IN MESOZOIC STEM GROUP BIRDS

9:30 **Kirchner-Smith, M. E.** 3D GEOMETRIC MORPHOMETRICS IN MODERN AND EXTINCT FOOT-PROPELLED DIVING BIRDS: A REEVALUATION OF THE TARSOMETATARSUS FOR SPECIES IDENTIFICATION

9:45 **Kambic, R. E., Biewener, A. A., Pierce, S. E.** CERVICAL INTER-VERTEBRAL KINEMATICS IN WILD TURKEYS: IMPLICATIONS FOR THE EVOLUTION OF THE AVIAN NECK

10:00 **BREAK**

10:15 **Ksepka, D. T., Stidham, T. A., Williamson, T. E.** A NEW SPECIES OF EARLY PALEOCENE LANDBIRD AND THE POST-CRETACEOUS DIVERSIFICATION OF BIRDS IN NORTH AMERICA

10:30 **Stidham, T., Hilton, R.** STEM OXYURINE STIFF-TAILED DUCKS (ANSERIFORMES: ANATIDAE) FROM THE EARLY TO MIDDLE MIOCENE OF NORTH AMERICA, AND THEIR IMPLICATIONS FOR THE TEMPORAL ORIGIN, EVOLUTION, AND INTERCONTINENTAL DISPERSAL OF THE CLADE

10:45 **Proffitt, J. V., Hutchinson, J. R., Clarke, J. A., Scofield, R.** FLIGHTLESS WING-PROPELLED DIVING AND THE EVOLUTION OF BODY SHAPE IN PENGUINS

11:00 **Smith, A.** THE POSITIVE EFFECTS OF COMBINING NEONTOLOGICAL AND PALEONTOLOGICAL DATA ON ESTIMATES OF BODY MASS EVOLUTION: AN EXAMPLE USING THE PAN-ALCIDAE (AVES, CHARADRIIFORMES)

WEDNESDAY MORNING, OCTOBER 14, 2015
TECHNICAL SESSION II (CONTINUED)

11:15 **Britt, B. B., Chure, D., Engelmann, G., Dalla Vecchia, F., Scheetz, R. D., Meek, S., Thelin, C., Chambers, M.** A NEW, LARGE, NON-PTERODACTYLOID PTEROSAUR FROM A LATE TRIASSIC INTERDUNAL DESERT ENVIRONMENT WITHIN THE EOLIAN NUGGET SANDSTONE OF NORTHEASTERN UTAH, USA INDICATES EARLY PTEROSAURS WERE ECOLOGICALLY DIVERSE AND GEOGRAPHICALLY WIDESPREAD

11:30 **Olin, D., Habib, M.** DIGITAL PTEROSAURS: BUILDING A VIRTUAL WING FROM SURFACE SCANS TO TEST AERODYNAMIC HYPOTHESES IN *PTERANODON*

11:45 **Wilson, L. E.** OSTEOHISTOLOGICAL INSIGHT INTO *PTERANODON* ONTOGENY

12:00 **Andres, B., Langston, W.** MORPHOLOGY AND PHYLOGENY OF *QUETZALCOATLUS* (PTEROSAURIA: AZHDARCHIDAE)

WEDNESDAY MORNING, OCTOBER 14, 2015
TECHNICAL SESSION III
HYATT REGENCY DALLAS, LANDMARK D
MODERATORS: Robert Reisz and Christian Kammerer

8:00 **Cisneros, J. C., Angielczyk, K., Kammerer, C., Marsicano, C., Smith, R., Fröbisch, J., Richter, M., Sadleir, R.** FIRST BONE RECORD OF TERRESTRIAL VERTEBRATES IN THE LOWER PERMIAN OF SOUTH AMERICA

8:15 **Tsuji, L. A., Sidor, C. A., Chiba, K., Angielczyk, K. D., Steyer, J.** THE PERMIAN AND TRIASSIC PARAREPTILES OF TANZANIA AND ZAMBIA: REVIEW OF DIVERSITY AND NEW LIFE HISTORY INSIGHTS PROVIDED BY OSTEOHISTOLOGY

8:30 **Reisz, R., Leblanc, A., Scott, D.** A NEW EARLY PERMIAN CAPTORHINID REPTILE (AMNIOTA: EUREPTILIA) FROM RICHARDS SPUR, OKLAHOMA, SHOWS REMARKABLE DENTAL AND MANDIBULAR CONVERGENCE WITH MICROSAURS

8:45 **MacDougall, M. J., Reisz, R. R.** THE UNIQUE PRESERVATIONAL ENVIRONMENT OF CAVE DEPOSITS AT THE RICHARDS SPUR LOCALITY OF OKLAHOMA

9:00 **Richards, E. J., Evans, D. C., Reisz, R. R.** COMMUNITY HISTOLOGY IN THE LOWER PERMIAN LOCALITY RICHARDS SPUR, OKLAHOMA

9:15 **Huttenlocker, A., Farmer, C. G.** VASCULAR CORRELATES OF RED BLOOD CELL SIZE AND THE EVOLUTION OF SYNAPSID BONE MICROSTRUCTURE

9:30 **Shelton, C.** *OPHIACODON* (BASAL SYNAPSID) BONE HISTOLOGY AND THE ORIGIN OF MAMMALIAN ENDOTHERMY

9:45 **Knaus, P. L., Van Heteren, A. H., Shelton, C. D., Sander, M.** THE EVOLUTION OF MAXIMUM METABOLIC RATE IN *DIMETRODON* (SPHENACODONTIDAE)

10:00 BREAK

10:15 **Bakker, R. T., Flis, C. J., George, C. D., Cook, L. A., Bell, T. H., Zoehfeld, K. W.** *DIMETRODON* AND THE EARLIEST APEX PREDATORS: THE CRADDOCK BONE BED AND GEORGE RANCH FACIES SHOW THAT AQUATIC PREY, NOT HERBIVORES, WERE KEY FOOD SOURCES

10:30 **Sidor, C. A., Knaub, C., Angielczyk, K. D., Beightol, C. V., Nesbitt, S. J., Smith, R. H., Steyer, J., Tabor, N. J., Tolan, S.** TANZANIA AND ZAMBIA YIELD AN UNPRECEDENTED FOSSIL RECORD OF BURNETIAMORPH THERAPSIDS

WEDNESDAY MORNING, OCTOBER 14, 2015

TECHNICAL SESSION III (CONTINUED)

10:45 **Whitney, M., Sidor, C. A.** MAMMAL-LIKE THECODONTY IN HERBIVOROUS MIDDLE PERMIAN TAPINOCEPHALIDS (THERAPSIDA, DINOCEPHALIA)

11:00 **Olroyd, S. L., Sidor, C. A., Angielczyk, K. D., Smith, R. M., Steyer, S. J., Tabor, N. J., Tolan, S.** A CHIMAERIC EMYDOPOID DICYNODONT (THERAPSIDA, ANOMODONTIA) FROM THE MIDDLE PERMIAN OF ZAMBIA

11:15 **Hopson, J. A., Sidor, C. A.** A JUVENILE SPECIMEN OF THE TRIRACHODONTID CYNODONT *CRICODON METABOLUS* FROM THE LUANGWA BASIN OF ZAMBIA: IMPLICATIONS FOR TOOTH REPLACEMENT IN GOMPHODONT CYNODONTS AND FOR TRIRACHODONTID SYSTEMATICS

11:30 **Kammerer, C.** A GIGANTIC CYNOGNATHID FROM THE TRIASSIC OF NAMIBIA AND THE EVOLUTION OF BODY SIZE IN CYNODONTS

11:45 **Rowe, T. B., Shepherd, G. M.** ORIGIN OF ORTHO-RETRONASAL OLFACTION IN BASAL CYNODONTS AND ITS ROLE IN MAMMALIAN CORTICAL EVOLUTION

12:00 **Jones, K. E., Polly, D., Head, J., Fernandez, V., Angielczyk, K. D., Pierce, S. E.** THE EVOLUTION OF AXIAL REGIONALIZATION IN MAMMALS: INSIGHTS FROM THE SYNAPSID FOSSIL RECORD

WEDNESDAY AFTERNOON, OCTOBER 14, 2015

SYMPOSIUM 1: ADVANCES IN MID-CRETACEOUS PALEOECOLOGY: UNDERSTANDING A MAJOR TERRESTRIAL TRANSITION

HYATT REGENCY DALLAS, LANDMARK AB

MODERATORS: Lindsay Zanno, Christopher Noto and Anthony Fiorillo

1:45 **Zanno, L. E., Arbour, V. M., Gates, T. A., Makovicky, P. J., Loewen, M. A., Button, K. A., Moyer, A. E., Bridges, T. K., Herzog, L. L.** BODY MASS TRANSFORMATIONS IN THE MID-CRETACEOUS OF NORTH AMERICA: HOW EUSTASY, RANGE RESTRICTIONS, AND CLADE SORTING SHAPED THE EVOLUTION OF DINOSAUR SIZE

2:00 **Arbour, V. M., Gates, T. A., Zanno, L. E.** INTERPRETING THE ANKYLOSAURIAN FOSSIL RECORD IN THE CONTEXT OF THE CRETACEOUS WESTERN INTERIOR SEAWAY OF NORTH AMERICA

2:15 **Makovicky, P. J., Zanno, L. E., Gates, T. A.** THE ADVENT OF NORTH AMERICA'S LATE CRETACEOUS FAUNA REVISITED: INSIGHTS FROM NEW DISCOVERIES AND IMPROVED PHYLOGENIES

2:30 **Noto, C. R.** WHAT WAS HAPPENING "ACROSS THE POND"? THE WOODBINE FORMATION AS AN EXAMPLE OF AN EARLY LATE CRETACEOUS APPALACHIAN ECOSYSTEM

2:45 **Adams, T. L., Noto, C. R., Drumheller, S.** THE CROCODYLIFORM DIVERSITY OF THE WOODBINE FORMATION (CENOMANIAN) OF TEXAS AND THE TRANSITION FROM EARLY TO MID-CRETACEOUS ECOSYSTEMS

3:00 **Suarez, C. A., Suarez, M. B., You, H., Li, D., Trieschmann, B.** ISOTOPIC COMPOSITION OF LOWER CRETACEOUS HEKOU GROUP VERTEBRATES OF LANZHOU PROVINCE, CHINA SUPPORTS COOL CLIMATES IN THE MID-LATE VALANGIAN

3:15 **Suarez, M. B., You, H.** WARM AND WET: LACUSTRINE PALEOENVIRONMENTS AS CRADLES FOR THE CRETACEOUS TERRESTRIAL REVOLUTION IN ASIA

3:30 **Fiorillo, A. R., McCarthy, P. J.** A PERSPECTIVE ON THE MID-CRETACEOUS FROM A DINOSAURIAN HIGH LATITUDE GREENHOUSE ECOSYSTEM, NORTH SLOPE, ALASKA

WEDNESDAY AFTERNOON, OCTOBER 14, 2015

SYMPOSIUM 1: ADVANCES IN MID-CRETACEOUS PALEOECOLOGY: UNDERSTANDING A MAJOR TERRESTRIAL TRANSITION (CONTINUED)

3:45 **Brusatte, S., Carr, T., Averianov, A., Sues, H., Muir, A., Butler, I.** DINOSAUR DYNASTIES: LARGE THEROPOD TURNOVER IN THE MID-CRETACEOUS AS REVEALED BY A NEW PHYLOGENY OF TYRANNOSAUROIDS AND NEW FOSSILS FROM UZBEKISTAN

4:00 **Rabi, M.** BIOGEOGRAPHICAL AND ECOLOGICAL PATTERNS DURING THE PEAK OF TURTLE DIVERSIFICATION IN THE MID-CRETACEOUS

WEDNESDAY AFTERNOON, OCTOBER 14, 2015

TECHNICAL SESSION IV

HYATT REGENCY DALLAS, LANDMARK C

MODERATORS: Vera Weisbecker and Robert Fordyce

1:45 **Weisbecker, V., Blomberg, S., Goldizen, A., Brown, M., Fisher, D.** WHAT IS A LARGE BRAIN GOOD FOR? BRAIN SIZE AND BEHAVIORAL COMPLEXITY DO NOT ASSOCIATE IN MARSUPIALS

2:00 **Ferreira-Cardoso, S., Castanhinha, R., Araújo, R., Walsh, S., Martins, N. E., Martins, R. M., Martins, G. G., Kardjilov, N., Hilger, A.** FLOCCULAR COMPLEX LOBE SIZE DOES NOT CORRELATE WITH VERTEBRATE ECOLOGY AND BEHAVIOR

2:15 **Gingerich, P. D.** NEW PARTIAL SKELETON, BODY SIZE, AND BRAIN SIZE IN THE LATE EOCENE WHALE *ZYGORHIZA KOCHII*, AND A COMPARISON OF ENCEPHALIZATION RESIDUALS IN ARCHAEOCETI (MAMMALIA, CETACEA)

2:30 **Houssaye, A., Tafforeau, P., De Muizon, C., Gingerich, P. D.** FROM LAND TO SEA—ARCHAEOCETE BONE MICROANATOMICAL INVESTIGATION

2:45 **Zouhri, S., Gingerich, P. D.** A NEW BARTONIAN LATE MIDDLE EOCENE ARCHAEOCETE FAUNA (CETACEA) FROM THE ARIDAL FORMATION AT GUERAN IN SOUTHWESTERN MOROCCO

3:00 **Boessenecker, R. W., Fordyce, R. E.** NEW FOSSILS FROM NEW ZEALAND REVEAL THE AFFINITIES OF "*MAUICETUS*"*LOPHOCEPHALUS* AND SKELETAL PLAN OF EOMYSTICETIDAE: OLIGOCENE BALEEN-BEARING TOOTHED MYSTICETES (MAMMALIA: CETACEA)

3:15 **Velez-Juarbe, J.** SIMOCETID DIVERSITY IN THE OLIGOCENE OF THE EASTERN PACIFIC REGION

3:30 **Deméré, T. A., Pyenson, N. D.** FILLING THE MIOCENE 'BALAENID GAP'—THE PREVIOUSLY ENIGMATIC *PERIPOLOCETUS VEXILLFER* KELLOGG, 1931 IS A STEM BALAENID (CETACEA: MYSTICETI) FROM THE MIDDLE MIOCENE (LANGHIAN) OF CALIFORNIA, USA

3:45 **Fordyce, R. E., Tanaka, Y., Ortega, M. E.** AN EARLY MIOCENE DOLPHIN FROM NEW ZEALAND EXPANDS THE RANGE AND DIVERSITY OF *NOTOCETUS*-LIKE PLATANISTOIDS

4:00 **Lambert, O., De Muizon, C., Urbina, M., Beatty, B. L., Di Celma, C., Bianucci, G.** PHYSETEROIDS FROM THE MIOCENE OF PERU: NEW DATA ON *ACROPHYSETER* AND *LIVYATAN* SUPPORTS MACRORAPTORIAL FEEDING IN SEVERAL EXTINCT SPERM WHALES

WEDNESDAY AFTERNOON, OCTOBER 14, 2015

TECHNICAL SESSION V

HYATT REGENCY DALLAS, LANDMARK D

MODERATORS: Gabriel Bever and Sarah Werning

1:45 **Petermann, H., Gauthier, J.** A NOVEL NON-DESTRUCTIVE METHOD FOR SKELETOCHRONOLOGY AND ITS PALEONTOLOGICAL AND PALEOECOLOGICAL APPLICATIONS

WEDNESDAY AFTERNOON, OCTOBER 14, 2015

TECHNICAL SESSION V (CONTINUED)

2:00 **Werning, S., Schweitzer, M. H., Padian, K.** WHEN MICROSTRUCTURE ISN'T ENOUGH: ADDITIONAL DIAGNOSTIC CRITERIA TO TEST AMONG HYPOTHESES OF BONE TISSUE IDENTITY

2:15 **Chiba, K., Evans, D. C., Ryan, M. J.** ASSESSMENT OF AGE RETROCALCULATION METHODS IN DINOSAUR GROWTH STUDIES: A CASE STUDY USING THE CENTROSAURINE CERATOPSID *CENTROSAURUS APERTUS* (CAMPANIAN)

2:30 **Rothschild, B. M., Wilhite, D. R., McLeod, D., Ting, H.** IDENTIFICATION OF MUSCLE ATTACHMENT SITES IN FOSSILS: PRESUMPTIVE VERSUS SURFACE MICROSCOPIC LOCALIZATION

2:45 **Hill, J. J., Donoghue, P. C., Rayfield, E. J.** EVOLUTION OF THE LOWER JAW OF GNATHOSTOMES

3:00 **Bever, G. S.** CONSERVED VARIABILITY AND THE VERTEBRATE FOSSIL RECORD: IMPLICATIONS FOR EVOLUTIONARY PATTERNS AND PROBLEMS IN DEEP TIME

3:15 **Gelnaw, W.** NEW TECHNIQUES FOR REMOVING THE EFFECT OF MORPHOLOGICAL INTEGRATION ON PHYLOGENETIC ANALYSIS

3:30 **Zhang, Y.** WHAT ARE CHARACTERS, CHARACTER STEPS, AND PARSIMONY?

3:45 **Matzke, N. J.** BAYESIAN TIP-DATING WITH CONTINUOUS CHARACTERS USING BEASTMASTER

4:00 **Sansom, R., Wills, M., Williams, T.** PHYLOGENY AND EVOLUTIONARY HISTORY OF MAMMALS UNDERMINED BY RELIANCE ON DENTAL MORPHOLOGY

WEDNESDAY, OCTOBER 14, THROUGH SATURDAY, OCTOBER 17, 2015

POSTER SYMPOSIUM: INSIGHTS FROM 3D-IMAGING BASED ANALYSES OF CARNIVORAMORPHANS AND THEIR RELATIVES: SYSTEMATICS, SINUSES AND SABERTOOTHS

HYATT REGENCY DALLAS, MARSALIS HALL

ORGANIZERS: Camille Grohé, Michelle Spaulding, and Z. Jack Tseng

AUTHORS WILL BE PRESENT AT THEIR POSTERS: Wednesday, October 14, from 4:15 – 6:15 p.m.

Posters must be removed by 6:30 p.m., Saturday, October 17

B1 **Tseng, Z., Spaulding, M., Grohé, C.** INTRODUCTION TO THE 3-D CARNIVORAMORPHAN POSTER SYMPOSIUM: TOOLS OF THE TRADE IN 3-D IMAGING BASED ANALYSES OF VERTEBRATE STRUCTURES

B2 **Fabre, A., Salesa, M. J., Cornette, R., Antón, M., Morales, J., Peigne, S.** QUANTITATIVE INFERENCES ON THE LOCOMOTOR BEHAVIOR OF EXTINCT SPECIES: NEW INSIGHTS FROM 3D SURFACE GEOMETRIC MORPHOMETRICS APPROACHES

B3 **Martín-Serra, A., Figueirido, B., Serrano, F., Palmqvist, P.** MODULAR EVOLUTION OF THE CARNIVORAN PELVIC GIRDLE: A THREE-DIMENSIONAL MORPHOMETRIC APPROACH

B4 **Cuff, A. R., Randau, M., Pierce, S. E., Hutchinson, J. R., Goswami, A.** RECONSTRUCTING THE EVOLUTIONARY BIOMECHANICS OF THE FELID POSTCRANIUM

B5 **Randau, M., Hutchinson, J. R., Cuff, A. R., Pierce, S. E., Goswami, A.** RECONSTRUCTING THE LOCOMOTORY ECOLOGY OF THE AMERICAN CHEETAH, *MIRACINONYX TRUMANI*, WITH LINEAR AND 3D ANALYSIS OF VERTEBRAL MORPHOLOGY ACROSS LIVING AND FOSSIL CATS

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WEDNESDAY, OCTOBER 14, THROUGH SATURDAY, OCTOBER 17, 2015
POSTER SYMPOSIUM: INSIGHTS FROM 3D-IMAGING BASED ANALYSES OF CARNIVORAMORPHANS AND THEIR RELATIVES: SYSTEMATICS, SINUSES AND SABERTOOTHS (CONTINUED)

B6 **Polly, P., Lawing, A., Bormet, A. K., Fuentes Gonzalez, J.** FORM, FUNCTION, AND CLADE SORTING: A PHYLOGENETIC AND ECOLOGICAL ANALYSIS OF CARNIVORAN TARSAL EVOLUTION USING 3D DATA

B7 **Grohé, C., Rössner, G. E., Spaulding, M.** REALITY OR FANTASY? ASSESSING THE CONDITION OF FOSSIL SPECIMENS WITH CT DATA

B8 **Curtis, A.** FRONTAL SINUS MORPHOLOGICAL DISPARITY IN CARNIVORA

B9 **Pérez-Ramos, A., Martín-Serra, A., Pérez-Claros, J., Shubert, B. W., Pastor, F. J., Figueirido, B.** THE INFLUENCE OF SKULL SHAPE MODULARITY ON INTERNAL STRUCTURES: A 3D-PILOT STUDY USING BEARS (MAMMALIA, CARNIVORA)

B10 **Bird, D. J., Van Valkenburgh, B.** VISUALIZING THE OLFACTORY IMPRINT WITHIN MAMMAL SKULLS: 3D IMAGING AND THE CRYPTIC CRIBRIFORM PLATE

B11 **Spaulding, M., Flynn, J. J., Hughes, E., Pilla, N. J.** CT-IMAGING AND VIRTUAL ENDOCAST RECONSTRUCTION IN CARNIVORAMORPHA (MAMMALIA)

WEDNESDAY, OCTOBER 14, THROUGH SATURDAY, OCTOBER 17, 2015
SVP 2015 EDWIN H. AND MARGARET M. COLBERT PRIZE COMPETITION POSTERS
HYATT REGENCY DALLAS, MARSALIS HALL

AUTHORS WILL BE PRESENT AT THEIR POSTERS: Thursday, October 15, from 4:15 – 6:15 p.m.
Posters must be removed by 6:30 p.m., Saturday, October 17

B12 **Glynn, A., Motani, R.** QUANTITATIVE FRAMEWORK FOR INFERRING DIETS FROM SKULL AND JAW MORPHOLOGY OF EXTANT AND FOSSIL ACTINOPTERYGIANS AND ELASMOBRANCHS

B13 **Hodnett, J. M., Maisey, J. G., Suazo, T., Elliott, D. K., Lucas, S. G.** A NEAR COMPLETE CTENACANTHIFORM SHARK FROM THE MIDDLE PENNSYLVANIAN (MISSOURIAN) TINAJAS MEMBER OF THE ATRASADO FORMATION, CENTRAL NEW MEXICO

B14 **Oreska, M. P., Carrano, M. T., Murch, A. L.** *ALBANERPETON* REMAINS FROM THE LOWER CRETACEOUS CLOVERLY FORMATION WITH IMPLICATIONS FOR THE BIOGEOGRAPHY, ONTOGENY, AND PALEOECOLOGY OF ALBANERPETONTIDS

B15 **Lemberg, J. B., Shubin, N. H., Ross, C. F., Westneat, M. W., Daeschler, E. B.** RECONSTRUCTION OF CRANIAL KINEMATICS IN *TIKTAALIK ROSEAE* WITH INSIGHT INTO THE EVOLUTION OF THE TERRESTRIAL VERTEBRATE FEEDING SYSTEM

B16 **Wosik, M., Evans, D. C.** ONTOGENETIC LONG BONE HISTOLOGY OF *EDMONTOSAURUS ANNECTENS* (ORNITHISCHIA: HADROSAURIDAE) FROM A MONODOMINANT BONEBED

B17 **Moore, A. J., Mo, J., Clark, J., Xu, X.** NEW CRANIAL MATERIAL OF *BELLUSAURUS SUI* (DINOSAURIA: SAUROPODA) FROM THE MIDDLE-LATE JURASSIC SHISHUGOU FORMATION OF CHINA SUPPORTS NEOSAUROPOD AFFINITIES

B18 **Li, Z., Clarke, J. A.** NEW INSIGHT INTO THE ANATOMY OF THE HYOLINGUAL APPARATUS OF *ALLIGATOR MISSISSIPPIENSIS* AND IMPLICATIONS FOR RECONSTRUCTING FEEDING IN EXTINCT ARCHOSAURS

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WEDNESDAY, OCTOBER 14, THROUGH SATURDAY, OCTOBER 17, 2015

SVP 2015 EDWIN H. AND MARGARET M. COLBERT PRIZE COMPETITION POSTERS (CONTINUED)

B19 **Nagesan, R., Anderson, J.** MOBILITY OF THE NECK OF *NICHOLLSSAURA BOREALIS* (PLESIOSAURIA; LEPTOCLEIDIDAE) FROM THE LOWER ALBIAN OF NORTHWESTERN ALBERTA

B20 **Trevethan, I. J.** BODY TEMPERATURE VARIATION OF MOSASAURS (SQUAMATA: MOSASAURIDAE) FROM THE WESTERN INTERIOR SEAWAY OF KANSAS, USA

B21 **Paparella, I., Palci, A., Nicosia, U., Caldwell, M. W.** EXCEPTIONAL SOFT-TISSUE PRESERVATION IN A NEW MARINE PYTHONOMORPH FROM THE UPPER CRETACEOUS (CAMPANIAN) OF SOUTHERN ITALY

B22 **Dickson, B. V., Losos, J. B., Pierce, S. E.** ECOMORPHOLOGICAL CONVERGENCE OF THE SEMICIRCULAR CANALS IN *ANOLIS* LIZARDS

B23 **Viola, P. A., Kemp, A. D., Kirk, E. C., Bhullar, B., Cifelli, R. L., Martínez, R. N., Rougier, G. W., Wallace, R. V., Rowe, T. B.** VESTIBULAR SENSITIVITY IN EXTANT MONOTREMES AND IN MESOZOIC MAMMALIAMORPHS

B24 **Bertrand, O., Silcox, M., Amador-Mughal, F.** *CEDROMUS WILSONI* (CEDROMURINAE, SCIURIDAE): OLDEST SCIURID ENDOCAST AND EARLY BRAIN EVOLUTION IN SQUIRRELS

B25 **Mychajliw, A. M., Cussen, L., Everson, K., Olson, L., Hadly, E. A.** PUTTING THE 'ANCESTOR' IN ANCESTRAL STATE RECONSTRUCTIONS: PHYLOGENIES WITH FOSSIL TIPS REVEAL HIDDEN EVOLUTIONARY PATTERNS IN SMALL MAMMALS

B26 **Leslie, C. E., Peppe, D. J., Atchley, S. C., Williamson, T., Heizler, M., Nordt, L.** REVISED AGE CONSTRAINTS FOR LATE CRETACEOUS TO EARLY PALEOCENE STRATA FROM THE DAWSON CREEK SECTION, BIG BEND NATIONAL PARK, WEST TEXAS, USA

B27 **Lannoye, E., Eberle, J.** A NEW MIDDLE PALEOCENE MAMMALIAN FAUNA FROM THE FORT UNION FORMATION, GREAT DIVIDE BASIN, WYOMING

B28 **Hovatter, B. T., Wilson, G. P.** FAUNAL ANALYSIS OF EARLIEST TORREJONIAN (TO1) MAMMALS FROM NORTHEASTERN MONTANA, USA

B29 **Hilbert-Wolf, H. L., Roberts, E. M., Kane, T., O'Connor, P. M., Stevens, N.** SYNTHESIZING TAPHONOMIC, SEDIMENTOLOGIC, AND GEOCHRONOLOGIC ANALYSES OF THE UPPER OLIGOCENE NSUNGWE FORMATION (RUKWE RIFT BASIN, TANZANIA) TO UNRAVEL EVOLUTIONARY PATTERNS AND ECOLOGICAL CHANGE AMID AN EVOLVING LANDSCAPE

B30 **Cicak, T., Keller, J., McNulty, K., Fox, D.** RODENT DENTAL TOPOGRAPHIC ANALYSIS: THE PROMINENCE OF PREMOLARS

B31 **Burgman, J. E., Ungar, P. S., Leichliter, J. N., Avenant, N. L.** DENTAL MICROWEAR ANALYSIS IN SOUTH AFRICAN RODENTIA AS AN ENVIRONMENTAL PROXY

B32 **El Adli, J. J., Fisher, D. C., Cherney, M. D., Labarca, R., Lacombat, F.** FIRST ANALYSIS OF TUSK GROWTH RATE AND SEASON OF DEATH OF A SOUTH AMERICAN GOMPHOTHERE

B33 **Zurowski, C., Jamniczky, H., Graf, D., Theodor, J.** FUNCTIONAL OCCLUSION IN A RODENT KNOCKOUT MODEL AND IMPLICATIONS FOR MAMMALIAN TOOTH EVOLUTION

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WEDNESDAY, OCTOBER 14, THROUGH SATURDAY, OCTOBER 17, 2015

SVP 2015 EDWIN H. AND MARGARET M. COLBERT PRIZE COMPETITION POSTERS (CONTINUED)

B34 **Whiting, E., Head, J.** PALEOCLIMATE RECONSTRUCTION USING THE VERTEBRATE FOSSIL RECORD: CONSTRAINING TEMPERATURE AND PRECIPITATION HISTORIES OF THE NEOGENE CENTRAL GREAT PLAINS BASED ON THE FOSSIL RECORD OF *ALLIGATOR*

B35 **Garrett, N. D., Fox, D. L., McNulty, K. P., Michel, L., Peppe, D. J.** EARLY MIOCENE PALEOENVIRONMENTS OF RUSINGA ISLAND, KENYA: NEW DATA FROM FOSSIL MAMMALIAN TOOTH ENAMEL STABLE ISOTOPE COMPOSITIONS

B36 **Engelman, R. K., Anaya, F., Croft, D. A.** PALAEOTHENTID MARSUPIALS (MAMMALIA: PAUCITUBERCULATA) FROM THE MIDDLE MIOCENE LOCALITY OF QUEBRADA HONDA, BOLIVIA

B37 **Crites, J. M., Desantis, L.** TEMPORAL VARIABILITY IN THE DIETARY BEHAVIOR OF *CANIS DIRUS* AT THE RANCHO LA BREA TAR PITS

B38 **Jones, D. B., Desantis, L.** DIETARY ECOLOGY OF HERBIVOROUS MEGAFAUNA FROM THE LA BREA TAR PITS IN SOUTHERN CALIFORNIA: EVIDENCE OF CHANGING DIETARY BEHAVIOR COINCIDENT WITH CLIMATE CHANGE

B39 **Taylor, D. S., Brawner, M. D., Terry, R.** UNEARTHING PATTERNS OF NICHE VARIABILITY AND DIET FLEXIBILITY IN GREAT BASIN SMALL MAMMALS THROUGH THE HOLOCENE

B40 **McHorse, B., Pierce, S. E.** CHANGING STRUCTURAL PROPERTIES AND MORPHOLOGY THROUGH EVOLUTIONARY DIGIT REDUCTION IN THE EQUIDAE (PERISSODACTYLA)

B41 **Laing, A., Hedrick, B., Dodson, P.** NEW QUANTITATIVE METHODS FOR DISCRIMINATING POSTURE OF VERTEBRATES BASED ON LONG BONES

B42 **Lungmus, J. K., Angielczyk, K. D., Sidor, C. A., Nesbitt, S. J., Smith, R. M., Steyer, J., Tabor, N. J., Tolan, S.** A NEW CISTECEPHALID DICYNODONT THERAPSIDA, ANAOMODONTIA) FROM THE MID-ZAMBEZI BASIN (ZAMBIA) AND ITS FOSSORIAL ADAPTATIONS

B43 **Fulwood, E. L., Boyer, D. M., Bloch, J. I.** A DIGITAL RECONSTRUCTION OF THE SKELETON OF MIDDLE PALEOCENE *APHRONORUS ORIELI* (PANTOLESTA: PENTACODONTIDAE) AND PALEOBIOLOGICAL INTERPRETATIONS

B44 **Hiramoto, J., Kohno, N.** THE OLDEST DELPHINID FROM THE SERRAVALLIAN OF JAPAN REVEALS THE ORIGIN AND DIVERGENCE OF OCEANIC DOLPHINS (DELPHINIDAE: ODONTOCETI: CETARTIODACTYLA)

B45 **Lanzetti, A., Bianucci, G., Geisler, J.** NEW EVIDENCE AND ANALYSES INDICATE THAT *TURSIOPS OSENNAE* IS A GLOBICEPHALINE (ODONTOCETI, DELPHINIDAE) FROM THE PLIOCENE OF SIENA BASIN (TUSCANY, ITALY)

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WEDNESDAY, OCTOBER 14, 2015

POSTER SESSION I

HYATT REGENCY DALLAS, LANDMARK CIRCLE

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

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

Posters Associated with Symposium 1: Advances in Mid-Cretaceous Paleoecology: Understanding A Major Terrestrial Transition

LC1 **You, H., Suarez, M. B., Suarez, C. A.** DINOSAUR FAUNAL TURNOVERS IN THE EARLY CRETACEOUS OF NORTHERN CHINA

LC2 **Chinzorig, T., Kobayashi, Y., Tsogtbaatar, K., Mahito, W., Rinchen, B., Shigeru, S.** FIRST ORNITHOMIMID (DINOSAURIA) FROM THE DJADOKHTA FORMATION (CAMPANIAN) OF TUGRIKIN SHIRE, MONGOLIA

LC3 **Martin, A. J., Rich, T. H., Vickers-Rich, P., Trusler, P.** TRACE FOSSILS FROM THE VALANGIAN–ALBIAN OF VICTORIA, AUSTRALIA AND WHAT THEY TELL US ABOUT VERTEBRATE ADAPTATIONS IN THE EARLY CRETACEOUS POLAR ENVIRONMENTS

LC4 **Kirkland, J. I., You, H., Alcalá, L., Loewen, M.** A NEAR-CONTINUOUS, WELL-DATED SEQUENCE OF CRETACEOUS TERRESTRIAL FAUNAS: MID-CRETACEOUS FAUNAL CHANGE IN THE NORTHERN HEMISPHERE AS VIEWED FROM UTAH

MARSALIS HALL

SVP 2015 Education and Outreach Poster Session

B46 **Marcy, A.** GO EXTINCT! AN EDUCATIONAL CARD GAME INTRODUCES STUDENTS TO READING EVOLUTIONARY TREES AND ENCOURAGES FURTHER EXPLORATION THROUGH STUDENT-DESIGNED EXPANSIONS

B47 **Denetclaw, U., Williamson, T. E.** INTRODUCING DINOSAURS TO NAVAJO MIDDLE SCHOOL STUDENTS

B48 **Adams, T. L., Koepke, J. H., Gonzalez, R., Azouggagh, D., Price, D., Shaffer, J., Ellis, A., Weissling, D., Choate, J., Wilkinson, H.** MUSEUMS, PARKS, AND DINOSAUR FOOTPRINTS: DEVELOPING PARTNERSHIPS IN PALEONTOLOGY

B49 **Lambert, W. D.** A CLASSROOM METHODOLOGY FOR INVESTIGATING THE POSSIBLE FUTURE EFFECTS OF GLOBAL CLIMATE CHANGE THROUGH STUDENT PALEOCLIMATIC ANALYSIS OF VERTEBRATE AND INVERTEBRATE PALEOFAUNAS

B50 **Levitt-Bussian, C. G., Runburg, M., Butcher, K. R., Collins, T., Hudson, M. A.** LEVERAGING PALEONTOLOGY RESEARCH, COLLECTIONS AND 3D TECHNOLOGIES TO PROMOTE CRITICAL THINKING

B51 **Kerr, T. J., Peek, S. L., Vietti, L. A., Kim, S. L., Clementz, M. T.** THE JUNIOR PALEONTOLOGIST PROGRAM: CHALLENGES AND SOLUTIONS OF DESIGNING AND IMPLEMENTING AN EDUCATIONAL MUSEUM ACTIVITY BOOKLET FOR A BROAD DEMOGRAPHIC

B52 **Thomas, J., Hall, K., Albright, K., Gates, T. A., Zanno, L. E.** "STUDENTS DISCOVER" SHARK TOOTH FORENSICS: A CITIZEN SCIENCE INITIATIVE BRIDGING MIDDLE SCHOOL STUDENTS, TEACHERS, AND PALEONTOLOGISTS

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B53 **MacFadden, B. J., Grant, C.** INTERNATIONAL RESEARCH EXPERIENCE FOR TEACHERS (RET): THE GREAT AMERICAN BIOTIC INTERCHANGE (GABI) IN PANAMA

B54 **Davis, M., Sarro, R., Schreiner, S., Leland, B., Van Den Honert, B., Zwick, R.** SCIENCE IN THE NEWS: ORGANIZING A SUCCESSFUL LECTURE SERIES FOR THE PUBLIC

B55 **Grant, C. A., Moran, S., Perez, V., Tovani, J., Hendrickson, M., Madden, J., Boyer, D. M., MacFadden, B.** PALEOTEACH: STEM INTEGRATION THROUGH PALEONTOLOGY AND 3D TECHNOLOGYB

B56 **Smith, K. M., Clyde, G., Widga, C.** MAMMOTH EXPEDITIONS: AN INNOVATIVE RESEARCH AND COLLABORATION PROGRAM FOR 21ST CENTURY STUDENTS

B57 **Nestler, J. H., Holtz, T. R., Claeson, K. M.** REAL TIME OUTREACH BETWEEN PALEONTOLOGISTS AND THE PUBLIC, THOUSANDS AT A TIME, USING THE MODERATED SCIENCE PLATFORM ASKSCIENCE

B58 **Gutierrez, K. A., Gay, R. J.** USING A HIGH SCHOOL PALEONTOLOGY CLASS TO DOCUMENT THE TERMINAL TRIASSIC PERIOD IN SOUTHEASTERN UTAH

B59 **Toth, N., Seppi, J., Irmis, R., Whittaker, M.** R.O.C.K.S.: REAL OPPORTUNITIES TO CONNECT KIDS WITH SCIENTISTS—A COLLABORATIVE OUTREACH PROGRAM BETWEEN SCIENTISTS, EDUCATORS, AND DIGITAL MEDIA TO BRING PALEONTOLOGY INTO THE CLASSROOM

B60 **Brown, C. M.** A CASE STUDY OF LIVE-TWEETING IN PALAEONTOLOGICAL FIELD RESEARCH

B61 **Dewar, E. W.** PRINCIPLES OF INTEGRATED COURSE DESIGN APPLIED TO COLLEGE COURSES ON VERTEBRATE PALEONTOLOGY AND EVOLUTION

B62 **Williams, S. A., Holtz Jr., T. R., Mathews, J. C., Tremaine, K. M., Brown, B. A., Atteberry, M., Rawlings, S.** UN-CONVENTIONAL SCIENTIFIC OUTREACH: USING SCIENCE FICTION AND MEDIA CONVENTIONS TO PROMOTE PALEONTOLOGY AND NATURAL HISTORY MUSEUMS

B63 **Schein, J. P., Wilson, G. P., Sidor, C. A., Debey, L. B., Poole, J. C., Malinowski, B. L.** TAPPING A NEW SOURCE: THE ANATOMY OF A SUCCESSFUL CROWDFUNDING CAMPAIGN FOR VERTEBRATE PALEONTOLOGY

B64 **Hunt-Foster, R. K., Matthews, N., Breithaupt, B., Lockley, M., Gierlinski, G., Foster, J.** TRAILING DINOSAUR TRACKS IN THE EARLY CRETACEOUS: THE DOCUMENTATION AND PUBLIC INTERPRETATION OF THE MILL CANYON DINOSAUR TRACKSITE, UTAH

B65 **Boyer, D. M., Gunnell, G. F., Kaufman, S., Thostenson, J., Grant, C.** MORPHOSOURCE: AN OPEN-ACCESS, PROJECT-BASED WEB ARCHIVE FOR RESEARCHERS, MUSEUMS, AND PUBLIC TO SHARE AND ACCESS 3D MORPHOLOGICAL DATASETS

B66 **White, L. D., Bean, J. R., Thanukos, A., Frankel, J.** NAVIGATING THE SCIENCE OF GLOBAL CHANGE: INTERACTIVE TOOLS TO ENHANCE STUDENT UNDERSTANDING

B67 **Moran, S. M., MacFadden, B. J., McLaughlin, C. A., Bokor, J., Broo, J., Mahoney, J.** EVOLVING EQUIDS: USING FOSSIL HORSES TO TEACH HIGH SCHOOL SCIENCE

B68 **Colvin, R., Beeck, J., Noto, C.** THE ARLINGTON ARCHOSAUR SITE, A UNIQUE URBAN EXCAVATION AS A SOURCE OF SCIENTIFIC EDUCATION AND PUBLIC OUTREACH IN TEXAS

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B69 **Doucette-Frederickson, J.** TEACHING THE 'E WORD': SCIENCE ANXIETY IN OKLAHOMA EDUCATORS

MARSALIS HALL

Regular Session Posters

B70 **Fleagle, J. G., Gilbert, C. C., Baden, A.** CRANIAL DIVERSITY OF MAMMALS: PAST AND PRESENT

B71 **Bloch, J. I., Chester, S. G., Holroyd, P. A.** POSTCRANIAL MORPHOLOGY OF EARLY EOCENE *CHOCTAWIUS* GIVES NEW INSIGHT ON THE RELATIONSHIP OF MICROSYOPIDS TO OTHER EUARCHONTANS

B72 **Kristjanson, H. L., Perry, J. G.** ESTIMATING BITE FORCE IN NEW PLESIADAPID MATERIAL FROM BERRU, FRANCE (THANETIAN, ELMA) AND CONSIDERATIONS FOR RECONSTRUCTING PLESIADAPIFORM JAW ADDUCTORS FROM EXTANT ANALOGUES

B73 **Everett, C. J., Holroyd, P. A., Ferrer, E. A.** MOLAR MORPHOMETRIC DISPARITY REFLECTS PHYLOGENY MORE THAN DIET IN EARLY EOCENE PRIMATES

B74 **Ramdarshan, A., Marivaux, L., Merceron, G.** DIETARY RECONSTRUCTION OF THREE EOCENE PRIMATES FROM THE SOUTH OF FRANCE

B75 **Atwater, A. L., Kirk, E.** DENTAL VARIABILITY IN *OMOMYS* (PRIMATES, OMOMYOIDEA) AND THE VALIDITY OF *O. LLOYDI*

B76 **Gilbert, C. C., Singh, N. P., Patel, B. A., Fleagle, J. G., Patnaik, R.** NEW SIVALADAPID PRIMATE FROM SUNETAR, A LOWER SIWALIK LOCALITY NEAR THE TOWN OF RAMNAGAR (JAMMU AND KASHMIR, INDIA)

B77 **Pilbro, C. D.** GIANT AYE-AYE (*DAUBENTONIA ROBUSTA*) PALEOECOLOGY AND BIOGEOGRAPHIC RANGE—A PROXY FOR MODERN AYE-AYE CONSERVATION

B78 **Ward, D., Underwood, C. J., Steurbaut, E.** STRATIGRAPHIC CONTEXT AND DATING OF THE MIDDLE AND LATE EOCENE VERTEBRATE LOCALITIES OF THE FAYUM, EGYPT

B79 **Zalmout, I. S., Memesh, A. M., Al-Mufareeh, Y. A., Haptari, M. A., Soubhi, S. S., Bahameem, A. A., Hyland, E. G., Abdulshakoor, A. J., Matari, A. H., Gingerich, P. D.** UJAYFA QUARRY IN THE SHUMAYSI FORMATION OF SAUDI ARABIA YIELDING *SAADANIUS HIJAZENSIS* AND OTHER MID-OLIGOCENE VERTEBRATES

B80 **Cooke, S. B., Tallman, M., Shearer, B. M., Link, A.** VERTEBRATE FAUNAL CHANGE THROUGH TIME IN THE MIDDLE MIOCENE SITE OF LA VENTA, COLOMBIA

B81 **Begun, D. R.** VERY OLD HOMINOID DIVERGENCE DATES BASED ON PALEONTOLOGICAL AND MOLECULAR DATA

B82 **Cote, S., Kingston, J., Kityo, R., Mugume, A., Jenkins, K., Winkler, A., MacLatchy, L.** A NEW EARLY MIOCENE FOSSIL LOCALITY AT NAPAK, UGANDA (~20 MA)

B83 **Bales, A. D.** EVOLUTION OF THE CATARRHINE FORELIMB AND THE PROBLEM OF FOSSIL ATTRACTION IN MORPHOLOGICAL SYSTEMATICS

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B84 **Hock, D.** A COMPREHENSIVE STUDY OF KEY PALEOENVIRONMENTAL CHANGES USING MAJOR FAUNAL TURNOVERS FOCUSING ON THE TURKANA BASIN, KENYA

B85 **Villaseñor, A., Bobe, R.** IS PLIOCENE HOMININ ABUNDANCE MEDIATED BY ECOLOGICAL FACTORS? A CASE STUDY FROM THE AFAR AND TURKANA BASINS, ETHIOPIA AND KENYA

B86 **Hensley-Marschand, B.** PALEOENVIRONMENT AND PALEOCLIMATE OF EARLY ASIAN HOMININS NEAR THEIR NORTHEASTERN RANGE LIMIT IN CHINA

B87 **Terhune, C., Curran, S., Fox, D., Garrett, N., Hubbard, J., Petculescu, A., Robinson, C., Robu, M., Stiuca, E.** PALEOENVIRONMENTAL CONDITIONS IN EARLY PLEISTOCENE ROMANIA: IMPLICATIONS FOR HOMININ DISPERSALS

B88 **Cammidge, T. S., Rankin, B. D., Zurowski, C. J., Sveen, M., Anderson, K., Friesen, A. J., Theodor, J. M.** FAUNAL ANALYSIS OF THE RECENTLY DISCOVERED EOCENE BACTRIAN HILL, REPO MAN AND ROSE CREEK LOCALITIES OF THE CYPRESS HILLS FORMATION, SASKATCHEWAN, WITH ADDITIONS TO SWIFT CURRENT CREEK LOCALITY

B89 **Anderson, D. K.** COMPARISON OF BASIN MARGINS TO BASIN CENTER ASSEMBLAGES REVEALS TAXONOMIC DISPARITY IN LATE EARLY TO MIDDLE EOCENE RODENT BIODIVERSITY

B90 **Coster, P., Beard, K., Aung Naing, S., Chit, S., Chaimanee, Y., Jaeger, J.** POSTCRANIAL MORPHOLOGY OF *PONDAUNGIMYS ANOMALUROPSIS* (RODENTIA, ANOMALUROIDEA) FROM THE LATE MIDDLE EOCENE PONDAUNG FORMATION OF CENTRAL MYANMAR

B91 **López-Antoñanzas, R., Knoll, F., Maksoud, S., Azar, D.** AT THE CROSSROADS BETWEEN ASIA AND AFRICA: PALEOBIOGEOGRAPHIC SIGNIFICANCE OF A NEW CTENODACTYLINE RODENT FROM THE MIOCENE OF LEBANON

B92 **Jiménez-Hidalgo, E., Guerrero Arenas, R., Smith, K. T.** THE OLDEST POCKET GOPHERS (RODENTIA: GEOMYIDAE) IN NORTH AMERICA

B93 **Samuels, J. X., Kraatz, B. P.** REVISED TAXONOMY AND BIOSTRATIGRAPHY OF LAGOMORPHA FROM THE JOHN DAY FORMATION, OREGON

B94 **Ruf, I., Tröscher, A., Maier, W.** SYSTEMATIC AND FUNCTIONAL SIGNIFICANCE OF THE ANTERIOR HINGE OF THE MALLEUS IN LAGOMORPHA (MAMMALIA)

B95 **Moretti, J. A., Johnson, E.** MICRO COMPUTED TOMOGRAPHY PROVIDES INSIGHTS INTO *AZTLANOLAGUS* (MAMMALIA, LAGOMORPHA, LEPORIDAE) REENTRANT PATTERN

B96 **Schubert, A., Ruf, I., Von Koenigswald, W.** ENAMEL ISLETS AND THE DEVELOPMENT OF HYPSODONTY IN FOSSIL AND EXTANT CASTORIDAE (RODENTIA, MAMMALIA)

B97 **Moroz, M., Smiley, T. M., Badgley, C.** VARIATION IN DENTAL MORPHOLOGY OF MODERN AND FOSSIL HETEROMYID ASSEMBLAGES

B98 **Guerrero-Arenas, R., Jimenez-Hidalgo, E., García-Barrera, P., Arroyo-Cabrales, J.** FIRST FOSSIL RECORDS OF MEXICAN RODENTS *PEROMYSCUS DIFFICILIS* AND *NEOTOMODON ALSTONI* IN THE MIXTECA ALTA OF OAXACA, SOUTHERN MEXICO

B99 **Carranza-Castañeda, O.** SOUTH AMERICAN INMIGRANTS FROM THE LATE BLANCAN-IRVINGTONIAN DEPOSITS FROM MEXICO

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B100 **Morgan, G. S., Bloch, J., Derenzis, A., Alicea, J., Perez, V., Denetclaw, U., Rincon, A., MacFadden, B., Wood, A.** MIOCENE RODENTS (SCIURIDAE, JIMOMYIDAE, HETEROMYIDAE, CRICETIDAE) FROM PANAMA

B101 **Bamba, K., Croft, D.** A REASSESSMENT OF THE MIDDLE MIOCENE LAGOSTOMINE CHINCHILLIDS (RODENTIA) OF QUEBRADA HONDA, BOLIVIA

B102 **Biedron, E. M., Hopkins, S. S.** COMPARISON OF UNGULATE AND SCIURID PALEOECOLOGY SUGGESTS SPATIAL AVERAGING IN OREGON LOCALITIES

B103 **Martin, R. A.** RAPID DWARFING IN PLEISTOCENE MUSKRATS OF THE MEADE BASIN FOLLOWING THE LAVA CREEK B ASHFALL

B104 **Calede, J. J., Cairns, K. D.** FIRST EVIDENCE OF A SMOOTH-INCISOR SICISTINE (RODENTIA: DIPODIDAE) IN NORTH AMERICA FROM THE CABBAGE PATCH BEDS OF WESTERN MONTANA

B105 **Longar, A. E., McNulty, K. P., Keller, J. S., Mitchell, J. N., Fox, D. L.** DISTINGUISHING SISTER SPECIES OF *PEROGNATHUS* (MAMMALIA, RODENTIA) USING LANDMARK GEOMETRIC MORPHOMETRICS OF MANDIBULAR SHAPE

B106 **Van Kolfschoten, T., Tesakov, A., Bell, C. J.** FIRST EUROPEAN *PHENACOMYS* (ARVICOLINAE, RODENTIA) AND AN INTEGRATED HIGH-LATITUDE HOLARCTIC BIOTA IN THE EARLY PLEISTOCENE

B107 **Kimura, Y., McDonough, M. M., Hawkins, M. T., Jacobs, L. L., Flynn, L. J., Tomida, Y.** ENHANCED FOSSIL CALIBRATION POINTS FOR MOLECULAR CLOCKS OF MUROID RODENTS

B108 **Deblois, M., Motani, R.** TESTING THE ACCURACY OF FLIPPER OUTLINE RECONSTRUCTION FROM SKELETAL ELEMENTS IN EXTANT TETRAPODS WITH POTENTIAL APPLICATION TO PLESIOSAURS AND ICHTHYOSAURS

B109 **Darcy, H.** ADDITIONAL RESEARCH AND TAXONOMIC RESOLUTION OF SALAMANDERS (AMPHIBIA: CAUDATA) FROM THE MIO-PLIOCENE GRAY FOSSIL SITE, TN

B110 **Clemens, M., Jacobs, L. L., Jacobs, B. B., Currano, E. D., Feseha, M.** A NEW PIPID FROG FROM THE MIOCENE OF ETHIOPIA

B111 **Baez, A. M., Turazzini, G. F., Martinelli, A. G., Jofré, G.** PERSISTENT PRESENCE OF INTRIGUING PIPID FROGS IN THE PLEISTOCENE OF THE PAMPEAN REGION OF ARGENTINA

B112 **Blain, H., Delfino, M., Prikryl, T., Berto, C., Arzarello, M.** NEW DATA FOR THE PALAEOBIOGEOGRAPHICAL HISTORY OF THE GENUS *PELOBATES* (AMPHIBIA, ANURA) IN ITALY

B113 **Vaughn, M., Foster, J. R., Nydam, R. L., Heckert, A. B., Hunt-Foster, R. K.** NEWLY REPORTED LISSAMPHIBIAN AND SQUAMATE TAXA FROM THE WILLIAMS FORK FORMATION (UPPER CRETACEOUS: CAMPANIAN), COLORADO: CLOSING THE GAP

B114 **Dilkes, D.** '*DISSOROPHUS*' *ANGUSTUS* (TEMNOSPONDYLI, DISSOROPHOIDEA) AND INCREASING VARIABILITY OF DISSOROPHID OSTEODERMS

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B115 **Steyer, J., Angielczyk, K. D., Sidor, C. A., Nesbitt, S. J., Smith, R. M., Peecook, B. R., Beightol, C. V., Tabor, N. J., Tsuji, L. A., Tolan, S.** THE AMPHIBIANS AWAKEN: NEW TEMNOSPONDYLS FROM TANZANIA AND ZAMBIA ILLUSTRATE CHANGES IN AMPHIBIAN DIVERSITY BEFORE AND AFTER THE MOTHER OF MASS EXTINCTIONS

B116 **Modesto, S. P., Reisz, R. R., MacDougall, M. J., Scott, D. M.** SKELETAL ANATOMY OF THE OLDEST KNOWN PARAREPTILE FROM THE UPPER CARBONIFEROUS OF PRINCE EDWARD ISLAND, CANADA

B117 **Wood, T. A., Nesbitt, S. J.** HOW DID THE OLDEST ARCHOSAURS OF NORTH AMERICA GROW?

B118 **Cerio, D. G., Ridgely, R., Witmer, L. M.** THE EYES HAVE IT: BOUNDING ESTIMATES OF EYE SIZE IN DINOSAURS WITH SOFT TISSUE RECONSTRUCTION AND THE EXTANT PHYLOGENETIC BRACKET APPROACH

B119 **Gee, B., Augustine, E., Chiappe, L., Schmitz, L.** THE IMPORTANCE OF SENSITIVITY ANALYSES FOR THE INFERENCE OF FUNCTION FROM STRUCTURE

B120 **Metz, E. T., Druckenmiller, P. S., Carr, G.** A NEW THALATTOSAUR FROM THE VESTER FORMATION (CARNIAN) OF CENTRAL OREGON, USA

B121 **Li, Z., Jiang, D., Rieppel, O., Motani, R., Tintori, A., Sun, Z.** A NEW SPECIES OF *XINPUSAURUS* (REPTILIA: THALATTOSAURIA) FROM THE MIDDLE TRIASSIC OF SOUTHWESTERN CHINA

B122 **Zhou, M., Jiang, D., Motani, R., Ji, C.** FORELIMB DIMORPHISM IN MIXOSAURIDS FROM THE ANISIAN GUANLING FORMATION OF PANXIAN, GUIZHOU

B123 **Druckenmiller, P. S., May, K., McCarthy, P., Fowell, S., Blodgett, R.** AGE, DEPOSITIONAL ENVIRONMENTS AND PALEOECOLOGY OF ALASKA'S OLDEST DINOSAUR FOSSILS FROM THE JURASSIC NAKNEK FORMATION

B124 **Myhrvold, N. P.** MAXIMUM GROWTH RATE DOES NOT DETERMINE DINOSAUR METABOLISM

B125 **Templeman, T., Moore, J., Atudorei, N., Varricchio, D.** STABLE ISOTOPE EVIDENCE FOR DINOSAUR ECOLOGY FROM CAMPANIAN EGGSHELL AT THE EGG MOUNTAIN LOCALITY, WESTERN MONTANA, USA

B126 **Tanaka, K., Zelenitsky, D. K., Saegusa, H., Ikeda, T., Debuhr, C. L., Therrien, F.** A DIVERSE FOSSIL EGGSHELL ASSEMBLAGE FROM THE LOWER CRETACEOUS SASAYAMA GROUP IN THE HYOGO PREFECTURE OF JAPAN REVEALS THE PRESENCE OF PREVIOUSLY UNKNOWN SMALL THEROPODS

B127 **Woodward, H. N., Rich, T. H., Vickers-Rich, P.** AN ONTOGENETIC HISTOANALYSIS OF POLAR DINOSAURS FROM VICTORIA, AUSTRALIA

B128 **Therrien, F., Zelenitsky, D. K., Quinney, A., Tanaka, K.** CONCRETIONARY DINOSAUR TRACKS FROM THE UPPER CRETACEOUS BELLY RIVER GROUP OF ALBERTA, CANADA: NEW MODE OF FOOTPRINT PRESERVATION IMPLIES WIDESPREAD OCCURRENCE OF UNRECOGNIZED TRACKS

B129 **Lockley, M., Xing, L., Li, R., Li, J., Matsukawa, M.** THE VALUE OF TETRAPOD TRACKS IN PALEOECOLOGICAL CENSUS STUDIES: EXAMPLES FROM THE CRETACEOUS OF CHINA

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WEDNESDAY, OCTOBER 14, 2015
POSTER SESSION I (CONTINUED)

B130 **Tanoue, K., Tatehata, J.** NEW INSIGHTS INTO THE DIVERSITY OF DINOSAURS FROM THE LOWER CRETACEOUS KANMON GROUP, SOUTHWESTERN JAPAN

B131 **Masuda, R., Saneyoshi, M., Ishigaki, S., Nishido, H., Tsogtobaatar, K.** STRATIGRAPHIC ASSIGNMENT OF DINOSAUR-BEARING EOLIAN SEDIMENTS IN THE GOBI DESERT, MONGOLIA AND ITS APPLICATION FOR A PROGRAM OF DINOSAUR-FOSSIL PROTECTION FROM ILLEGAL ACTIVITIES

B132 **Ridgwell, N. M., Chin, K., Upchurch, G., Sertich, J.** RARE DIRECT EVIDENCE OF ANGIOSPERM CONSUMPTION BY DINOSAURS BASED ON COPROLITES FROM THE KAIPAROWITS FORMATION OF UTAH

B133 **Lomax, D. R., Massare, J. A.** NEW SPECIES OF *ICHTHYOSAURUS* (REPTILIA: ICHTHYOSAURIA) FROM THE UPPER TRIASSIC-LOWER JURASSIC OF SOMERSET, U.K.

B134 **Kelley, N. P., Pyenson, N. D., Little, H., Depolo, P., Noble, P. J., Blundell, J.** BRINGING A TRIASSIC DEATH ASSEMBLAGE TO LIFE WITH PHOTOGRAMMETRY: DIGITIZING BERLIN-ICHTHYOSAUR STATE PARK

B135 **Lin, W., Ji, C., Jiang, D., Rieppel, O., Motani, R., Tintori, A., Sun, Z.** POSTCRANIAL DIFFERENCES BETWEEN *NOTHOSAURUS* AND *LARIOSAURUS* (SAUROPTERYGIA: NOTHOSAURIDAE) REVEALED BY THE NEW SPECIMENS FROM THE MIDDLE TRIASSIC OF SOUTHWESTERN CHINA

B136 **Sato, T., Zhao, L., Li, C., Xu, L., Wu, X.** ONTOGENY OF *YUNGUISAURUS* (SAUROPTERYGIA; PISTOSAUROIDEA)

B137 **Jiang, D., Lin, W., Rieppel, O., Motani, R., Tintori, A., Sun, Z.** A NEW ANISIAN (MIDDLE TRIASSIC) EOSAUROPTERYGIAN FROM PANXIAN, GUIZHOU PROVINCE, SOUTHWESTERN CHINA

B138 **Liu, X., Lin, W., Jiang, D., Rieppel, O., Sun, Z.** A NEW SPECIMEN OF *DIANDONGOSAURUS ACUTIDENTATUS* (SAUROPTERYGIA) FROM THE MIDDLE TRIASSIC OF YUNNAN, CHINA

B139 **Witzmann, F., Brainerd, E.** A REVISED SCENARIO OF CO_2 ELIMINATION IN EARLY TETRAPODS—INFERENCES FROM OSTEOLOGICAL CORRELATES OF GILLS, SKIN, AND LUNG VENTILATION

B140 **Turner, M. L., Sidor, C., Tsuji, L.** REMOVING ASSUMPTIONS OF ANATOMICAL ORIENTATION FROM CLADISTIC CHARACTERS: AN EXAMPLE FROM PAREIASAURS

B141 **Bridges, T. K., Schweitzer, M., Moyer, A.** ACTUALISTIC EXPERIMENTAL MODEL FOR THE PRESERVATION OF SKIN IN EXTINCT ARCHOSAURS

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THURSDAY MORNING, OCTOBER 15, 2015
ROMER PRIZE SESSION
HYATT REGENCY DALLAS, LANDMARK AB
MODERATOR: David Fox

8:00 **Anné, J.** PHYSIOLOGY OF EXTANT AND FOSSIL BONE USING SYNCHROTRON-BASED ANALYSIS

8:15 **Atterholt, J.** A STUDY OF THE INFLUENCE OF POST-NATAL DEVELOPMENT ON AVIAN EVOLUTION

8:30 **Borths, M. R.** THE PHYLOGENETIC RELATIONSHIPS AND BIOGEOGRAPHY OF HYAENODONTIDA: USING THE AFRO-ARABIAN RECORD TO EXPAND CHARACTER AND TAXON SAMPLING

THURSDAY MORNING, OCTOBER 15, 2015
ROMER PRIZE SESSION (CONTINUED)

8:45 **Bourke, J.** RECONSTRUCTING THE DIVERSITY OF NASAL ANATOMY AND AIRFLOW IN DINOSAURS WITH IMPLICATIONS FOR PHYSIOLOGY AND ECOLOGY

9:00 **Chen, M.** NON-ANALOG ECOLOGICAL STRUCTURE OF EARLY CRETACEOUS JEHOL MAMMAL COMMUNITIES

9:15 **Cherney, M. D.** SHIFT IN WEANING AGE SUPPORTS HUNTING-INDUCED EXTIRPATION OF SIBERIAN WOOLLY MAMMOTHS (*MAMMUTHUS PRIMIGENIUS*)

9:30 **Fraser, D.** CLIMATE AND MACROEVOLUTION DRIVE TRENDS IN NORTH AMERICAN CENOZOIC MAMMAL PHYLOGENETIC COMMUNITY ASSEMBLY

9:45 **Gold, M. L.** EVOLUTION OF THE FLIGHT-READY BRAIN IN THEROPOD DINOSAURS THROUGH NOVEL HIGH RESOLUTION IMAGING SYSTEMS

10:00 **BREAK**

10:15 **Halliday, T. J.** PALEOCENE PLACENTALS AND THE POST-CRETACEOUS RADIATION OF MAMMALS

10:30 **Kemp, M. E.** CONSERVATION PALEOBIOLOGY AS THE LENS FOR VIEWING THE FUTURE: CARIBBEAN LIZARDS AS A CASE STUDY

10:45 **Pineda-Munoz, S.** MULTI-PROXY DENTAL MORPHOLOGY ANALYSIS: A NEW APPROACH FOR INFERRING DIET

11:00 **Poole, K.** PHYLOGENY OF IGUANODONTIA (DINOSAURIA: ORNITHISCHIA) AND BIOMECHANICAL ANALYSIS OF THE CARPUS-DIGIT I COMPLEX

11:15 **Pritchard, A.** RESOLVING THE FIRST RADIATION OF CROWN REPTILES

11:30 **Stiegler, J.** PHYLOGENY AND CHRONOLOGY OF ARCHOSAUR RESPIRATORY AND PNEUMATIC INNOVATION SUGGESTS A COMMON MECHANISM FOR TRIASSIC-EARLY JURASSIC FAUNAL TURNOVER

11:45 **Tsai, H. P.** THE HIP JOINT FUNCTIONAL MODULE AND ITS SIGNIFICANCE IN THE EVOLUTION OF AVIAN LOCOMOTOR POSTURE

12:00 **Urban, D.** MECHANISMS BEHIND THE EVOLUTION OF THE DEFINITIVE MAMMALIAN MIDDLE EAR: INSIGHTS FROM DEVELOPMENT AND PALEONTOLOGY

THURSDAY MORNING, OCTOBER 15, 2015
TECHNICAL SESSION VI
HYATT REGENCY DALLAS, LANDMARK C
MODERATORS: Erin Maxwell and Nic Campione

8:00 **Randle, E. L., Sansom, R.** RECONSTRUCTING RELATIONSHIPS OF FOSSIL JAWLESS FISH (PTERASPIDIFORMES, HETEROSTRACI)

8:15 **Ahlberg, P., Chen, D., Blom, H., Sanchez, S.** THE ORIGIN OF THE OSTEICHTHYAN DENTITION: NEW DATA FROM THE SILURIAN VERTEBRATES *ANDREOLEPIS* AND *LOPHOSTEUS*

8:30 **Zhu, Y., Zhu, M., Ahlberg, P.** A NEW SILURIAN PLACODERM PROVIDES INSIGHT INTO EARLY EVOLUTION OF EYES IN JAWED VERTEBRATES

8:45 **Bronson, A. W., Maisey, J. G.** JAW SUSPENSION OF THE XENACANTH *ORTHACANTHUS TEXENSIS* – WHAT PHYLOGENETIC INFORMATION CAN CHONDRICHTHYAN JAWS PROVIDE?

THURSDAY MORNING, OCTOBER 15, 2015

TECHNICAL SESSION VI (CONTINUED)

9:00 **Gibson, S. Z.** MULTIDENTICULATE TEETH IN TRIASSIC FISH *HEMICALYPTERUS WEIRI* (OSTEICHTHYES: ACTINOPTERYGII): EVIDENCE FOR A SPECIALIZED FEEDING NICHE IN THE MESOZOIC

9:15 **Maxwell, E., Dick, D.** VERTEBRATE DIVERSITY AND OCEANIC ANOXIA IN THE POSIDONIA SHALE OF THE SOUTHWEST GERMAN BASIN (LOWER TOARCIAN, LOWER JURASSIC)

9:30 **Liu, J., Wilson, M. V., Murray, A. M.** GROWTH RATES DURING ONTOGENY OF EARLY EOCENE CATOSTOMIDS FROM BRITISH COLUMBIA, CANADA

9:45 **Claeson, K. M., Sarr, R., Hill, R. V., Sow, E., Malou, R., O'Leary, M. A.** NEW FOSSIL SCOMBRID (PELAGIA: SCOMBRIDAE) FISHES PRESERVED AS PREDATOR AND PREY FROM THE EOCENE OF SENEGAL

10:00 BREAK

10:15 **Criswell, K. E., Coates, M. I., Gillis, J.** EVOLUTION AND DEVELOPMENT OF THE CHONDRICHTHYAN VERTEBRAL COLUMN: THE EMBRYONIC ORIGIN OF CENTRA

10:30 **Campione, N., Gates, T., Kear, B., Blom, H., Ahlberg, P.** ECOLOGICAL AND PHYLOGENETIC CONSTRAINTS ON THE DENTAL MORPHOLOGY OF SHARKS

10:45 **Peart, S., Gates, T. A., Campione, N. E.** PHYLOGENETIC PREDICTIVE BODY SIZE ESTIMATES OF EXTINCT SHARKS

11:00 **Coates, M., Criswell, K., Tietjen, K., Olsen, A., Westneat, M.** *TRISTYCHIUS*: ADVANCED JAWS IN AN EARLY ELASMOBRANCH

11:15 **Pruitt, J., Tapanila, L., Wilga, C.** RETHINKING EDESTOID JAWS AND SPECIES WITH LARGE DATA SETS

11:30 **Underwood, C. J., Smith, M. M., Johanson, Z., Riley, A., Fraser, G., Kriwet, J.** TOOTH-LIKE STRUCTURES ON THE ROSTRUM OF THE CRETACEOUS BATOID *SCHIZORHIZA*.

11:45 **Miyashita, T., Fanti, F., Minelli, D., Larocca Conte, G.** AN EXCEPTIONALLY PRESERVED EOCENE SHARK AND THE RISE OF MODERN PREDATOR-PREY INTERACTIONS IN THE CORAL REEF FOOD WEB

12:00 **Motani, R., Wainwright, P. C.** PHYSIOLOGICAL CONSTRAINTS ON THE HIGHEST PALEOTEMPERATURE RECORDED BY VERTEBRATE FOSSILS 1: LIFECYCLE CONSTRAINTS

THURSDAY MORNING, OCTOBER 15, 2015

PREPARATORS' SESSION

HYATT REGENCY DALLAS, LANDMARK D

MODERATORS: Ronald Tykoski and William Simpson

8:00 **Smith, M. E., Parker, W. G., Marsh, A. D.** OBSERVATIONS ON PROSPECTING FOR FOSSILS IN EXPANDING CLAYS

8:15 **Balcarcel, A. M.** CONSOLIDATION OF WET AMAZONIAN SPECIMENS USING PRIMAL/RHOPLEX WS 24: FIELD AND LABORATORY APPLICATIONS

8:30 **Policelli, P., De Blieux, D., Kirkland, J., Madsen, S., Gray, D., Cross, J.** EXCAVATION AND COLLECTION OF A NINE-TON FIELD JACKET CONTAINING FOSSILS OF NUMEROUS IGUANODONT AND *UTAHRAPTOR* DINOSAURS FROM THE EARLY CRETACEOUS YELLOW CAT MEMBER OF THE CEDAR MOUNTAIN FORMATION IN EASTERN UTAH

THURSDAY MORNING, OCTOBER 15, 2015

PREPARATORS' SESSION (CONTINUED)

8:45 **Fair, M. R., May, P. J., Jabo, S. J., May, A. S.** THE RIGGING TECHNIQUES IMPLEMENTED FOR THE DE-INSTALLATION OF THREE CHALLENGING PLAQUE MOUNTS AT THE SMITHSONIAN INSTITUTION NATIONAL MUSEUM OF NATURAL HISTORY

9:00 **Lee, V., Balcarcel, A., West, A. R.** COMPARISON OF QUANTITATIVE ASSESSMENT METHODS FOR POLYMER CONSOLIDANT PENETRATION ON ROCK AND FOSSIL SUBSTRATES

9:15 **Cavigelli, J.** DESIGN AND USE OF A LARGE ADJUSTABLE TENT FOR DOING AIR ABRASIVE WORK ON LARGE DINOSAUR SPECIMENS

9:30 **Avrahami, H. M., Heckert, A. B., Martin, L.** COMPARISON OF NESTED SIEVES, TRADITIONAL SCREEN BOXES, AND PAINT SIEVES FOR THE RECOVERY OF MICROVERTEBRATE FOSSILS

9:45 **Salazar, R., Maybee, M.** PREPARATION OF DESICCATED IVORY: CASE STUDY OF *MAMMUT AMERICANUM*

10:00 **BREAK**

10:15 **Herbel, C. L., Pollaehne, N.** BRINGING A CONCRETE DINOSAUR SKELETON BACK TO LIFE

10:30 **Davies, K. L., Stowe, G. R.** VIRTUAL *AQUILOPS*: DIGITALLY RECONSTRUCTING A TINY CERATOPSIAN

10:45 **Browne, I. D.** A RELATIVELY INEXPENSIVE METHOD TO PRODUCE GOOD QUALITY PHOTOGRAMMETRIC MODELS OF VERTEBRATE MICROFOSSILS IN THE 1–2 MM SIZE RANGE

11:00 **Sadleir, R. W., Shinya, A.** GETTING 2D X-RAY SYSTEMS TO YIELD 3D IMAGES VIA CONE BEAM COMPUTED TOMOGRAPHY

11:15 **Keillor, T., Conroy, L., Sereno, P.** DIGITAL TO PHYSICAL: CONSIDERATIONS FOR FABRICATION OF PALEONTOLOGICAL REPLICAS FROM DIGITAL FILES

11:30 **Withdrawn**

11:45 **Yarborough, V. L., Fox, M.** MULTI-PART STORAGE JACKET FOR LARGE VERTEBRATE FOSSILS

12:00 **Benton, R. C., Starck, E. N., Varela, P. J., Moxness, L. D.** THE BADLANDS NATIONAL PARK FOSSIL PREPARATION LAB: BUILDING RELATIONSHIPS WITH POSITIVE OUTCOMES

THURSDAY AFTERNOON, OCTOBER 15, 2015

TECHNICAL SESSION VII

HYATT REGENCY DALLAS, LANDMARK AB

MODERATORS: Caleb Brown and Mike Burns

1:45 **Burns, M. E.** INTRASPECIFIC VARIATION IN LATE CRETACEOUS NODOSAURIDS (ANKYLOSAURIA: DINOSAURIA)

2:00 **Barta, D. E., Norell, M. A.** NEW SPECIMENS OF *HAYA GRIVA*: IMPACTS OF NOVEL ANATOMICAL INFORMATION AND SPECIMEN-LEVEL ANALYSIS ON ORNITHISCHIAN DINOSAUR PHYLOGENY

2:15 **Sartin, C. E., McDonald, A., Kirkland, J.** OSTEOHISTOLOGY SUGGESTS ONE IGUANODONT TAXON IN THE LOWER YELLOW CAT MEMBER OF THE CEDAR MOUNTAIN FORMATION (CRETACEOUS), UTAH

THURSDAY AFTERNOON, OCTOBER 15, 2015
TECHNICAL SESSION VII (CONTINUED)

2:30 **Crystal, V., Fricke, H., Sertich, J., Miller, I.** FOCUSING ON THE FLOODPLAIN: VARIATIONS IN HADROSAURID BEHAVIOR, SOIL PROCESS, AND FOREST STRUCTURE OVER THE LATE CRETACEOUS LANDSCAPE OF WESTERN NORTH AMERICA

2:45 **Leblanc, A. R., Evans, D. C., Reisz, R. R.** TIMING IS EVERYTHING: HETEROCHRONY AND THE EVOLUTION OF THE HADROSAURID DENTAL BATTERY

3:00 **Freedman Fowler, E. A.** ANAGENESIS AND ONTOGENY OF HADROSAURINE DINOSAURS IN THE CAMPANIAN (LATE CRETACEOUS) WESTERN INTERIOR OF NORTH AMERICA: TWO NEW TRANSITIONAL TAXA FROM THE JUDITH RIVER FORMATION OF MONTANA

3:15 **Gates, T. A.** MACROEVOLUTIONARY TRENDS IN THE PREORBITAL SKULL REGION OF ORNITHOPOD (ORNITHISCHIA) DINOSAURS

3:30 **Hedrick, B.** QUANTIFYING THE IMPACT OF DIAGENETIC DEFORMATION OF DINOSAUR FOSSILS ON GEOMETRIC MORPHOMETRICS STUDIES

3:45 **Evans, D. C., Ryan, M.** A NEW CENTROSAURINE CERATOPSID FROM THE OLDMAN FORMATION (MIDDLE CAMPANIAN), ALBERTA, CANADA, AND THE EVOLUTION OF CERATOPSID NASAL ORNAMENTATION

4:00 **Brown, C. M., Henderson, D. M.** CONVERGENT EVOLUTION IN HORNED DINOSAUR CRANIAL ORNAMENTATION (ORNITHISCHIA: CERATOPSIDAE) REVEALED BY A NEW MAASTRICHTIAN CHASMOSAUR

THURSDAY AFTERNOON, OCTOBER 15, 2015
TECHNICAL SESSION VIII
HYATT REGENCY DALLAS, LANDMARK C
MODERATORS: Samantha Hopkins and Adam Hartstone-Rose

1:45 **Furbish, R. M., Berta, A.** SOMETHING OLD, SOMETHING NEW, SOMETHING SWIMMING IN THE BLUE: AN ANALYSIS OF THE MIOCENE PINNIPED *ALLODEMUS*, ITS PHYLOGENETIC POSITION AND SWIMMING MODE

2:00 **Hopkins, S. S., Chiono, A. J., Price, S. A.** CARNASSIAL TOOTH MORPHOLOGY IS STRUCTURED BOTH BY ECOLOGY AND PHYLOGENY AMONG MAMMALIAN CARNIVORES (MAMMALIA: CARNIVORA)

2:15 **Hartstone-Rose, A., Brown, K. N., Drayton, K. D., Leischner, C. L., Antonelli, T.** THE DIVERSE DIETS OF THE MIO-PLIOCENE CARNIVORANS OF LANGEBAANWEG, SOUTH AFRICA

2:30 **Smith, G. J., Graham, R. W., Desantis, L., Donohue, S. L.** BERGMANN'S RESPONSE AND DIETARY VARIABILITY IN NORTH AMERICAN BLACK BEARS (*URSUS AMERICANUS*)

2:45 **Manafzadeh, A. R., Holroyd, P. A., Rankin, B. D.** USING THE GEOMETRIC PROPERTIES OF JAWS TO CONSTRAIN DIETARY RECONSTRUCTIONS OF EOCENE FAUNIVORES

3:00 **Wroe, S., Coates, G., Attard, M., Clausen, P., Sherratt, E., Klinkhamer, A., Tseng, J., Emerson, L.** THE RELATIONSHIP BETWEEN PREY SIZE AND CRANIAL STRESS IN TERRESTRIAL MAMMALIAN CARNIVORES

3:15 **Madern, A.** WHERE'S DINNER? VARIATION IN CARNIVORE DISTRIBUTIONAL RESPONSES TO VALLESIAN FAUNAL TURNOVER

THURSDAY AFTERNOON, OCTOBER 15, 2015
TECHNICAL SESSION VIII (CONTINUED)

3:30 **Van Valkenburgh, B., Hayward, M. W., Ripple, W. J., Meloro, C., Roth, V. L.** THE IMPACT OF LARGE TERRESTRIAL CARNIVORES ON PLEISTOCENE ECOSYSTEMS

3:45 **Orcutt, J. D.** ECOMORPHOLOGY OF AUSTRALIAN CARNIVORE GUILDS

4:00 **Solé, F., Godinot, M., Laurent, Y., Smith, T.** EVOLUTION OF THE EUROPEAN MESONYCHID MAMMALS, AND THEIR BEARINGS ON THE EUROPEAN PALEOECOSYSTEMS AND BIOSTRATIGRAPHY

THURSDAY AFTERNOON, OCTOBER 15, 2015
TECHNICAL SESSION IX
HYATT REGENCY DALLAS, LANDMARK D
MODERATORS: Brian Rankin and Thomas Cullen

1:45 **Smith, S. M., Wilson, G. P.** SPECIES DELIMITATION IN THE PROBLEMATIC CRETACEOUS–PALEOGENE GENUS *MESODMA* (MULTITUBERCULATA, NEOPLAGIAULACIDAE) AND THE IMPORTANCE OF DIFFERENTIAL TAXONOMIC DIAGNOSES

2:00 **Hoffmann, S., Krause, D. W., Kirk, E. C.** INNER EAR MORPHOLOGY OF A NEW LATE CRETACEOUS MALAGASY MAMMAL INDICATES CONVERGENCE IN COCHLEAR EVOLUTION

2:15 **Grossnickle, D. M.** JAW AND MOLAR MORPHOLOGIES IN EARLY MAMMALS EVOLVED IN CONCERT TO ALLOW INCREASED OCCLUSAL COMPLEXITY

2:30 **Lautenschlager, S., Gill, P., Fagan, M., Rayfield, E. J.** MORPHOLOGICAL EVOLUTION OF THE MAMMALIAN JAW ADDUCTOR COMPLEX

2:45 **Rankin, B. D., Vavrek, M. J., Holroyd, P. A., Theodor, J. M.** PATTERNS OF DIVERSITY AMONG LATEST CRETACEOUS MAMMALIAN ASSEMBLAGES FROM NORTH AMERICA

3:00 **Varricchio, D. J., Moore, J. R., Jackson, F. D., Wilson, G. P.** RETURN TO EGG MOUNTAIN: AN EXCEPTIONAL RECORD OF LATE CRETACEOUS TERRESTRIAL PALEOECOLOGY FROM THE TWO MEDICINE FORMATION OF MONTANA, USA

3:15 **Cullen, T. M., Evans, D. C., Ryan, M. J., Currie, P. J.** NEW DATA ON DINOSAUR FAUNAL TURNOVER AND EXTINCTION TIMING IN THE DINOSAUR PARK FORMATION (LATE CRETACEOUS: CAMPANIAN) OF ALBERTA, CANADA

3:30 **Williams, S. A., D'Emic, M. D., Bennett, S., Mathews, J. C., Tremaine, K. M., Bhattacharya, J. P.** A NEW TERRESTRIAL VERTEBRATE FAUNA FROM THE LATE CRETACEOUS FERRON SANDSTONE OF NORTH AMERICA

3:45 **Rogers, R., Curry Rogers, K., Carrano, M.** PATTERNS OF PRESERVATION IN ANCIENT COASTAL WETLANDS: TAPHONOMY OF VERTEBRATE MICROFOSSIL BONEBEDS IN THE UPPER CRETACEOUS (CAMPANIAN) JUDITH RIVER FORMATION, MONTANA

4:00 **Gatesy, S., Falkingham, P.** AN IN-DEPTH LOOK AT 'SHALLOW' DINOSAUR TRACKS

THURSDAY, OCTOBER 15, 2015

POSTER SESSION II

HYATT REGENCY DALLAS, LANDMARK CIRCLE

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

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

Posters associated with Preparator's Session

LC1 **Cavin, J. L.** MAKING A PERMANENT BASE FOR A THIN FOSSIL USING EPOXY

LC2 **Pinsdorf, M., Jabo, S., Kroehler, P., Miller, M. T., Wagner, D. E., Zdinak, A., Giterman, A.** ARMATURES OLD AND NEW FOR VERTEBRATE FOSSIL MOUNTS IN THE FOSSIL HALLS OF THE NATIONAL MUSEUM OF NATURAL HISTORY

LC3 **Rhue, V. R.** DESIGNING A HOLISTIC INTERNSHIP FOR UNDERGRADUATE STUDENTS IN COLLECTIONS CARE

LC4 **Bastiaans, D., Guliker, M. D., Brinkman, D. L., Schulp, A. S.** RESTORING A RESTORED RESTORED *TRICERATOPS* '? *BREVICORNUS*' SKULL FROM THE LANCE FORMATION, WYOMING, USA

LC5 **Birthisel, T. A.** PLASTERED: AN EXAMINATION OF UNORTHODOX JACKETING MATERIALS

MARSALIS HALL

Regular Session Posters

B46 **Santos, G., Parham, J. F., Beatty, B. L.** THE MOST ONTOGENETICALLY ADVANCED SPECIMEN OF *DESMOSTYLUS* AND IMPLICATIONS FOR ONTOGENY AND SENESCENCE OF DESMOSTYLIANS

B47 **Beatty, B. L.** POLYMORPHISMS, OCCLUSAL OPTIMIZATION, AND MORPHOLOGICAL INTEGRATION OF THE POSTCANINE DENTITION OF *DESMOSTYLUS HESPERUS* (ORDER DESMOSTYLIA)

B48 **Kohno, N., Fiorillo, A. R., Jacobs, L. L., Chiba, K., Kimura, Y., Kobayashi, Y., Nishida, Y., Polcyn, M. J., Tanaka, K.** DESMOSTYLIAN REMAINS FROM UNALASKA (USA)

B49 **Uno, H., Kimura, M.** TWO MORPHOLOGICAL TYPES IN LOWER MOLARS OF PALEOPARADOXIID FROM THE MIDDLE MIOCENE TONOKITA FORMATION IN AKAN, HOKKAIDO, JAPAN

B50 **Semprebon, G. M., Sanders, W., Lister, A. M., Morgan, M. E., Cerling, T. E., Rivals, F., Göhlich, U., Fahlke, J. M.** DIETARY RECONSTRUCTION OF FOSSIL PROBOSCIDEANS FROM THE SIWALIK SERIES OF PAKISTAN USING ENAMEL MICROWEAR AND CARBON ISOTOPES

B51 **Sanders, W. J., Bibi, F., Beech, M. J., Fox, M., Hill, A.** TAXONOMIC, DEVELOPMENTAL, AND EVOLUTIONARY IMPLICATIONS OF MORPHOLOGICAL EVALUATION OF ARCHAIC LATE MIOCENE ELEPHANTS FROM THE BAYNUNAH FORMATION, ABU DHABI EMIRATE, UNITED ARAB EMIRATES

B52 **Al-Mufareeh, Y. A., Memesh, A. M., Haptari, M. A., Soubhi, S. A., Bahameem, A. A., Al-Massari, A. M., Matari, A. H., Zalmout, I. S.** THE LAST PLEISTOCENE ELEPHANT OF THE NAFUD DESERT, NORTHWESTERN SAUDI ARABIA

B53 **Scott, E., Cumo, D., Atterholt, J., Springer, K.** FIRST EVIDENCE OF CO-OCCURRING *MAMMUTHUS MERIDIONALIS* AND *M. COLUMBI* FROM VICTORVILLE, WESTERN MOJAVE DESERT, CALIFORNIA

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B54 **Secord, R., Williamson, T. E., Brusatte, S. L., Peppe, D. J.** STABLE ISOTOPE PALEOECOLOGY OF A DIVERSE LATE TORREJONIAN (EARLY PALEOCENE) MAMMALIAN FAUNA FROM THE SAN JUAN BASIN, NEW MEXICO

B55 **Montellano Ballesteros, M., Fox, R. C.** A NEW SPECIES OF THE PHENACODONTID CONDYLARTH *ECTOCION*, FROM THE GAO MINE LOCALITY, (LATE PALEOCENE), PASKAPOO FORMATION, ALBERTA, CANADA

B56 **Poust, A. W.** HOW DID THE ARCHAIC UNGULATE *MENISCOTHERIUM* GROW? BONES AND TEETH TELL DIFFERENT TALES

B57 **Shelley, S. L., Williamson, T. E., Brusatte, S. L.** RESOLVING THE HIGHER-LEVEL PHYLOGENETIC RELATIONSHIPS OF "TRIISODONTIDAE"("CONDYLARTHRA") WITHIN PLACENTALIA

B58 **Burger, B. J.** THE SYSTEMATIC POSITION OF THE SABER-TOOTHED AND HORNED GIANTS OF THE EOCENE: THE UINTATHERES (ORDER DINOCERATA)

B59 **Miller, E. R., Bown, T. M., Sileem, A. H., Sallam, H. M., Gunnell, G. F.** STRATIGRAPHIC AND PALEOECOLOGICAL DISTRIBUTION OF ANTHRACOTHERES IN THE FAYUM, EGYPT

B60 **Tsubamoto, T., Kunimatsu, Y., Nakatsukasa, M.** A LARGE AND PRIMITIVE HIPPO-LIKE LOWER MOLAR FROM THE LOWER MIOCENE OF KENYA

B61 **Morgan, M. E., Spencer, L., Scott, E., Domingo, M., Badgley, C., Barry, J. C., Flynn, L. J., Pilbeam, D.** DETECTING DIFFERENCES IN FORAGE IN C3-DOMINATED ECOSYSTEMS: MESOWEAR AND STABLE ISOTOPE ANALYSES OF MIOCENE BOVIDS FROM NORTHERN PAKISTAN

B62 **Solounias, N., Danowitz, M., Kortlandt, V., Hou, S., Domalski, R., Mihlbachler, M.** MULTIVARIATE MESOWEAR ANALYSIS OF GIRAFFID FEEDING ECOLOGIES IN THE LATE MIOCENE PIKERMIAN BIOME FAUNAS OF GREECE AND CHINA

B63 **Domalski, R., Hou, S., Danowitz, M., Solounias, N.** *SCHANSITHERIUM*: NEW INSIGHTS ON A LATE MIOCENE GIRAFFIDAE FROM GANSU, CHINA

B64 **Locke, E. M., Rowan, J., Campisano, C. J., Reed, K. E.** FOSSIL GIRAFFIDAE (MAMMALIA, ARTIODACTYLA) FROM 2.8 MA SEDIMENTS AT LEE ADOYTA, LEDI-GERARU: IMPLICATIONS FOR THE PALEOBIOLOGY OF *SIVATHERIUM MAURUSIUM*

B65 **Rincon, A. F., Bloch, J. I.** NEW EARLY MIOCENE CAMELIDS (ARTIODACTYLA, FLORIDATRAGULINAE) FROM PANAMA AND THE RELATIONSHIP OF FLORIDATRAGULINES TO CAMELINAE

B66 **De Renzis, A. M., Rincon, A. F., Mackenzie, K. A., Bloch, J. I.** NEW FOSSILS OF THE RARE EARLY MIOCENE FLORIDATRAGULINE CAMEL *FLORIDATRAGULUS NANUS* FROM FLORIDA AND SOUTHERN CENTRAL AMERICA

B67 **Yann, L. T., Desantis, L.** DIETARY VARIABILITY IN PLIO-PLEISTOCENE CAMELIDS

B68 **Zhang, Z.** ALLOMETRIC SCALING OF MERYCODONT ANTILOCAPRID HORN CORES

B69 **Danowitz, M., Domalski, R., Solounias, N.** THE ATYPICAL MORPHOLOGY OF THE ATLANTO-OCCIPITAL JOINT OF *PROLIBYTHERIUM* (RUMINANTIA, MAMMALIA)

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B70 **Jurestovsky, D., Mead, J.** LATE PLEISTOCENE *SAIGA* (ARTIODACTYLA, BOVIDAE) FROM THE HOLARCTIC

B71 **Holt, E. M.** PLEISTOCENE *CERVUS ELAPHUS* IN CALIFORNIA INHABITED XERIC SHRUBLAND MUCH LIKE EXTANT TULE ELK

B72 **Martin, J. M., Wallace, S. C.** POST-CRANIAL MORPHOMETRIC EVALUATION OF THE GENUS *BISON*: 40,000 YEARS OF BODY SIZE CHANGE IN RESPONSE TO ABRUPT TEMPERATURE SHIFTS, WITH IMPLICATIONS FOR THE *BISON* INDUSTRY

B73 **Itoh, M., Nakaya, H., Asfaw, B., Beyene, Y., Suwa, G.** EARLY PLEISTOCENE REDUNCINI (BOVIDAE) FROM THE KONSO FORMATION, SOUTHERN ETHIOPIA

B74 **Woodruff, A. L., Schubert, B.** LATE PLEISTOCENE FLAT-HEADED PECCARIES (*PLATYGONUS COMPRESSUS*) FROM BAT CAVE, MISSOURI, WITH COMMENTS ON THEIR PALEOBIOLOGY

B75 **Prothero, D. R.** THE HESPERHYINE PECCARIES: IMPLICATIONS OF THEIR UNEXPECTED DIVERSITY FOR PALEONTOLOGICAL DATABASES

B76 **Bradham, J., Desantis, L. R., Jorge, M., Galetti, M., Keuroghlian, A.** DIETARY VARIABILITY AS INFERRED FROM STABLE CARBON ISOTOPES IN WHITE-LIPPED PECCARIES: A CAUTIONARY TALE REVEALED FROM HAIR AND ENAMEL TISSUES

B77 **Hanson, D. A.** AN EARLY ARIKAREEAN (MIDDLE OLIGOCENE) MAMMAL ASSEMBLAGE FROM WEST CENTRAL MONTANA

B78 **Peredo, C. M., Uhen, M. D.** IDENTIFYING AND EVALUATING THE ROLE OF PALEOGEOGRAPHY FOR MARINE MAMMAL DISPERSAL ACROSS OCEAN REGIONS USING BETA DIVERSITY METRICS

B79 **Buchholtz, E. A., Anwar, S. B., Johnson, L. A., Ruiz, A. C., Gillett, M. A.** THE VERTEBRAL COLUMN OF ODONTOCETE CETACEANS: THE EVOLUTION OF DEVELOPMENT

B80 **Manthi, F., Jacobs, L. L., Polcyn, M. J., Winkler, D. A., Scotese, C. R.** CT ASSESSMENT AND PHYLOGENETIC RELATIONSHIPS OF A MIOCENE BEAKED WHALE FROM KENYA

B81 **Murakami, M., Hirayama, R., Isaji, S.** THE CETACEAN FAUNA OF THE UPPERMOST MIOCENE SENHATA FORMATION OF CHIBA, JAPAN: INSIGHT INTO PALEOBIOGEOGRAPHY

B82 **Nelson, M. D., Sidor, C. A.** FIRST OCCURRENCE OF A MIOCENE SQUALODELPHINID (CETACEA, ODONTOCETI) FROM WASHINGTON STATE

B83 **Tanaka, Y., Fordyce, R. E.** BRIDGING THE EARLY MIOCENE GAP IN ODONTOCETE HISTORY: NEW DOLPHIN FROM KAIKOURA, NEW ZEALAND, HELPS RESOLVE RELATIONSHIPS FOR *PAPAHU*

B84 **Borce, B., Deméré, T. A., Berta, A.** INTRASPECIFIC VARIATION IN CRANIAL AND MANDIBULAR MORPHOLOGY OF THE EXTINCT RIVER DOLPHIN *PARAPONTOPORIA STERNBERGI* FROM THE UPPER PLIOCENE SAN DIEGO FORMATION, SOUTHERN CALIFORNIA, USA

B85 **Holbrook, L.** THE PHYLOGENY OF PERISSODACTYLA (MAMMALIA): EXAMINING THE EFFECT OF OUTGROUP CHOICE

B86 **Rej, J. E., Lucas, S. G.** MORPHOLOGICAL COMPARISON AND TAXONOMIC STATUS OF TWO EARLY EOCENE HORSES FROM THE WESTERN USA: *MINIPPUS JICARILLAI* AND *SIFRHIPPUS SANDRAE*

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B87 **O'Sullivan, J. A., Hulbert Jr., R. C., Rincon, A.** MESOWEAR ANALYSIS OF A NEW PARAHIPPINE EQUID FROM FLORIDA

B88 **Ferrusquia-Villafranca, I., Pérez-Crespo, V., Morales-Puente, P., Ruiz-González, J., Martínez-Hernández, E., Cienfuegos-Alvarado, E.** CARBON STABLE ISOTOPE COMPARISONS OF LATE CENOZOIC EQUIDS FROM MEXICO: A FIRST APPROACH TO ASSESSING THEIR DIET THROUGH TIME

B89 **Pérez-Crespo, V. A., Carbot-Chanona, G., Morales-Puente, P., Cienfuegos-Alvarado, E., Otero, F. J.** PALEOECOLOGY INFERENCES USING CARBON AND OXYGEN STABLE ISOTOPES FOR THE RANCHOLABREAN MAMMALS FROM DEPRESSION CENTRAL OF CHIAPAS, MÉXICO

B90 **Abrams, K. D.** DENTAL MICROWEAR VARIATION IN *TELEOCERAS FOSSIGER* (PERISSODACTYLA: RHINOCEROTIDAE), AND THE ROLE OF MASTICATION IN THE PRODUCTION OF MICROWEAR FEATURES

B91 **Wilson, P. J., Zhang, C.** STABLE ISOTOPE ANALYSIS OF THE EARLY HEMPHILLIAN *TELEOCERAS FOSSIGER* (PERISSODACTYLA: RHINOCEROTIDAE) FROM THE HIGH PLAINS OF KANSAS: PALEODIET AND PALEOCLIMATIC RECONSTRUCTION

B92 **Sun, B., Bernor, R. L.** THE ORIGIN, EVOLUTION AND BIOGEOGRAPHIC EXTENSION OF CHINESE HIPPARIONIN HORSES, *PLESIOHIPPARION* AND *PROBOSCIDIPPARION*, LATE MIOCENE – PLEISTOCENE OF EURASIA

B93 **Priego-Vargas, J., Bravo-Cuevas, V. M.** LONG- AND SHORT-TERM ABRASION EFFECT IN THE DIET OF *EQUUS CONVERSIDENS* FROM LATE PLEISTOCENE LOCALITIES IN CENTRAL AND SOUTHERN MEXICO

B94 **Barron-Ortiz, C. R., Pérez-Crespo, V., Arroyo-Cabrales, J., Theodor, J. M., Morales-Puente, P., Cienfuegos-Alvarado, E.** DIETARY RECONSTRUCTION OF TWO POPULATIONS OF *EQUUS CONVERSIDENS* (MAMMALIA: EQUIDAE) FROM MEXICO: NEW INSIGHTS INTO THE DIETARY PLASTICITY OF A WIDESPREAD PLEISTOCENE EQUID SPECIES

B95 **Famoso, N. A.** QUANTIFYING VARIATION IN THE OLIGOCENE EQUID *MIOHIPPUS* (MAMMALIA, PERISSODACTYLA) OF OREGON

B96 **Schellhorn, R.** HEAD POSTURE IN PLEISTOCENE RHINOCEROSES

B97 **Protopopov, A., Potapova, O., Plotnikov, V., Maschenko, E., Boeskorov, G., Klimovskii, A., Banderov, A., Ivanov, S., Kolesov, S., Pavlov, I.** THE FROZEN MUMMY OF THE WOOLLY RHINOCEROS, *COELODONTA ANTIQUITATIS* BLUM., 1799 CALF: A NEW DATA ON EARLY ONTOGENESIS OF THE EXTINCT SPECIES

B98 **Wang, B., Secord, R.** PALEOGEOGRAPHY AND BODY SIZE CHANGE IN RHINOCEROSES (RHINOCEROTIDAE) THROUGH THE LATE MIOCENE OF NORTH AMERICA

B99 **Maguire, K.** DIETARY NICHES OF EQUIDS REMAIN STABLE ACROSS THE MID-MIOCENE CLIMATIC OPTIMUM

B100 **Loughney, K. M., Smith, S. Y.** PHYTOLITH ASSEMBLAGES OF THE BARSTOW FORMATION (MIDDLE MIOCENE), SOUTHEASTERN CALIFORNIA, THROUGH THE MIDDLE MIOCENE CLIMATIC OPTIMUM

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B101 **Theodor, J.** PARTITIONING CHANGE IN BODY SIZE AMONG HERBIVORES DURING THE MIDDLE MIOCENE CLIMATIC OPTIMUM

B102 **Mitchell, D. R., Wood, A. R.** INCREASED MAMMAL BETA DIVERSITY IN NORTH AMERICA DURING MIOCENE STRENGTHENING OF THE LATITUDINAL TEMPERATURE GRADIENT

B103 **Boardman, G. S., Moore, J. R., Dewar, E. W., Weissmann, G. S.** DETERMINING THE DRIVER BEHIND LARGE-SCALE ECOLOGICAL PATTERNS IN THE LATEST EOCENE–EARLIEST OLIGOCENE WHITE RIVER GROUP (USA): CLIMATE VERSUS GEOMORPHOLOGY

B104 **Barboza, M., Parham, J. F., Kussman, B. N.** VERTEBRATE FAUNA AND UNGULATE BIOSTRATIGRAPHY OF THE HIGHLY FOSSILIFEROUS OSO SAND MEMBER, CAPISTRANO FORMATION, ORANGE COUNTY, CA

B105 **Kussman, B. N., Parham, J. F., Babilonia, L. C.** BIOSTRATIGRAPHIC ANALYSIS OF MAMMALIAN TAXA REVISES THE AGE OF RICH PLEISTOCENE SITES FROM THE LA HABRA FORMATION (ORANGE COUNTY, CALIFORNIA) FROM RANCHOLABREAN TO IRVINGTONIAN

B106 **Tucker, S. T., McMullin, J. D., Joeckel, R. M.** CLARENDONIAN–BLANCAN VERTEBRATE BIOSTRATIGRAPHY AT THE EASTERN EDGE OF THE GREAT PLAINS, EAST-CENTRAL NEBRASKA, USA

B107 **Meachen, J., Cooper, A., McGuire, J., Higgins, P., Tybout, S.** NATURAL TRAP CAVE: A PLEISTOCENE TREASURE TROVE

B108 **Suraprasit, K., Panha, S., Bocherens, H., Chaimanee, Y., Chavasseau, O., Jaeger, J.** MIDDLE PLEISTOCENE VERTEBRATE COMMUNITY FROM KHOK SUNG (NORTHEASTERN THAILAND): FAUNAL COMPOSITION, DIETS, AND NICHE PARTITIONING OF SYMPATRIC MAMMALS

B109 **Serrano, F. J., Palmqvist, P. J., Chiappe, L. M., Sanz, J. L.** ESTIMATION AND CALIBRATION OF AERODYNAMIC PARAMETERS IN MESOZOIC STEM BIRDS

B110 **Peteya, J. A., Clarke, J. A., Li, Q., Shawkey, M. D.** NEW DETAILS ON THE PLUMAGE AND COLORATION OF AN EARLY CRETACEOUS ENANTIORNITHINE BIRD

B111 **Tanaka, T., Tokaryk, T., Kobayashi, Y.** A NEW SMALL HESPERORNITHIFORM FROM THE UPPER CRETACEOUS PIERRE SHALE OF MANITOBA

B112 **Mohr, S. R., Currie, P. J.** THE DEVELOPMENT OF BIRD TEETH FROM THE LATE CRETACEOUS OF ALBERTA

B113 **McIntosh, A. P.** GEOMETRIC MORPHOMETRIC ANALYSIS OF PEDAL CLAW SHAPE OF THE EARLY CRETACEOUS BIRD *CONFUCIUSORNIS SANCTUS* (AVES: CONFUCIUSORNITHIDAE) INDICATES CLOSE SIMILARITY WITH EXTANT PASSERINES (NEORNITHES: PASSERIFORMES)

B114 **Wang, X., Clarke, J., Huang, J.** ORNITHURINE BIRD FROM THE EARLY CRETACEOUS OF CHINA PROVIDE NEW EVIDENCE FOR THE TIMING AND PATTERN OF THE EVOLUTION OF AVIAN SKULL

B115 **O'Connor, J. K., Sullivan, C., Zhou, Z., Zheng, X.** EVOLUTION AND FUNCTIONAL SIGNIFICANCE OF DERIVED STERNAL OSSIFICATION PATTERNS IN ORNITHOTHORACINE BIRDS

B116 **Hu, D., Gao, L., Xu, X., Hou, L.** A NEW ENANTIORNITHINE SPECIMEN FROM THE LOWER CRETACEOUS OF NORTHERN HEBEI, CHINA

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B117 **Cost, I. N., Spates, A., Sellers, K. C., Davis, J. L., Middleton, K. M., Witmer, L. M., Holliday, C. M.** BIOMECHANICS OF THE AVIAN FEEDING APPARATUS

B118 **Mateus, O., Jacobs, L. L., Polcyn, M. J., Myers, T. S., Schulp, A. S.** THE FOSSIL RECORD OF TESTUDINES FROM ANGOLA FROM THE TURONIAN TO OLIGOCENE

B119 **Buskuskie, T. R., Wilson, L. E.** PRELIMINARY OSTEOHISTOLOGY OF THE TYPE SPECIMEN OF *NIOBRARASAURUS COLEII* (DINOSAURIA: NODOSAURIDAE) AND COMPARISON WITH POTENTIAL JUVENILE MATERIAL

B120 **Hill, R. V., D'Emic, M. D., Bever, G. S., Norell, M. A.** BRAINCASE ANATOMY AND ONTOGENY IN JUVENILE *PINACOSAURUS GRANGERI* (ORNITHISCHIA: ANKYLOSAURIA)

B121 **Tremaine, K., D'Emic, M., Williams, S., Hunt-Foster, R. K., Foster, J., Mathews, J.** PALEOECOLOGICAL IMPLICATIONS OF A NEW SPECIMEN OF THE ANKYLOSAUR *MYMOORAPELTA MAYSI* FROM THE HANKSVILLE-BURPEE QUARRY, LATEST JURASSIC (TITHONIAN) MORRISON FORMATION (BRUSHY BASIN MEMBER)

B122 **Baron, M. G., Norman, D. B., Barrett, P. M.** POSTCRANIAL ANATOMY OF *LESOTHOSAURUS DIAGNOSTICUS* (DINOSAURIA: ORNITHISCHIA) FROM THE LOWER JURASSIC OF SOUTHERN AFRICA: IMPLICATIONS FOR BASAL ORNITHISCHIAN TAXONOMY AND SYSTEMATICS

B123 **Breeden, B. T., Rowe, T. B.** NEW SPECIMENS OF THE THYREOPHORAN DINOSAUR *SCUTELLOSAURUS LAWLERI* FROM THE LOWER JURASSIC KAYENTA FORMATION OF NORTHERN ARIZONA

B124 **Ullmann, P., Lacovara, K.** EVALUATING THE INFLUENCE OF BODY SIZE ON APPENDICULAR ANATOMY OF TITANOSAURIAN SAUROPODS

B125 **Yoshida, J., Carpenter, K., Kobayashi, Y.** FIRST RECORD OF A SOMPHOSPONDYLAN SAUROPOD FROM UTAH, AND PALEOECOLOGY OF SAUROPODS IN UTAH DURING THE ALBIAN

B126 **Woolley, H., Sertich, J., Forster, C. A., Munyikwa, D., Sampson, S. D., Curry Rogers, K., Rogers, R. R.** TITANOSAURIAN AND OTHER VERTEBRATE REMAINS FROM THE CRETACEOUS GOKWE FORMATION, CENTRAL ZIMBABWE

B127 **Fowler, E., Voegele, K., Ullmann, P., Feldman, V., Lacovara, K.** RESTORING *DREADNOUGHTUS*: USING LATTICE DEFORMERS IN AUTODESK MAYA TO RETRO-DEFORM FOSSILS FROM AN EXCEPTIONALLY COMPLETE TITANOSAUR

B128 **Schroeter, E. R., Cleland, T. P., Schweitzer, M. H., Lacovara, K. J.** INVESTIGATING MOLECULAR PRESERVATION IN *DREADNOUGHTUS SCHRANI*, AN EXCEPTIONALLY COMPLETE TITANOSAUR FROM ARGENTINA

B129 **Foster, J. R.** DANGERS OF LOW SAMPLE SIZE IN STUDIES OF SAUROPOD DINOSAUR SPECIES DIVERSITY: A MORRISON FORMATION CASE STUDY

B130 **Holwerda, F., Schmitt, A., Tschopp, E.** ONTOGENETIC DIFFERENCES IN TOOTH REPLACEMENT RATES IN ADULT AND JUVENILE DIPLODOCIDS

B131 **Knoll, F., Ridgely, R. C., Witmer, L. M.** COMPARATIVE PALEONEUROLOGY OF THE BASAL DICRAEOSAURID SAUROPOD *SUUWASSEA EMILIEAE*

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B132 **Whitlock, J. A., Wilson, J. A.** RE-DESCRIPTION OF *'MOROSAURUS' AGILIS*, A CURIOUS JUVENILE SAUROPOD FROM THE MORRISON FORMATION OF NORTH AMERICA, WITH APPLICATION OF PHOTOGRAMMETRIC VISUALIZATION METHODS

B133 **Hanik, G. M., Whitlock, J. A., Lamanna, M. C.** A JUVENILE SAUROPOD FROM THE MORRISON FORMATION OF NORTH AMERICA

B134 **Sivam, D. P., Currie, P. J., Myhrvold, N. P.** SUPERSONIC SAUROPODS: THE PHYSICAL MODEL

B135 **Corsini, J. A.** RELATIONSHIPS AMONG WHITE RIVER TORTOISES FROM TWO LOCALITIES

B136 **Bourque, J. R., Wood, A. R., Hendy, A. J.** A PRELIMINARY REPORT ON THE TURTLES FROM THE LATE MIOCENE OF CENTRAL PANAMA

B137 **Biewer, J., Sankey, J., Hutchison, H., Wagner, H., Garber, D.** FIRST IDENTIFICATION AND DESCRIPTION OF THE GREAT PLAINS GIANT TORTOISE *HESPEROTESTUDO* CF. *H. ORTHOPYGIA* FROM THE EARLY PLIOCENE (HEMPHILLIAN) MEHRTEN FORMATION OF STANISLAUS COUNTY, CALIFORNIA

B138 **Gren, J. A., Madsen, H., Sjövall, P., Lindgren, J.** SOFT TISSUES IN AN EOCENE SEA TURTLE HATCHLING PROVIDES CLUES ABOUT PRESERVATION AND TAPHONOMY

B139 **Gard, H. J., Fordyce, R. E., Lee, D. E.** A LATE OLIGOCENE CHELONIID TURTLE FROM SOUTHERN NEW ZEALAND

B140 **Lucas, S. G., Lichtig, A. J.** EOCENE TURTLES FROM THE SAN JOSE FORMATION, SAN JUAN BASIN, NEW MEXICO

B141 **Herzog, L. L., Zanno, L. E., Makovicky, P. J.** NEW RECORDS OF SOLEMYDID TURTLES IN NORTH AMERICA: SPECIMENS FROM THE UPPER CRETACEOUS MUSSENTUCHIT MEMBER OF THE CEDAR MOUNTAIN FORMATION

B142 **Brinkman, D. B., Scheetz, R., Jensen, C., Britt, B., Ortiz, N.** A BASAL BAENID TURTLE PROVIDES INSIGHTS INTO THE AQUATIC FAUNA OF THE EARLY CRETACEOUS (APTIAN) CEDAR MOUNTAIN FORMATION OF WEST-CENTRAL UTAH

B143 **Hirayama, R., Takisawa, T., Sasaki, K., Sonoda, T., Yoshida, M., Takekawa, A., Mitsuzuka, S., Kobayashi, Y., Tsuihiji, T., Tsutsumi, Y.** TERRESTRIAL VERTEBRATES FROM THE LATE CRETACEOUS (SANTONIAN) OF IWATE PREFECTURE, EASTERN JAPAN

B144 **Chapman, S. D., Anquetin, J.** FIRST OCCURRENCE OF THE PLESIOCHELYID TURTLE *PLESIOCHELYS ETALLONI* FROM THE LATE JURASSIC KIMMERIDGIAN OF ENGLAND, UNITED KINGDOM

B145 **López Conde, O. A., Sterli, J., Alvarado Ortega, J.** THE OLDEST RECORD OF TURTLES IN MEXICO (LATE JURASSIC, SABINAL FORMATION, OAXACA)

B146 **Lichtig, A. J., Lucas, S. G.** A SIMPLE METHOD OF INFERRING THE PALEOENVIRONMENTS OF EXTINCT TURTLES

B147 **Withdrawn**

*Numbers beginning with "B" represent the poster board number in Marsalis Hall.
*Numbers beginning with "LC" represent the poster board number in Landmark Circle.

B148 **Dodson, P., Li, L., Sallan, L.** USING AVIAN, REPTILIAN, AND MAMMALIAN DATA TO TRACK THE EVOLUTION OF VISION IN SAUROPOD DINOSAURS

B149 **Sattler, F., Schwarz, D.** TOOTH FORMATION AND REPLACEMENT PATTERN OF DIPLODOCID SAUROPODS FROM THE TENDAGURU FORMATION (LATE JURASSIC, TANZANIA)

B150 **Li, L., Dodson, P.** IMPLICATIONS OF AVIAN, REPTILE, AND MAMMALIAN DATA ON THE EVOLUTION OF VISION IN SAUROPOD DINOSAURS

B151 **Boles, Z., Lacovara, K.** TAPHONOMY OF A K/PG MARINE BONEBED, MANTUA TOWNSHIP, NEW JERSEY

B152 **Frederickson, J. A., Lipka, T. R., Cifelli, R. L.** FAUNAL COMPOSITION AND PALEOENVIRONMENTS OF THE ARUNDEL CLAY (POTOMAC GROUP, LOWER CRETACEOUS)

B153 **Widlansky, S. J., Clyde, W., O'Connor, P., Roberts, E., Stevens, N.** MAGNETOSTRATIGRAPHY OF THE CRETACEOUS GALULA FORMATION FROM THE RUKWA RIFT BASIN, TANZANIA

B154 **Gilbert, M. M., Buatois, L., Renaut, R.** NEW MICROVERTEBRATE MATERIAL FROM THE BELLY RIVER GROUP, DINOSAUR PARK FORMATION (CAMPANIAN) OF SOUTHWESTERN SASKATCHEWAN, CANADA

B155 **Adams, A. L., Busbey, A.** STRATIGRAPHY AND PALEONTOLOGY OF THE WESTERN ROSILLOS MOUNTAIN RANCH, BREWSTER COUNTY, TX: A REVISION OF PREVIOUS MAPPING

B156 **Redman, C. M., Moore, J., Varricchio, D.** A NEW VERTEBRATE MICROFOSSIL LOCALITY IN THE UPPER TWO MEDICINE FORMATION IN THE VICINITY OF EGG MOUNTAIN

B157 **Knauss, G., Johnson, S. L., Hall, L., Fox, N., Meyers, V.** FROM GRASSLANDS TO WELL PAD: A MITIGATION PALEONTOLOGICAL DISCOVERY, LANCE FORMATION (MAASTRICHTIAN), WYOMING PROVES THE VALUE OF IMPLEMENTING BEST PRACTICES

B158 **Schmeisser McKean, R. L., Gillette, D. D.** TAPHONOMY OF MARINE VERTEBRATES IN THE UPPER CRETACEOUS TROPIC SHALE, SOUTHERN UTAH

B159 **King, L. R., Heckert, A. B., Avrahami, H. M.** A PRELIMINARY ANALYSIS OF A POTENTIALLY NEW LATE CRETACEOUS VERTEBRATE MICROFOSSIL SITE IN THE LANCE (CREEK) FORMATION AT THE BOLAN RANCH, NIOBRARA COUNTY, WYOMING

B160 **Paik, M. S., Hafif, B. L., Dominguez, M., Farke, A. A.** PALEOECOLOGICAL IMPLICATIONS OF A FAUNAL ASSEMBLAGE FROM “8220;DUNCAN'S MICROSITE” IN TH KAIPAROWITS FORMATION (UPPER CRETACEOUS), SOUTHERN UTAH, U.S.A.

B161 **Pérez García, A., Bolet, A., Escaso, F., Houssaye, A., De Miguel Chaves, C., Mocho, P., Narváez, I., Torices, A., Vidal, D., Ortega, F.** THE VERTEBRATE FAUNA FROM THE UPPER CAMPANIAN SITE OF ARMUÑA (SEGOVIA PROVINCE, CENTRAL SPAIN)

B162 **Vivas González, R., Rivera-Sylva, H. E., González Cervantes, A., Alfaro Ortíz, L. M.** PRELIMINARY REPORT OF A HADROSAUR GRAVEYARD FROM THE CERRO DEL PUEBLO FORMATION (UPPER CRETACEOUS, CAMPANIAN), COAHUILA, MEXICO

B163 **Trujillo, K. C., Carrano, M. T., Chamberlain, K. R.** A U-PB ZIRCON AGE FOR REED'S QUARRY 9, UPPER JURASSIC MORRISON FORMATION, ALBANY COUNTY, WY

*Numbers beginning with "B" represent the poster board number in Marsalis Hall.
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THURSDAY, OCTOBER 15, 2015
POSTER SESSION II (CONTINUED)

B164 **Kligman, B.** A NEW LATE TRIASSIC MICROVERTEBRATE FAUNA FROM THE BLUE MESA MEMBER OF PETRIFIED FOREST NATIONAL PARK

B165 **Lu, H., Jiang, D., Motani, R., Guo, W., Tintori, A., Rieppel, O., Sun, Z., Ji, C., Ni, P., Fu, W.** CORRELATION BETWEEN CHANGES IN PALEOENVIRONMENT AND MARINE REPTILE FAUNAL COMPOSITION IN THE MIDDLE TRIASSIC XINGYI FAUNA (GUIZHOU, SOUTHWESTERN CHINA)

B166 **Voris, J. T., Heckert, A. B., Vaughn, M. C., Hoffman, D. K., Avrahami, H. M., Straka, K. M., Schneider, V.** THE MICROVERTEBRATE ASSEMBLAGE OF THE DOWN'S QUARRY, UPPER TRIASSIC (ADAMANIAN), ST. JOHNS, ARIZONA

B167 **Busbey, A. B.** A CAMPANIAN-AGED LACUSTRINE DEPOSIT ON A VOLCANIC MAAR IN THE AGUJA FORMATION, BREWSTER COUNTY, TEXAS

B168 **Graf, J., Tabor, N., Ferguson, K., Jacobs, L. L., Winkler, D., Lee, Y., May, S. R.** STABLE ISOTOPE GEOCHEMISTRY OF DINOSAUR EGGSHELL FROM THE GOBI DESERT, MONGOLIA

FRIDAY MORNING, OCTOBER 16, 2015
TECHNICAL SESSION X
HYATT REGENCY DALLAS, LANDMARK AB
MODERATORS: Yoshi Kobayashi and Adam Marsh

8:00 **Griffin, C. T., Nesbitt, S. J.** DOES THE MAXIMUM BODY SIZE OF THEROPOD DINOSAURS INCREASE ACROSS THE TRIASSIC-JURASSIC BOUNDARY? INTEGRATING PHYLOGENY, GROWTH, AND BODY SIZE

8:15 **Marsh, A. D.** A COMPREHENSIVE STUDY OF *DILOPHOSAURUS WETHERILLI*: ANATOMY, TAXONOMY, AND EVOLUTIONARY RELATIONSHIPS OF THE FIRST LARGE-BODIED THEROPOD IN NORTH AMERICA

8:30 **Burch, S. H.** EVOLUTION OF THE FORELIMB MUSCULATURE IN EARLY THEROPODS: EVIDENCE FOR THE ACQUISITION OF NEW PREDATION STRATEGIES

8:45 **Carrano, M. T., Choiniere, J.** NEW INFORMATION ON THEROPOD FORELIMB EVOLUTION FROM THE FOREARM AND MANUS OF *CERATOSAURUS NASICORNIS* (DINOSAURIA, THEROPODA)

9:00 **Sereno, P. C., Fish, F. E., Myhrvold, N.** SWIMMING FUNCTION IN THE CRETACEOUS GIANT *SPINOSAURUS AEGYPTIACUS* BASED ON THE KINEMATICS OF UNDULATORY SWIMMING IN THE AMERICAN ALLIGATOR

9:15 **Carr, T. D., Henderson, M., Erickson, G., Peterson, J., Williams, S., Currie, P., Scherer, R., Harrison, B.** A SUBADULT *TYRANNOSAURUS REX* AND ITS BEARING ON THE *NANOTYRANNUS* HYPOTHESIS

9:30 **Van Der Reest, A. J., Wolfe, A., Currie, P. J.** A NEW SPECIMEN OF ORNITHOMIMID (THEROPODA) FROM DINOSAUR PROVINCIAL PARK PROVIDES UNPRECEDENTED DETAILS OF DINOSAUR PLUMAGE AND FEATHER EVOLUTION

9:45 **Kobayashi, Y., Chinzorig, T., Tsogtbaatar, K., Barsbold, R.** A NEW THERIZINOSAUR WITH FUNCTIONALLY DIDACTYL HANDS FROM THE BAYANSHIREE FORMATION (CENOMANIAN-TURONIAN), OMNOGOVI PROVINCE, SOUTHEASTERN MONGOLIA

10:00 **BREAK**

10:15 **Button, K., Zanno, L., You, H., Kirkland, J.** DICHOTOMOUS EVOLUTION OF TOOTH GROWTH AND REPLACEMENT STRATEGIES IN HERBIVOROUS DINOSAURS

FRIDAY MORNING, OCTOBER 16, 2015

TECHNICAL SESSION X (CONTINUED)

10:30 **Funston, G. F., Currie, P. J.** AN ARTICULATED CAENAGNATHID SKELETON FROM THE HORSESHOE CANYON FORMATION OF ALBERTA, CANADA, AND ITS PHYLOGENETIC AND PALEOBIOLOGICAL IMPLICATIONS

10:45 **Lü, J., Chen, R., Kobayashi, Y., Lee, Y.** A NEW OVIRAPTORID DINOSAUR (DINOSAURIA: OVIRAPTOROSAURIA) FROM THE LATE CRETACEOUS OF SOUTHERN CHINA

11:00 **Zelenitsky, D. K., Currie, P. J., Carpenter, K., Lü, J.** BABY LOUIE: A THEROPOD PERINATE FROM THE CRETACEOUS OF CHINA REVEALS AFFINITY OF THE LARGEST KNOWN DINOSAUR EGGS

11:15 **Wiemann, J., Yang, T., Sander, P.** THE COLORFUL EGGS OF DINOSAURS: HOW FOSSIL METABOLITES REVEAL NESTING BEHAVIOR

11:30 **Moyer, A., Zheng, W., Norell, M., Schweitzer, M.** MICROSCOPIC AND IMMUNOHISTOCHEMICAL ANALYSES OF THE CLAW OF THE NESTING DINOSAUR, *CITIPATI OSMOLSKAE*

11:45 **Xu, X., Zheng, X., Sullivan, C., Wang, X., Xing, L., Wang, Y., Zhang, X., O'Connor, J., Zhang, F., Pan, Y.** A BIZARRE NEW THEROPOD FROM THE JURASSIC OF HEBEI, CHINA, AND THE DIVERSIFICATION OF THE SCANSORIOPTERYGIDAE

12:00 **Currie, P., Evans, D.** EXQUISITELY PRESERVED SPECIMEN OF *SAURORNITHOLESTES LANGSTONI* (THEROPODA, DROMAEOSAURIDAE) FROM DINOSAUR PROVINCIAL PARK, UPPER CRETACEOUS OF ALBERTA CANADA

FRIDAY MORNING, OCTOBER 16, 2015

TECHNICAL SESSION XI

HYATT REGENCY DALLAS, LANDMARK C

MODERATORS: Paul Morse and Alistair Evans

8:00 **Morse, P. E., Silcox, M. T., Bloch, J. I., Boyer, D. M.** A NEW SMALL SPECIES OF *ARCTODONTOMYS* (MICROSYOPIDAE, EUARCHONTA) FROM THE PALEOCENE-EOCENE THERMAL MAXIMUM AND THE EFFECTS OF GLOBAL CLIMATE CHANGE ON MICROSYOPINES

8:15 **Prufrock, K. A., Boyer, D. M., Silcox, M. T.** TAKING A BITE OUT OF THE COMPETITION HYPOTHESIS: USING DENTAL TOPOGRAPHY TO EXAMINE RESOURCE OVERLAP BETWEEN NORTH AMERICAN STEM PRIMATES AND RODENTS

8:30 **López-Torres, S., Silcox, M. T., Holroyd, P. A.** RE-ANALYSIS OF OMOMYOID MATERIAL FROM THE MIDDLE EOCENE OF SOUTHERN CALIFORNIA AND THE EXTINCTION OF NORTH AMERICAN PAROMOMYID PLESIADAPIFORMS

8:45 **Silcox, M. T., Dunn, R. H., Kumar, K., Rana, R., Sahni, A., Smith, T., Rose, K. D.** AN EXCEPTIONALLY WELL PRESERVED PRIMATE PETROSAL FROM THE EARLY EOCENE OF INDIA

9:00 **Boyer, D. M., Bloch, J. I., Kirk, E. C., Gilbert, C. C., Allen, K. L., Gunnell, G. F., Yapuncich, G. S., Kay, R. F., Seiffert, E. R.** RE-EVALUATION OF PROMONTORY ARTERIAL DOMINANCE IN EARLY PRIMATES

9:15 **Beard, K., Coster, P., Salem, M. J., Chaimanee, Y., Jaeger, J.** DISCOVERY OF THE FIRST OLIGOCENE PRIMATES FROM LIBYA ILLUMINATES PARAPITHECID PHYLOGENY AND BIOGEOGRAPHY

9:30 **MacLatchy, L., Kingston, J.** ISOTOPIC ANALYSES OF MODERN AND FOSSIL HOMINOIDS

9:45 **Ward, C. V., Plavcan, J. M., Manthi, F. K.** DIETARY BEHAVIOR, MORPHOLOGY AND THE ORIGIN OF *AUSTRALOPITHECUS*

FRIDAY MORNING, OCTOBER 16, 2015
TECHNICAL SESSION XI (CONTINUED)

10:00 **BREAK**

10:15 **Evans, A. R., Daly, E., Catlett, K. K., Paul, K. S., King, S. J., Skinner, M. M., Schwartz, G. T., Jernvall, J.** THE EVOLUTION AND DEVELOPMENT OF HOMININ TOOTH SIZE

10:30 **Rook, D. L., Schechtman-Rook, A.** EFFICIENT QUANTITATIVE MEASUREMENTS OF ENAMEL OCCLUSAL WEAR WITH A WATERSHED SEGMENTATION ALGORITHM

10:45 **Keller, J. S., Cicak, T. S., McNulty, K. P., Fox, D. L.** 3D DENTAL SHAPE DESCRIPTORS PREDICT TROPHIC CATEGORIES ACROSS MULTIPLE ORDERS OF NORTH AMERICAN MAMMALS

11:00 **Torgeson, J., McNulty, K. P., Keller, J. S., Fox, D. L.** EXPLORING RODENT HEAD-SPACE: GEOMETRIC MORPHOMETRICS APPLIED TO HETEROMYID CRANIA (RODENTIA: HETEROMYIDAE)

11:15 **Marcy, A., Hadly, E. A., Weisbecker, V.** GEOMETRIC MORPHOMETRICS OF POCKET GOPHER (*THOMOMYS*) DIGGING ANATOMY: ADAPTATION TO SOIL SEPARATES FROM PHYLOGENETIC SIGNAL

11:30 **Fox, D. L., Femal, B. J., Fetrow, A. C., Roepke, E. W., Fox-Dobbs, K., Haveles, A. W., Martin, R. A., Polissar, P., Snell, K. E., Uno, K. T.** PALEOENVIRONMENTAL FRAMEWORK OF RODENT COMMUNITY EVOLUTION IN THE MEADE BASIN (SW KANSAS, USA) OVER THE LAST 4.5 MILLION YEARS

11:45 **Lightner, E., Clementz, M., Minckley, T., Fox-Dobbs, K.** LEPORID RESPONSE TO INCREASED POST-GLACIAL C_4 GRASS ABUNDANCE

12:00 **Flynn, L. J., Ji, X., Jablonski, N., Su, D., Kelley, J.** AN ORIENTAL PROVINCE SMALL-MAMMAL FAUNA FROM THE MIOCENE OF SOUTH CHINA

FRIDAY MORNING, OCTOBER 16, 2015
TECHNICAL SESSION XII
HYATT REGENCY DALLAS, LANDMARK D
MODERATORS: Hans Dieter-Sues and Derek Larson

8:00 **Sues, H., Schoch, R. R.** A MIDDLE TRIASSIC STEM-TURTLE FROM GERMANY AND THE EVOLUTION OF THE TURTLE BODY PLAN

8:15 **Lawver, D. R.** SKELETAL VARIATION IN *NAOMICHELYS* (TESTUDINATA: SOLEMYDIDAE): INSIGHTS FROM A NEW SPECIMEN FROM THE LOWER CRETACEOUS OF MONTANA

8:30 **Vavrek, M. J., Campione, N. E., Fanti, F., Bell, P. R.** PALEOARCTIC TURTLES FROM THE WAPITI FORMATION (GRANDE PRAIRIE, ALBERTA, CANADA) AND THEIR IMPLICATIONS FOR LATE CRETACEOUS BIOGEOGRAPHY

8:45 **Nicholson, D. B., Holroyd, P. A., Barrett, P. M.** THE LATITUDINAL GRADIENT IN MESOZOIC NON-MARINE TURTLES

9:00 **Holroyd, P. A., Hutchison, J., Nicholson, D. B., Goodwin, M. B.** NETWORK ANALYSIS DEMONSTRATES SOUTHERN PROVINCIALITY IN CAMPANIAN NORTH AMERICAN TURTLES

9:15 **Vermillion, W. A., Chyn, K. M., Denman, M. P., Lafon, C., Fitzgerald, L., Lawing, A.** THE GHOST OF CLIMATE PAST: HISTORIC PRECIPITATION EXPLAINS CONTEMPORARY SPECIES RICHNESS IN NORTH AMERICAN TURTLES

FRIDAY MORNING, OCTOBER 16, 2015

TECHNICAL SESSION XII (CONTINUED)

9:30 **Lively, J. R.** IMPLICATIONS OF THE MORPHOLOGY OF THE BONY LABYRINTH FOR PALEOECOLOGY AND SYSTEMATICS OF TURTLES

9:45 **Campbell, M., Caldwell, M., Dal Sasso, C.** RE-EVALUATION OF *APHANIZOCNEMUS LIBANENSIS* - TO BE OR NOT TO BE A DOLICHOSAUR

10:00 **BREAK**

10:15 **Demar Jr., D. G., Conrad, J. L., Head, J. J., Varricchio, D. J., Wilson, G. P.** PHYLOGENETICS AND PALEOBIOLOGY OF A LATE CRETACEOUS STEM IGUANIAN FROM MONTANA

10:30 **Simoes, T. R., Wilner, E., Caldwell, M. W., Weinschütz, L., Kellner, A. W.** AN OLD WORLD LIZARD IN THE LATE CRETACEOUS OF SOUTH AMERICA REVISES EARLY LIZARD EVOLUTION IN GONDWANA

10:45 **Conrad, J. L., Norell, M. A.** ANGUIMORPHA (SQUAMATA) AND THE IMPORTANCE OF FOSSILS

11:00 **Cernansky, A., Klembara, J., Muller, J.** A NEW LATE OLIGOCENE SQUAMATE FAUNA FROM GERMANY

11:15 **Folie, A., Kumar, K., Rana, R. S., Solé, F., Sahni, A., Rose, K. D., Smith, T.** NEW DIVERSE EARLY EOCENE SNAKE ASSEMBLAGE FROM TADKESHWAR LIGNITE MINE, WESTERN INDIA

11:30 **Da Silva, F. O., Di-Poi, N.** SKULL SHAPE SUPPORTS A TERRESTRIAL-FOSSORIAL TRANSITION IN THE EARLY EVOLUTION OF SNAKES THROUGH HETEROCHRONY

11:45 **Larson, D. W., Evans, D. C.** ECOMORPHOLOGICAL RELATIONSHIPS BETWEEN DIET AND MORPHOLOGY IN EXTANT *VARANUS* LIZARDS

12:00 **Melstrom, K.** QUANTIFYING REPTILE TOOTH COMPLEXITY: IMPLICATIONS FOR RECONSTRUCTING THE DIET OF EXTINCT AMNIOTES

FRIDAY AFTERNOON, OCTOBER 16, 2015

TECHNICAL SESSION XIII

HYATT REGENCY DALLAS, LANDMARK AB

MODERATORS: Jordan Mallon and Dominic White

1:45 **Mallon, J.** NO EVIDENCE FOR SEXUAL DIMORPHISM IN NON-AVIAN DINOSAURS

2:00 **Moore, J. R., Varricchio, D. J.** THE EVOLUTION OF DIAPSID REPRODUCTIVE ECOLOGY AND INFERENCES ABOUT EXTINCT TAXA

2:15 **Bailleul, A. M.** ONTOGENY OF SUTURAL CLOSURE IN THE SKULLS OF EXTANT ARCHOSAURS: RECONSIDERING MATURITY ASSESSMENT IN NON-AVIAN DINOSAURS

2:30 **Gould, F. D., Falkingham, P.** A GEOMETRIC MORPHOMETRIC APPROACH TO UNDERSTANDING VARIATION IN DINOSAUR FOOTPRINT OUTLINES

2:45 **Takasaki, R., Kobayashi, Y.** CONSTRUCTION OF A METHOD TO IMPLY FUNCTION OF GASTROLITHS FROM THEIR FEATURES AND ITS APPLICATION TO THE HERBIVOROUS ORNITHOMIMOSAUR *SINORNITHOMIMUS*

3:00 **Bertozzo, F., Lambertz, M., Sander, P.** CAN WE PREDICT THE PRESENCE OF AIR SACS IN THE POSTCRANIAL SKELETON OF DINOSAURS USING HISTOLOGICAL ANALYSIS?

3:15 **Lloyd, G. T., Soul, L. C.** DETECTING PHYLOGENETIC SIGNALS OF ENDEMISM AND DISPERSAL: THE EFFECTS OF PANGAEAN BREAKUP AND AVIAN FLIGHT ON MESOZOIC DINOSAURS

FRIDAY MORNING, OCTOBER 16, 2015

TECHNICAL SESSION XIII (CONTINUED)

3:30 **White, D. E.** ANATOMICAL AND POSTURAL ADAPTATIONS TO LARGE SIZE IN DINOSAURS

3:45 **D'Emic, M.** ACCOUNTING FOR SCALING ISSUES IN THE ESTIMATION OF GROWTH RATE SUGGESTS ENDOTHERMY IN NON-AVIAN DINOSAURS

4:00 **Grady, J., Enquist, B., Dettweiler-Robinson, E., Wright, N., Felisa, S.** DINOSAUR ENERGETICS AND THERMOREGULATION: THE EVIDENCE FROM GROWTH

FRIDAY AFTERNOON, OCTOBER 16, 2015

SYMPOSIUM 2: CONSERVATION PALEOBIOLOGY: INSIGHTS INTO MODERN ECOSYSTEMS FROM VERTEBRATE RECORDS

HYATT REGENCY DALLAS, LANDMARK C

MODERATORS: Larisa DeSantis and Josh Miller

1:45 **Lyman, R.** ADDRESSING THE CHALLENGE OF MAKING PALEOZOOLOGY RELEVANT TO CONSERVATION POLICIES AND AGENDAS

2:00 **Badgley, C.** HISTORICAL BASELINES OF DIVERSITY AND TURNOVER FROM THE MAMMALIAN FOSSIL RECORD

2:15 **Desantis, L. R.** MAMMALIAN RESPONSES TO CLIMATE CHANGE: LESSONS LEARNED FROM BOTH 'DEEP-TIME' EXPERIMENTS AND MODERN ECOLOGICAL STUDIES

2:30 **Smith, F. A., Tome, C. P., Elliott Smith, E. A., Lyons, S., Newsome, S. D., Stafford, T. W.** UNRAVELING THE CONSEQUENCES OF THE TERMINAL PLEISTOCENE MEGAFAUNA EXTINCTION ON MAMMAL COMMUNITY ASSEMBLY

2:45 **Feranec, R. S., Kozlowski, A. L.** ASSEMBLING ECOSYSTEMS DURING GLOBAL WARMING: MEGAFAUNAL COLONIZATION AND SUCCESSION IN GLACIATED NEW YORK AFTER THE LAST GLACIAL MAXIMUM

3:00 **Davis, E. B., McGuire, J. L., Koo, M. S.** LAST GLACIAL MAXIMUM FOSSIL RECORD OF MAMMALS SHOWS STRONG MIS-MATCH WITH ECOLOGICAL NICHE MODEL HINDCASTS: ROOM FOR IMPROVEMENT?

3:15 **Louys, J., O'Connor, S., Aplin, K.** HOLOCENE EXTINCTION OF TIMOR'S ENDEMIC GIANT MURID COMMUNITY, AND IMPLICATION FOR MODERN MURID CONSERVATION ON ISLANDS

3:30 **Behrensmeyer, A. K., Odock, F. L., Faith, J. T., Miller, J. H.** INSIGHTS FOR CONSERVATION PALEOBIOLOGY FROM 35 YEARS OF TAPHONOMIC RESEARCH IN MODERN AFRICAN ECOSYSTEMS

3:45 **Miller, J. H., Wald, E.** ANTLERS OF THE ARCTIC NATIONAL WILDLIFE REFUGE: BASELINES OF BIOLOGICAL VARIABILITY FROM BONES ON THE TUNDRA

4:00 **Fox-Dobbs, K., Ray, J., Ezenwa, V.** UNTANGLING THE ECOLOGY OF A MIXED-FEEDER: INDIVIDUAL BIOLOGICAL VERSUS ENVIRONMENTAL CONTROLS ON GAZELLE DIET IN A KENYAN SAVANNA ECOSYSTEM AND IMPLICATIONS FOR CONSERVATION

4:15 **Koch, P. L., Brault, E. K., Welch, A. J., Nye, J. W., Niven, L., Hall, B., Hoelzel, A.** ASSESSING THE VULNERABILITY OF ANTARCTIC SEALS TO ENVIRONMENTAL CHANGE: INSIGHTS FROM STUDIES OF SEAL MUMMIES

FRIDAY AFTERNOON, OCTOBER 16, 2015

TECHNICAL SESSION XIV

HYATT REGENCY DALLAS, LANDMARK D

MODERATORS: P. Martin Sander and Robin O'Keefe

1:45 **Depolo, P., Angster, S., Kelley, N., Noble, P.** THREE-DIMENSIONAL VISUALIZATION OF THE BERLIN ICHTHYOSAUR STATE PARK FOSSIL BEDS FROM TERRESTRIAL LIDAR DATA

2:00 **Lawrence Wujek, J. D.** MARY ANNING'S MARINE REPTILES: TAXONOMY, SYSTEMATICS, MORPHOMETRICS AND EVOLUTION OF THE ICONIC *ICHTHYOSAURUS*

2:15 **Wolniewicz, A. S., Motani, R.** A NEW GENUS AND SPECIES OF ICHTHYOSAUR (REPTILIA, ICHTHYOPTERYGIA) FROM THE BLUE LIAS FORMATION (LOWER JURASSIC) OF THE UNITED KINGDOM

2:30 **Wintrich, T.** THE FIRST TRIASSIC PLESIOSAUR: A SKELETON FROM THE RHAETIAN OF GERMANY AND ITS IMPLICATIONS FOR THE EVOLUTION OF PLESIOSAUR LOCOMOTION

2:45 **O'Keefe, F., Otero, R. A., Soto-Acuña, S., O'Gorman, J. P., Chatterjee, S.** CRANIAL ANATOMY OF *MORTURNERIA SEYMOURENSIS* AND THE EVOLUTION OF MYSTICETE-LIKE FILTER FEEDING IN AUSTRAL ARISTONECTINE PLESIOSAURS

3:00 **Sander, P., Hayashi, S., Houssaye, A., Nakajima, Y., Sato, T., Wintrich, T.** THE EVOLUTION OF PLESIOSAUR BONE HISTOLOGY: EVIDENCE FROM LONG BONES AND VERTEBRAE

3:15 **Vanburen, C. S.** THE EVOLUTION AND FUNCTION OF FUSED CERVICAL VERTEBRAE IN MARINE AMNIOTES

3:30 **Polcyn, M. J., Jacobs, L. L., Schulp, A. S., Mateus, O., Araújo, R.** TETHYAN AND WEDDELLIAN BIOGEOGRAPHIC MIXING IN THE MAASTRICHTIAN OF ANGOLA

3:45 **Connolly, A., Martin, L., Hasiotis, S.** PALEOBIOGEOGRAPHICAL IMPLICATIONS OF THE PARIETAL EYE, THROUGH THE PARIETAL FORAMEN, IN MOSASAURS

4:00 **Konishi, T.** A MOSASAUR (SQUAMATA: MOSASAURIDAE) SNEEZE: A HYPOTHESIS CONCERNING SALT EXCRETION IN THE TOP PREDATORS OF THE CRETACEOUS SEAS

FRIDAY, OCTOBER 16, 2015

POSTER SESSION III

HYATT REGENCY DALLAS, LANDMARK CIRCLE

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

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

Posters Associated with Symposium 2: Conservation Paleobiology: Insights into Modern Ecosystems from Vertebrate Records

LC1 **Pyenson, N. D., Kelley, N. P.** CONVERGENT TAPHONOMY AND MACROECOLOGY IN THE EVOLUTION OF MARINE TETRAPODS FROM THE TRIASSIC TO THE ANTHROPOCENE

LC2 **McGuire, J. L., Lawler, J., Schloss, C.** USING A CONSERVATION FRAMEWORK TO EXAMINE LANDSCAPE DIVERSITY, CLIMATE, AND VERTEBRATE RICHNESS

LC3 **Bell, C. J.** SWINGING THE DOUBLE-EDGED SWORD: COMMUNICATING THE RELEVANCE OF PALEONTOLOGICAL DATA TO CONSERVATION BIOLOGY

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FRIDAY, OCTOBER 16, 2015
POSTER SESSION III (CONTINUED)
MARSALIS HALL
Regular Session Posters

B46 **Pinakhina, D.** ACANTHODIANS FROM THE EIFELIAN/GIVETIAN BOUNDARY BEDS OF THE LEMOVZHA RIVER (NW RUSSIA)

B47 **Glinskiy, V., Pinakhina, D.** ON THE NATURE OF ULTRASCULPTURE IN THE DERMAL SKELETON OF PSAMMOSTEIDS (AGNATHA: PTERASPIDIFORMES)

B48 **Afanassieva, O.** EVIDENCE OF GROWTH AND REGENERATION OF THE EXOSKELETON IN OSTEOSTRACANS (AGNATHA, VERTEBRATA)

B49 **Mann, A., Rudkin, D., Laflamme, M., Evans, D. C.** DEVONIAN VERTEBRATE REMAINS FROM PELEE ISLAND, ONTARIO AND A NEW SPECIES OF *ONYCHODUS*

B50 **Miguel, R., Gallo, V., Wu, F.** NEW DATA ABOUT *CHANGXINGIA ASPRATILIS* (SARCOPTERYGII: ACTINISTIA) WITH COMMENTS ON ITS SYSTEMATIC POSITION IN MAWSONIIDAE

B51 **Itano, W.** MICROWEAR OBSERVED ON TEETH OF *EDESTUS MINOR*: EVIDENCE FOR AN UNUSUAL FEEDING STRATEGY

B52 **Maisey, J. G., McKinzie, M., Williams, R. R.** A PENNSYLVANIAN 'SUPERSHARK' FROM TEXAS

B53 **Ivanov, A. O., Johnson, G. D., Hearst, J.** NEW EARLY-MIDDLE PERMIAN CHONDRICHTHYAN FAUNAS FROM GUADALUPE MOUNTAINS NATIONAL PARK, TEXAS, USA

B54 **Hamm, S. A., Barnes, K.** MORPHOLOGICAL VARIATION IN *PTYCHODUS MORTONI* (ELASMOBRANCHII: PTYCHODONTIDAE)

B55 **Popov, E. V., Biriukov, A. V.** EARLY AND MIDDLE CENOMANIAN ELASMOBRANCHS FROM THE VOLGA REGION, RUSSIA

B56 **Ikegami, N.** A NEW ANACORACID SHARK FROM THE LATE CRETACEOUS MIFUNE GROUP, KUMAMOTO PREFECTURE, JAPAN

B57 **Bazzi, M., Campione, N., Kear, B., Blom, H., Ahlberg, P.** DISPARITY DYNAMICS OF LAMNIFORM SHARKS ACROSS THE CRETACEOUS-PALAEOGENE BOUNDARY

B58 **Becker, M. A., Griffiths, M. L., Maisch IV, H. M., Gonzalez, B. G., Eagle, R. A., Rosenthal, Y.** RECONSTRUCTING TRANSATLANTIC MIGRATIONS IN THE LATE MESOZOIC AND MIDDLE CENOZOIC LAMNIFORM SHARKS FROM NEW JERSEY UTILIZING SEAWATER SR/CA AND ‘CLUMPED’ ISOTOPE PALEOTHERMOMETRY FROM TOOTH ENAMELOID

B59 **Cortez, C., Parham, J. F.** AN ARTICULATED SKELETON OF *CARCHARODON HASTALIS* (LAMNIFORMES, LAMNIDAE) FROM THE 'MONTEREY FORMATION', ORANGE COUNTY, CALIFORNIA

B60 **Sánchez, L., Solorzano, A., Caceres, C., Nuñez Flores, M., Reyes, A., Tavares, R., Rincón, A.** A MULTI-SPECIFIC SHARK NURSERY AREA IN THE LATE MIOCENE OF CAUJARAO FORMATION, VENEZUELA

B61 **Engelbrecht, A., Kriwet, J., Mörs, T., Reguero, M.** REVISION OF EOCENE ANTARCTIC CARPET SHARKS AND GROUND SHARKS (CHONDRICHTHYES, ORECTOLOBIFORMES, CARCHARINIFORMES)

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B62 **Divay, J. D., Murray, A.** IMPLICATIONS OF CENOZOIC MICROVERTEBRATE ASSEMBLAGES FOR THE FORMATION OF THE MODERN NORTH AMERICAN FRESHWATER ICHTHYOFAUNA.

B63 **Denton, J. S., Maisey, J. G.** APPLICATIONS OF REACTION-DIFFUSION MODELS TO ANALYSIS OF FOSSIL CHONDRICHTHYAN DEVELOPMENT

B64 **Shimada, K.** THE OLDEST NORTH AMERICAN RECORD OF THE LATE CRETACEOUS BONY FISH, *PENTANOGMIUS* (ACTINOPTERYGII: TSELFATIIFORMES) FROM DALLAS COUNTY, TEXAS, USA

B65 **Fielitz, C., González Rodríguez, K. A.** THE BULLDOG FISH: AN UNUSUAL TELEOSTEAN FOSSIL FISH FROM THE MUHI QUARRY (CRETACEOUS: LATE ALBIAN-EARLY CENOMANIAN) OF MEXICO

B66 **Mehling, C. M.** HUGE CRETACEOUS FISH COPROLITE WITH ARTICULATED FISH INCLUSIONS

B67 **Johnson-Ransom, E. D., Shimada, K.** FOSSIL FISHES FROM THE PFEIFER SHALE MEMBER OF THE UPPER CRETACEOUS GREENHORN LIMESTONE IN NORTH-CENTRAL KANSAS, U.S.A.

B68 **Ramirez, B., Turner, D., Macrini, T.** TAXONOMIC AND PROVENANCE ANALYSIS OF A LEGACY COLLECTION OF FOSSIL FISH BONES FROM LIVE OAK COUNTY, TEXAS

B69 **Pfaff, C., Kriwet, J.** MACROEVOLUTIONARY PATTERNS OF THE LOCOMOTOR SYSTEM IN NON-MURAENOID EELS (TELEOSTEI: ELOPOMORPHA)

B70 **Prikryl, T.** NEW ANATOMICAL DATA ON AN OLIGOCENE MORID FISH *EOPHYCIS* (GADIFORMES) FROM THE CENTRAL PARATETHYS (POLAND)

B71 **Gottfried, M. D., Fordyce, R. E.** NOVEL LATERAL LINE AND CAUDAL FIN MORPHOLOGY IN A PALEOGENE 'TARPON' (MEGALOPIDAE) FROM NEW ZEALAND

B72 **Núñez, M., Solórzano, A., Rincón, A., Sánchez, L.** AN OTOLITH-BASED FISH FAUNA FROM THE EARLY MIOCENE OF THE CASTILLO FORMATION, VENEZUELA

B73 **Vernygora, O. V.** UNCOVERING PATTERNS OF THE EARLY DIVERSIFICATION AND BIOGEOGRAPHY OF THE CLUPEOMORPHA: A NEW BASAL CLUPEOMORPH FROM THE NORTHWEST TERRITORIES, CANADA

B74 **Stringer, G. L.** EOCENE FISH OTOLITHS PROVIDE EVIDENCE OF INTERACTION WITH MARINE INVERTEBRATES DURING THE TAPHONOMIC PROCESS

B75 **Smith, G., Stearley, R.** GROWTH AND SIZE OF THE 200 KG MIOCENE SPIKETOOTH SALMON: EARLY EVOLUTION OF THE PACIFIC SALMON MIGRATORY LIFE HISTORY

B76 **Whalen, C. D.** TRENDS IN VERTEBRATE AND CEPHALOPOD DIVERSITY IN THE 'AGE OF FISHES'

B77 **Sankey, J., Biewer, J., Wilson, W., Basuga, J., George, M., Palacios, F., Wagner, H., Hutchison, H., Garber, D.** KAYAKING FOR PALEO – RELOCATING AND DOCUMENTING THE TURLOCK LAKE FOSSIL SITES, UPPER MEHRTEN FORMATION (EARLY PLIOCENE; HEMPHILLIAN LMA), STANISLAUS COUNTY, CALIFORNIA

B78 **Beightol V, C. V., Vilhena, D., Sidor, C. A., Angielczyk, K. D., Nesbitt, S. J., Tabor, N. J.** BIOGEOGRAPHIC BIPARTITE NETWORK ANALYSIS MADE ACCESSIBLE TO PALEOBIOLOGICAL RESEARCHERS

B79 **Withdrawn**

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B80 **Blob, R. W., Huttenlocker, A. K., Kammerer, C. F., Sidor, C. A.** COMPARATIVE ALLOMETRY OF FEMORAL CURVATURE IN GORGONOPSIAN VERSUS THEROCEPHALIAN THERAPSIDS

B81 **Piculjan, L., Angielczyk, K. D., Sidor, C. A., Tolan, S., Kammerer, C. F., Fröbisch, J.** CRANIAL ANATOMY OF THE ZAMBIAN DICYNODONT *SYOPS VANHOEPENI*

B82 **Beck, A. L., Scheckel, J.** MORPHOLOGIC INDICATORS OF FOSSORIALITY AND THE EVOLUTION OF BURROWING IN DICYNODONTS (AMNIOTA, SYNAPSIDA)

B83 **Peecook, B. R., Nesbitt, S. J., Steyer, J., Smith, R. M., Tolan, S., Tabor, N. J., Angielczyk, K. D., Sidor, C. A.** WE'RE GONNA NEED A BIGGER BAG: MICROFOSSIL SAMPLING ADDS SUBSTANTIAL DIVERSITY TO THE MIDDLE TRIASSIC NTAWERE FORMATION OF ZAMBIA

B84 **Gay, R. J.** DID THE HUNT FOR EARLY MAMMALS IN ARIZONA CREATE A SIGNIFICANT SAMPLING BIAS?

B85 **Rayfield, E., Lautenschlager, S., Gill, P., Fagan, M.** DIGITAL RESTORATION OF THE CRANIAL MUSCULOSKELETAL ANATOMY OF *MORGANUCODON OEHLERI*

B86 **Wang, Y.** REVISITING THE PHYLOGENETIC RELATIONSHIPS OF SHUOTHERIIDAE (SHUOTHERIDIA, MAMMALIAFORMES)

B87 **Miyata, K., Azuma, Y., Shibata, M.** EUTRICONODONT MAMMAL FROM THE LOWER CRETACEOUS KITADANI FORMATION, TETORI GROUP, FUKUI, JAPAN, AND ITS IMPLICATION TO THE FAMILY TRICONODONTIDAE

B88 **Brannick, A. L., Wilson, G. P.** NEW SPECIMENS AND MORPHOLOGY OF THE LOWER JAW OF THE LATE CRETACEOUS METATHERIAN *EODELPHIS* MATTHEW, 1916

B89 **Kotrappa, M. S., Farke, A. A.** ANATOMY OF THE ENDOSSEOUS LABYRINTH IN THE MULTITUBERCULATE MAMMAL *NEOPLAGIAULAX*

B90 **Williamson, T. E., Brusatte, S. L., Secord, R., Shelley, S.** A NEW TAENIOLABIDOID MULTITUBERCULATE FROM THE MIDDLE PUERCAN (PU2) OF THE NACIMIENTO FORMATION, NEW MEXICO, AND A REVISION OF TAENIOLABIDOID SYSTEMATICS AND PHYLOGENY

B91 **Scott, C. S., Weil, A., Theodor, J. M.** A DIMINUTIVE NEW SPECIES OF *CATOPSALIS* (MAMMALIA, MULTITUBERCULATA, TAENIOLABIDIDAE) FROM THE PALEOCENE OF SOUTHERN ALBERTA, CANADA

B92 **Schultz, J. A., Martin, T.** THE INNER AND MIDDLE EAR OF JURASSIC PAULCHOFFATIID MULTITUBERCULATES

B93 **Brink, A. A.** AN EARLY CAMPANIAN MAMMALIAN FAUNA FROM THE BIG BEND REGION OF TEXAS

B94 **Cifelli, R. L., Davis, B. M.** SECOND EUTHERIAN MAMMAL FROM THE CLOVERLY FORMATION (LOWER CRETACEOUS) OF MONTANA

B95 **Cohen, J. E., Cifelli, R. L.** THE FIRST EUTHERIAN MAMMALS FROM THE EARLY LATE CRETACEOUS OF NORTH AMERICA

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B96 **Bamforth, E. L., Tokaryk, T. T., Fendley, I. M.** NOTABLE CRETACEOUS–PALEOGENE (K–PG) BOUNDARY EXPOSURES IN SOUTHWEST SASKATCHEWAN, CANADA: A WINDOW ONTO EXTINCTION

B97 **Montanari, S., Brusatte, S. L., Secord, R., Williamson, T. E.** COMPARISONS OF STABLE ISOTOPE TROPHIC NICHE METRICS IN EXTANT SMALL MAMMAL COMMUNITIES: IMPLICATIONS FOR UNDERSTANDING MAMMALIAN COMMUNITY COMPOSITION AT THE K-PG BOUNDARY

B98 **Vietti, L. A., Kerr, T. J., Haupt, R. J., Clementz, M. T.** OVERVIEW AND SIGNIFICANCE OF THE UNIVERSITY OF WYOMING VERTEBRATE FOSSIL COLLECTION

B99 **Madan, M., Rayfield, E., Bright, J.** SCALING AND FUNCTIONAL MORPHOLOGY OF STRIGIFORM HIND LIMBS

B100 **Canoville, A., De Buffrénil, V.** ONTOGENETIC DEVELOPMENT AND INTRASPECIFIC VARIABILITY OF BONE MICROSTRUCTURE IN PENGUINS, WITH IMPLICATIONS FOR PALEOECOLOGICAL INFERENCE

B101 **Hellert, S.** VARIATION IN FORE- AND HIND LIMB INTEGRATION PATTERNS OF AVIAN THEROPODS

B102 **Early, C. M., Witmer, L. M.** NEUROANATOMY, ENDOCASTS, AND THE EVOLUTION OF BRAINS AND BEHAVIOR IN BIRDS

B103 **Smith, N., Ksepka, D.** FIVE WELL-SUPPORTED FOSSIL CALIBRATIONS WITHIN THE 'WATERBIRD' ASSEMBLAGE (TETRAPODA, AVES)

B104 **Yury-Yáñez, R. E.** ADDITIONAL MATERIALS OF THE PLIOCENE PENGUIN *'PYGOSCELIS' GRANDIS* (AVES, SPHENISCIFORMES), AND THE GENERIC STATUS OF THE SPECIES

B105 **Degrange, F. J., Tambussi, C. P.** ENDOCRANIAL ANATOMY OF *MADRYNORNIS MIRANDUS* (AVES, SPHENISCIFORMES), A CROWN-PENGUIN FROM THE EARLY LATE MIOCENE OF PATAGONIA

B106 **Richards, M. D., Fordyce, R. E.** NEW PARTIAL SKELETON OF LATE EOCENE *PALAEEUDYPTES*-LIKE PENGUIN FROM CENTRAL OTAGO, NEW ZEALAND

B107 **Ando, T.** NEW SKELETAL ELEMENTS OF PLOTOPTERIDS FROM JAPAN

B108 **Syverson, V. J., Madan, M., Prothero, D. R.** STASIS IN GREAT HORNED OWLS FROM THE LA BREA TAR PITS DURING THE LAST GLACIAL-INTERGLACIAL CYCLE

B109 **Holloway, W. L.** THE EFFECTS OF CRANIAL SUTURES ON STRAIN DISTRIBUTION PATTERNS IN THE AMERICAN ALLIGATOR CRANIUM

B110 **Haupt, R. J., Hastings, A. K., Clementz, M. T.** QUANTITATIVE ANALYSIS OF FOSSIL CROCODYLIAN TEETH TO IDENTIFY A POTENTIAL JUVENILE REFUGE OR NESTING GROUND IN THE MIOCENE OF PANAMA

B111 **Sellers, K. C., Davis, J. L., Middleton, K. M., Holliday, C. M.** ONTOGENY AND BIOMECHANICS OF THE AMERICAN ALLIGATOR SKULL

B112 **Brochu, C.** NEW SHARP-NOSED CROCODILES (*MECISTOPS*) FROM THE MIO-PLIOCENE OF THE LAKE TURKANA BASIN OF KENYA AND THE TRANSITION FROM BROAD TO SLENDER SNOUTS IN CROCODYLIDS

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B113 **Solórzano, A., Rincón, A. D., Núñez Flores, M., Sánchez, L.** INSIGHT INTO THE ORIGINS OF THE NEOGENE CROCODILIAN ASSEMBLAGES IN THE NORTHERN NEOTROPICS: EVIDENCE FROM THE EARLY MIOCENE CASTILLO FORMATION, VENEZUELA

B114 **Tennant, J. P., Mannion, P. D., Upchurch, P.** ENVIRONMENTAL DRIVERS OF CROCODYLIFORM DIVERSITY AND EXTINCTION THROUGH THE JURASSIC/CRETACEOUS BOUNDARY

B115 **Takekawa, A., Hirayama, R., Aoki, R., Skutschas, P., Kuzmin, I.** NEW ARTICULATED POSTCRANIAL MATERIAL OF *PARALLIGATOR GRADILIFRONS* (CROCODYLIFORMES) FROM MONGOLIA

B116 **Meunier, L., Larsson, H. C.** REDESCRIPTION AND PHYLOGENETIC AFFINITIES OF *ELOSUCHUS CHERIFIENSIS* (CROCODYLIFORMES)

B117 **Godoy, P. L., Bronzati, M., Langer, M. C., Eltink, E., Marsola, J. A., Cidade, G. M., Montefeltro, F. C.** THE POSTCRANIAL ANATOMY OF *PISSARRACHAMPSA SERA* (MESOEUCROCODYLIA, BAURUSUCHIDAE), FROM THE LATE CRETACEOUS OF BRAZIL

B118 **Tsuihiji, T., Watabe, M., Tsogtbaatar, K., Witmer, L. M.** A NEW SPECIMEN OF *SHARTEGOSUCHUS* (ARCHOSAURIA: CROCODYLIFORMES) FROM THE UPPER JURASSIC IN SHAR TEG, WESTERN GOBI DESERT, MONGOLIA

B119 **Weinbaum, J. C., Hungerbuehler, A.** NEW CROCODYLOMORPH FOSSILS FROM THE LATEST TRIASSIC OF EASTERN NEW MEXICO

B120 **Cossette, A.** A NEW SPECIMEN OF THE ALLIGATOROID *BOTTOSAURUS HARLANI* FROM THE PALEOCENE OF NEW JERSEY, AND ITS PHYLOGENETIC IMPLICATIONS

B121 **Miller-Camp, J.** THE INTERPLAY OF SNOUT LENGTH AND FEEDING ECOLOGY BETWEEN ALLIGATOROIDS AND OTHER CO-OCCURING CROCODYLIFORMS

B122 **Callahan, W. R., Pellegrini, R. A., Schein, J. P., McCauley, J. D., Parris, D. C.** A NEARLY COMPLETE SPECIMEN OF *HYPOSAURUS ROGERSII* (CROCODYLOMORPHA, DYROSAURIDAE) FROM THE LATE CRETACEOUS-EARLY PALEOGENE OF NEW JERSEY

B123 **Kuhn-Hendricks, S. M.** TOOTH FRACTURE: A METHOD FOR DETERMING BITE FORCES IN MOLARIFORM TEETH

B124 **Jones, A. S., Button, D. J., Cuff, A. R., Rayfield, E. J.** THE CRANIAL BIOMECHANICS OF *EFFIGIA OKEEFFEAE* AND ITS CONVERGENCE WITH ORNITHOMIMOSAURIDAE

B125 **Quattro, M. R., Hungerbuehler, A., Martz, J. W., M'Sadoques, J. G., Weinbaum, J. C.** NEW PSEUDOPALATINE PHYTOSAUR SPECIMENS FROM THE SONSELA MEMBER OF THE CHINLE FORMATION OF NORTHEASTERN ARIZONA INDICATE INCREASED REVUELTIAN PHYTOSAUR DIVERSITY

B126 **Hoffman, D. K., Miller-Camp, J. A., Heckert, A. B.** DIFFERENCES IN PHYTOSAUR (DIAPSIDA:ARCHOSAURIFORMES) TOOTH ENAMEL MICROSTRUCTURE BETWEEN BASINS AND POSSIBLE ECOLOGICAL IMPLICATIONS

B127 **Snively, E., Henderson, D. M., Wick, E., Sokup, R., Roth, P., Dupor, M.** CERATOPSIAN DINOSAURS COULD TURN MORE QUICKLY AND IGUANODONTIANS COMPARABLY TO CONTEMPORANEOUS LARGE THEROPODS

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B128 **Bykowski, R.** MODELING ECOLOGICAL ASSOCIATIONS AND HABITAT PREFERENCES OF HORNED DINOSAURS: A CASE STUDY USING THE CERATOPSIAN FOSSIL RECORD

B129 **Erickson, G. M., Kaye, D. I., Sidebottom, M. A., Sawyer, W. G., Norell, M. A., Krick, B. A.** WEAR BIOMECHANICS IN THE SLICING DENTITION OF THE GIANT HORNED DINOSAUR, *TRICERATOPS*

B130 **Wilson, J. P., Scannella, J. B., Horner, J. R.** A REASSESSMENT OF CRANIAL ONTOGENY IN *EINIOSAURUS PROCURVICORNIS* AND *ACHELOUSAURUS HORNERI*: IMPLICATIONS FOR CENTROSAURINE TAXONOMY AND EVOLUTION

B131 **Scannella, J. B., Wolff, E., Horner, J. R.** SEVERE CRANIAL PATHOLOGIES IN *TRICERATOPS* FROM THE HELL CREEK FORMATION, MONTANA

B132 **Campbell, J. A., Ryan, M. J., Schröder-Adams, C. J., Holmes, R. B.** EVOLUTIONARY TRENDS IN *VAGACERATOPS* (ORNITHISCHIA: CERATOPSIDAE) AND THE STATUS OF *KOSMOCERATOPS* IN THE UPPER CRETACEOUS (CAMPANIAN) DINOSAUR PARK FORMATION OF ALBERTA

B133 **Varriale, F. J.** DENTAL MICROWEAR IN *PACHYCEPHALOSAURUS* AND *STEGOCERAS* SUPPORTS ORTHAL MASTICATION IN PACHYCEPHALOSAURIA (ORNITHISCHIA)

B134 **Dufault, D. M., Evans, D. C., Sereno, P. C.** DERIVED PACHYCEPHALOSAURID SQUAMOSALS (ORNITHISCHIA: MARGINOCEPHALIA) FROM THE UPPER DINOSAUR PARK FORMATION, SOUTHERN ALBERTA

B135 **Cantrell, A. K., Suazo, T. L., Lucas, S. G., Sullivan, R. M.** THE FIRST NEARLY COMPLETE JUVENILE *PENTACERATOPS*, FROM THE UPPER CRETACEOUS KIRTLAND FORMATION (HUNTER WASH MEMBER), SAN JUAN BASIN, NEW MEXICO

B136 **Wade, D. J., Varricchio, D. J., Moore-Nall, A., Norell, M.** DESCRIPTION AND GEOCHEMICAL ANALYSIS OF A BASAL NEOCERATOPSIAN ASSEMBLAGE FROM THE UPPER CRETACEOUS OF MONGOLIA

B137 **Marsola, J. C., Bittencourt, J. S., Da-Rosa, Á. A., Langer, M. C.** A SMALL-SIZED SAURISCHIAN DINOSAUR FROM THE LATE TRIASSIC SANTA MARIA FORMATION, SOUTHERN BRAZIL

B138 **Hartman, S., Lovelace, D., Linzmeier, B. J.** USING ECOLOGICAL MODELLING TO QUANTIFY THERMAL CONSTRAINTS ON TWO LATE TRIASSIC DINOSAURS

B139 **Gardner, J. D., Woodruff, D., Wilson, J. P., Flora, H. M., Horner, J. R., Organ, C. L.** BIOMECHANICAL ADAPTATIONS TO INCREASED BODY SIZE IN THE NEURAL SPINES OF THEROPOD DINOSAURS

B140 **Persons, W. S., Currie, P. J.** SEXUALLY SELECTED BRIDGES IN THE FITNESS LANDSCAPE AND IMPLICATIONS FROM THE FUNCTIONAL HISTORY OF FEATHER EVOLUTION

B141 **Sorkin, B.** A RE-EVALUATION OF SEVERAL CHARACTER STATES IN NON-COELUROSAURIAN TETANURAE (DINOSAURIA: THEROPODA) WITH IMPLICATIONS FOR PHYLOGENY OF BASAL TETANURANS

B142 **Wills, S.** ISOLATED DROMAEOSAURID TEETH FROM THE BATHONIAN (MIDDLE JURASSIC) OF DORSET, UNITED KINGDOM

B143 **Senter, P.** RANGE OF MOTION IN THE FORELIMB OF THE THEROPOD DINOSAUR *DILOPHOSAURUS WETHERILLI*

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B144 **Fong, R. K., Leblanc, A. R., Reisz, R. R.** THE DENTAL HISTOLOGY OF THE EARLY DINOSAUR *COELOPHYSIS BAURI*

B145 **Klingler, J.** TRACHEAL AND ESOPHAGEAL DISPLACEMENT IN THE REMARKABLY PRESERVED COMPSOGNATHID *SCIPIONYX SAMNITICUS*

B146 **Georgalis, G. L., Delfino, M.** A NEW DIVERSE SQUAMATE FAUNA FROM THE LATE MIOCENE OF NORTHERN GREECE

B147 **Stilson, K. T., Bell, C. J., Mead, J. I.** A COMPARISON OF MORPHOLOGICAL AND GENETIC PHYLOGENIES FOR AUSTRALIAN AGAMIDAE, WITH IMPLICATIONS FOR THE FOSSIL RECORD

B148 **Croghan, J. A., Morhardt, A., Caldwell, M., Breithaupt, B.** HOW CONSERVED IS NEUROANATOMY IN SNAKES? COMPARING THE ENDOCASTS OF A 32-MILLION-YEAR-OLD SNAKE AND ITS EXTANT RELATIVES

B149 **Bochaton, C.** SUBFOSSIL LIZARDS FROM THE GUADELOUPE ISLANDS: 30 000 YEARS OF SPECIES TURNOVER IN A LESSER ANTILLEAN ARCHIPELAGO

B150 **Power, A.** SKELETAL VARIATION IN *GEHYRA* GECKOS

B151 **Harding, R., Stilson, K. T., Bell, C. J.** TESTING THE VALIDITY OF PUBLISHED MORPHOLOGICAL CHARACTER DESCRIPTIONS OF NORTH AMERICAN PLEISTOCENE LIZARDS REFERRED TO THE GENUS *SCELOPORUS*

B152 **Yamashita, M., Konishi, T., Everhart, M. J.** UTILITY OF SCLEROTIC RINGS IN MOSASAUR PHYLOGENY AND BEYOND: NEW INSIGHTS FROM THE SUBFAMILY MOSASAURINAE

B153 **Street, H. P., Caldwell, M. W.** A GAME OF RIDDLES: REASSESSING NEW ZEALAND'S ENDEMIC MOSASAURINE DIVERSITY

B154 **Jimenez-Huidobro, P., Bullard, T., Caldwell, M.** NEW DATA ON A POTENTIAL NEW SPECIES OF THE YOUNGEST KNOWN TYLOSAURINE MOSASAUR FROM THE UPPER CAMPANIAN BEARPAW FORMATION OF SASKATCHEWAN, CANADA.

B155 **Van Vranken, N. E.** PHYLOGENETIC REASSESSMENT AND PALEOECOLOGY OF THE MOSASAUR *TYLOSAURUS KANSASENSIS*

B156 **Withdrawn**

B157 **Lee, H., Lee, Y., Fiorillo, A. R.** THE FIRST CRETACEOUS LIZARD TRACKWAYS

B158 **Chavarría Arellano, M. L., Simoes, T., Montellano Ballesteros, M.** NEW SPECIMENS OF *DICHOTODON BAJAENSIS* (SQUAMATA, BORIOTEIIOIDEA) FROM THE LATE CRETACEOUS OF BAJA CALIFORNIA, MéXICO, REVEAL UNUSUAL TOOTH REPLACEMENT AMONGST LIZARDS

B159 **Mathews, J. C., Samonds, K. E.** A NEW JUVENILE SUBFOSSIL CROCODILE FROM THE ANJOHIBE CAVE, NORTHWESTERN MADAGASCAR

B160 **Hagen, C. J., Roberts, E. M., Liu, J., Sullivan, C., Wang, Y., Xu, X.** TAPHONOMY, AGE, AND GEOLOGICAL CONTEXT OF THE ORIGINAL *LOTOSAURUS ADENTUS* (ARCHOSAURIA, POPOSAUROIDEA) BONEBED IN THE MIDDLE TRIASSIC BADONG FORMATION, HUNAN, CHINA

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POSTER SESSION III (CONTINUED)

B161 **Martínez, R. N., Heckert, A. B.** NOVEL MORPHOLOGICAL INSIGHTS FROM AN INCOMPLETE, ARTICULATE SKELETON OF A PRIMITIVE AETOSAUR (ARCHOSAURIA, PSEUDOSUCHIA) FROM THE UPPER TRIASSIC ISCHIGUALASTO FORMATION, SAN JUAN PROVINCE, ARGENTINA

B162 **Lund, E. K.** FORM AND EVOLUTION OF THE NARIAL REGION IN CERATOPSIAN DINOSAURS: INSIGHTS FROM GEOMETRIC MORPHOMETRICS

B163 **Fry, J. J.** CLADISTIC ANALYSIS OF *PENTACERATOPS* SPECIMENS FROM THE SAN JUAN BASIN, NEW MEXICO

B164 **Kruk, B., Burns, M. E., Currie, P. J.** A NEW SPECIES OF *PACHYRHINOSAURUS* (CERATOPSIDAE, PACHYROSTRA) FROM THE WAPITI FORMATION (UPPER CAMPANIAN) OF ALBERTA, CANADA

SATURDAY MORNING, OCTOBER 17, 2015

SYMPOSIUM 3: THE SHAPE OF THINGS TO COME: GEOMETRIC MORPHOMETRICS IN VERTEBRATE PALEONTOLOGY

HYATT REGENCY DALLAS, LANDMARK AB

MODERATOR: Marc Jones, Emma Sherratt and Akinobu Watanabe

8:00 **Watanabe, A.** HOW MANY LANDMARKS ARE ENOUGH? IDENTIFYING ADEQUATE SAMPLING OF LANDMARKS FOR CAPTURING THE SHAPE OF SPECIMENS

8:15 **Marugan-Lobon, J., Prieto, G.** GEOMETRIC MORPHOMETRICS AND THEORETICAL MORPHOLOGY

8:30 **Head, J. J., Polly, P.** SNAKING THROUGH A GRADIENT: COMBINING GEOMETRIC MORPHOMETRICS AND MAXIMUM LIKELIHOOD TO MODEL AN ANATOMICAL CONTINUUM

8:45 **Vitek, N. S., Manz, C. L., Bloch, J. I., Boyer, D. M., Strait, S. G.** DIFFERENTIATING TOOTH SHAPE USING AUTOMATED THREE-DIMENSIONAL GEOMETRIC MORPHOMETRICS: TESTING ALIGNMENT SENSITIVITY AND UTILITY FOR ANALYSES OF SMALL MAMMALS ACROSS THE PALEOCENE-EOCENE THERMAL MAXIMUM

9:00 **Sherratt, E., Collyer, M., Adams, D.** GEOMORPH: TOOLS FOR ANALYSING HIGH-DIMENSIONAL DATA OF FOSSIL AND MODERN TAXA

9:15 **Savriama, Y., Jernvall, J.** THE INVISIBLE FOSSIL: RECONSTRUCTING INTERMEDIATE MORPHOLOGIES USING GEOMETRIC MORPHOMETRICS

9:30 **Tallman, M., Amenta, N., Delson, E., Frost, S. R., Ghosh, D., Terwilliger, A., Rohlf, F.** ADDING PHYLOGENETIC TREES TO IMPROVE VIRTUAL RETRODEFORMATION: CERCOPITHECIDAE AS A TEST CASE

9:45 **Goswami, A., Polly, P.** SHAPING SHAPE: HOW PHENOTYPIC INTEGRATION AND MODULARITY INFLUENCE THE EVOLUTION OF ORGANISMAL FORM

10:00 **BREAK**

10:15 **Jones, M. E., Humphries, E. D., Worthy, T. H., Sherratt, E.** GEOMETRIC MORPHOMETRIC ANALYSIS OF HOLOCENE DENTARIES FROM NEW ZEALAND REFERRED TO *SPHENODON* SP., AND DENTARY SHAPE VARIATION AMONGST RHYNCHOCEPHALIA (REPTILIA: LEPIDOSAURIA)

10:30 **Wilson, L. A., Colombo, M., Sánchez-Villagra, M. R., Salzburger, W.** EVOLUTION OF OPERCLE BONE SHAPE IN CICHLID FISHES FROM LAKE TANGANYIKA – UNCOVERING ADAPTIVE TRAIT INTERACTIONS IN EXTANT AND EXTINCT SPECIES FLOCKS

SATURDAY MORNING, OCTOBER 17, 2015

SYMPOSIUM 3: THE SHAPE OF THINGS TO COME: GEOMETRIC MORPHOMETRICS IN VERTEBRATE PALEONTOLOGY (CONTINUED)

10:45 **Yi, H., Norell, M. A.** LANDMARKS IN THE BONY LABYRINTH: SHAPE OF THE INNER EAR PREDICTS PALEOECOLOGY OF LIMB-REDUCED FOSSIL REPTILES

11:00 **Milne, N., Fitton, L., O'Higgins, P.** THE APPLICATION OF GEOMETRIC MORPHOMETRIC TECHNIQUES TO THE ANALYSIS OF DEFORMATIONS IN FINITE ELEMENT ANALYSIS

11:15 **Angielczyk, K. D., Polly, P. D., Stayton, C. T.** QUANTITATIVE EVOLUTIONARY MODELING AS A FRAMEWORK FOR A NEW SYNTHESIS OF GEOMETRIC MORPHOMETRICS AND FINITE ELEMENT ANALYSIS

11:30 **Baab, K. L., Perry, J. M., Rohlf, F., Jungers, W. L.** LEMUR CRANIOMANDIBULAR DIVERSIFICATION IN RELATION TO DIETARY ECOLOGY

11:45 **McNulty, K., Fox, D. L., Keller, J. S., Torgeson, J., Longar, A.** ASSESSING THE PALEOBIOLOGY OF NORTH AMERICAN RODENTS USING NEW APPROACHES IN GEOMETRIC MORPHOMETRIC ANALYSIS

12:00 **MacLeod, N.** AUTOMATED ASSESSMENT AND IDENTIFICATION OF VERTEBRATE MORPHOLOGY FROM IMAGES AND 3D MODELS: MAKING THE JUMP FROM GEOMETRIC MORPHOMETRICS TO COMPUTER VISION, ARTIFICIAL INTELLIGENCE, AND DEEP LEARNING

SATURDAY MORNING, OCTOBER 17, 2015

TECHNICAL SESSION XV

HYATT REGENCY DALLAS, LANDMARK C

MODERATORS: Darin Croft and Jonathan Mitchell

8:00 **Nabavizadeh, A.** PROBOSCIDEAN JAW MUSCLE MECHANICS AND THE EVOLUTION OF FEEDING AND THE PROBOSCIS IN ELEPHANTS

8:15 **Gardiner, J., Brassey, C.** ADVANCED SHAPE-FITTING ALGORITHMS APPLIED TO ESTIMATES OF MAMMOTH AND SLOTH BODY MASS

8:30 **Macrini, T. E., Perini, F. A., Flynn, J. J., Bamba, K., Ni, X., Croft, D. A., Wyss, A. R.** NEW DATA BEARING ON THE EVOLUTION OF THE ENDOCRANIAL CAVITY OF NOTOUNGULATA (MAMMALIA), AND A PHYLOGENETIC ANALYSIS BASED ON CRANIODENTAL CHARACTERS

8:45 **McGrath, A. J., Anaya, F., Croft, D.** NEW SOUTH AMERICAN NATIVE UNGULATES (LITOPTERNA: MACRAUCHENIIDAE) FROM THE MIDDLE MIOCENE (SERAVALLIAN; LAVENTAN SOUTH AMERICAN LAND MAMMAL AGE) OF QUEBRADA HONDA, BOLIVIA

9:00 **Croft, D. A., Anaya, F., Brandoni, D., Carlini, A. A., Catena, A. M., Ciancio, M. R., Engelman, R. K.** NEW MAMMAL FAUNAL DATA FROM CERDAS, BOLIVIA, A LOW LATITUDE NEOTROPICAL SITE THAT CHRONICLES THE END OF THE MIDDLE MIOCENE CLIMATIC OPTIMUM IN SOUTH AMERICA

9:15 **West, A. R., Flynn, J. J.** CHRONOLOGIC CALIBRATION AND CROSS-CONTINENTAL CORRELATION OF THE SOUTH AMERICAN LAND MAMMAL 'AGES': UPDATE 2015

9:30 **Wood, A. R., Rincon, A. F., Morgan, G. S., Bloch, J. I., MacFadden, B. J.** THE NEW WORLD TROPICS AS A CRADLE OF MAMMALIAN BIODIVERSITY: A PRE-GABI RECORD

9:45 **Pian, R., Gill, L. L., Provost, K. L., Wray, A. K., Cracraft, J. L.** THE FIRST AMERICAN BIOTIC INTERCHANGE: FINDING CONGRUENCE IN FOSSIL AND MOLECULAR DATA

10:00 BREAK

SATURDAY MORNING, OCTOBER 17, 2015
TECHNICAL SESSION XV (CONTINUED)

10:15 **Villavicencio, N. A., Lindsey, E. L., Martin, F., Borrero, L. A., Moreno, P. I., Marshal, C., Barnosky, A. D.** HUMANS, CLIMATE, AND VEGETATION CHANGE CAUSE MEGAFAUNAL EXTINCTIONS AT THE PLEISTOCENE-HOLOCENE TRANSITION IN THE ULTIMA ESPERANZA REGION (SOUTHERN PATAGONIA, CHILE)

10:30 **Spano, N., Bhullar, H. S., Lindsey, E., Villavicencio, N., Barnosky, A. D.** THE ECOLOGICAL CONSEQUENCES OF LATE-QUATERNARY MEGAFAUNAL EXTIRPATIONS IN SOUTHERN BRAZIL

10:45 **Lindsey, E., Villavicencio, N., Barnosky, A. D., Marshall, C.** THE DISAPPEARANCE OF PLEISTOCENE MEGAFAUNA FROM THE SOUTH AMERICAN PAMPAS AND THE EFFECTS OF DIFFERENT ANALYTICAL METHODS ON INTERPRETING EXTINCTION DYNAMICS

11:00 **Davis, M.** WHAT HAPPENED TO FUNCTIONAL DIVERSITY DURING THE LATE PLEISTOCENE MEGAFAUNAL EXTINCTION?

11:15 **Alroy, J., Bradshaw, C. J., Brook, B. W., Cooper, A., Johnson, C. N.** DELAYED EXTINCTION OF MEGAFAUNA FOLLOWING HUMAN ARRIVAL IN AUSTRALIA

11:30 **Mitchell, J. S., Angielczyk, K. D.** DEATH OF A COMMUNITY: SPECIES EXTINCTIONS ARE NOT INDEPENDENT

11:45 **Orzack, S., Myhrvold, N., Sivam, D.** DINOSAUR AND MAMMALIAN EXTINCTION DYNAMICS AND THEIR DEPENDENCY ON BODY SIZE AND LIFE HISTORY

12:00 **McHugh, J. B.** RADIATIONS AND EXTINCTIONS OF TEMNOSPONDYLI AND THE AMPHIBIAN RESPONSE TO THE END-PERMIAN MASS EXTINCTION

SATURDAY MORNING, OCTOBER 17, 2015
TECHNICAL SESSION XVI
HYATT REGENCY DALLAS, LANDMARK D
MODERATORS: Gabrial Sobral and Alex Hastings

8:00 **Chure, D. J., Andrus, A. S., Britt, B. B., Engelmann, G. F., Pritchard, A. C., Scheetz, R., Chambers, M.** MICRO CT IMAGERY REVEALS A UNIQUE MANUS MORPHOLOGY WITH DIGGING/SCRATCHING ADAPTATIONS IN THE SAINTS AND SINNERS QUARRY (SSQ) DREPANOSAUR, NUGGET SANDSTONE (LATE TRIASSIC), NORTHEASTERN UT

8:15 **Sobral, G., Sookias, R., Bhullar, B., Smith, R., Butler, R., Müller, J.** NEW INFORMATION ON THE BRAINCASE OF *EUPARKERIA CAPENSIS*

8:30 **Heckert, A. B.** VARIATION IN THE ORNAMENTATION PATTERN OF AETOSAUR (ARCHOSAURIA: SUCHIA) OSTEODERMS: TAXONOMIC AND PALEOBIOLOGICAL IMPLICATIONS

8:45 **Parker, W. G.** IMPROVED PHYLOGENETIC RESOLUTION TRACKS AETOSAURIAN (ARCHOSAURIA: PSEUDOSUCHIA) DIVERSITY THROUGH LATE TRIASSIC EXTINCTION EVENTS

9:00 **Nesbitt, S. J., Sidor, C., Irmis, R., Stocker, M., Angielczyk, K., Smith, R.** THE ANATOMY OF *ASILISAURUS KONGWE* (DINOSAURIFORMES: SILESAURIDAE) AND CLOSELY-RELATED TAXA PROVIDES NEW INSIGHTS INTO THE ANATOMICAL AND CHRONOLOGICAL EVOLUTION OF DINOSAURIFORMS

9:15 **Irmis, R. B., Chure, D. J., Wiersma, J. P.** LATITUDINAL GRADIENTS IN LATE TRIASSIC NON-MARINE ECOSYSTEMS: NEW INSIGHTS FROM THE UPPER CHINLE FORMATION OF NORTHEASTERN UTAH, USA

SATURDAY AFTERNOON, OCTOBER 17, 2015
TECHNICAL SESSION XVI (CONTINUED)

9:30 **Drymala, S., Zanno, L.** NEW CLADES AND CHARACTERS IN BASAL CROCODYLOMORPH PHYLOGENETICS

9:45 **Sullivan, C., Liu, J., Pan, Y., Wang, Y., Amiot, R.** A NEW BASAL CROCODYLOMORPH WITH UNEXPECTED SKELETAL AND SOFT-TISSUE FEATURES FROM THE MIDDLE-LATE JURASSIC DAOHUGOU BIOTA OF NORTHEAST CHINA

10:00 **BREAK**

10:15 **Morris, Z. S., Abzhanov, A.** EMBRYOS REVEAL NOVEL DEVELOPMENTAL TRAJECTORIES IN THE EVOLUTION OF CROCODYLIAN CRANIAL SHAPE

10:30 **Araújo, R., Castanhinha, R., Martins, G. G., Nhamutole, N., Du, T. Y., Fernandez, V., Tafforeau, P., Larsson, H., Martins, R. M., Sucena And Léon, É.** DEEP TIME CONSERVATIVE DEVELOPMENTAL PATTERNS REVEALED BY CROCODYLOMORPHA EMBRYOS FROM THE LATE JURASSIC OF PORTUGAL

10:45 **Larsson, H. C., Sereno, P. C., Evans, D. C.** NEW GIANT LATE CRETACEOUS CROCODYLIFORM WITH FEEDING ADAPTATIONS CONVERGENT ON SPINOSAURIDS

11:00 **Figueiredo, R. G., Kellner, A. W.** A REVIEW OF THE GENUS *ARARIPESUCHUS* (MESOEUCROCODYLIA) FROM THE CRETACEOUS OF GONDWANA

11:15 **Souza, R. G., Riff, D., Kellner, A.** THE EVOLUTION OF THE GAVIALOIDEA: A SOUTH AMERICAN PERSPECTIVE

11:30 **Hastings, A. K., Hellmund, M.** RARE IN SITU PRESERVATION OF ADULT CROCODYLIAN WITH EGGS FROM THE MIDDLE EOCENE GEISELTAL FOSSILLAGERSTÄTTE, GERMANY

11:45 **Ferguson, A. L., Varricchio, D. J., Piña, C., Jackson, F. D.** FROM EGGS TO HATCHLINGS: NEST SITE TAPHONOMY OF AMERICAN CROCODILE (*CROCODYLUS ACUTUS*) AND BROAD SNOUTED CAIMAN (*CAIMAN LATIROSTRIS*)

12:00 **Holliday, C., Sellers, K. C., Tsai, H. P., Vickaryous, M. K., Ross, C. F., Porro, L. B., Davis, J., Witmer, L. M.** PMJS AND TMJS: CONVERGENCE IN THE CRANIOMANDIBULAR JOINTS OF CROCODYLIFORMS AND MAMMALS

SATURDAY AFTERNOON, OCTOBER 17, 2015
TECHNICAL SESSION XVII
HYATT REGENCY DALLAS, LANDMARK AB
MODERATORS: Mike Habib and Martin Kundrat

1:45 **Habib, M., Chiappe, L.** ELASTIC TITANS: FUNCTIONAL ANALYSIS OF SAUROPOD NECKS REVEALS POTENTIAL FOR ELASTIC DAMPENING AND A NOVEL BLOOD FLOW ASSISTANCE MECHANISM

2:00 **Fronimos, J. A., Wilson, J. A., Baumiller, T. K.** WHY SAUROPOD POSTAXIAL CERVICAL VERTEBRAE ARE ALWAYS OPISTHOCOELOUS: PROXIMALLY-CONCAVE VERTEBRAL CENTRA CONFER GREATER STABILITY UNDER ROTATION

2:15 **Atwood, N. J., Woodruff, D. C., May, A.** THE STRUCTURAL PRESERVATION OF A TITANOSAURID (DINOSAURIA: SAUROPODA) VERTEBRAL LIGAMENT

2:30 **Woodruff, D., Storrs, G. W., Curry Rogers, K., Carr, T. D., Wilson, J.** THE SMALLEST KNOWN DIPLODOCID SKULL: NEW INSIGHTS INTO SAUROPOD CRANIAL DEVELOPMENT

SATURDAY AFTERNOON, OCTOBER 17, 2015
TECHNICAL SESSION XVII (CONTINUED)

2:45 **Schmitt, A., Knoll, F., Tschopp, E.** PALEONEUROLOGY OF *EUROPASAURUS HOLGERI*, AN INSULAR DWARF SAUROPOD FROM NORTHERN GERMANY

3:00 **Mannion, P., Allain, R., Moine, O.** THE EARLIEST KNOWN TITANOSAURIFORM SAUROPOD DINOSAUR AND THE EVOLUTION OF BRACHIOSAURIDAE

3:15 **Gorscak, E., O'Connor, P., Gomani Chindebvu, E.** THE RE-EVALUATION OF THE SAUROPOD DINOSAURS FROM THE DINOSAUR BEDS OF MALAWI REVEAL A HIDDEN DIVERSITY FOR SUB-EQUATORIAL AFRICAN FAUNAS

3:30 **Kundrát, M., Coria, R. A., Manning, T. W., Snitting, D., Chiappe, L. M., Nudds, J., Ahlberg, P. E.** *IN OVO* 3D PRESERVATION OF A TITANOSAURIAN (DINOSAURIA: SAUROPODA) EMBRYONIC SKULL

3:45 **Wilson, J. A., Pol, D., Zaher, H.** THE SKULL OF *TAPUIASAURUS MACEDOI* (DINOSAURIA: SAUROPODA), A BASAL TITANOSAUR FROM THE EARLY CRETACEOUS OF BRAZIL

4:00 **Curry Rogers, K., Whitney, M., Bagley, B., D'Emic, M.** TINY TITANOSAURS: PRIMARY GROWTH AND EARLY ONTOGENY IN A VERY YOUNG SAUROPOD FROM MADAGASCAR

SATURDAY AFTERNOON, OCTOBER 17, 2015
TECHNICAL SESSION XVIII
HYATT REGENCY DALLAS, LANDMARK C
MODERATORS: Tara Smiley and Amy Chew

1:45 **Brocklehurst, N.** A SIMULATION-BASED EXAMINATION OF THE RESIDUAL DIVERSITY ESTIMATES AS A METHOD OF CORRECTING FOR SAMPLING BIAS

2:00 **Anemone, R., Emerson, C., Nachman, B., Phillips, P. L.** EXPLORING THE STRATIGRAPHIC AND SEDIMENTOLOGIC CHARACTERISTICS OF A PALEOGENE MAMMAL LOCALITY USING THREE DIMENSIONAL DIGITAL OUTCROP MODELS

2:15 **Birlenbach, D. M., Marcot, J. D.** COMMUNITY STRUCTURE OF NORTH AMERICAN MAMMALS DURING THE PALEOCENE AND EOCENE

2:30 **Peppe, D. J., Williamson, T., Secord, R., Flynn, A., Davis, A. J., Brusatte, S. L.** DRIVERS OF FAUNAL TURNOVER OF EARLY PALEOCENE MAMMALIAN COMMUNITIES IN THE SAN JUAN BASIN, NEW MEXICO, USA

2:45 **Chew, A.** DIFFERENT MECHANISMS OF BODY SIZE CHANGE DURING THE HYPERTHERMALS OF THE EARLY EOCENE

3:00 **Smiley, T. M., Badgley, C.** PATTERNS OF MIOCENE MAMMALIAN DIVERSITY ACROSS SPATIAL SCALES IN THE GREAT BASIN OF WESTERN NORTH AMERICA

3:15 **Doman, J. H., Coutros, P. R.** ENVIRONMENTAL HETEROGENEITY OF A LATE MIOCENE EAST AFRICAN LANDSCAPE: INTRODUCING NEW MAMMALIAN FAUNA AND INTEGRATING MULTIPLE PALEOECOLOGICAL METHODS AND MODERN FOREST ECOLOGY TECHNIQUES IN THE MPESIDA BEDS, BARINGO, KENYA

3:30 **Du, A., Rowan, J., Patterson, D. B.** QUANTIFYING THE HABITAT PREFERENCES OF LARGE MAMMALS IN PLIOCENE-PLEISTOCENE EASTERN AFRICA USING ESTIMATED FRACTION WOODY CANOPY COVER

SATURDAY AFTERNOON, OCTOBER 17, 2015
TECHNICAL SESSION XVIII (CONTINUED)

3:45 **Rowan, J., Franklin, J., Reed, K. E.** LATE PLEISTOCENE BIOGEOGRAPHY AND CLIMATIC NICHE EVOLUTION IN PLAINS ZEBRA *EQUUS QUAGGA* AND BLUE WILDEBEEST *CONNOCHAETES TAURINUS*

4:00 **Lazagabaster, I. A., Kamilar, J., Reed, K., Rowan, J.** A PHYLOGENETICALLY CONTROLLED APPROACH TO EXAMINE THE TEMPO AND MODE OF EVOLUTION IN AFRICAN UNGULATE CRANIODENTAL TRAITS AND DIET

SATURDAY AFTERNOON, OCTOBER 17, 2015
TECHNICAL SESSION XIX
HYATT REGENCY DALLAS, LANDMARK D
MODERATORS: Laura Porro and Jason Pardo

1:45 **Struble, M., Organ, C., Laurin, M.** PALEOGENOMICS OF ANCIENT TETRAPODS AND THE IMPLICATIONS FOR TRACKING MAJOR EVENTS OF EXPANSION AND CONTRACTION OF THE MODERN TETRAPOD GENOME SIZE

2:00 **Marjanović, D.** MYSTERIES IN THE PHYLOGENY OF EARLY TETRAPODS AND THEIR EVOLUTIONARY IMPLICATIONS

2:15 **Porro, L. B., Clack, J. A., Rayfield, E. J.** ANATOMY AND THREE-DIMENSIONAL RECONSTRUCTION OF THE SKULL OF THE STEM TETRAPOD *CRASSIGYRINUS SCOTICUS*

2:30 **Maddin, H. C., Piekarski, N., Sefton, E. M., Hanken, J.** REEVALUATION OF THE HOMOLOGY OF THE BONES OF THE TETRAPOD CRANIAL VAULT

2:45 **Fröbisch, N., Bickelmann, C., Olori, J., Witzmann, F.** THE EVOLUTION OF REGENERATIVE CAPACITIES AND PREAXIAL POLARITY IN LIMB DEVELOPMENT - INSIGHTS FROM PALEOZOIC AMPHIBIANS

3:00 **Jia, J., Chen, J., Gao, K.** A NEW SALAMANDER FROM THE UPPER JURASSIC TIAOJISHAN FORMATION OF HEBEI PROVINCE, CHINA, AND EARLY EVOLUTION OF SALAMANDROIDS

3:15 **Szostakiwskyj, M., Pardo, J. D., Anderson, J. S.** VARIATION IN THE ADAPTATIONS FOR HEAD FIRST BURROWING IN RECUMBIROSTRAN 'MICROSAURS' (LEPSPONDYLI), AS REVEALED BY MICRO-COMPUTED TOMOGRAPHY

3:30 **Pardo, J. D., Szostakiwskyj, M., Anderson, J. S.** PHYLOGENETIC RELATIONSHIPS OF RECUMBIROSTRAN 'LEPOSPONDYLS' INFERRED FROM NEUROCRANIAL MORPHOLOGY

3:45 **Tarailo, D. A.** PHYLOGENETIC CLUSTERING AND GEOGRAPHIC DISPERSAL AMONG PERMO–TRIASSIC TETRAPODS

4:00 **Tabor, N. J., Myers, T. S., Smith, R. M., Sidor, C. A., Angielczyk, K. D., Nesbitt, S. J.** CHANGES IN PRIMARY PRODUCTIVITY AND MEAN ANNUAL RAINFALL IN THE LATE PALEOZOIC AND EARLY MESOZOIC OF AFRICA CORRELATE WITH TETRAPOD DIVERSITY

SATURDAY, OCTOBER 17, 2015

POSTER SESSION IV

HYATT REGENCY DALLAS, LANDMARK CIRCLE

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

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

Posters Associated with Symposium 3: The Shape of Things to Come: Geometric Morphometrics in Vertebrate Paleontology

LC1 **Gray, J. A., Reed, E. H., McDowell, M. C.** AGAMID (REPTILIA: SQUAMATA) ASSEMBLAGES FROM SOUTH AUSTRALIA SUGGEST DIFFERENCES BETWEEN PLEISTOCENE AND MODERN DISTRIBUTIONS THAT REFLECT CLIMATE CHANGES

LC2 **Marr, M. M., Schreve, D., MacLeod, N.** CLIMATIC INSTABILITY AND ECOMORPHOLOGICAL CHANGE IN *MICROTUS AGRESTIS* AND *MICROTUS ARVALIS* OVER THE PLEISTOCENE-HOLOCENE BOUNDARY

LC3 **Burroughs, R. W., Grossnickle, D. M., Jass, C. N., Bell, C. J.** ENAMEL PATTERNS AND SURFACE MORPHOLOGY OF THE LOWER FIRST MOLARS OF *LEMMISCUS CURTATUS* (RODENTIA: ARVICOLINAE)

LC4 **Knigge, R. P., Vinyard, C. J., McNulty, K. P.** A NEW WAY OF COMBINING BIOMECHANICAL DATA AND 3D GEOMETRIC MORPHOMETRICS WITH IMPLICATIONS FOR STUDYING FOSSIL PRIMATE MASTICATORY FUNCTION

LC5 **Massey, J. S., McNulty, K.** ONTOGENETIC SHIFTS IN *GORILLA* AND *PAN* WITH HETEROCHRONIC IMPLICATIONS

LC6 **Hand, S. J., Lopez Aguirre, C., Archer, M., Armstrong, K. N., Black, K. H., Wroe, S., Wilson, L. A.** ANCESTRAL RECONSTRUCTION OF SKULL FORM IN OLD WORLD LEAF-NOSED BATS (HIPPOSIDERIDAE AND RHINONYCTERIDAE) USING GEOMETRIC MORPHOMETRICS

LC7 **Humphrey, L. T., Wilson, L. A.** A VIRTUAL GEOMETRIC MORPHOMETRIC APPROACH TO THE QUANTIFICATION OF LONG BONE BILATERAL ASYMMETRY AND CROSS-SECTIONAL SHAPE

LC8 **Black, K. H., Travouillon, K. J., Myers, T. J., Archer, M., Hand, S. J., Wilson, L. A.** FUNCTIONAL AND GEOMETRIC MORPHOMETRIC ANALYSIS OF A MIDDLE MIOCENE BANDICOOT (MARSUPIALIA, PERAMELEMORPHIA) SKELETON FROM THE RIVERSLEIGH WORLD HERITAGE AREA, AUSTRALIA

MARSALIS HALL

Regular Session Posters

B46 **Gaudin, T. J., Croft, D.** PALEOGENE XENARTHRA AND THE EVOLUTION OF SOUTH AMERICAN MAMMALS

B47 **Macias, M. K.** GIS ANALYSIS OF NORTH AMERICAN GIANT GROUND SLOTH (XENARTHRA: PILOSA) PALEOBIOGEOGRAPHY

B48 **Grass, A.** INTEGRATION AND MODULARITY IN THE SLOTH SCAPULA

B49 **Green, J. L., Kalthoff, D.** ORTHODENTINE MICROWEAR IN *MEGATHERIUM AMERICANUM* (XENARTHRA: MEGATHERIIDAE): DO MICROWEAR PATTERNS IN SLOTHS REFLECT HABITAT MORE THAN DIET?

*Numbers beginning with "B" represent the poster board number in Marsalis Hall.
*Numbers beginning with "LC" represent the poster board number in Landmark Circle.

B50 **Narducci, R. E., Bourque, J. R., Hulbert, R. C., Bloch, J. I.** THE CEPHALIC SHIELD OF THE EARLY PLEISTOCENE PAMPATHERE *HOLMESINA FLORIDANUS* (XENARTHRA, CINGULATA, PAMPATHERIIDAE)

B51 **Kitao, E. B., Macias, M. K.** DEPOSITIONAL ENVIRONMENT AND TAPHONOMIC ANALYSIS OF A *PARAMYLODON HARLANI* (XENARTHRA: PILOSA) QUARRY AT VANDENBERG AIR FORCE BASE, SANTA BARBARA COUNTY, CALIFORNIA

B52 **Heck, C., Varricchio, D., Gaudin, T., Ballard, H., Horner, J. R.** BONE GROWTH IN THE NINE-BANDED ARMADILLO (*DASYPUS NOVEMCINCTUS*): IMPLICATIONS FOR EXTINCT TAXA

B53 **Rincón, A. D., McDonald, H. G., Solórzano, A. D., Núñez Flores, M., Macsotay, O.** RIO YUCA FORMATION: A NEW EARLY MIOCENE VERTEBRATE ASSEMBLAGE FROM VENEZUELA

B54 **Harper, T.** NEW TAENIODONT REMAINS FROM THE EARLY EOCENE WILLWOOD FORMATION, BIGHORN BASIN, WYOMING

B55 **Smith, T., Kumar, K., Rana, R. S., Solé, F., Folie, A., Sahni, A., Rose, K. D.** NEW EARLY EOCENE MAMMAL ASSEMBLAGE FROM TADKESHWAR LIGNITE MINE, WESTERN INDIA

B56 **Rosenbach, K. L., Vitek, N. S., Manz, C. L., Bloch, J. I., Boyer, D. M., Strait, S. G.** MORPHOLOGICAL DISPARITY OF INSECTIVORES (MAMMALIA, EULIPOTYPHLA) ACROSS RAPID ENVIRONMENTAL CHANGES DURING THE PALEOCENE-EOCENE THERMAL MAXIMUM

B57 **Penkrot, T. A., Zack, S. P.** SMALL LIPOTYPHLAN TARSALS FROM THE EOCENE OF SAN DIEGO COUNTY, CALIFORNIA

B58 **Arbor, T. C., Tornow, M. A.** SMALL MAMMALS OF THE MIDDLE CHADRONIAN (LATE EOCENE) WHITEHEAD CREEK LOCAL FAUNA OF NEBRASKA

B59 **Andrianavalona, H. T., Ramihangihajason, T. N., Gottfried, M., Samonds, K. E.** PICKING THROUGH THE TRASH: THE VALUE OF TARGETED SCREENING FOR DECIPHERING MADAGASCAR'S FOSSIL RECORD

B60 **Oberg, D., Hopkins, S. S., Whistler, D.** NEW MICROMAMMALS FROM THE MASCALL FORMATION OF OREGON'S MIDDLE MIOCENE

B61 **Hielscher, R. C., Schwermann, A. H., Martin, T.** INFERRING DIET FROM MOLAR RELIEF: INDEX VALUES FOR EXTANT BATS AND OPOSSUMS WITH APPLICATION TO CRETACEOUS *ALPHADON*

B62 **Person, J. J., Boyd, C. A.** FIRST BAT (MAMMALIA: CHIROPTERA) REPORTED FROM THE OLIGOCENE OF NORTH DAKOTA

B63 **Czaplewski, N. J., Morgan, G. S., Corner, R. G.** BARSTOVIAN BATS (CHIROPTERA: VESPERTILIONIDAE) FROM THE MYERS FARM LOCAL FAUNA, NEBRASKA

B64 **Gunnell, G. F., Winkler, A. J., Manthi, F. K.** PLIOCENE BATS (CHIROPTERA) FROM THE KANAPOI FORMATION, NORTHERN KENYA

B65 **Jones, M. F., Hasiotis, S. T.** NEOICHNOLOGY OF AN ECOLOGICALLY AND MORPHOLOGICALLY DIVERSE FAMILY OF BATS (CHIROPTERA: PHYLLOSTOMIDAE) AND IMPLICATIONS FOR IDENTIFYING BAT TRACES IN THE FOSSIL RECORD

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B66 **Ahrens, H. E.** PHYLOGENETIC RELATIONSHIPS AND EVOLUTIONARY TRENDS IN OXYAENIDAE (MAMMALIA: LAURASIATHERIA)

B67 **Bastl, K., Nagel, D., Gunnell, G., Weber, G., Morlo, M., Pfaff, C.** THE BONY LABYRINTH OF *HYAENODON EXIGUUS* AND A REVISED DESCRIPTION OF THE MIDDLE EAR OF A DERIVED HYAENODONTA (MAMMALIA)

B68 **Friscia, A. R.** ECOLOGICAL TRENDS AND REPLACEMENT IN THE CARNIVOROUS MAMMALS OF AFRICA ACROSS THE PALEOGENE/NEOGENE BOUNDARY

B69 **Matsui, K., Kawabe, S., Endo, H., Kobayashi, S., Tsuihiji, T.** QUANTITATIVE ANALYSIS OF AQUATIC ADAPTION IN OLFACTORY AND OPTIC CHARACTERS IN THE SKULL OF CARNIVORA

B70 **Lofgren, D., Shen, C., Buday, N., Ylagan, C., Lofgren, K., Homidan, J., Santana-Grace, D., Lai, R.** COPROLITES FROM PIPESTONE SPRINGS MAIN POCKET, MONTANA, AND THEIR PALEOECOLOGICAL AND TAPHONOMIC SIGNIFICANCE

B71 **Balisi, M., Casey, C., Van Valkenburgh, B.** ECOLOGICAL SUCCESS IN SPACE AND TIME AMONG NORTH AMERICAN FOSSIL CANIDS

B72 **Casey, C. S., Balisi, M., Van Valkenburgh, B.** TEASING APART THE RELATIONSHIP BETWEEN ECOMORPHOLOGY AND GEOGRAPHIC DISTRIBUTION IN THE FOSSIL RECORD OF NORTH AMERICAN CANIDAE

B73 **Boyd, C. A., Person, J. J., Barnes, B.** REVISION OF CANIFORM DIVERSITY FROM THE LITTLE BADLANDS AREA (OLIGOCENE) OF NORTH DAKOTA

B74 **Pardi, M. I., Smith, F. A.** THE ONSET OF TROPHIC DOWNGRADING IN NORTH AMERICA: BIOTIC RESPONSES OF CANIDS TO THE TERMINAL PLEISTOCENE MEGAFAUNA EXTINCTION

B75 **Barrett, P. Z., Boyd, C. A., Pagnac, D. C.** TAXONOMIC AND PHYLOGENETIC REVISIONS OF NORTH AMERICAN NIMRAVIDAE

B76 **Harper-Judd, J. A., Steppan, S. J.** RESOLVING DEEP DIVERGENCES: A FOSSIL-CALIBRATED PHYLOGENY OF THE AELUROIDEA

B77 **Kottkamp, S. P., Orcutt, J. D.** ENGAGING THE RATCHET: CARNIVORY IN *HESPEROCYON* ACROSS THE EOCENE-OLIGOCENE BOUNDARY

B78 **Magallanes, I., Parham, J. F., Boessenecker, R. W.** DESCRIPTION OF THE MOST COMPLETE FOSSIL WALRUS AND ITS IMPLICATIONS FOR ODOBENID PHYLOGENY

B79 **Dewaele, L., Amson, E., Louwye, S., Lambert, O.** REAPPRAISAL OF THE FOSSIL SEAL *PHOCA VITULINOIDES* FROM THE NEOGENE OF THE NORTH SEA BASIN, WITH BEARING ON THE GEOLOGICAL AGE, PHYLOGENETIC AFFINITIES, AND LOCOMOTION OF A NEW DIMINUTIVE MIOCENE PHOCINE SPECIES

B80 **Churchill, M., Uhen, M. D.** THE USE OF SEAL LIMB BONES (PHOCIDAE: CARNIVORA) IN TAXONOMY AND SYSTEMATICS: NEW INSIGHTS FROM MORPHOMETRIC ANALYSIS

B81 **Koretsky, I., Rahmat, S.** FIRST RECORD OF POSTCRANIAL BONES IN THE EXTINCT SUBFAMILY DEVINOPHOCINAE (CARNIVORA, PHOCIDAE)

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B82 **Egi, N., Ogino, S., Maung Thein, Z., Sein, C., Htike, T., Nishioka, Y., Tsubamoto, T., Takai, M.** CARNIVORANS FROM THE IRRAWADDY SEDIMENTS (MYANMAR; LATE MIDDLE MIOCENE TO EARLY PLEISTOCENE) AND THEIR CHRONOLOGICAL CHANGES

B83 **Robson, S., McLaughlin, W., Walsh, T., Hopkins, S. S.** *ICTITHERIUM VIVERRINUM*: FIRST CARNIVORE FROM THE MIOCENE IN KYRGYZSTAN

B84 **Wang, X., Rybczynski, N., Harington, R., Tedford, R. H.** ELUCIDATE THE ABSTRUSE: FIRST RECORD OF A BASAL EURASIAN FOSSIL BEAR (*PROTARCTOS*) FROM THE PLIOCENE CANADIAN HIGH ARCTIC

B85 **Bredehoeft, K., Samuels, J.** CARNIVORA FROM THE RATTLESNAKE FAUNA (EARLY HEMPHILLIAN, LATE MIOCENE) OF OREGON

B86 **Mackenzie, K. A., Hulbert Jr., R. C.** A NEW SPECIES OF *CYNARCTOIDES* (MAMMALIA, CARNIVORA, CANIDAE) FROM THE ARIKAREEAN OF NORTHERN FLORIDA

B87 **Holte, S. E., Rincon, A. F.** FIRST RECORD OF PROCYONIDS FROM THE THOMAS FARM FOSSIL SITE, GILCHRIST COUNTY, FLORIDA

B88 **Baskin, J. A.** NEW AILURID AND MUSTELIDS (MAMMALIA, CARNIVORA) FROM THE EARLY HEMINGFORDIAN OF FLORIDA

B89 **Binder, W. J., Cervantes, K., Meachen, J. A.** MEASURES OF RELATIVE DENTARY STRENGTH IN RANCHO LABREA *SMILODON FATALIS* OVER TIME

B90 **Gabay, T.** AN ENDOCRANIAL COMPARISON OF PLEISTOCENE *SMILODON FATALIS* OF DORCHESTER COUNTY, SOUTH CAROLINA TO PREHISTORIC AND MODERN FELIDS

B91 **Schmerge, J., Burnham, D., Timm, R.** DIRE STRAITS IN THE ICE AGE—A MAMMOTH SCAVENGED BY A WOLF IN THE LATE PLEISTOCENE OF KANSAS

B92 **Lynch, L. M.** WHEN IS ENOUGH ENOUGH? EVALUATION OF DNA SEQUENCE LENGTH IN *MARTES AMERICANA* WITH APPLICATION TO ADNA EXTRACTIONS

B93 **Archer, M., Craig, H., Hand, S. J.** DID YOUNG HYPERCARNIVOROUS MARSUPIAL LIONS (*THYLACOLEO CARNIFEX*) MATURE INTO CARNIVORY-CHALLENGED ADULTS?

B94 **Strait, S. G.** THE ELUSIVE BAUBELLUM/BACULUM: WOULD YOU KNOW IT IF YOU HAD A GENITAL BONE?

B95 **Ferrer, E. A.** THE IMPORTANCE OF PHYLOGENY IN TEMPORAL AND REGIONAL DIVERSITY AND DISPARITY DYNAMICS

B96 **Bandeira, K. L., Souza, R. G., Riff, D.** DISCUSSION ON PARSIMONY ANALYSIS OF ENDEMICITY (PAE) METHODOLOGY WITH PHILOSOPHICAL PERSPECTIVES

B97 **Walters, K. E., Davis, E. B.** CHANGES IN UNITED STATES MAMMAL DIVERSITY OVER THE 20TH CENTURY: IMPLICATIONS FOR FUTURE RESPONSE TO CLIMATE CHANGE

B98 **Jones, L. S.** USING MULTI-IMAGE PHOTOGRAMMETRY TO MODEL FAUNAL REMAINS

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B99 **Wang, Y., Sullivan, C., Stidham, T.** THE MYTH, MEDICINAL USES, AND MODERN SCIENCE OF "DRAGON BONES": THE PAST AND PRESENT IMPACT OF TRADITIONAL PRACTICES ON VERTEBRATE PALEONTOLOGY IN CHINA

B100 **Liu, J., Ramezani, J., Li, L., Sullivan, C., Shang, Q., Xu, G.** HIGH-PRECISION TEMPORAL CALIBRATION OF MIDDLE TRIASSIC VERTEBRATE BIOSTRATIGRAPHY: U-PB ZIRCON CONSTRAINTS FOR THE *SINOKANNEMEYERIA* FAUNA OF NORTHERN CHINA

B101 **Chan, N. R.** PTEROSAURS VS. BIRDS? A COMPARISON OF MORPHOSPACES CONSTRUCTED USING FUNCTIONALLY ANALOGOUS TRAITS

B102 **Lessner, E. J., Stocker, M. R., Smith, N. D., Turner, A. H., Irmis, R. B., Nesbitt, S. J.** A NEW TAXON OF RAUISUCHID (ARCHOSAURIA, PSEUDOSUCHIA) FROM THE UPPER TRIASSIC OF NEW MEXICO INCREASES THE DIVERSITY AND TEMPORAL RANGE OF THE CLADE

B103 **Norman, D.** THE PHYLOGENETICS OF DERIVED NON-HADROSAURIAN ORNITHOPOD DINOSAURS

B104 **Hickie, E., Evans, D. C., Maddin, H. C.** BRAINCASE ANATOMY OF *MAIASAURA PEEBLESORUM*

B105 **Scott, E., Ryan, M. J., Evans, D. C.** THE FIRST MONODOMINANT HADROSAUR BONEBED FROM THE OLDMAN FORMATION (CAMPANIAN) OF ALBERTA PRESERVES A COHORT OF *GRYPOSAURUS* JUVENILES, WITH IMPLICATIONS FOR POST-HATCHLING HADROSAUR BEHAVIOR

B106 **Bramble, K. K., Currie, P. J.** A JUVENILE *HYPACROSAURUS ALTISPINUS* (DINOSAURIA: HADROSAURIDAE) BONEBED FROM THE HORSESHOE CANYON FORMATION (UPPER CRETACEOUS) OF ALBERTA, CANADA

B107 **Ryan, M. J., Lamanna, M. C., Currie, P. J., Koppelhus, E. B., Sloboda, W.** POSSIBLE NON-AVIAN DINOSAUR FOOTPRINTS FROM THE CRETACEOUS ATANE FORMATION OF GREENLAND

B108 **Guenther, M. F., Prieto-Marquez, A.** ANATOMY OF *MAIASAURA* NEONATES FROM THE UPPER CRETACEOUS OF MONTANA (USA) AND THE EARLY ONTOGENY OF HADROSAURID DINOSAURS

B109 **Borinder, N. H., Campione, N., Poropat, S. F., Kundrat, M., Kear, B.** POSTCRANIAL ANATOMY AND PHYLOGENETIC AFFINITIES OF *TANIUS SINENSIS* (ORNITHOPODA; HADROSAUROIDEA) FROM THE LATE CRETACEOUS OF CHINA

B110 **Prieto-Marquez, A., López-Antoñanzas, R.** ON THE ANATOMY AND RELATIONSHIPS OF THE SAUROLOPHINE DINOSAURS FROM CARELESS CREEK QUARRY (MONTANA, USA)

B111 **King, J. L.** MORPHOMETRIC ANALYSIS OF SEMICIRCULAR CANALS IN THERIZINOSAURIA (THEROPODA: MANIRAPTORA) WITH IMPLICATIONS FOR ENDOCRANIAL MODIFICATION DURING A TROPHIC SHIFT

B112 **McFeeters, B., Ryan, M. J., Schröder-Adams, C., Evans, D. C.** MORPHOLOGICAL AND TAXONOMIC DIVERSITY IN ORNITHOMIMIDS REFERRED TO *STRUTHIOMIMUS ALTUS* FROM THE CAMPANIAN OF ALBERTA

B113 **Krumenacker, L., Scofield, G.** A DIVERSE THEROPOD TOOTH ASSEMBLAGE FROM THE MID-CRETACEOUS (ALBIAN-CENOMANIAN) WAYAN FORMATION OF IDAHO

B114 **Germano, P. D., Varrichio, D. J.** TAPHONOMIC DESCRIPTION OF THREE RECENTLY DISCOVERED *TROODON* CLUTCHES FROM EGG MOUNTAIN

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B115 **Bradley, G. J., Glasier, J. R., Currie, P. J.** COMPARING TOOTH MACROWEAR IN A JUVENILE AND ADULT SPECIMEN OF *GORGOSAURUS LIBRATUS:* CHANGES IN FEEDING BEHAVIOR THROUGHOUT ONTOGENY IN TYRANNOSAURIDS

B116 **Cuesta, E., Ortega, F., Sanz, J.** ULNAR BUMPS OF *CONCAVENATOR*: QUILL KNOBS OR MUSCULAR SCARS? MYOLOGICAL RECONSTRUCTION OF THE FORELIMB OF *CONCAVENATOR CORCOVATUS* (LOWER CRETACEOUS, LAS HOYAS, SPAIN)

B117 **Brum, A. S., Machado, E. B., Campos, D. D., Kellner, A. W.** THE FIRST RECORD OF NOASAURIDAE (THEROPODA) FROM THE ADAMANTINA FORMATION (CAMPANIAN-MAASTRICHTIAN), BAURU GROUP, BRAZIL

B118 **Jasinski, S. E., Sullivan, R. M., Dodson, P.** LATE CRETACEOUS DROMAEOSAURID THEROPOD DINOSAURS (DINOSAURIA: DROMAEOSAURIDAE) FROM SOUTHERN LARAMIDIA AND IMPLICATIONS FOR DINOSAUR FAUNAL PROVINCIALITY IN NORTH AMERICA

B119 **Flora, H. M., Wilson, J. P., Gardner, J. D., Fowler, D. W.** A THREE-DIMENSIONALLY ARTICULATED PROBABLE OVIRAPTOROSAUR FROM THE HELL CREEK FORMATION OF MONTANA

B120 **Smith, D. K., Wolfe, D. G., Sanders, K.** ADDITIONAL BRAINCASE MATERIAL FROM THE NORTH AMERICAN THERIZINOSAUR *NOTHRONYCHUS MCKINLEYI* (TURONIAN: MORENO HILL FORMATION, WEST-CENTRAL NEW MEXICO)

B121 **Torices, A., Canudo, J., Company, J., Currie, P. J., Ortega, F., Pereda-Suberbiola, X., Pérez-García, A.** THE UPPER CRETACEOUS THEROPOD RECORD OF THE IBERIAN PENINSULA

B122 **Holtz, T. R., Williams, S. A., Tremaine, K.** A NEW SPECIMEN OF *ANZU* (CAENAGNATHIDAE, OVIRAPTOROSAURIA): IMPLICATIONS FOR THE PROPOSED CAENAGNATHINAE/ELMISAURINAE DIVISION AND FOR CURSORIALITY IN CAENAGNATHIDS

B123 **Hunt-Foster, R. K., Foster, J. R.** FIRST OCCURRENCE OF AN OVIRAPTOROSAUR (THEROPODA: MANIRAPTORA) FROM THE MESAVERDE GROUP (WILLIAMS FORK FORMATION) OF NORTHWESTERN COLORADO

B124 **Ishigaki, S., Tsogtbaatar, K.** FIRST DISCOVERY OF DIDACTYL THEROPOD FOOTPRINTS FROM THE UPPER CRETACEOUS OF MONGOLIA

B125 **Pittman, M., Stiegler, J. B., Xu, X.** A NEW PARVICURSORINE ALVAREZSAUROID SPECIMEN IVPP V20341 (DINOSAURIA: THEROPODA) FROM THE UPPER CRETACEOUS GOBI BASIN: A SPECIMEN OF *LINHENYKUS* OR AN EIGHTH GENUS?

B126 **Ford, T. L.** TACTILE FACED THEROPODS

B127 **Fortner, J. D.** A SMALL THEROPOD DINOSAUR FROM THE AGUJA FORMATION (UPPER CRETACEOUS), BIG BEND NATIONAL PARK, TEXAS

B128 **Canale, J. I., Novas, F. E.** NEW INFORMATION ABOUT THE ANATOMY AND PHYLOGENETIC RELATIONSHIPS OF *SKORPIOVENATOR BUSTINGORRYI* (THEROPODA, CERATOSAURIA) FROM THE UPPER CRETACEOUS OF NEUQUéN PROVINCE, PATAGONIA, ARGENTINA

B129 **Wolff, E. D., Varricchio, D. J., Hanna, R. R.** INITIAL WORK ON THE CURSORIAL PATHOLOGY OF *TROODON FORMOSUS*

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B130 **Frigot, R. A.** THE PTEROSAURIAN PELVIS: AN ANALYTICAL VIEW OF MORPHOLOGICAL DISPARITY AND IMPLICATIONS FOR LOCOMOTOR EVOLUTION

B131 **Breithaupt, B. H., Matthews, N. A., Connely, M. V., Meyers, V. L.** PTEROSAUR TRACKS, TERRESTRIAL LOCOMOTION, AND PHOTOGRAMMETRIC ICHNOLOGY

B132 **Cheng, X., Jiang, S., Wang, X., Kellner, A.** DESCRIPTION OF A NEW WUKONGOPTERID PTEROSAUR WITH A DIFFERENT TYPE OF PREMAXILLARY CREST FROM THE JURASSIC OF CHINA AND ITS IMPLICATIONS FOR ONTOGENY

B133 **Brink, K. S., Larson, D., Evans, D.** ENAMEL MICROSTRUCTURE IN ORNITHOCHEIRID PTEROSAURS

B134 **Carroll, N.** REASSIGNMENT OF *MONTANAZHDARCHO MINOR* AS A NON-AZHDARCHID MEMBER OF THE AZHDARCHOIDEA

B135 **Myers, T. S.** NEW PTEROSAUR MATERIAL FROM THE LATE CRETACEOUS OF NORTH TEXAS

B136 **Kellner, A. W., Weinschütz, L. C., Manzig, P. C., Moura, C. C., Martins, N. O.** A NEW BASAL AZHDARCHOID (PTEROSAURIA, PTERODACTYLOIDEA) FROM THE CRETACEOUS BAURU BASIN

B137 **Ehret, D. J., Harrell Jr., T., Ebersole, J. A.** FEEDING TRACES ON *PTERANODON LONGICEPS* (REPTILIA: PTEROSAURIA) BONES FROM THE LATE CRETACEOUS (CAMPANIAN) MOOREVILLE CHALK IN ALABAMA, USA

B138 **Rodrigues, T., Jiang, S., Cheng, X., Ma, Y., Wang, X., Kellner, A.** AN ALMOST COMPLETE ISTIODACTYLID (PTEROSAURIA, PTERODACTYLOIDEA) FROM THE CRETACEOUS OF CHINA PROVIDES THE FIRST INFORMATION ON THE TAIL OF THIS CLADE

B139 **Padian, K., Cunningham, J. R., Langston, W. A.** POST-CRANIAL FUNCTIONAL MORPHOLOGY OF *QUETZALCOATLUS* (PTEROSAURIA: AZHDARCHOIDEA)

B140 **Baumgart, S. L., Sereno, P.** WING PNEUMATICITY IN MODERN BIRDS COMPARED TO A CRETACEOUS PTEROSAUR

B141 **Jacisin, J. J., Whiting, E., Ricker, A., Wallace, J., Head, J.** NEOGENE HERPETOFAUNAS FROM THE CENTRAL GREAT PLAINS: DIVERSITY, MODERNIZATION, AND RELATIONSHIPS TO CLIMATE CHANGE

B142 **Hebdon, N., Higgins, P.** A MARINE REPTILE IN THE STEELE SHALE: A NEW LOOK AT THE WESTERN INTERIOR SEAWAY IN THE HANNA BASIN, WYOMING

B143 **De Blieux, D., Kirkland, J., Martz, J., Madsen, S., Milner, A. R., Santucci, V.** SIGNIFICANT VERTEBRATE FOSSIL LOCALITIES DISCOVERED DURING CONTINUING PALEONTOLOGICAL RESOURCE INVENTORY AND MONITORING OF THE LATE TRIASSIC CHINLE FORMATION AT CAPITOL REEF NATIONAL PARK

B144 **Syromyatnikova, E., Tesakov, A., Titov, V.** PRELIMINARY REPORT ON HERPETOFAUNA FROM THE SOLNECHNODOLSK LOCALITY (LATE MIOCENE), RUSSIA

B145 **Winkler, D. A., Ruoff, K., Clemens, M., Jacobs, L.** CHANGES IN SMALL TETRAPOD FAUNAS DURING THE EARLY TO LATE CRETACEOUS TRANSITION IN NORTH CENTRAL TEXAS

B146 **Fraser, N. C., Brusatte, S., Clark, N., Challands, T. J., Foffa, D., Liston, J., Panciroli, E., Ross, D., Walsh, S., Young, M.** OVER THE SEA TO SKYE: HUNTING FOR HEBRIDEAN MIDDLE JURASSIC FAUNAS

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B147 **Rivera-Sylva, H. E., Frey, E., Stinnesbeck, W., Padilla Gutierrez, J., González González, A. H., Amezcua Torres, N.** THE LATE CRETACEOUS LAS AGUILAS DINOSAUR GRAVEYARD, COAHUILA, MEXICO

B148 **Schulp, A. S., Bastiaans, D., Kaskes, P., Manning, P. L., Larson, P. L.** A NEW, MATURE, AND PATHOLOGIC SPECIMEN OF *TYRANNOSAURUS REX*

B149 **Ma, Q., Rayfield, E.** RECONSTRUCTING THE CRANIAL MUSCULOSKELETAL ANATOMY OF TWO MANIRAPTORAN THEROPOD DINOSAURS AND IMPLICATIONS FOR AVIAN EVOLUTION

B150 **Maldonado, J. J., Bertog, J.** NEW SPECIES OF *OPISTHIAS* (SPHENODONTIDAE) FROM THE AARON SCOTT QUARRY IN THE BRUSHY BASIN MEMBER OF THE MORRISON FORMATION IN CENTRAL UTAH

B151 **Withdrawn**

B152 **Hu, Han, O'Connor, Jingmai K., Zhou, Zhonghe** A NEW SPECIES OF PENGORNITHIDAE (AVES: ENANTIORNITHES) FROM THE LOWER CRETACEOUS OF CHINA SUGGESTS A SPECIALIZED SCANSORIAL HABITAT PREVIOUSLY UNKNOWN IN EARLY BIRDS

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Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

DENTAL MICROWEAR VARIATION IN *TELEOCERAS FOSSIGER* (PERISSODACTYLA: RHINOCEROTIDAE), AND THE ROLE OF MASTICATION IN THE PRODUCTION OF MICROWEAR FEATURES

ABRAMS, Kelsie D., Fort Hays State University, Hays, KS, United States of America, 67601

Dental microwear analysis is the study of microscopic features on the surfaces of teeth, and is used to reconstruct and analyze diet in extinct and extant animals. Microwear analysis is typically conducted on the protocone, as this cusp is the first point of contact between upper and lower teeth during the chewing stroke. However, the role of mastication in the production and variation of microwear features on other cusps has not been evaluated. The goal of this project is to analyze the jaw mechanics and intra-cusp microwear variation of the North American Miocene rhinoceros, *Teleoceras fossiger*. The lower second molars of 11 *T. fossiger* specimens were selected because of the number of complete dentaries available for study. Cusps were cleaned and prepared for microwear analysis using standard procedures. A total of 31 cusps from 11 teeth were sampled in order to capture potential variation produced during the entire chewing stroke. Pits and scratches were identified and counted using 0.4 mm^2 areas, and the data were analyzed in R 3.1.1. Eleven paired t-tests and one Wilcoxon paired sample test resulted in p-values greater than the significance level of 0.0042, indicating that there is no significant variation in the number of pits or scratches between cusps or between individuals.

It was expected that protoconids and hypoconids would have higher numbers of pits than other cusps because food particles are crushed against these facets during Phase 1 of the chewing stroke. It was also expected that metaconids and entoconids would have higher numbers of scratches due to the grinding portion of the Phase 2 of the chewing stroke. Phase 1 facets collide with upper teeth at higher pressures and speeds than Phase 2 facets, and Phase 2 facets are more resistant to grinding because of the presence of Hunter-Schreger Bands. Despite the variation in pressures, speeds, and resistance to force, results of this study indicate that there are no significant differences in feature variation between cusps. The lack of variation suggests that masticatory processes do not play a significant role in the production of microwear features, and that all cusps participate equally in the breakdown of food particles. However, results of this study only apply to rhinoceros species, as these animals have a unique combination of mastication and tooth morphology, and the role of mastication in the production of features in other ungulates needs to be assessed separately.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

STRATIGRAPHY AND PALEONTOLOGY OF THE WESTERN ROSILLOS MOUNTAIN RANCH, BREWSTER COUNTY, TX: A REVISION OF PREVIOUS MAPPING

ADAMS, Ashley L., Drexel University, Philadelphia, PA, United States of America, 19104; BUSBEY, Arthur, Texas Christian University, Fort Worth, TX, United States of America

Cretaceous–Paleogene strata have been a subject of study in the Big Bend area since the mid-20th century. This study focuses on a previously unexplored 6 km^2 area of Cretaceous–Paleogene aged strata on the Rosillos Mountain Ranch, a private 25,000 acre ranch located just north of, and largely surrounded by, Big Bend National Park (BBNP). Previous geologic maps that included a portion of the ranch, such as the 2011 USGS Geological Map of BBNP, relied heavily on aerial imagery and even older maps for lithologic boundaries. Well exposed strata on the ranch had not been mapped or prospected in the field. Broad, structurally uncomplicated exposures of the Aguja, Javelina, and Black Peaks Formations crop out in the field area. Field work for this study took place over five separate visits, mostly during 2013, and focused on stratigraphic analysis, data collection for geologic mapping and the recovery of fossil material. The closest mapping in BBNP has been in Paint Gap Hills to the south and Grapevine Hills and along Tornillo Creek to the southeast.

A geologic map of the area based on field observations and high resolution georeferenced imagery was created and includes substantial revisions to unit contacts found on previously published maps. Stratigraphic analysis was conducted and a detailed stratigraphic column was produced, aiding in our understanding of the regional lithostratigraphy. Detailed descriptions of the lithologies, and high-resolution georeferenced images along the transect, address some of the confusion in the literature as to the distinctiveness of these units. Although extensive effort was expended, few vertebrate fossils were recovered. Material collected included a subadult cf. *Alamosaurus* humerus, an indeterminate juvenile hadrosaur ischium and a fragmentary and indeterminate turtle.

Although the K/Pg boundary, in the lower portion of the Black Peaks Formation, is widely exposed, no clear lithostratigraphic boundary was detected and no fossils were found in the area where the boundary should be.

Grant Information
Geological Society of America Graduate Student Research Grant
Dallas Paleontological Society Frank Crane Memorial Scholarship

Symposium 1 (Wednesday, October 14, 2015, 2:45 PM)

THE CROCODYLIFORM DIVERSITY OF THE WOODBINE FORMATION (CENOMANIAN) OF TEXAS AND THE TRANSITION FROM EARLY TO MID-CRETACEOUS ECOSYSTEMS

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Crocodyliform fossils are common throughout the middle Cenomanian (96 Ma) Woodbine Formation of north-central Texas, but their remains are typically fragmentary and represented by isolated teeth, vertebrae, and osteoderms. Previously, the only two taxa recognized from the Woodbine Formation have been *Terminonaris* and *Woodbinesuchus*. Both these taxa are longirostrine pholidosaurs, occupying marginal to fully marine paleoenvironments. The Arlington Archosaur Site (AAS), located within the upper strata of the Woodbine Formation, preserves a diverse assemblage of terrestrial and coastal vertebrates including sharks, bony fishes, lungfish, turtles, amphibians, mammals, crocodyliforms and dinosaurs. At least four crocodyliform taxa have been identified based on numerous isolated cranial and post cranial remains, including isolated teeth of several morphotypes. The dominant constituent of the assemblage represents a new species distinguished by a partially complete skull from a single large individual. Phylogenetic analysis recovers it as the sister taxon to the neosuchian *Paluxysuchus newmani* from the Lower Cretaceous Twin Mountains Formation of Texas. Eusuchians are represented by isolated procoelous vertebrae and the lower jaw of a small hylaeochampsid with highly specialized dentition. Fragmentary cranial remains and isolated teeth are assignable to *Terminonaris* sp., as well as several teeth that show possible affinities with *Woodbinesuchus*. Two additional tooth morphotypes cannot be assigned beyond that of Crocodyliformes indet. The presences of such a diverse assortment of crocodyliforms at the AAS suggests individuals exhibiting widely disparate body plans and size ranges were occupying separate niches within a marginal marine ecosystem. Furthermore, fragmentary remains recovered from other sites in the Woodbine Formation can be assigned to these taxa and demonstrate a wider distribution within the formation. The Early to Late Cretaceous transition of north-central Texas has been characterized as a rapid turnover with little to no overlap between assemblages. However, Crocodyliformes show similar taxonomic endemism within the Lower Cretaceous Trinity Group (Aptian–Albian) of Texas as that of the Woodbine Formation, including specimens referable to Pholidosauridae and Hylaeochampsidae. Recent discoveries in both the Late Aptian Twin Mountains Formation and the early middle Cenomanian Woodbine Formation indicate that the mid Cretaceous transition may have been more gradual for crocodyliforms.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

MUSEUMS, PARKS, AND DINOSAUR FOOTPRINTS: DEVELOPING PARTNERSHIPS IN PALEONTOLOGY

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The Witte Museum and Texas Parks & Wildlife have teamed up to bring a diversity of students, teachers, and volunteers of all ages together to document a dinosaur tracksite located within the Government Canyon State Natural Area (GCSNA) in Bexar County, Texas. Multiple footprints of sauropod and theropod dinosaurs occur in exposures of the upper Glen Rose Formation (Lower Cretaceous, early Albian). Although dinosaur tracks are found throughout the Glen Rose Formation and other Lower Cretaceous units across Texas, they have not been previously described from Bexar County. Because GCSNA is accessible to the public and managed by the Texas Parks & Wildlife Department, it provides the focal point for a unique partnership opportunity. Under the guidance of researchers, volunteers participated in data gathering, mapping, and molding of the tracks. In addition, technical specialists provided expertise in various methods of high resolution, noninvasive three-dimensional scanning of the track surface. As a result, participants play a role in better understanding track preservation and paleoecology of the dinosaur fauna present in Bexar County, Texas during the Early Cretaceous. As these fossils are public resources, it is vital for the public to be actively involved with research projects when possible. In this way, the public can not only claim they assisted in making a contribution to science, but through their personal connection provide resource protection and public interpretation. The Witte Museum and Texas Parks & Wildlife are working together to devise methods of conservation and protection for the site. Once the project is completed and the tracksite is preserved, it will serve as an educational resource for people of all ages. Tours and educational programs will be offered by Government Canyon State Natural Area and the Witte Museum. Additionally, the outcome of this important partnership will make possible future paleontological research collaborations.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

EVIDENCE OF GROWTH AND REGENERATION OF THE EXOSKELETON IN OSTEOSTRACANS (AGNATHA, VERTEBRATA)

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Osteostracans (Osteostraci) are among the most ancient armored jawless vertebrates, known from the early Silurian to the late Devonian. The cephalothoracic division of the osteostracan body was encased in a dorsoventrally flattened shield composed of more or less fused tesserae (poligonal plates), the flexible body was protected with separate scales. The sculpture and the histological structure of the external skeleton of *Paraungulaspis arctoa* and *Reticulaspis menneri* from the Lower Devonian deposits of the Severnaya Zemlya Archipelago (Russia) were studied. The remains come from the upper part of the Severnaya Zemlya Formation of October Revolution Island. The microstructural study of exoskeletal fragments revealed the presence of several generations of dentine (tubercles, ridges and three-dimensional reticular structures) in the exoskeleton of the species under investigation. Successive initiation of the dentine structures leads to vertical growth (the thickening of the shield and scales) of the external skeleton during ontogenesis. It is suggested that the injury of the covering tissues of the osteostracan body could stimulate a formation of new generations of dentine tissue in damaged parts of exoskeleton (regeneration). The cavities of the odontocytes of elongated form were found in mesodentine tissue of dentine network on the surface of the exoskeleton. The position and form of odontocyte cavities indicate the existance of mechanical tension in the tissues of growing parts of the osteostracan armor. The phenomena are described for the first time in osteostracans.

Technical Session VI (Thursday, October 15, 2015, 8:15 AM)

THE ORIGIN OF THE OSTEICHTHYAN DENTITION: NEW DATA FROM THE SILURIAN VERTEBRATES *ANDREOLEPIS* AND *LOPHOSTEUS*

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The origin of the osteichthyan dentition, characterized by basal resorption and shedding of teeth that are then replaced in the same position, is not well understood. This is partly because one of the most critical diagnostic features, buried cup-shaped resorption surfaces underlying the teeth, cannot be observed externally. By using propagation phase contrast synchrotron microtomography, we are able to visualize these features in 3D and reconstruct the dental ontogeny of two disarticulated Silurian vertebrates, *Andreolepis* from Sweden and *Lophosteus* from Estonia. Both genera are placed in the osteichthyan stem group in the majority of recent phylogenetic analyses.

Andreolepis and *Lophosteus* both have marginal tooth-bearing bones and an inner dentition (oral or, less probably, pharyngeal) carried on cushion-shaped bones. There is no evidence for larger oral dentition-bearing bones such as coronoids or prearticulars. The teeth and dermal bone odontodes of both genera lack enamel and enameloid; enamel is present on the scales of *Andreolepis* but not *Lophosteus*.

In both *Andreolepis* and *Lophosteus*, the first functional dentition on the marginal jawbones consists of non-shedding "teeth" organized in transverse files. This dentition indisputably had a biting function, as the overgrown tips frequently show in vivo breakage, but it is not sharply demarcated from the external dermal ornament. Later, this dentition is overgrown by dermal ornament, and a new dentition of shedding teeth develops in a more lingual position. The teeth in this dentition show basal resorption, shedding and replacement, but unlike a crown osteichthyan dentition the teeth are organized in transverse files rather than a longitudinal row. The cushion-shaped bones show a succession from non-shedding to shedding teeth in both genera, but the details differ between the two. In *Lophosteus*, non-sheding teeth are overgrown and resorbed apically, after which shedding teeth develop on top of the tooth stumps; in *Andreolepis*, some individual non-shedding teeth are eventually shed and replaced, so that shedding teeth with resorption-cup bases are found interspersed among non-shedding teeth.

Phylogenetic analyses place *Andreolepis* crownward of *Lophosteus* in the osteichthyan stem group; *Lophosteus* is very close to the gnathostome crown group node and could even fall outside it. This implies that their shared dental attributes are not merely primitive for Osteichthyes but could be ancestral for crown Gnathostomata.

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Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

PHYLOGENETIC RELATIONSHIPS AND EVOLUTIONARY TRENDS IN OXYAENIDAE (MAMMALIA: LAURASIATHERIA)

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Oxyaenidae was a clade of relatively abundant and diverse carnivores during the Paleocene and Eocene of North America and Eurasia. The family first appeared in the Paleocene of North America and was one of the first clades of mammalian carnivores to achieve large body sizes and hypercarnivorous diets. However, the clade is rarely the focus of analyses of Paleogene carnivore diversity and ecology, with no published phylogenetic analyses and little known about their ecology compared to Hyaenodontidae and Carnivoramorpha. Here, I present the first phylogenetic analysis of the family. Twenty species, which represent the majority of North American oxyaenid taxonomic diversity, were included in the analysis along with four outgroup taxa (*Cimolestes*, *Palaeosinopa*, *Didymictis*, and *Vulpavus*). A parsimony analysis using ratchet and TBR was run using 117 dental and postcranial characters in TNT with 1000 iterations. As expected, the earliest oxyaenid genus, *Tytthaena*, was recovered as the most basal member of the clade, followed by a paraphyletic assemblage of *Dipsalidictis* species and a monophyletic clade of *Oxyaena*. *Patriofelis*, previously hypothesized to be derived from *Oxyaena*, fell within the palaeonictines in this analysis as sister to *Palaeonictis* and *Ambloctonus*. This group, along with *Dipsalodon*, formed a clade of large-bodied, dentally specialized oxyaenids. This phylogeny confirmed most established taxonomic hypotheses, with the exception of the paraphyletic genera *Dipsalidictis* and *Palaeonictis* and recovery of *Patriofelis* within palaeonictine oxyaenids. Overall trends in the clade indicate more basal taxa were dentally generalized and likely scansorial, whereas more derived taxa were ambulatory predators specialized for hypercarnivory and bone-cracking. This study provides the necessary first step to pursuing broader analyses of the macroevolutionary patterns and ecology of eutherian carnivores by establishing the phylogenetic relationships of this important Paleogene clade.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

THE LAST PLEISTOCENE ELEPHANT OF THE NAFUD DESERT, NORTHWESTERN SAUDI ARABIA

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The lake deposits of the Ti's al Ghadha fossil site south of the Nafud Desert in northwestern Saudi Arabia preserves evidence of a vertebrate fauna that lived in the Arabian Peninsula during the Middle–Late Pleistocene. This fauna Includes fish, reptiles, birds, and mammals. The fossil mammals are diverse in this biotope and have a strong affinity with their East African Pleistocene relatives. Mammals here include Perissodactyla (Equidae), Proboscidea (Elephantidae), Artiodactyla (Hippopotamidae, Bovidae, and Camelidae), and Carnivora (Felidae, Canidae, and Hyaenidae).

Ongoing fieldwork and systematic excavation from a single bone bed at the Ti's al Ghadha fossil site has produced a rich inventory of new fossil vertebrate materials that have the best preservation of all Pleistocene fossil sites in the Nafud Desert. Among the mammals excavated in 2014 and 2015, elephant remains were very abundant. Remains were excavated from several localities and represented by isolated cranial and postcranial elements of 12 individuals. Furthermore, one locality at Ti's al Ghadha produced many skeletal elements that appear to be a partial associated skeleton of a single individual. This partial skeleton includes an atlas, axis, fourth cervical vertebra, 15 thoracic vertebrae, three caudal vertebrae, 17 ribs, hyoids, right and left scapulae, left humerus, partial right ulna and radius, three carpal and metacarpals, and the right rear leg with complete femur, knee, tibia, and fibula. Furthermore, the new fossil elephant sample preserves a range of elements from individuals of different ages, providing evidence for the study of ontogenetic development in the species. These individuals were represented by partial skull roof, adult and juvenile lower jaws, isolated adult and juvenile tusks, isolated vertebrae and ribs of young and adult individuals, and isolated limb bones.

Evaluation of cranial and postcranial elements of all elephants from Ti's al Ghadha shows that these remains closely resemble those of that lived in East Africa between 4 and 0.5 Ma. Based on dental size and morphology, this can be assigned to *Elephas recki recki*. The Ti's al Ghadha's *Elephas recki* may have migrated through the Arabian Peninsula to reach Eurasia, and this may help in understanding the phylogenetic connection between African and Eurasian *Elephas*. Also, it suggests a place with abundant water supply and, together with the rest of the fauna, the elephants provide evidence of a more well-watered ecosystem present in this area during the time they lived there.

Grant Information
Fieldwork and research project are supported by the Saudi Geological Survey-Jeddah-Kingdom of Saudi Arabia.

Technical Session XV (Saturday, October 17, 2015, 11:15 AM)

DELAYED EXTINCTION OF MEGAFAUNA FOLLOWING HUMAN ARRIVAL IN AUSTRALIA

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The timing of Australian Pleistocene vertebrate extinctions is controversial, with some authors claiming that a large number occurred prior to human arrival in the middle of the last glacial cycle. A new compilation of 215 high-quality, calibrated radioisotopic age estimates makes it possible to put credible intervals (CIs) on last appearance dates for 12 common genera. To do so, we employed a simple Bayesian method in which the conditional probability of the data given extinction in a time interval i, called E_i, is equal to the chance that all dates would have fallen prior to the youngest observed date given that the taxon existed up to i. The prior probability of extinction is held uniform across all n intervals up to the present. The chance of extinction in i is then E_i divided by the sum of E_j, where j ranges from 1 to n. The 95% CI on the last appearance of any megafaunal taxon is 27–40 ka, with a median of 35 ka, and the CIs for all 12 genera are centered around 37 ka. There is no evidence for major continent-wide climate changes at this time. Similar results arise after restricting the data set to mainland southeast Australia (i.e., New South Wales, Victoria, and South Australia). We also examined 332 radiocarbon dates for archaeological sites, not including some anomalous values for the Northern Territory, and obtained a CI of 50–61 ka for first human arrival with a median of 54 ka. This calculation assumes that invasion could not have taken place before the estimated first appearance of humans in Eurasia, which is around 72 ka based on recently published molecular data; the results are virtually identical if we use a bound of 143 ka for the origin of modern humans. Thus, there was a delay of at least 10 kyr between human arrival and the end of the extinction wave, unlike the situation in North America in which overlap was around 1 kyr. Our results refute the hypothesis that megafaunal extinctions were staggered throughout the Middle and Late Pleistocene and predated human arrival in many cases. This claim rests on selective use of data and failure to account for the poor sampling of age ranges for rare megafaunal taxa, which leads to overestimation of last appearance dates. Instead, the data imply that the mass extinction most likely resulted from human overkill that was delayed by the spatially variable spread of human populations, and perhaps also by technological limits.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

COMPARISON OF BASIN MARGINS TO BASIN CENTER ASSEMBLAGES REVEALS TAXONOMIC DISPARITY IN LATE EARLY TO MIDDLE EOCENE RODENT BIODIVERSITY

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Recent paleontological studies of Wasatchian/Bridgerian boundary faunas have highlighted the significance of basin margin areas in elucidating North American mammalian community structure during the Early Eocene Climatic Optimum. However, the late Early to Middle Eocene rodent faunas from basin margins have yet to be studied in detail. As part of an ongoing systematic revision of the genus *Sciuravus*, comparisons were made between species of *Sciuravus* recovered from two basin margin sites (South Pass and Raven Ridge) to those found in coeval basin center localities (Wind River Fm, Bridger Fm). Six different species of *Sciuravus* are found at South Pass in sediments deposited along the northeastern margin of the Green River Basin, Wyoming. Three different species of *Sciuravus* have been identified from Raven Ridge, located in the northeastern corner of the Uinta Basin, Utah. Eleven different species of *Sciuravus* are found in basin center localities (Green River Basin, Bridger Formation). Specimens of *Sciuravus* are strangely absent from the well sampled Davis Ranch locality (biochron Br1a), a South Pass equivalent assemblage from the Wind River Basin, Wyoming. Based on the biostratigraphic data available, *S. nitidus*, the genotype, appears in basin center localities at about the same time that several other species of *Sciuravus* (*S. popi*, *S.*

eucristadens, and *S. powayensis*) appear in basin margin areas. The latter species have distinctive, complex upper molar crown patterns. It is likely that *S. nitidus*, with its generalized morphology, was ancestral to other basin center species of *Sciuravus*. Less clear is the ancestry of the basin margin species. Evolution of *S. popi*, *S. eucristadens*, and *S. powayensis* in the late Early Eocene (biochron Br1a), a time when *Sciuravus* was absent or rare in basin center environments, supports previous hypotheses that closely spaced and range restricted habitats are ideal conditions for promoting evolutionary innovation. The basin margin species, which are later found in basin center localities in the Middle Eocene (biochrons Br1b-Br3), potentially represent anachronistic taxa. Results of this study support previous data, which suggest that late Early to Middle Eocene basin margin faunas differ significantly from coeval-basin center assemblages.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

NEW SKELETAL ELEMENTS OF PLOTOPTERIDS FROM JAPAN

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Plotopteridae is an extinct bird family known as a northern counterpart of penguins. They existed from the late Eocene to the early Miocene, and about 20 specimens have been found throughout the North Pacific rim. Five genera and seven species have been described since the first described *Plotopterum joaquinensis*. Plotopterids are considered to have had a penguin-like mode of life, using their penguin-like wings for under-water propulsion. However, the skeletal morphology of plotopterids that suggests the comparison with penguins has not been adequately described, despite the known taxonomic diversity of the group, partly because of incomplete preservation. Newly found skeletal elements from Japan and a review of known elements could fill the gap in the morphological information of these extinct diving birds. A well-preserved proximal scapula from the Jinnobori Formation, Ashiya Group, early Oligocene, provides details of fine structure and enables the reconstruction of the triosseal canal in plotopterids. While penguins have an elongate acromial end of the clavicle to match the long acrocoracoid process of the coracoid, plotopterids have an extremely long acromion of the scapula, probably to be proportional to the similarly long acrocoracoid process of the coracoid. The long acromion, hence the large triosseal canal, indicates a robust tendon for M. supracoracoideus and a relatively large size of the muscle, comparable to that in penguins. Other skeletal elements such as a coracoid, a quadrate, and a pelvis are found in the Jinnobori Formation. The Yukiaino Sandstone, Kishima Group, Oligocene, yields several plotopterids specimens such as a sternum, a cranium, an ulna, and tarsometatarsi. The large sternum is one of the largest sterna among the flightless, wing-propelled diving birds. The length (>400 mm) does not exceed that in the Kairuku penguin (*Kairuku* spp.) from the late Oligocene of New Zealand, but the width is much larger, suggesting the basic body plan in plotopterids was different from the contemporaneous fossil penguins in the Southern Hemisphere. The sternum is larger than that in *Hokkaidornis abashiriensis* by 25% in length and the estimated body size would be comparable to that in *Copepterix titan*, the largest plotopterid ever described. The cranium from the same formation lacks the facial region, but retains the posterior part including the brain case. These new specimens also indicate there were much wider morphological variation among the group than we knew.

Technical Session II (Wednesday, October 14, 2015, 12:00 PM)

MORPHOLOGY AND PHYLOGENY OF *QUETZALCOATLUS* (PTEROSAURIA: AZHDARCHIDAE)

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Giant extinct organisms defy the imagination and challenge science to understand them. Among these, the azhdarchid pterosaurs stand out as the largest known flying organisms. Over the past 30 years, this charismatic group has had hundreds of fragmentary specimens referred to it, spanning over 85 million years from the Late Jurassic to the latest Cretaceous. If valid, these reports would imply one of the greatest ghost lineages in the fossil record and require a massive undocumented radiation of other pterosaur lineages beginning in the Jurassic.

Determining the inclusion of specimens within the Azhdarchidae has been problematic, largely because the two taxa on which it was based, *Azhdarcho* and *Quetzalcoatlus*, were incompletely described or incompletely known. These taxa were also used to phylogenetically define the Azhdarchidae in 2003, but this has rarely been followed because the relationships of these taxa and the other azhdarchids were not resolved until 2013. Newly described and accessible material of *Azhdarcho* and *Quetzalcoatlus*, respectively, combined with a phylogenetic analysis of referred azhdarchid specimens, allows better resolution of the evolutionary relationships and history of the azhdarchid pterosaurs.

The earliest reported occurrences of azhdarchids in the Late Jurassic and Early Cretaceous are of ctenochasmatoids. Despite a tendency to refer most Late Cretaceous pterosaur material to the Azhdarchidae, the clade only dates back to the Turonian. A tapejarid, ornithocheiran, thalassodromine, and the pteranodontids also survive to the early Late Cretaceous. Most of the specimens previously referred to the Azhdarchidae, but now recovered outside of the group, are on the azhdarchid branch as non-azhdarchid neoazhdarchians. These specimens range from the Aptian, when the lineage would have split from the chaoyangopterids at the latest, to the latest Cretaceous, and so comprise the last surviving pterosaurs along with the Azhdarchidae and one *Nyctosaurus* specimen. The giant and smaller morphs of *Quetzalcoatlus* are recovered as sister taxa and so are closely related as either a single species or sister species.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

PICKING THROUGH THE TRASH: THE VALUE OF TARGETED SCREENING FOR DECIPHERING MADAGASCAR'S FOSSIL RECORD

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Larger-bodied animals are often prioritized in both fossil collection and preparation, yet in recent decades, small fossils have been increasingly recognized as an important component of paleontological studies. In particular, small vertebrates can be important indicators of climate change, and can contribute greatly to our understanding of past environments. However, small fossils are generally more delicate and may be more susceptible to destructive taphonomic processes, and may be more easily overlooked by field collectors and method of collection (e.g., prospecting techniques, sieve size, collection priorities, and site choice). Maximizing the recovery of small and easily overlooked specimens is particularly important in deciphering the Malagasy record given the paucity of post-Cretaceous and pre-Holocene fossil data from the island.

To try and address this gap in knowledge, we undertook targeted screening of Miocene sediments from Nosy Makamby, northwestern Madagascar. ~100 kilograms of sediment were processed using both wet screening and dry screening techniques with sieves ranging from 0.5 to 2 mm. While previous exploration (largely surface collection) yielded fossils of invertebrates (gastropods and bivalves), sharks, rays, bony fish, turtles, crocodiles, and mammals, our targeted screening produced numerous fossils of groups that were not previously discovered, including teeth, vertebrae, spines, denticles of previously undetected bony fish, selachians, crocodylians, and mammals. Of special note was the discovery of isolated ray teeth from what appears to be a new species of *Dasyatis* or *Himantura* (family Dasyatidae), as well as one heavily worn small terrestrial mammal tooth. This work demonstrates the potential of sediments that might otherwise be discarded to yield valuable paleontological data, how employing new field collection methods may have great potential, and the benefits of taking a 'closer look.'

Technical Session XVIII (Saturday, October 17, 2015, 2:00 PM)

EXPLORING THE STRATIGRAPHIC AND SEDIMENTOLOGIC CHARACTERISTICS OF A PALEOGENE MAMMAL LOCALITY USING THREE DIMENSIONAL DIGITAL OUTCROP MODELS

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While geologists have generated realistic three-dimensional digital outcrop models (3D DOMs) representing sedimentary architectures, reservoirs, aquifers, and fluvial dynamics, this approach has not to our knowledge been applied in paleontological settings. We demonstrate how the synthesis of traditional stratigraphic, sedimentary, and petrographic data with high resolution 3D digital outcrop models allows new insights into the formation and taphonomy of a paleontological site in the Paleogene of Wyoming. The Smiley Draw fauna from the Tim's Confession locality in the Great Divide Basin of southwestern Wyoming represents a rich and diverse early Eocene mammalian fauna first collected in 2009.

Although geological outcrops are inherently multiscalar and three-dimensional in the field, visualizing and communicating this complexity in two dimensions (e.g., via geologic maps) can result in simplification and loss of detail. More fine-grained and multi-scaled (spanning members to individual beds to mineral grains) analyses can be accomplished by the creation of 3D digital outcrop models. We created 3D DOMs of the sandstone complex at Tim's Confession using two approaches: photogrammetry using Agisoft's PhotoScan software, and terrestrial LiDAR. A series of ground control points were set throughout the outcrop using high resolution differential GPS in order to allow georeferencing of both 3D models and their incorporation into our basin-wide GIS database.

Traditional geologic analysis of Tim's Confession indicates that it represents an immature fluvial sandstone complex with associated floodplain deposits. The section primarily consists of a fining-upward point bar geometry with depositional structures that include planar and trough cross-beds, ripple cross-laminations, convolute bedding, and skolithos burrows. The typical sandstones are poorly-sorted, angular to subangular, fine to medium grained litharenite with calcite cement. Mammalian fossils appear to be most concentrated in the ripple cross-laminae associated with the upper reaches of the point bar complex. By combining this geological data and analysis with realistic three-dimensional models of the sandstone outcrop, we can better understand the depositional and taphonomic history of this important fossil locality. In this way, these models contribute to our larger goals of developing and testing predictive models for fossil location based on remotely sensed imagery, geospatial analytical methods, and geological knowledge.

Grant Information
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Symposium 3 (Saturday, October 17, 2015, 11:15 AM)

QUANTITATIVE EVOLUTIONARY MODELING AS A FRAMEWORK FOR A NEW SYNTHESIS OF GEOMETRIC MORPHOMETRICS AND FINITE ELEMENT ANALYSIS

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Geometric morphometrics (GM) and finite element analysis (FEA) are important techniques for the study of the evolution of form and function. Both focus on aspects of organismal form, use similar geometric data, and produce highly graphical outputs, so it is tempting to try to use them together. However, previous attempts at such synthesis have produced mixed results, potentially because GM measures shape differences whereas FEA models stresses and strains based on deformation of a single shape. Here, we show how the two can be used in a phylogenetic framework to test the relative contributions of several functional factors to the evolution of a clade. FEA is used to measure the performance of morphologies with respect to one or more functional factors, such as the relative strain induced by a loading regime. The distribution of the performance values across a morphospace derived from GM describes a performance surface for that factor. The combination of two or more performance surfaces describes a

quantitative adaptive landscape that can be used to predict the direction morphological evolution would take if a combination of functions was selected for. Expected paths of evolution also can be derived for hypotheses about the relative importance of multiple functional factors, which can be tested against real evolutionary pathways known from phylogenies or fossil sequences. Finally, magnitudes of evolutionary trade-offs between functional factors can be estimated using maximum likelihood. We apply these methods to an earlier study of carapace strength and hydrodynamic efficiency in emydid turtles. We find that strength and hydrodynamic efficiency explain about 45% of the variance in shell shape; drift and other unidentified functional factors are necessary to explain the remaining variance. Measurement of the proportional trade-off between shell strength and hydrodynamic efficiency shows that aquatic turtles generally sacrifice strength for streamlining and terrestrial species favor stronger shells. Fossils of several Cenozoic turtles show that they faced similar constraints and made comparable trade-offs, suggesting that the selective regime operating on small to mid-sized emydid turtles has remained relatively static over the past 50 million years. Some of these results could have been approximated with GM or FEA alone, but it is the quantitative evolutionary framework linking the two that provides the predictive power necessary for quantitative description and testing of the importance of alternative functional factors.

Romer Prize Session (Thursday, October 15, 2015, 8:00 AM)

PHYSIOLOGY OF EXTANT AND FOSSIL BONE USING SYNCHROTRON-BASED ANALYSIS

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The chemistry of bone is extremely complex, reflecting different physiological processes and pathways occurring throughout the skeleton. Many of these processes are moderated by trace elements that fluctuate within the organic matrix and the bioapatite of bone. These trace elements can be correlated with specific physiological processes, making it possible to use them as biomarkers for bone physiology. Furthermore, if these trace elements are stable within the bioapatite structure, then differential distributions of trace elements can also be used to determine physiological processes in extinct organisms through deep time. In this study we focus on mapping and quantifying trace elements that are crucial for the maintenance and repair of bone within both extant and extinct organisms by using a combination of multi-scale synchrotron X-ray fluorescence elemental mapping (mm–dm at micron scale resolution) and X-ray Absorption Spectroscopy (XAS-elemental coordination chemistry).

These analyses allow for the differentiation between endogenous and exogenous elemental contributions through a combination of elemental mapping, quantification, and coordination chemistry. Results reveal zinc to be differentially distributed within: (1) the fracture callus of a large carnivorous dinosaur (*Allosaurus fragilis*: ~146 million years old); (2) the secondary osteons of an extinct dugong (*Metaxytherium* sp.: ~17 million years old); and (3) within the plexiform tissue of an extinct hyena (*Crocuta crocuta spelaea*: ~40 thousand years old). These tissues all consist of actively remodeling or ossifying bone at the time of death. The distributions and concentrations of zinc are consistent with those found in modern tissues from comparable species. Additionally, XAS revealed that zinc is within a six-fold coordination with oxygen in all specimens, which is consistent with that seen in extant bone.

From these results, we conclude that trace metals, in this case zinc, may be used as a biomarker for active ossification within the fossil record. Zinc is crucial for the ossification and mineralization of bone and, as the coordination chemistry shows, zinc is stable within the apatite structure over time. Therefore the study of the chemistry of both extant and fossil bone can provide great insight into the evolution of bone physiology.

Grant Information
Deans Award, University of Manchester
Jurassic Foundation

Technical Session XVI (Saturday, October 17, 2015, 10:30 AM)

DEEP TIME CONSERVATIVE DEVELOPMENTAL PATTERNS REVEALED BY CROCODYLOMORPHA EMBRYOS FROM THE LATE JURASSIC OF PORTUGAL

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The extraordinary rarity of fossilized embryos is a major hurdle for the integration of the fossil record, which remains a fundamental unresolved question in evolutionary biology. Here we report the first Crocodylomorpha embryos discovered from the Lourinhã Formation, Assenta Member, Late Jurassic of Portugal. *In ovo* complete embryos were revealed by propagation phase contrast X-ray synchrotron microtomography (ESRF, Grenoble) performed in the thirteen-egg clutch. We ascribed the embryos to Atoposauria, the Mesozoic dwarf crocodiles, based on linear regression estimates on egg dimensions, clutch size and volume. By performing morphometry of the limb bones and ossification onset, we determined that the embryos are from the second third of the incubation period, and at the earliest moments of ossification. Strikingly, the ~150 Ma-old fossil embryos' anatomy is nearly indistinguishable from that of extant crocodilians, as shown by 3D landmark-based geometric morphometrics and spherical harmonics. This work reveals that despite a wide morphological disparity among adult Mesozoic Crocodylomorpha, osteological developmental patterns of ossification are highly conserved since the Late Jurassic.

Grant Information
FCT/MEC through the EXPL/BIA-EVF/0665/2013 project and the SFRH/BPD/96205/2013 scholarship, by ESRF (proposal HG-24) and by a Jurassic Foundation grant

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

SMALL MAMMALS OF THE MIDDLE CHADRONIAN (LATE EOCENE) WHITEHEAD CREEK LOCAL FAUNA OF NEBRASKA

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Previously reported lists of Nebraska's Chadronian-age faunas indicate diverse arrays of mammals with dozens of represented species. However, current understanding of the diversity of these faunas, their distribution, and their relationships to other regional faunas is hampered by uncertainty regarding the temporal control of paleontological samples where commingling with younger Orellan-age specimens is likely. Moreover, many of the taxa represented within these samples are known to span the Eocene–Oligocene boundary.

We initiated exploration and field collection of Chadronian-age deposits within the Oglala National Grassland of Sioux and Dawes Counties, NE in 2011 in order to collect fossil samples with the potential to address these gaps in knowledge. Fossil localities were evaluated to determine whether recovered specimens could be confidently assigned to Chadronian deposits. Here we present findings from one such Chadronian locality, the Whitehead Creek locality. This locality involves a series of low-lying exposures of the Peanut Peak Member of the Chadron Formation. The temporal control of this sample contributes to our ability to produce specimen descriptions and species designations of Nebraska's late Eocene faunas.

The Whitehead Creek Local Fauna is a diverse, middle Chadronian small mammal fauna. Currently, 29 genera representing 19 families and nine mammalian orders have been identified. In addition to several species previously recognized from other Chadronian localities in the Great Plains Faunal Province, the Whitehead Creek Local Fauna demonstrates temporal and/or geographic range extensions for five taxa, *Apetemys* sp., *Litoyoderimys* cf. *L. lustrorum*, *Jaywilsonomys* sp., *Pseudocylindrodon* cf. *P. tobeyi*, and a currently unidentified species of Sciuravidae. Whereas the Whitehead Creek Local Fauna is largely consistent with a middle Chadronian age, the presence of relict and immigrant taxa is consistent with other middle Chadronian localities of the Great Plains Faunal Province where relicts persist after their extinctions elsewhere.

Grant Information
Support for this project was provided by an IOER grant to TCA and a SCSU Faculty Improvement Grant to MAT.

Symposium 1 (Wednesday, October 14, 2015, 2:00 PM)

INTERPRETING THE ANKYLOSAURIAN FOSSIL RECORD IN THE CONTEXT OF THE CRETACEOUS WESTERN INTERIOR SEAWAY OF NORTH AMERICA

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Several studies have invoked the hypothesis that nodosaurid ankylosaurs exploited a wider range of habitats than ankylosaurids to explain the overrepresentation of nodosaurids in marine depositional environments. Here we quantitatively investigate this pattern in a stratigraphic and phylogenetic context, using a newly developed database of Cretaceous North American ankylosaur occurrences. In this analysis, we recover some taxa previously considered nodosaurids as basal ankylosaurids, decreasing the number of nodosaurids preserved in marine sediments compared to previous studies.

Approximately half of North American ankylosaurs recovered from marine sediments are known from major transgressive-regressive cycles of the Western Interior Seaway (Kiowa, Greenhorn, Niobrara, Claggett, and Bearpaw) during the late Early through Late Cretaceous. Total (terrestrial and marine) ankylosaur occurrences decrease during emplacement of the seaway, are low during the Greenhorn and Niobrara cycles, and rise sharply during the Claggett cycle. During the low abundance Greenhorn and Niobrara cycles, 40% of all ankylosaur fossil localities represent marine environments, compared to less than 7% during the other cycles when total occurrences are high; all identifiable Greenhorn and Niobrara ankylosaurs are nodosaurids. Scrutiny of global nodosaurid relative abundances in marine sediments reveals a strong influence of the localized North American Cretaceous record and equally can be interpreted as an absence of terrestrial occurrences rather than a disproportionate abundance of marine occurrences (i.e., paleoenvironmental sampling bias rather than habitat signal).

Globally, no ankylosaurine ankylosaurids are known from marine sediments. Basal ankylosaurids occur in North America until the late Albian, but ankylosaurines originated in the continental sediments of Asia and only appear in Laramidia during the Campanian. The absence of non-ankylosaurine ankylosaurids in North America during the Greenhorn and Niobrara cycles may reflect 1) low sample sizes or 2) regional extinction of ankylosaurids in North America, and the absence of ankylosaurines during this time may reflect 1) low sample sizes, 2) the absence of preserved preferred ankylosaurine habitats, or 3) constraints on the timing of immigration into North America from Asia. The North American ankylosaur record highlights the difficulty in interpreting habitat preferences in the context of a shifting seaway, extinctions, and immigrations.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

DID YOUNG HYPERCARNIVOROUS MARSUPIAL LIONS (*THYLACOLEO CARNIFEX*) MATURE INTO CARNIVORY-CHALLENGED ADULTS?

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The Lioness-sized Australian Pleistocene Marsupial Lion (*Thylacoleo carnifex*; Thylacoleonidae), with its enormous longitudinally-orientated, blade-like carnassials (P3/3) and correspondingly reduced remainder of the dentition, except for the stabbing I/1, has been described as the most specialised mammalian carnivore that ever evolved-anywhere.

Assumptions that this marsupial lion was a hypercarnivore have in the past been questioned, in part because of its lack of enlarged canines. However, age-related changes

in wear patterns exhibited by the hypertrophied carnassials raise an entirely different possibility-that this species changed its diet from conventional mammalian carnivory when young, involving vertically-shearing premolar blades, to a different diet when fully mature, signaled by oblique, more transversely-orientated shearing blades on the same teeth.

We measured the strike angle of the primary blades of P3/ and P/3 with respect to the vertical axis of the tooth in 57 specimens from cave deposits in New South Wales and South Australia and found that this transformed from approximately 0° in unworn carnassials to 60° in the carnassials of older adults. While a near vertical (orthal) bite involving these carnassials would readily enable ossivory, a behavior commonly attributed to marsupial lions, a relatively transverse shearing bite would limit the capacity for ossivory.

We suggest that while young adults in social, perhaps family, groups of these marsupials may have consumed bones as well as flesh, older individuals may have been primarily focused on flesh alone-or potentially had an even more omnivorous diet given their developing capacity for relatively transverse mastication. In terms of social behavior, one possibility is that older individuals may have eaten the softer (probably more coveted) tissues of carcasses before younger individuals were allowed to scavenge the remainder, including more difficult to process elements such as bones.

We have noted specialised structures of M1/ that appear to be devoted to thegosis for the purpose of maintaining sharpness of the P/3 blade. Efforts to identify more than one direction of tooth/tooth movement of the lower jaw as evidenced by the direction of striations on the occlusal surface of the blades were unsuccessful. This may be because of thegotic over-printing on blade surfaces, or it may be because the thegotic stroke was in the same (but oppositely driven) direction as the masticatory stroke.

Technical Session I (Wednesday, October 14, 2015, 11:00 AM)

INTRA- AND INTER-MICROSCOPE DIFFERENCES IN DENTAL MICROWEAR TEXTURE ANALYSIS

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Dental microwear looks at microscopic surface features of teeth (e.g., pits and scratches), which have been shown to be distinctive between dietary groups (e.g., dicot leaf-eating browsers vs. grass eating grazers). Early methods used manual counts of features, which were both time consuming and liable to inconsistencies between researchers. Dental microwear texture analysis uses scale-sensitive fractal analysis (SSFA), an algorithmic quantification of entire 3D surfaces collected using confocal profilometry. This 3D method has been partially favored as it provides a more repeatable and objective surface characterization. However, serial scanning and analysis in SSFA on data collected from a single microscope revealed that elements of standard methodologies can create substantial differences between scans that contained identical raw data, but also that these differences can just as easily be negated by minor methodological changes. The effects of microscope variability on overall dietary inferences are still being investigated, though if proven, this may require re-analysis of many samples collected and published upon previously. A comparison between seven microscopes differing in specifications showed significant differences between instruments. Some differences could be reconciled through a series of filters and thresholding of data, which also improve objectivity by minimising the need for manual editing of scans. Other microscopes were more problematic, particularly when differing considerably in specifications. Collectively, direct comparison of identical surfaces on multiple microscopes reveals the importance of maintaining similar parameters and continuously evaluating comparability of data as technological methods are improved.

Grant Information
Work was undertaken on a Flinders University Travel Fellowship awarded to Sam Arman.

Romer Prize Session (Thursday, October 15, 2015, 8:15 AM)

A STUDY OF THE INFLUENCE OF POST-NATAL DEVELOPMENT ON AVIAN EVOLUTION

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In order to fully understand the processes that influence phenotypic evolution, it is necessary to explore the role that developmental channeling plays in shaping morphology. In my doctoral research, I have investigated how an increased understanding of ontogenetic patterns gives insight into the evolution of birds. Here, I present the results of an integrative study combining material from multiple levels of the biological hierarchy (clade, individual organism, and cell), using both paleontological and neontological data. Specifically, I studied post-natal gross morphological change and cellular growth in a phylogenetically broad sampling of Cretaceous and modern avians, using ontogenetic series when available.

A three-dimensional geometric morphometric analysis of ontogenetic cranial shape change indicates that a relatively high level of developmental constraint governs the evolution of the skull, although shape at onset of growth is a more variable characteristic, in large part because hatchling chicks already have cranial morphology very similar to that of adults. Histological study of extant bird skeletons also indicates high variability in onset of growth among taxa and reveals a common pattern of greater skeletal maturity of the femur relative to the humerus at the time of hatching. This is interpreted as an example of a 'spandrel', later exapted by semi-precocial taxa in which pelvic limbs appear to achieve functional maturity before pectoral limbs for adaptive reasons. Histological analysis of Cretaceous avians indicates this trait of differential maturity between limb elements may have a very deep evolutionary origin, and could explain substantial microstructural differences that persist into adulthood in some extinct taxa. I focused in particular on growth in members of the Enantiornithes, and further conclude that this group exhibits a greater diversity of growth strategies than originally hypothesized, although with no apparent relationship to body size or geological age, and that this clade had a unique developmental mode not directly comparable that of to any crown-group birds. Finally, phylogenetic and functional constraints appear to have a much greater influence on cellular growth of long bones than on cranial shape change, for which developmental channeling is a primary influence.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

DENTAL VARIABILITY IN *OMOMYS* (PRIMATES, OMOMYOIDEA) AND THE VALIDITY OF *O. LLOYDI*

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Omomys lloydi was first described based on dental material from the Br1b Powder Wash locality in Utah. The related species *O. carteri* is also found at Powder Wash, and is thought to differ from *O. lloydi* in size but not dental morphology. The initial description of *O. lloydi* justified the recognition of this smaller species on the basis of (1) high variability in a sample of 25 *Omomys* second lower molars from Powder Wash (length CV = 7.73) and (2) bimodality in m2 crown dimensions. *O. lloydi* has since been described from Br1a localities at South Pass, Wyoming, and from the Ui1 Dogie Mountain locality in Texas. Here we examine dental variability in *O. carteri* using a sample of 36 teeth from the Devil's Graveyard Formation of Texas (Ui1b–Ui3) and 865 teeth from the Bridger Basin of Wyoming (Br1–Br3). These data were compared with measurements of *O. lloydi* in an attempt to assess the validity of the species. Linear crown dimension coefficients of variation for the entire *Omomys* sample (4.5–9.3) are well within the range of extant primates. Most lower molar dimensions of *O. lloydi* from Powder Wash fall immediately below the range of the measurements for *O. carteri*. Powder Wash specimens attributed to *O. lloydi* also fall outside the 99% bivariate normal ellipses fit to plots of molar length by width in *O. carteri*. Nevertheless, we are unable to distinguish *O. lloydi* from typical outliers of *O. carteri*. Because *O. carteri* and *O. lloydi* do not differ in morphology, we cannot reject the null hypothesis that the Powder Wash *Omomys* sample represents a single species (*O. carteri*) that encompasses a slightly smaller size range than *O. carteri* samples from Texas or the Bridger Basin. By contrast, all specimens from South Pass that have been attributed to both *O. carteri* and *O. lloydi* are consistently smaller than the combined *O. carteri* sample. Similarly, the only complete tooth from Dogie Mountain attributed to *O. lloydi* (an m2) has crown dimensions well below the range *O. carteri*. These findings suggest that there is no clear justification for recognizing two species of *Omomys* from Powder Wash. If so, then *O. lloydi* is most conservatively recognized as a junior synonym of *O. carteri*. By contrast, the consistently smaller size of specimens attributed to *Omomys* from South Pass and Dogie Mountain suggests that these specimens are not *O. carteri*. Furthermore, if *O. lloydi* is not a valid species, then the South Pass and Dogie Mountain primates cannot represent either of the commonly recognized species of *Omomys* and require taxonomic revision.

Grant Information
National Science Foundation Graduate Research Fellow

Technical Session XVII (Saturday, October 17, 2015, 2:15 PM)

THE STRUCTURAL PRESERVATION OF A TITANOSAURID (DINOSAURIA: SAUROPODA) VERTEBRAL LIGAMENT

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Within the past decade exceptional preservation of original organic components have been reported from several dinosaurian families, including members of Sauropodomorpha. Here we document the preservation of a vertebral ligament in the dorsal and sacral series of a titanosaur (potentially *Alamosaurus sanjuanensis*). Unlike other cases of tissue preservation, this structure does not represent biomineralization of the original organic components. Histology, morphology, and comparative anatomy from extant taxa as well as the preferential placement on the vertebral column suggests that it represents the partial preservation of the nuchal ligament. While preservation of other sauropod connective tissues are known (cervical ribs; via direct biomineralization of the tendon), this case represents the first reported non-biomineralized tissue from a sauropod. Due to the locality of the specimen, this structure could be interpreted to be a chemically-mediated micritic concretion. However, the internal fabric (features, porosity structure, and texture) are unlike other concretions from the region. The remaining possibility is that this feature is a cast that either represents: (1) calcareous mud that infilled the void from the decomposed vertebral ligament; or (2) micritic replacement of the original organic components. In consideration of the location and external and internal morphologies compared to modern vertebral ligaments, we believe this structure to be the micritic replacement of the original tissue via microbially-mediated processes. Along with the suggestive external morphology, internally we interpret some of the unusual structures to represent the remnants of the collagen and elastin fascicles that are strongly overprinted by a thrombolitic fabric recording microbial activity prior to lithification. In consideration of the interpreted depositional history, we theorize that post-deposition, bacteria deposited the micrite as a byproduct of metabolization. Subsequently, the recognition of this structure as a vertebral ligament, the largest of such thus documented, substantiates previous findings on the morphological attributes of sauropod vertebral ligaments.

Preparators' Session (Thursday, October 15, 2015, 9:30 AM)

COMPARISON OF NESTED SIEVES, TRADITIONAL SCREEN BOXES, AND PAINT SIEVES FOR THE RECOVERY OF MICROVERTEBRATE FOSSILS

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Traditional methods for screen washing sediment to recover microfossils involve the use of bulky 'screen boxes' and/or expensive, nested sedimentary sieves. Although nested sieves offer a wide range of benefits such as modular capability, sorting of sediment and fossils by size, and durability, we have investigated using paint sieves as an alternative because they are lightweight and easily transportable in the field. Paint sieves are inexpensive (~$2.50 each) and can be found at any local hardware store, whereas the nested sieves can cost more than $200 for a functional set and screen boxes have to be custom built. In initial tests, the 5-gallon paint sieves (Bluehawk® brand found at a local home center) can hold a larger load (up to 2.5 kg of benonitic sediment) than the nested 8 in (~20 cm) sieves, which quickly become clogged at ~1 kg. The paint sieves offer a continuous 3-dimensional surface area, compared to the nested sieves, which only filter on one side, and the typical 3–5 screened sides of traditional boxes. Paint sieves are designed to handle heavy liquid loads such as viscous paint, whereas traditional sedimentary sieves are intended for dry sediment. An elastic band on the paint sieve facilitates use with a variety of containers. The soft fabric of paint sieves is another positive feature because it is less likely to damage either delicate microfossils or skin. Paint sieves can be effectively labeled, employed with desired sediments, and then disposed of to avoid cross contamination. With reused nested sieves, there exists the risk of cross contamination between samples. Even with these benefits, the paint sieves have some drawbacks relative to the nested sieves. Nested sieves are standardized and can effectively sort sediment by size, and offer the ability to easily observe what has been left after washing before removing the sediment and fossils from the mesh. They are durable and can be reused almost limitless times, while the paint sieves have a limited number of uses (but are surprisingly long-lasting). Microscopic analysis of the paint sieves indicates that when 'relaxed' they have irregular polygonal openings with an average aperture area of 0.16 mm^2 and maximum aperture length of 0.6 mm. With the fabric stretched (e.g., under load, the more relevant measure) the actual aperture area appears to remain the same or even shrink due to the design of the interwoven fibers, and decreases to an average area of 0.15 mm^2. In practice, one of us (LM) reports finding fossils as small as 0.1 mm long, and frequently only 0.25 mm long, in concentrate from paint sieving.

Grant Information
Project developed from an Appalachian State University Research Council
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Symposium 3 (Saturday, October 17, 2015, 11:30 AM)

LEMUR CRANIOMANDIBULAR DIVERSIFICATION IN RELATION TO DIETARY ECOLOGY

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Lemuriforms are a monophyletic clade of primates found exclusively in Madagascar that include eight subfossil genera; many of the subfossils are substantially larger than any living species. Lemurs exhibit impressive craniomandibular and ecological diversity, but a phylogenetic multivariate multiple regression analysis failed to recover a strong relationship between skull anatomy and feeding ecology. However, the phylogenetic comparative method may be problematic given the strong partitioning of both morphology and ecology along clade lines (low subclade disparity). Therefore, to further test the hypothesis that dietary adaptation influenced lemur skull evolution, we performed two sets of analyses focused on within-clade ecological divergence and between-clade ecological convergence in lemurs.

Three-dimensional landmarks were acquired from crania of 33 genera and mandibles of 18 genera of extant and extinct lemurs. Landmarks were superimposed via generalized Procrustes analysis. First, we tested whether species exhibiting ecological divergence within a clade were more morphologically distinct than other within-clade species comparisons (using Procrustes distances). Similarly, we tested whether species exhibiting ecological convergence in different lineages were more similar to one another than other species pairs from these same clades. The second major component of this study involved a functionally explicit test of the ecomorphology hypothesis. We identified the details of cranial and mandibular morphology associated with these instances of ecological divergence and convergence via comparisons of mean shapes, and assessed this variation relative to predictions based on biomechanical theory and experimental analyses.

The results of the distance-based analyses were broadly consistent with the hypothesis that ecology is driving cranial, and to a lesser extent, mandibular diversification in lemurs. A notable exception was the extinct putative-folivore *Megaladapis,* whose cranial shape was very different from other folivorous lemurs. The functional tests highlighted several cases where cranial and mandibular form appears adapted for functional demands related to diet. For example, a higher position of the mandibular condyle and a posteriorly expanded gonial region result in increased leverage and larger muscle attachments for oral processing of bamboo pith in *Hapalemur simus* compared to *H. griseus*. Feeding ecology likely played an important role in the evolution and diversification of lemur skull shape.

Symposium 2 (Friday, October 16, 2015, 2:00 PM)

HISTORICAL BASELINES OF DIVERSITY AND TURNOVER FROM THE MAMMALIAN FOSSIL RECORD

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The current biodiversity crisis includes loss of species and entire ecosystems, as well as disruption of ecosystem processes around the world. One of the main challenges facing conservation biologists and planners is to understand the long-term normal range of ecosystem properties and processes. The concept of historical baselines refers to the species diversity and abundance of populations known in earlier times before current and historical levels of exploitation. Comparing modern ecosystems to their historical baselines provides a basis for assessing the scope of human impacts, alternative ecosystem states, and possible targets for population and ecosystem restoration. The fossil record extends the written and archeological records of historical baselines into geologic time.

I present four geohistorical trends in species diversity and faunal turnover from the Cenozoic mammalian record with relevance for conservation. Data are from the FAUNMAP and MIOMAP databases and the Harvard-Geological Survey of Pakistan Siwalik database. (1) In continental settings, immigration is a common occurrence and rarely disrupts resident faunas. Islands are another matter. (2) Different forms of climate change cause different turnover dynamics, with outcomes dependent on the duration of relative climatic stability and the rate of change to a new stable state or to an oscillating mode. The initial change to a new state is accompanied by extinction of many species and change in faunal structure within ecosystems. (3) Geographic ranges of species are dynamic and can tolerate geologically rapid shifts without extinction, as long as their bioclimatic requirements are continuously distributed along the direction of range shifts. (4) For most mammalian herbivores, dietary niches are conserved within moderate (not narrow) dietary breadth. When vegetation changes substantially, as in forest to grassland, most species do not persist. Species with the greatest dietary breadth shift to the new resource.

These findings have implications for conservation over the next century. Habitat loss is a more serious problem than invasive species. Large geographic-range shifts are to be expected. Landscapes, especially agricultural landscapes, that are managed to support high levels of biodiversity will be more critical to the viability of species than a network of protected areas.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

PERSISTENT PRESENCE OF INTRIGUING PIPID FROGS IN THE PLEISTOCENE OF THE PAMPEAN REGION OF ARGENTINA

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In the last eight years, paleontological prospecting in Pleistocene continental outcrops in the province of Buenos Aires has yielded disarticulated anuran bones ascribed to the "archaeobatrachian" crown-group Pipidae, based on the distinctive morphology of these bones possibly related to aquatic adaptations. These records are remarkable owing to their geographical location, further south than the distribution of the living South American representatives, currently restricted to lowlands of northern South America and eastern Panama. However, paleontological evidence demonstrates that the lineage represented today by Pipidae (i.e., Pipimorpha) reached central Patagonia in Late Cretaceous and Paleogene times. We describe material recently collected from the upper Reconquista river basin, west of the city of Buenos Aires (34°41'S 58°48'W). The anuran-bearing beds have been referred to the Lower Green Luján Sequence, whose age range is 55-30 Ka (OIS3). Previous records in the Pampean region are from mid Pleistocene (230-125 Ka) beds of coastal cliffs (38°26'S 58°14W) and late Lujanian (late Pleistocene) outcrops of central Buenos Aires province (36°44'S 61°45'W). In all these cases, remains consist of well-preserved but incomplete ilia and, occasionally, sacrourostylar complexes bearing a condyle for the articulation with the posterior-most presacral centrum. A dorsal crest is lacking along the preserved portion of the ilium shaft, which represents more than 60% of its estimated total length, resembling the condition of known Cretaceous and early Tertiary pipimorphs but unlike the crested shafts of extant pipids. In having a well-developed dorsal prominence, reduced ventral and dorsal acetabular expansions in the acetabular plane, and relatively elongate acetabulum, the ilium from the Reconquista river site conforms to those of pipids, but retains plesiomorphic features such as the longer than high dorsal prominence bearing an inconspicuous protuberance. The fragmentary sacrum is fused to the urostyle; it bears a tiny mid-dorsal ridge only between the flat articular facets of the elongate prezygapophyses unlike the living South American pipids. Although we were unable to determine the phylogenetic position of the taxon represented by these remains unambiguously, available data support their referral to a new pipid taxon. Still-undiscovered pipids bearing archaic features may have persisted in more northerly refugia, the Pleistocene rapid climatic changes probably causing latitudinal shifts and/or extinctions.

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Technical Session XIII (Friday, October 16, 2015, 2:15 PM)

ONTOGENY OF SUTURAL CLOSURE IN THE SKULLS OF EXTANT ARCHOSAURS: RECONSIDERING MATURITY ASSESSMENT IN NON-AVIAN DINOSAURS

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It is generally theorized that the sutures in the skulls of vertebrates are open early in ontogeny and progressively close as maturity is attained. This generalization has been used for decades in paleontology to assess maturity in non-avian dinosaurs. However, it has not been demonstrated that these structures are indicators of maturity in extant archosaurs. Therefore, in this study, the sequence and degree of sutural closure were investigated in the skulls of two extant archosaurs: the emu, *Dromaius novaehollandiae* (n=24) and the American alligator, *Alligator mississippiensis* (n=50). The results obtained by means of a modified cladistic analysis (with characters describing the degrees of fusion and interdigitation) show that sutural closure is a good proxy for maturity in *D. novaehollandiae* (42 characters), but not in *A. mississippiensis* (80 characters). Almost all the sutures in the skull of *D. novaehollandiae* progressively obliterate through ontogeny (15 out of 20) and the obliteration of some sutures can be used as benchmarks for sexual and skeletal maturity. In *A. mississippiensis,* a completely different pattern is seen: only two sutures (the interfrontal and interparietal) out of 36 obliterate completely and they do so during embryonic development. Therefore, these obliterations do not correlate with sexual or skeletal maturity in this species. Moreover, as maturity progresses, sutures become wider and appear more open in large, old

individuals compared to smaller, younger individuals. Histological analyses confirm that the sutural bone fronts do not fuse during ontogeny in sutures that present an open morphology. The pattern observed in American alligators likely reflects cranial mechanics instead of ontogeny, where open sutures accommodate the increasing stress received by alligator skulls due to dietary changes through their life cycle. This study suggests that all previous maturity assessments of non-avian dinosaur specimens based on the degree of closure of their sutures should be carefully reconsidered. As of today, limb bone histology appears to be the most accurate method to assess maturity in the Dinosauria.

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Technical Session III (Wednesday, October 14, 2015, 10:15 AM)

***DIMETRODON* AND THE EARLIEST APEX PREDATORS: THE CRADDOCK BONE BED AND GEORGE RANCH FACIES SHOW THAT AQUATIC PREY, NOT HERBIVORES, WERE KEY FOOD SOURCES**

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The early Permian *Dimetrodon* is one of the earliest terrestrial apex predators. The single richest locale is the Craddock Bone Bed (CBB) in the Arroyo Formation near Seymour, TX. In restorations, *Dimetrodon* often appear feeding upon large land herbivores, e.g., *Diadectes* and *Edaphosaurus;* an alternative view, Olson's Aquatic Food Base Theory (AFBT) recognizes non-terrestrial prey as key for dimetrodont food webs. In an eleven year study, the Houston Museum of Natural Science and the Whiteside Museum of Natural History mapped all CBB bones and teeth in three dimensions. The CBB is a trough measuring 204 m north–south and 37 m east–west, with a maximum depth of 4.2 m; bone concentrations occur at all levels. The CBB floor is a concave-up conglomerate of reworked caliche. The trough was filled by at least a dozen separate bone-rich units (≤ 10 cm) of red silty mudstone separated by zones of caliche nodules and green root traces. Over 45% of the bones are severely tooth-marked; ubiquitous shed *Dimetrodon* teeth are mingled with tooth-marked bones in every depositional unit. The CBB lacks any structures that indicate high current energy, so the hydraulic forces probably did not wash in bones from beyond the trough, though bloated whole carcasses could have floated in.

There are 39 *Dimetrodon*, one each of the large herbivores *Edaphosaurus* and *Diadectes*, three of the large non-herbivore, non-apex carnivore *Secodontosaurus,* and three of the semi-terrestrial amphibian *Eryops* calculated form postcrania. Did benthic amphibians and fish fill the gap in prey? The benthic amphibian *Diplocaulus* is abundant in every bone-rich unit. There are 88 dismembered *Diplocaulus* skulls. Xenacanth sharks are very common in several layers; each shark carried a large, well ossified head spine. There are 134 individual sharks based on head spines. Shark and diplocaulid body masses varied from 10 to 87 kg. AFBT is corroborated: dimetrodonts fed intensively on aquatic prey at the CBB.

We found 32 new sites in red mudstones with caliche nodule beds. Combined, the sites show the rank frequency seen at CBB: (1) shark; (2) = *Diplocaulus;* (3) = *Dimetrodon;* (4) = other aquatic amphibians; (5) = large herbivores. The new George Ranch sites, in coarsening-upward silty sandstones with little caliche, offer heuristic contrast to the CBB: Uniquely for Arroyo sites, *Edaphosaurus* is the most common vertebrate, while benthic amphibians and sharks are rare. If the AFBT is correct, then dimetrodonts should be rare. This prediction is confirmed. *Dimetrodon* bones are very rare and shed teeth are absent.

Technical Session II (Wednesday, October 14, 2015, 8:15 AM)

MOSAIC EVOLUTION AND THE INFLUENCE OF FLIGHT ON NEUROANATOMICAL VARIATION WITHIN THEROPODS

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Living birds comprise the only vertebrate group that has an encephalization index (i.e., brain volume relative to body size) that approaches the uniquely expanded values of mammals. The broad suite of complex behaviors exhibited by crown-group birds, including sociality, vocal learning, parental care, and flying suggests the origins of their encephalization was driven by numerous selective pressures, and that the historical pattern may be more intricate than a single, or perhaps gradual, expansion. A mosaic pattern of evolution in which neuroanatomical regions transform differentially has already been established for mammals. The deep history of the avian system, however, remains obscured by over 100 Ma of evolution between the divergence of crocodylians and the origin of the crown group radiation. Here we use recently developed comparative approaches to assess which of a range of adaptive regimes are potentially contributing most significantly to the measured relative volumes of digitally partitioned endocasts of birds and their non-avian ancestors. Our analyses show that relative total endocranial, cerebral, and cerebellar volumes are responsible for the majority of variation within this lineage. To identify the most likely evolutionary scenario underlying the evolution of brain organization we used generalized Ornstein-Uhlenbeck models, hypothesizing powered flight as one of several adaptive regimes that drove volumetric variation. We found that powered flight is the favored regime only in the cerebral partition, with all avialans sharing a similar volumetric signature. This regime, however, is only slightly more probable than one in which vocal learning underlies the observed variation. The variation present in relative endocranial and cerebellar partitions is best explained by adaptive regimes other than powered flight, reinforcing the hypothesis that the evolutionary history of the modern bird brain is influenced by a range of selective pressures.

Preparators' Session (Thursday, October 15, 2015, 8:15 AM)

CONSOLIDATION OF WET AMAZONIAN SPECIMENS USING PRIMAL/RHOPLEX WS 24: FIELD AND LABORATORY APPLICATIONS

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AMNH expeditions to river localities in the Peruvian Amazon have provided opportunities for experimentation with Primal/Rhoplex (or Acrysol) WS 24 ("Rhoplex" here), an acrylic colloidal dispersion that sets through the evaporation of water. Field conditions on these expeditions are extremely wet and provide challenges for both collection and field stabilization of fossil material. Swift excavating, often during downpours, and jacketing in situ are often necessary for specimen retrieval. Field consolidation is trickier still, since solvent-based consolidants like Paraloid B72 and Butvar B76 are ineffective in wet conditions. Additionally, the acquisition of solvents such as acetone and ethanol is difficult in this part of the world, making the use of water-based consolidants rather practical. The use of Rhoplex on fossil material is not well documented, but neither are many other methods for wet consolidation. Here, we present the results of our field experimentation. Our findings indicate qualitative improvements in surface stability when Rhoplex is applied at well-timed intervals during the drying process-mainly, reduced surface cracking and flaking that can occur as specimens dry.

International travel requires some planning since Rhoplex is a liquid and is unavailable for purchase in Peru. However, its water-solubility eliminates the need to travel with restricted organic solvents like acetone and ethanol. Ideally, Rhoplex should be diluted in purified water, but compromises are made when using it in the field, where it is mixed with local tap water, or even with stream water on site. Solutions applied range between 15:1 and 20:1 parts water to concentrate. This method requires forethought and careful timing, but is easy to implement in both the field and laboratory.

Treatment occurs at the localities or at our lodgings, which double as ad hoc 'field labs.' Specimens are treated as follows: 1) only during the damp phase, not when specimens are sodden; 2) specimens exposed in half jackets receive several applications in the 'field lab'; 3) once dry, specimens are further consolidated with Butvar B76. Proper application hinges on monitoring consolidant coloration and its interaction with the specimen during the damp phase. No negative interactions have been observed in the application of either Butvar B76 or Paraloid B72 once the specimens are dry. Although specimen preservation is excellent at these Amazon sites, consolidation during both wet and dry phases notably improves specimen conservation and stability.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

EVOLUTION OF THE CATARRHINE FORELIMB AND THE PROBLEM OF FOSSIL ATTRACTION IN MORPHOLOGICAL SYSTEMATICS

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Stem catarrhines from the Miocene exhibit a suite of features that would not be predicted based on our knowledge of the morphology of crown groups. Quadrupedal crown cercopithecoids might be expected to more closely approximate the primitive condition than hominoids with their derived suspensory behaviors and orthograde body postures. However, the Miocene fossil record is inconsistent with this grade-based scenario of catarrhine evolution. The conservative view would place nearly all fossil non-cercopithecoid catarrhines within the hominoid clade. Early consideration of Miocene catarrhines followed this scheme and relics of it still persist today. However, researchers now recognize that cercopithecoids and hominoids are both derived relative to the basal catarrhine morphotype for which there is no modern analog. The radiation of crown catarrhines involved rapid evolutionary changes, and as a result stem catarrhines appear gradistically more similar to each other, despite the presence of key synapomorphies linking them with crown clades. This has proved a barrier to resolving the relationships of the group. This analysis re-examines the evolution of the forelimb, which is morphologically distinct in hominoids and ceropithecoids from each other and a platyrrhine outgroup. The analysis uses a data set of 340 characters drawn from the elbow, wrist and hand of 11 species of Miocene catarrhines. Parsimony analyses support a phylogenetic scenario that links all the fossil taxa with crown hominoids but disagrees with phylogenetic analyses drawn from the cranium, pelvis and foot. A character analysis of the forelimb using BayesTraits and accounting for correlated evolution with a phylogenetic generalized least squares analysis demonstrates this result is misleading. The character analyses infer homoplasy in the catarrhine forelimb and the results indicate that stem catarrhines exhibit a unique mosaic of features not present in modern catarrhines. These results provide an explanation for the disagreement concerning the phylogenetic position of many of these taxa and caution against overweighting the forelimb in analyses focused on stem catarrhines.

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Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

ECOLOGICAL SUCCESS IN SPACE AND TIME AMONG NORTH AMERICAN FOSSIL CANIDS

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A taxon displays intrinsic ecological properties-such as diet, locomotor mode, and body size-that may promote individual success. Evolutionary optima in these intrinsic properties have been identified in mammals; and yet how these optima are reached remains unclear, especially over long time scales. How do intrinsic properties impact extrinsic properties, such as taxon success in space (geographic range) and time (taxon longevity)? We explore this question using the North American fossil record of canids, whose taxonomic diversity, morphological disparity, and relatively dense sampling make

them an ideal system for examining how success in space and time varies with ecological strategy, specifically body size and degree of carnivory. Because less specialization enables a taxon to withstand disturbance by taking advantage of a wider resource base, we predicted that a generalist (mesocarnivorous) diet, with small or average body size, characterizes canids that have longer taxon duration and more stable range size and locality coverage over time. We compiled occurrence data for North American fossil canids from the Miocene Mammal Mapping Project and the Fossilworks database, and calculated three extrinsic properties for each species: a) stratigraphic span, b) geographic range size, and c) locality coverage. We analyzed the geographic properties (b and c) from two perspectives: 1) as a time-averaged snapshot, examining only average and maximum values of these properties; and 2) as a moving picture, considering taxon resilience–the manner in which these measures of 'success' changed–through time. In the first perspective, across all Canidae, body size showed a weak negative relationship with stratigraphic span, locality coverage, and range size. As degree of carnivory correlates with body size, carnivory also showed a negative relationship with all three properties. However, from the second perspective, we observed trophic differences in taxon resilience. Smaller, more hypocarnivorous taxa displayed more gradual changes in the two geographic properties, supporting the prediction that small size, although not necessarily a generalist diet, contribute to stability over time. However, despite this apparent ecomorphological optimum, mean size and mean carnivory increased over the 40 million years of canid history, suggesting that other factors–perhaps interactions with other carnivoran competitors –significantly shaped the canid evolutionary trajectory.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

A REASSESSMENT OF THE MIDDLE MIOCENE LAGOSTOMINE CHINCHILLIDS (RODENTIA) OF QUEBRADA HONDA, BOLIVIA

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Quebrada Honda, a middle Miocene locality in Bolivia, represents an important interval in the history of the Cenozoic mammals of South America. Lying between the northern locality of La Venta, Colombia and southern localities in Patagonia, Quebrada Honda fills an important biogeographical gap in the midsection of the continent. Due to the intrinsic connection between an environment and its inhabitants, a thorough understanding of the paleofauna of Quebrada Honda is required to generate an accurate paleoenvironmental reconstruction of the locality and compare the site to others similar in age and/or geographic position.

Lagostomine chinchillids are amongst the most abundant fossils present at Quebrada Honda. However, the vast majority of this material has not been identified beyond the genus level (*Prolagostomus*) due in part to questions of how to identify intraspecific versus interspecific variation. To address this problem, we performed a qualitative and quantitative analysis of variation within the modern plains viscacha (*Lagostomus maximus*), the most closely related living species. *Prolagostomus* itself is similar to modern *Lagostomus*; major dental differences include less well defined laminae, a distinctly trilaminar M3 in *Lagostomus* but not *Prolagostomus*, and laminae that are more similar in size and shape within a tooth.

Sign-rank and t-tests suggest that metric variation seen within Quebrada Honda chinchillid specimens (n = 121) exceeds that in modern *Lagostomus* and that more than one species is present at the site. Using a combination of type specimens, classic literature, and context provided by the variation of modern *Lagostomus*, we assign most of the Quebrada Honda specimens to *Prolagostomus profluens*. This species is identified by distinctive enamel reduction patterns, especially wide anterior laminae except in P4 and M3, and a short prolongation on M3. *Prolagostomus divisus* is the next most abundant species. It is similar to *Prolagostomus profluens* but differs in having more quadrangular cheek teeth, a relatively narrow P4, narrower anterior laminae across all cheek teeth, and a longer, more posteriorly oriented prolongation on M3. One lagostomine specimen is of uncertain taxonomic assignment. Both of the species identified at Quebrada Honda are also found at Santa Cruz, Argentina, a late early Miocene locality some 3,000 km to the south. This suggests a very wide temporal and geographic range for these chinchillid species.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

NOTABLE CRETACEOUS–PALEOGENE (K–PG) BOUNDARY EXPOSURES IN SOUTHWEST SASKATCHEWAN, CANADA: A WINDOW ONTO EXTINCTION

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The latest Mesozoic and earliest Cenozoic rocks of southwest Saskatchewan contain some of the finest exposures of the Cretaceous–Paleogene (K–Pg) Boundary in North America. The upper Maastrichtian (‘Lancian’) Frenchman Formation, coeval with the Hell Creek and Lance formations in the USA, and the overlying Paleocene Ravenscrag Formation preserve a complete and continuous sequence of time immediately before, during, and after the end-Cretaceous mass extinction event. These fluvial-deltaic deposits are fossiliferous, contain a wealth of vertebrate, invertebrate, and plant fossil data on both sides of the boundary. The continuous, fine-scale sequence of strata up to and across the Boundary also renders these sites ideal for geochemical studies of the extinction. Here we present three notable K–Pg Boundary sites from southwest Saskatchewan, found in Grasslands National Park (GNP), Chambery Coulee, and along Highway 37. Ongoing research into the abundant vertebrate microsites in the Frenchman Formation at GNP and Chambery Coulee has provided insights into pre-extinction paleoecological patterns during the latest Maastrichtian, and into the nature of paleobiodiversity drivers in the region. Plant macrofossil (leaf) data from GNP and Chambery Coulee have provided new paleoclimate estimates for central Canada, and have elucidated the role of forest fires in structuring Cretaceous forest ecosystem. The Highway 37 K–Pg Boundary site, in addition to being highly fossiliferous, contains geochemical clues about the nature of the extinction. Sediment samples from one meter below and one meter above the K–Pg Boundary clay were analyzed for sulphur concentration. The isotopic composition ($\delta^{34}S$) of the samples is currently being compared to values found in Chicxulub impact target rocks and rocks from volcanic sources. The stratigraphic relationship between any observed changes is suggested to constrain a relative timeline for the Deccan Traps volcanism and the Chicxulub impact, thus helping to elucidate the relationship each event had with the mass extinction and its recovery period. The K–Pg Boundary sites in Saskatchewan are one of the best places in North America to study the nature of the world’s second-largest terrestrial mass extinction, and lend insight into the ecological patterns post-extinction recovery. The Royal Saskatchewan Museum, in collaboration with other institutions, continues to explore these unique and intriguing localities.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

DISCUSSION ON PARSIMONY ANALYSIS OF ENDEMICITY (PAE) METHODOLOGY WITH PHILOSOPHICAL PERSPECTIVES

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Biogeography methodologies were created to hypothesize the biogeographical history of taxa. The Parsimony Analysis of Endemicity (PAE) method classifies areas by their shared taxa in data composed of area vs. taxon matrices. The Most Parsimonious Cladogram (MPC), under the application of the parsimony algorithm, is generated in order to detect areas of endemism. The MPC is made rooting the PAE cladogram on a hypothetical ‘all-zero’ outgroup. Several critiques of this method can be partially summarized in: (1) the random area chosen, usually by geometrical divisions, not reflecting patterns or a historical approach; (2) use of a hypothetical outgroup for the rooting process; (3) the ingroup is considered to always be monophyletic, sharing the same biogeographic history; (4) the criterion of tree evaluation considers common ancestry, which is inapplicable to endemism; (5) the link between biogeographic processes (e.g., dispersion, vicariance, extinction) and the revealed pattern and; (6) the problem of taxon sampling that obscures the real distribution of a taxa. In the present work we defend PAE, answering the critics by proposing some changes in methodology. We propose a different confection and data treatment: (1) the area needs to be clearly chosen by methodology, prioritizing areas with the same history (e.g., same or compatible geological formation); (2) the analysis must be made without a root, then choose it based on the next node starting from the area that shares less taxa with others, making the ingroup not monophyletic a priori; (3) areas of endemism do not descend from each other; the MPC made by areas vs. taxa create a signal that some species share or not the same biogeographical history; (4) the biogeographic answer to the distribution can be found answering the question “Why does area X ...+ n have taxon A in contrast to area W ...+ n that does not have this taxon?”; we suggest that taxa must be selected at least at species level; finally, (5) taxon sampling will be a recurrent problem like missing data in phylogenetic analyses. We conclude that PAE can be helpful to find shared biogeographical history with the suggested modifications. We also conclude that taxa incongruently shared as parallelisms represent dispersal events and reversions represent local extinctions. Finally, the taxa congruently shared by two or more areas (synendemic), will represent synapomorphies and vicariance events.

Grant Information

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Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

VERTEBRATE FAUNA AND UNGULATE BIOSTRATIGRAPHY OF THE HIGHLY FOSSILIFEROUS OSO SAND MEMBER, CAPISTRANO FORMATION, ORANGE COUNTY, CA

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The Oso Sand Member is the highly fossiliferous, nearshore facies of the Capistrano Formation, which spans the southwestern rim of the Los Angeles Basin in Orange County, California. Over 20 vertebrate taxa have been identified from this unit, including well preserved fossils of marine taxa, such as a nearly complete skull of a blue marlin and the most complete fossil walrus found to date. In addition to other marine mammals (whales and seacows), terrestrial mammals are also known from the Oso Sand Member including gomphotheriids, rhinocerotids, antelocaprids, canids, cricetids, and lagomorphs. Despite the abundance of material from Oso Sand Member sites, just three papers have reported on this unit: one paper focused on the skull of the blue marlin mentioned above, the other two mentioned mammal fossils in passing. We provide an overview of all known vertebrate fossils from Oso Sand Member, and establish a more refined age for the Oso Sand Member, which will help provide a temporal framework for ongoing paleontological studies. Based on stratigraphic correlation, the Capistrano Formation is reported as Upper Miocene to Lower Pliocene. Previous workers have referred to undescribed specimens to place the Oso Sand Member in the Hemphillian North American Land Mammal Age. Partial camelid teeth are identified as *Alforjas*, known from the late early to latest Hemphillian (Hh2 to Hh4). Horse teeth previously referred to *Pliohippus* (Barstovian to Hemphillian) are reidentified as *Dinohippus interpolatus*, which is characteristic of the early late Hemphillian (Hh3). Based on these identifications, we can constrain the age of the Oso Sand Member to the early late Hemphillian (Hh3). By better defining the age of the Oso Sand Member, we can place the marine and terrestrial vertebrate fossils from this unit into a more precise chronostratigraphic framework that allows us to make more detailed comparisons to other late Neogene faunas in California.

Grant Information

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Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

POSTCRANIAL ANATOMY OF *LESOTHOSAURUS DIAGNOSTICUS* (DINOSAURIA: ORNITHISCHIA) FROM THE LOWER JURASSIC OF SOUTHERN AFRICA: IMPLICATIONS FOR BASAL ORNITHISCHIAN TAXONOMY AND SYSTEMATICS

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Although ornithischian dinosaurs dominated Cretaceous ecosystems, the early evolution of the clade during the Late Triassic–Early Jurassic is still poorly understood. *Lesothosaurus diagnosticus* is one of the earliest ornithischians, known from multiple specimens that are from the Upper Elliot Formation (Hettangian–Sinemurian) of South Africa and Lesotho. Although this taxon has been central to discussions of early ornithischian evolution, its postcranial anatomy remains poorly documented. This study provides the first comprehensive postcranial redescription of *L. diagnosticus*, based on the syntype material and other referred specimens housed in collections in the UK and South Africa. A previously described large ornithischian specimen from the Lower Jurassic is referred to *L. diagnosticus*, altering our interpretation of the syntype material of this taxon, which we now consider to represent a juvenile. With this additional information on ontogenetic variation, the diagnoses of several early ornithischians were reassessed and the validity of another taxon, *Stormbergia dangershoeki*, was called into question. Further examination of the available material revealed that the character combinations used to distinguish *L. diagnosticus* and *S. dangershoeki* are most likely examples of intraspecific and ontogenetic variation. We therefore propose that *S. dangershoeki* should be considered a junior subjective synonym of *L. diagnosticus*.

Following this redescription and taxonomic revision, a phylogenetic analysis was carried out using TnT 1.1, with new scores for a number of characters for *L. diagnosticus*. Previous analyses have recovered *L. diagnosticus* as a basal ornithischian or basal thyreophoran but this study recovered the taxon as a basal neornithischian, a position previously suggested for *Stormbergia*. This study demonstrates the importance of considering the ontogenetic status of a specimen when including it in a phylogenetic analysis.

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Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

TAXONOMIC AND PHYLOGENETIC REVISIONS OF NORTH AMERICAN NIMRAVIDAE

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The Nimravidae is a family of extinct carnivores commonly referred to as 'false saber-tooth cats'. Since their initial discovery, they have prompted difficulty in taxonomic assignments and number of valid species. Past revisions have only examined a handful of genera, while more recent cladistic analyses lacked character criteria, and utilized now antiquated methodology, resulting in questions to our understanding of valid taxa and their phylogenetic relationships. To resolve issues of specific validity, the phylogenetic species concept (PSC) was utilized to maintain consistency in diagnosing valid species, while simultaneously employing justified character criteria and linear morphometric analyses for confirming the validity of current taxa. Determined valid species and taxonomically informative characters were then employed in three differential cladistic analyses to create competing hypotheses of interspecific relationships. The results suggest the validity of 13 species and six monophyletic genera. The first in depth reviews of *Pogonodon* and *Dinictis* returned two valid species (*P. platycopis*, *P. davisi*) for the former, while only one for the latter (*D. felina*). The taxonomic validity of *Nanosmilus* is upheld. Two main clades with substantial support were returned for all cladistic analyses, the Hoplophoneini and Nimravini, with intermediate positions relative to these main clades for the European taxa: *Eofelis, Dinailurictis bonali*, and *Quercylurus major*; and the North American taxa *Dinictis* and *Pogonodon*. *Eusmilus* is determined to represent a non-valid genus for North American taxa, suggesting non-validity for Old World nimravid species as well. *Hoplophoneus mentalis* is declared nomen dubium, while the validity of *Hoplophoneus oharrai* is reinstated. Finally, one new species, *Hoplophoneus* sp. nov. was also identified.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

DIETARY RECONSTRUCTION OF TWO POPULATIONS OF *EQUUS CONVERSIDENS* (MAMMALIA: EQUIDAE) FROM MEXICO: NEW INSIGHTS INTO THE DIETARY PLASTICITY OF A WIDESPREAD PLEISTOCENE EQUID SPECIES

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Equus conversidens is a Pleistocene equid that had a wide geographic distribution, ranging from southern Canada to central Panama. One factor that determines the distribution of species is diet. The extensive geographic distribution of *E. conversidens* may suggest a relatively broad dietary spectrum. Alternatively, if this species had a narrow dietary spectrum, it could still have acquired a broad geographic distribution if the vegetation that it depended on was widely distributed. We tested these hypotheses at a regional scale by reconstructing the diet of approximately contemporaneous samples of *E. conversidens* from two geographic areas of Mexico. The first sample comes from Cedral, a site located at 1,700 meters above sea level (m a.s.l.) in the Central Mexican Plateau. The second sample comes from Loltun, a cave located in the Yucatan peninsula at an elevation of 40 m a.s.l. Paleoenvironmental reconstructions indicate an open habitat with scattered trees at Cedral in which grasses and forbs were the dominant vegetation. At Loltun there is evidence of grasses, but also indications of thorn forest and tropical deciduous forest. Given this setting, we predicted that if *E. conversidens* was predominantly a grazing ungulate, the population at Loltun would have selected grasses over other available vegetation. We used the extended mesowear method and bulk carbon and oxygen stable isotope analyses to reconstruct the diet of *E. conversidens* from the two study sites. A discriminant function analysis using mesowear data of modern ungulate species classified the Cedral sample with the modern grazing ungulates, whereas the sample from Loltun was classified with extant mixed feeders. The mesowear score of *E. conversidens* from Cedral (2.02) is significantly different from the mesowear score of the sample from Loltun (1.28). In contrast, the mean carbon isotope values for the two populations are not statistically different and indicate a mixed C3/C4 diet. The mesowear signature and carbon isotope values of *E. conversidens* from Cedral suggest that this population had a primarily grazing diet which, given its geographic location and elevation, may have included both C4 and C3 grasses. The population from Loltun had a mixed feeding diet, which likely included a combination of C4 grasses and C3 plants such as shrubs and forbs. These results indicate that *E. conversidens* was not a dedicated grazing ungulate and that it had a broader dietary spectrum than previously recognized. This dietary plasticity may have allowed the species to inhabit diverse environments.

Technical Session VII (Thursday, October 15, 2015, 2:00 PM)

NEW SPECIMENS OF *HAYA GRIVA*: IMPACTS OF NOVEL ANATOMICAL INFORMATION AND SPECIMEN-LEVEL ANALYSIS ON ORNITHISCHIAN DINOSAUR PHYLOGENY

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Intraspecific variation (including ontogenetic variation) may impact the placement of fossil specimens on phylogenetic trees, though the extent of these effects is not currently well understood in dinosaur systematics. *Haya griva*, a basal ornithischian dinosaur from the Upper Cretaceous Javkhlant Formation of Mongolia, is known from a large sample size of specimens that collectively characterize nearly its entire skeletal anatomy. As one of the best-represented basal ornithischians, *Haya* thus forms a case study for investigating the influence of intraspecific variation on the hypothesized relationships of taxa within this relatively unsettled portion of dinosaur phylogeny. We scored nine specimens of *Haya griva* for 255 characters in a recent ornithischian data matrix. One of these specimens likely represents a juvenile or subadult individual based on its relatively large eyes, short rostrum, and open cranial sutures, though it lacks long bones suitable for histological age analysis.

We ran two phylogenetic analyses with revised character scores based on recently prepared specimens of *Haya griva*, which offer new skeletal information not presented in the original description of this taxon. One analysis treated each specimen as a separate operational taxonomic unit (OTU), and the other treated all *H. griva* specimens as a single polymorphic composite OTU. When run with the same search parameters in TNT, the analysis with multiple *H. griva* OTUs resolved this taxon as sister to all orodromine and thescelosaurine ornithischians on the strict consensus tree, whereas the analysis with a single polymorphic composite OTU placed *H. griva* as an indeterminate basal neornithischian on a less-resolved strict consensus tree. The juvenile specimen groups with all other *Haya* specimens in the specimen-level analysis, suggesting that the current placement of *H. griva* is robust to at least some degree of ontogenetic variation.

Collectively, these results suggest that 1) *Haya griva* exhibits a complex mosaic of character states relative to other basal ornithischians and may occupy a more basal position than previously thought, 2) proposed ornithischian dinosaur relationships remain unstable, 3) the phylogenetic placement of even well understood taxa may be altered when new specimens become available and a fuller range of variation is taken into account, and 4) both new sources of characters and an increased understanding of the impacts of individual and ontogenetic variation on phylogenies are needed.

Grant Information
The Richard Gilder Graduate School at the American Museum of Natural History and the American Museum of Natural History Division of Paleontology

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

NEW AILURID AND MUSTELIDS (MAMMALIA, CARNIVORA) FROM THE EARLY HEMINGFORDIAN OF FLORIDA

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One new species of ailurid and two new genera and species of mustelids are recognized from the early Hemingfordian (He1) Miller Local Fauna, Dixie/Levy County, Florida. The ailurid is closely related to the European early Miocene *Amphictis*, but is smaller than the Old World species. Two new genera of oligobunine mustelids are present. One is a small hypercarnivore with a reduce metaconid on m1 that is related to *Promartes*. The second is a small hypocarnivore with an enlarged metaconid on m1 that is related to *Brachypsalis*. Additional mustelids include two leptarctines (*Craterogale* sp. and *Leptarctus ancipidens*) and two additional oligobunines (*Brachypsalis* sp. and cf. *Oligobunis* sp.). These small carnivores most closely resemble those of the early Hemingfordian Runningwater Formation of the better known northern Great Plains faunas. Cf. *Amphicitis*, *Craterogale*, *Leptarctus*, *Brachypsalis*, and *Oligobunis* also occur in the Runningwater Formation. Of these, *Leptarctus* is the only genus shared in common with the early Hemingfordian Thomas Farm Local Fauna of Florida. This indicates that the Miller Local Fauna is older than Thomas Farm. The Runningwater Formation is earliest He1; Thomas Farm, the latest He1 or earliest He2.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

RESTORING A RESTORED RESTORED *TRICERATOPS* '? *BREVICORNUS*' SKULL FROM THE LANCE FORMATION, WYOMING, USA

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In 1956, a skull of the ornithischian dinosaur *Triceratops* crossed the Atlantic, from the Yale Peabody Museum in the USA to the Delft University Geological Museum in the Netherlands, in exchange for an invertebrate fossil collection from the former Dutch colony of Timor.

The skull was originally classified as the 'plesiotype' of *T.* '? *brevicornus'*, or simply 'skull 21'. It most likely represents the better part of YPM VP 001832, a skull excavated during the Yale-Hatcher 1891 Cretaceous Expeditions. It was recovered from the 'Ceratopsian locality 21', Lance Formation, near Lightning Creek, Converse County, Wyoming, USA. The specimen comprises most of the skull base, including the majority of the condylar region, sub-orbitals up to the nasal bone rostrally, and the lower jaws.

The fossil was in all likelihood seriously damaged when the shipping crate moved around in the cargo hold of the ship during a storm over the Atlantic Ocean. Perhaps worse, upon unloading the shipment at the Delft Museum, the crate got dropped from the truck. Once unpacked, the museum staff was greeted with a challenge of about 600 pieces. The subsequent repair and restoration work in the Netherlands during the late 1950s left something to be desired, particularly when mapped against more recent reconstructions.

Following the recent merger of multiple collections (including the Delft collection) into the Dutch national natural history museum, Naturalis Biodiversity Center in Leiden, new reconstruction efforts are now under way to restore the specimen. The disassembly of the specimen provided an interesting opportunity to reverse-engineer the approach of various labs, and document a stratigraphy of the materials and methods applied in the excavation and the earlier restorations of the specimen.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

THE BONY LABYRINTH OF *HYAENODON EXIGUUS* AND A REVISED DESCRIPTION OF THE MIDDLE EAR OF A DERIVED HYAENODONTA (MAMMALIA)

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The genus *Hyaenodon* was present in North America, Europe, and Asia from the late Eocene until the early Miocene. It was one of the most successful predators of its time. Despite the fact that much of the anatomy of *Hyaenodon* has been previously studied and documented, the systematic position of this genus within Hyaenodonta remains unclear. Details of the structures of the bony labyrinth and the middle ear region are known to be taxonomically useful in other mammalian groups but have never before been precisely documented in *Hyaenodon* or other hyaenodontans. Based on non-invasive computed tomography scanning we identify new characters of the bony labyrinth that provide a basis for comparison and may help to unravel the exact systematic position of *Hyaenodon* when other hyaenodontans are similarly analyzed in the future. We examined this area in a broken left skull fragment 'MNHN Qu8594' of *Hyaenodon exiguus* from Quercy (Oligocene) deposits in France. Using 3D visualization software, the auditory ossicles (stapes) and the bony labyrinth were segmented and then virtually reconstructed. The malleus was not preserved and the incus was not segmented, but investigated separately without computed tomography scanning. The semicircular canals are large and their overall shape is quite similar to the canals of the vestibular system found in extant carnivores. The cochlea shows 2.5 turns and is rotated anteriorly. The turns of the cochlea are flattened dorso-ventrally. The morphology of the stapes is not unusual: the footplate is oval-shaped and surrounded by two similar sized crura. New observations made concerning the bulla and the tympanic cavity lead to a revised description of the internal structure of the bulla and the first description of the stapes. The morphology of the incus is reminiscent of felids and viverrids, especially concerning the incudo-mallear facet. Preliminary results and the inflated bulla suggest that *Hyaenodon* was not a specialist in detecting low acoustic frequencies, but maybe was capable of detecting sound over a wide frequency range.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

WING PNEUMATICITY IN MODERN BIRDS COMPARED TO A CRETACEOUS PTEROSAUR

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Birds and pterosaurs, the largest vertebrate powered fliers to evolve, redistribute the mass of their wing skeleton with the presence of pneumatic spaces within the long bones and carpal elements. The proportion of air to bone, or an 'air-bone ratio', has never been estimated in either group for either individual bones of the wing skeleton as a whole. Computed-tomographic scans were taken of the wing bones of soaring birds (pelican, stork, vulture) and a large Cretaceous pterosaur from Africa. Initial results indicate that pterosaur wing bones at mid-length along the wing skeleton (metacarpal 4, phalanx 1) have an air-bone ratio of approximately 2.0, whereas an air-bone ratio in the same portion of the wing skeleton in the avians under study was approximately 1.0. The pterosaur thus has twice as much air relative to bone than in soaring birds for comparable wing elements. In the pterosaur, in addition, the air-bone ratio increased in more distal elements of the wing skeleton, in contrast to the air-bone trend in the bird wings under study. The higher air-bone ratio and its increasing value in the distal wing skeleton of pterosaurs may be related to differences in wing structure. Pterosaurs must maintain subcylindrical wing bones along the entire length of the leading edge of the wing, whereas in birds the distal bones form a flattened anchor to primary feathers. More data is needed from a range of birds and pterosaurs to understand how pneumaticity scales with body size, wing design, and wing bone architecture.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

DISPARITY DYNAMICS OF LAMNIFORM SHARKS ACROSS THE CRETACEOUS-PALAEOGENE BOUNDARY

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Previous studies have demonstrated that Late Cretaceous shark diversity was coupled with high origination rates, but subsequently suffered substantial losses as a direct consequence of the K-Pg boundary mass extinction. However, our understanding of extinction dynamics across this interval lacks an ecological perspective. In particular, the occurrence of a selective decline in shark ecodiversity, similar to that documented in actinopterygian fishes, remains uncertain. To address this question, we selected lamniform dental morphology as a model system because of its well sampled, ecologically relevant, and diverse record across the K-Pg interval. A two-dimensional geometric morphometric approach, based on a sample of 477 teeth spanning the Cenomanian–Priabonian, was applied to (1) test the taxonomic pattern of decreasing diversity across the K-Pg boundary, and (2) test the hypothesized selective extinction of lamniform taxa, especially from open-water pelagic niche-spaces. Our results show that dental disparity in lamniforms underwent a notable but not significant decline from the Maastrichtian to early stages of the Palaeocene. We attribute our statistical uncertainty to limited global sampling from the early Palaeocene. Nevertheless, a significant shift in morphospace occupation is recovered with low and broad, together with robust high-crowned cutting teeth being noticeably absent and coincident with an overall shift towards distally recurved dentitions. Such notable changes in overall morphology suggest selective extinction of both durophagous and macropredatory lamniforms at the end of the Cretaceous, with post-Mesozoic survival evinced in soft-bodied and zooplanktivorous feeding morphotypes. Moreover, this pattern is persistent until the Palaeocene/Eocene boundary, and concurs with apparent taxonomic radiations amongst odontaspids, otodontids, and mitsukurinids, as well as non-lamniform carcharhiniforms. We therefore conclude that although the K-Pg extinction event was not demonstrably catastrophic for lamniform shark disparity, it did have a profound effect on the range of observable ecomorphologies, perhaps reflecting extrinsic alterations in available prey such as hard-shelled pelagic cephalopods and marine amniotes.

Technical Session XI (Friday, October 16, 2015, 9:15 AM)

DISCOVERY OF THE FIRST OLIGOCENE PRIMATES FROM LIBYA ILLUMINATES PARAPITHECID PHYLOGENY AND BIOGEOGRAPHY

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The newly discovered Zallah Incision local fauna (ZILF) derives from early Oligocene rocks in the Sirt Basin of central Libya. Based on mammalian biostratigraphy, ZILF correlates well with quarries V and G in the Jebel Qatrani Formation, Fayum Province, Egypt, yielding an interpolated absolute age of ~31 Ma. At least three taxa of anthropoid primates, all of which are new at the species level or above, are currently known from ZILF. The best documented of these new Libyan Oligocene primates is a species of the parapithecid genus *Apidium*. The new *Apidium* from ZILF resembles contemporary species of *Apidium* from Egypt (*A. bowni* and *A. moustafai*) in terms of size, but it shares multiple dental synapomorphies with *Apidium phiomense*, the youngest and largest species of *Apidium* currently known. The apparent sister group relationship between Egyptian *A. phiomense* and the new Libyan *Apidium* from ZILF conflicts with previous hypotheses regarding the phylogeny of *Apidium*, whereby *A. phiomense* was thought to have evolved in situ in the Fayum from earlier species of *Apidium* inhabiting that region. Although the paleoenvironmental conditions prevailing at ZILF and the Jebel Qatrani Upper Sequence quarries are thought to have been similar, climatic deterioration during the early Oligocene likely fostered habitat fragmentation at regional geographic scales across North Africa, promoting allopatric speciation among widespread populations of *Apidium* and other arboreal taxa. Based on new data bearing on parapithecids from ZILF and the Jebel Qatrani Formation, a phylogenetic analysis of Parapithecidae was conducted. Oligocene parapithecids can be segregated into two clades corresponding to the subfamilies Parapithecinae (containing *Parapithecus* and *Simonsius*) and Qatraniinae (including *Qatrania* and *Apidium*). Despite its small size and its stratigraphic occurrence low in the Jebel Qatrani Formation, *Qatrania* is not a basal member of Parapithecidae.

Grant Information
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Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

POLYMORPHISMS, OCCLUSAL OPTIMIZATION, AND MORPHOLOGICAL INTEGRATION OF THE POSTCANINE DENTITION OF *DESMOSTYLUS HESPERUS* (ORDER DESMOSTYLIA)

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Variation is the basic material for evolution, but can be challenging to obtain for large fossil species that are rare or incompletely preserve and lack living representatives. Proboscideans and mysticetes have living representatives that allow study of larger samples from single populations, but desmostylians are completely extinct. To better understand their enigmatic biology, dental polymorphisms were studied from 240 isolated postcanine teeth of *Desmostylus hesperus* from a single locality, the Sharktooth Hill Bonebed (15.9–15.2 Ma) of the Round Mountain Silt, California. Isolated upper and lower deciduous fourth premolars and all adult upper and lower molars were included in this study. Supernumerary cusps were identified for each tooth, and measurements of

crown length, width, and height were measured with digital calipers. Macroscopic wear features were identified for each specimen, including the concavity/convexity of the crown and the exposure of dentine lakes for each cusp to aid recognition of the effect of wear stage on morphology.

Among uppers, supernumerary cusps were most commonly found beside primary cusps, particularly the buccal cusps, the paracone and metacone. This may be because accessory cusps B, A, C, and X are already ubiquitous. Supernumerary cusps of lowers are rare in comparison with uppers. Those that exist are most common beside the hypoconid or between the accessory cusps Z and Y (or in the case of dp4, ZZ, YY, and XX). Wear profiles of uppers most commonly display concave relief, with labial edges of crowns forming a grinding surface that was most likely a Phase I facet. Wear of lowers tend to be flat or convex, particularly on the buccal side of the crown. Cusp additions to upper teeth are most numerous on the buccal sides of teeth, which may be the result of selective pressure for increasing the tooth mass for this Phase I facet. Cusp additions appear characteristic of the Desmostylidae, and these patterns specific to upper versus lower postcanine teeth may reflect some sort of incomplete pleiotropy of the developmental control of cusp additions from tooth to tooth. Previous studies of dental ontogeny indicate that only a few postcanine teeth are in occlusion in each quadrant at any given stage of life and in extreme increases in body size. Along with tooth size, this new data indicates that the addition of cusps in the Desmostylidae is found mostly consistent from tooth to tooth and optimized to improve occlusal function.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

MORPHOLOGIC INDICATORS OF FOSSORIALITY AND THE EVOLUTION OF BURROWING IN DICYNODONTS (AMNIOTA, SYNAPSIDA)

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Among the extinct ancestors of mammals, Dicynodontia is a clade easily recognized by characteristic turtle-like beaks, toothless except for a pair of large tusks. Dicynodonts were an ecologically important group of herbivores with a cosmopolitan distribution across the Permo–Triassic boundary. Evidence exists that some dicynodonts were burrowers; for example *Diictodon* has been found fossilized in burrows. Despite the description of dicynodonts as generally fossorial, this assumption has yet to be rigorously tested. Here we test for the presence of morphological indicators of burrowing behavior in dicynodonts using quantitatively identified osteological correlates of fossoriality in extant mammals.

We collected linear measurements on the forelimb and hind limb skeletons of 45 Permian to Triassic dicynodonts and 157 extant mammals spanning 15 orders. Extant mammals were binned into three categories: fossorial, subterranean, or non-digging. RMA regression analyses indicate that fossorial taxa have more disparate hind and forelimbs than nonfossorial taxa, and confirm that the humeral epicondyles and olecranon processes of fossorial taxa are relatively larger than those of non-diggers. Discriminant function analyses clearly distinguish between the three functional groups, demonstrating a morphologic continuum from the least to most fossorial among extant taxa. The addition of dicynodonts to these analyses supports the prior notion That *Cistecephalus* and *Kawingasaurus* were fossorial, and *Cistecephalus* was likely subterranean. Unfortunately, the lack of articulated and associated fossil material restricts the utility of these analyses largely to isolated limb elements, in particular the humerus. Nonetheless, these analyses shed the light on the behavior of the smaller dicynodonts, as the large Triassic forms fall well to the non-fossorial extreme of the limb shape space. Mapping inferred fossoriality into a phylogenetic context indicates that there was a single clade of specialized burrowing dicynodonts and that other burrowers, such as *Robertia* were not closely related. Our results suggest that burrowing has evolved independently multiple times within dicynodonts. Working out the distribution of burrowing in dicynodonts adds to our knowledge of the taxonomic and paleobiologic patterns of the critical end-Permian extinction. Use of simple metrics provides a framework for using limited resources to answer important questions in paleontology, and to teach scientific inquiry to those with limited prior knowledge.

Grant Information
The work was partially supported by Faculty Research Funds from Augustana College, Rock Island, IL.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

RECONSTRUCTING TRANSATLANTIC MIGRATIONS IN THE LATE MESOZOIC AND MIDDLE CENOZOIC LAMNIFORM SHARKS FROM NEW JERSEY UTILIZING SEAWATER SR/CA AND 'CLUMPED' ISOTOPE PALEOTHERMOMETRY FROM TOOTH ENAMELOID

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Lamniform shark teeth with global distribution can be recovered from time-constrained and regionally traceable stratigraphic marker beds in the New Jersey Coastal Plain during the Late Mesozoic and Middle Cenozoic. By employing 'clumped' isotope paleothermometry (D_{47}) in contemporaneous fossil shark tooth enameloid, we have reconstructed seawater Sr/Ca (Sr/Ca_{sw}) from three New Jersey lamniform shark genera. Comparisons of these reconstructed Sr/Ca_{sw} values measured from *Cretalamna*, *Squalicorax*, and *Striatolamia*, to that of the same contemporaneous genera found in Africa, provide excellent intercontinental agreement. Similar intercontinental geochemical data demonstrate the reliability of shark tooth enameloid to archive the Sr/Ca evolution of open ocean seawater chemistry.

All three New Jersey lamniform genera have a worldwide fossil record, with each species providing stage boundary stratigraphic resolution. Similar Sr/Ca evolution, along with their stratigraphically-constrained geographical distribution, reinforces the likelihood that transatlantic migratory behavior in lamniform sharks existed throughout the Tethyan ocean and into modern times. Recent tagging studies of lamniforms support the New Jersey Sr/Ca_{sw} data, and demonstrate large-scale seasonal migrations throughout the Atlantic Ocean Basin likely occurred with regular frequency.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

VERY OLD HOMINOID DIVERGENCE DATES BASED ON PALEONTOLOGICAL AND MOLECULAR DATA

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Recent conclusions about mutation rates and generation times in extant hominoids have pushed back estimates of the timing of events in hominoid evolution. Ironically, while molecular dates have historically called into question the antiquity of divergence dates from the fossil record, the newest dates from the molecular record exceed those currently derived from the fossil record by millions of years. The most recent observations of mutation rates and generation times in hominoids yield an estimate of the hominin/panin divergence between 7 and 13 Ma, the older date about 6 million years older than the first evidence of a hominin in the fossil record. The divergence of the gorilla clade may be as much as 19 Ma (8–19 Ma) and that of the pongines 14–25 Ma. The latter two divergence dates are especially inconsistent with the fossil record, or are they? I present evidence to suggest that these earlier divergence dates may find support from the fossil record. *Dryopithecus* (including *Pierolapithecus*) more closely resembles *Gorilla* than other hominoids in facial morphology. The oldest specimens potentially attributable to *Dryopithecus*, from Can Mata in Catalonia, around 12.5 Ma, may conceivably represent the earliest gorillas. The more derived taxa *Hispanopithecus* and *Rudapithecus* also share features with *Gorill*a not found in *Pan* and hominins.

The suggested age of 18 Ma for the hominine-pongine divergence is more problematic. However, *Nacholapithecus* (15 Ma), though damaged, is described as preserving a premaxillary morphology more like that of *Pongo* than any other middle Miocene ape. Its forelimb morphology may also presage that of suspensory hominids. If *Nacholapithecus* is a pongine and the Ponginae is more than 18 Ma, then much of the early Miocene ape fossil record may postdate the hominine-pongine divergence. *Proconsul, Ekembo, Morotopithecus, Afropithecus* and other taxa attributed by most to stem Hominoidea may then record terminal taxa postdating the origin of the great apes. Rather than occurring in Eurasia after 15 Ma, the hominine-pongine divergence may have occurred much earlier and in Africa. Some morphological evidence supports the conclusion that early Miocene apes may be stem hominids rather than stem hominoids, extending the divergence date of the Hominidae to at least 18 and probably more like 20 Ma. This has dramatic implications for the interpretation of the hominoid fossil record, in particular, the timing of events and the amount of homoplasy required to account from the relatively late appearance of the modern hominoid body plan.

Grant Information
NSERC, National Geographic, Alexandre von Humboldt Stiftung

Symposium 2 (Friday, October 16, 2015, 3:30 PM)

INSIGHTS FOR CONSERVATION PALEOBIOLOGY FROM 35 YEARS OF TAPHONOMIC RESEARCH IN MODERN AFRICAN ECOSYSTEMS

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Research on modern bone assemblages in Kenyan conservation areas shows that the remains of dead vertebrates-large ungulates in particular-faithfully record many aspects of the ecology of living populations and add important information not available from standard live census methods. Taphonomic study in Amboseli National Park spans 35 years (1975 to 2010), and similar bone survey methods provide shorter-term samples in Shompole/Ol Kiramatian Conservation Area (2006–2007), Meru National Park (2007–08) and Tsavo National Park (2013). These projects involve collaboration with conservationists and the Kenya Wildlife Service, the first government organization to include taphonomic surveys in wildlife monitoring protocols.

Correlation tests between bone and live data from the four different tropical ecosystems show overall fidelity in representation of mammal community structure and richness, large herbivore relative abundances, and habitat use. While air and ground surveys of live animals record daytime habitat distributions, bones show where deaths occur at any time. For the major herbivores in Amboseli, live-dead comparisons across habitats thus reflect diurnal patterns of foraging (day) vs. predator avoidance (night). Bone surveys recover species not recorded by live censuses, resulting in more complete documentation of biodiversity. Quantitative comparisons between taphonomic data and fluctuations in living populations reveal that skeletal completeness and bone damage are sensitive indicators of fluctuations in mortality and changes in predator pressures through time. Bone damage also provides evidence for human-wildlife interactions (e.g., cutmarks on bones, hyena damage to domestic animal carcasses). Surface bone assemblages represent cumulative mortality over years to decades, and these time-averaged samples can be parsed into shorter temporal bins using calibrated weathering stages. This approach allowed successive bone surveys in Amboseli to track ecosystem change over 4 decades (1960s through early 2000s), showing close agreement with live survey data for the same period. These results demonstrate that modern bone surveys contribute meaningfully to quantifying complex ecological systems, track population-level dynamics through time, and fill gaps in current knowledge of animal communities, while simultaneously increasing understanding taphonomic process and bias in the fossil record.

Grant Information
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Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

BIOGEOGRAPHIC BIPARTITE NETWORK ANALYSIS MADE ACCESSIBLE TO PALEOBIOLOGICAL RESEARCHERS

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Paleobiogeography is a fundamental facet of paleontological research-contributing largely to our understanding of important biological and geological principles such as vicariance, geographic dispersal, adaptive radiation, and plate tectonics. Despite these contributions, paleobiogeography utilizes methods that lack evident diagrams or statistically validated metrics. Originally, paleobiogeographic visualizations focused on range maps, which encircled occurrences of a single taxon or taxa that were paleogeographically dispersed. However, these maps are not statistically validated. Today, paleobiogeography employs cluster/gradient, phylogenetics, and ordination approaches. However, these newer approaches lead to abstruse figures that are not usually validated with statistics. More recently, bipartite networks (i.e., taxon:locality) have been adapted to provide explicit diagrams and statistical analyses of biogeographic structure. Bipartite analysis stems from network analysis, which was originally developed to detect links between communities and provide clear-cut visualizations of social networks. Both the assessment of how interconnected communities are and the visualizations network analyses make it a superb tool to identify how homogenous biogeographic communities are across time and space. Bipartite analysis utilizes four metrics to assess biogeographic structure, which are: (1) the average number of taxon-locality connections relative to the maximum possible connections (i.e., biogeographic connectedness); (2) the number of distinct sub-clusters within the bipartite diagram (i.e., network clusters); (3) the average number of basins a taxon is found in (i.e., average occurrences); and (4) the average number of endemics. To assess significance, the metrics are iteratively subsampled (i.e., bootstrapped). Still, creating a bipartite network diagram from presence-absence data, generating the four metrics of biogeographic structure, and generating bootstrap analyses are currently inaccessible to most paleobiological researchers. To demonstrate the workflow, we use previously published occurrence data of taxa fromthe Late Permian and Middle Triassic of Gondwana. We take this data through all the steps of building the network visualization, calculating the four metrics of biological structure and assessing the significance of these metrics with bootstrapping methods.

Grant Information
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Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

SWINGING THE DOUBLE-EDGED SWORD: COMMUNICATING THE RELEVANCE OF PALEONTOLOGICAL DATA TO CONSERVATION BIOLOGY

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A diverse array of perspectives, techniques, and tools are now used by paleobiologists to document and interpret data from the past on various time scales. The potential predictive power of paleobiological data lies in the fact that those data record the actual response of fauna and flora to past environmental perturbations. Conservation biologists and policymakers certainly can benefit from the careful analysis and interpretation of paleontological data, and the potential for collaboration with paleobiologists is real. There are, however, challenges to the establishment of meaningful collaboration, and both groups must take these under careful consideration. Professional training of individuals in the disparate fields may not typically include courses or other formal instruction in the fundamentals of the other discipline(s), so a form of mutual ignorance often is present at the outset. In my experience, paleobiological data often are ignored for the simple reason that non-paleobiologists do not believe or accept the data derived from paleobiological analysis, including basic data such as taxonomic identification and resolution in the fossil record. To overcome this barrier, paleobiologists must be careful to openly acknowledge foundational assumptions that underlie their work, to embrace the uncertainties that are inherent in their discipline, and to interpret their data responsibly. Conservation biologists must work to understand that the extant biota as we see it today is the result of a long and complicated history, and that ecological tolerances or organisms we see today are themselves subject to evolutionary transformation. That sword cuts both ways because taxon-based paleoecological approaches often still operate under the assumption that modern ecological tolerances of particular taxa can be held constant and unchanging for the purpose of paleoecological reconstruction. Such approaches not only rely upon a starting condition that denies that evolution takes place, they also reinforce a common misconception held by neontologists. Independent tests of the stability or plasticity of ecological tolerances through time are essential if we are to reliably interpret the fossil record, and to use that record to make predictive statements about the possible consequences of environmental perturbations on modern and future ecosystems.

Preparators' Session (Thursday, October 15, 2015, 12:00 PM)

THE BADLANDS NATIONAL PARK FOSSIL PREPARATION LAB: BUILDING RELATIONSHIPS WITH POSITIVE OUTCOMES

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The development of a new fossil preparation lab in 2012 has forged strong relationships for Badlands National Park. Open to public view, the fully functioning lab is an accessible interface into the science of paleontology, often reaching those who otherwise would not be reached. Interactions with visitors, staff, researchers, artists, students, and other federal entities have generated synergies with positive and sometimes unexpected outcomes.

By encouraging protection of fossil resources, the fossil preparation lab has produced a sense of conservation stewardship, manifested in a number of ways. One of the park's most successful collaborations is the Visitor Site Report (VSR) program. Visitors are encouraged not to disturb fossils in the park and report their finds by submitting a VSR. As a direct result of the lab's influence, the program has increased to well over 250 reports per year and has led to a number of scientifically significant discoveries. Subsequently, the park has developed an interpretive display where visitors who complete a VSR are featured, and their photos and names are posted. Many of the fossils prepared in the lab are from VSRs, offering a visitor the experience of a direct and almost immediate contribution to paleontology. After four seasons of successful operation, the fossil preparation lab has witnessed an increase in visitation of over 40% and has become a central focus of park interpretive programs. It was recently featured in *Parents Magazine* as a must-see destination while visiting South Dakota. Additionally, the establishment of the lab now provides an opportunity for scientific illustration which has been utilized by the park's Artist in Residence program. The lab also provides a meeting place for researchers, where fossils can be prepared and images projected onto a SMART Board, facilitating discussion and topical research. Other fossil parks are also served by the lab, addressing their backlog of unprepared fossils.

Construction contractors often work in the park, unfamiliar with paleontological resources or the regulations which protect them. By spending time in the lab, workers develop a sense of responsibility for park fossil resources and are much more willing to cooperate with NPS paleontological monitoring personnel.

The Badlands fossil preparation lab provides a tangible model of paleontological resource conservation and protection. Bridging the gap from abstract concepts to physical examples, the lab has fostered a deeper understanding and appreciation of the significance of fossil resources.

Technical Session I (Wednesday, October 14, 2015, 12:00 PM)

NEW SYSTEMATIC AND BIOGEOGRAPHIC INTERPRETATIONS OF THE LATE MIOCENE (9–7.4 MA) MARAGHEH HIPPARIONS, NORTHWEST IRAN

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Maragheh is a classical Pikermian-type late Miocene faunal series in Northwest Iran ranging in age from 9.0–7.4 Ma. Maragheh has been known and repeatedly exploited for its rich fossil vertebrate assemblage, since its discovery in 1840 by the Russian Explorer M. Khanikoff. Major collections of Maragheh fauna are maintained by a number of European and Japanese natural history museums and universities. The Natural History Museum of Tehran, Iran (MMTT) undertook joint field expeditions with UCLA to Maragheh, Iran in the mid-1970s, which has yielded an important stratigraphically and chronologically well resolved assemblage. Studies of the Maragheh hipparions have yielded systematic, biostratigraphic, zoogeographic and paleoecologic interpretations that are significantly revised by the current study. Our current study goes beyond previous systematic investigations by incorporating study and statistical analysis of Maragheh hipparion postcrania to better discriminate lineages. Our analysis provides the following results: there are two species belonging to the genus *Hipparion* s.s., *H. gettyi* and *H. campbelli;* there are two species belonging to the genus *Cremohipparion*, *Cr. moldavicum* and *Cr. matthewi;* one species belonging to *"Hipparion"* (genus uncertain), *"H". urmiense*. The two species of *Hipparion* have biogeographic relationships with species ranging from southern France to China, eastward, and Libya, southwestward. The two species of *Cremohipparion* have relationships with taxa ranging from Greece to China, and also IndoPakistan. *"Hipparion" urmiense* is most closely comparable to species of *Hippotherium* that range from Central Europe and Ukraine, through the Balkans, to Turkey and Iran. Recent stable isotopic research on Maragheh hipparions indicated that there was a negative shift in carbon isotopes, suggesting possible uplift of the Iranian Plateau and a shift from C4 to C3 grasses after ~8.97 Ma. Oxygen isotope values further reveal a decrease in seasonality at Maragheh after 7.89 Ma, which also supports a cooling trend in the late Miocene. These isotopic shifts correlate with the transition from European MN 11 to MN 12, when Pikermian faunas achieved their maximum geographic extension.

Grant Information
NSF SGP Program

Technical Session XIII (Friday, October 16, 2015, 3:00 PM)

CAN WE PREDICT THE PRESENCE OF AIR SACS IN THE POSTCRANIAL SKELETON OF DINOSAURS USING HISTOLOGICAL ANALYSIS?

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One of the most striking features of the skeleton in birds is the high degree of postcranial skeletal pneumaticity, which is a result of the invasion of diverticula of the pulmonary air sacs into the bones. The avian respiratory system consists of a set of usually nine highly compliant air sacs (paired cranial thoracic and cervical sacs, a single clavicular sac, paired caudal thoracic and abdominal sacs) that act like bellows and move the air through the almost volume-constant lung, which is attached to the axial skeleton. Pulmonary diverticula are hypothesized to have been present in saurischian non-avian dinosaurs. For the Sauropoda it is hypothesized that the cervical and anterior thoracic vertebrae were pneumatized by diverticula of putative cervical air sacs, whereas the posterior dorsal vertebrae and the proximal caudals were pneumatized by diverticula of putative abdominal air sacs. In the titanosaurian sauropod *Alamosaurus*, even the pubis appears to be pneumatized, possibly by diverticula of abdominal air sacs as well.

However, the presence of air sacs in extinct species so far is inferred only by osteological correlates such as fossae or pleurocoels. We were interested in whether there are also microscopic correlates. To this end, we analyzed histological sections from vertebral centra and pelvic elements of several sauropods, which were previously interpreted as being pneumatized. The samples were taken from the contact area between the bone and the putative air sac. For comparison, we examined the histology of bones that are directly attached to or intruded by pulmonary tissue in extant turtles and birds, respectively. We also examined pneumatized skulls of several extinct and extant mammals, in which the air spaces are not lined by pulmonary tissue. We hypothesized that bone resorption and redeposition induced by the invading parts of the pulmonary system is different from typical secondary bone resorption producing trabecular bone. In camellate bone of sauropods, the camellae are indeed lined by a thin continuous layer of lamellar bone set off from non-pneumatized compact and trabecular bone by a sharp resorption line. This layer differs from the continuously remodeled trabeculae with cross-cutting resorption lines that surround bone marrow. Thus, histological analysis could serve as an additional test for pneumatization by pulmonary air sacs.

Colbert Prize (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

CEDROMUS WILSONI (CEDROMURINAE, SCIURIDAE): OLDEST SCIURID ENDOCAST AND EARLY BRAIN EVOLUTION IN SQUIRRELS

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Sciuridae (squirrels) is both the most primitive and the most diverse family of the rodent suborder Sciuromorpha, represented by 273 extant species. Sciurid rodents can be terrestrial, arboreal, or even gliders. The fossil sciurid *Cedromus wilsoni* is known from a complete skull from Wyoming (Late Orellan, Oligocene) and has been classified into its own subfamily because it had not yet attained full sciuromorphy, suggesting it belongs near the base of the suborder. A virtual endocast of *C. wilsoni* was obtained from high resolution microCT data. That endocast was compared to one of the most primitive rodents, *Paramys*, and to the ischyromyine *Ischyromys*, since Ischyromyinae is considered one of the most closely related groups to the origins of Scuiromorpha. These comparisons provide the opportunity to study the neuroanatomical changes occurring near the base of Sciuridae.

The body mass of *C. wilsoni* is 269 g (based on skull length) and the volume of the virtual endocast is 3.6 cm^3, yielding an encephalization quotient (EQ) of 1.09 using Eisenberg's equation. Compared to other rodents, *C. wilsoni* has a higher EQ than *Ischyromys typus* (0.51), also from the Orellan, and falls within the range of variation of modern rodents (i.e., higher than *Spermophilus richardsonii* EQ = 0.82, but lower than *Sciurus carolinensis* EQ = 1.36). *Cedromus wilsoni* also has a larger neocortical surface area (31.8%) compared to *I. typus* (20.6%), suggesting that one of the changes occurring at the base of sciurids might be an increase in neocortical surface area. This suggests an enhancement in functions other than olfaction (e.g., vision, audition and motor functions) in early squirrels. Sciurids also have smaller olfactory bulbs (*Cedromus wilsoni*: 2.98%; *S. carolinensis*: 3.2%) compared with the most primitive rodents (*Paramys copei*: 6.05%; *P. delicatus*: 4.7%). In contrast, *Cedromus wilsoni* had proportionally larger paraflocculi (3.2%) compared to *I. typus* (1.6%). As that region of the cerebellum plays a role in eye movement control, this function may have been enhanced in early squirrels, suggesting a change in the relative importance of the different sensory modalities.

The study of the endocast of *C. wilsoni* suggests that early squirrels were more visually oriented animals and exhibited more complex neocortical functions compared to more primitive rodents. These transitions may have laid the groundwork for the subsequent diversification of the family.

Grant Information
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Technical Session V (Wednesday, October 14, 2015, 3:00 PM)

CONSERVED VARIABILITY AND THE VERTEBRATE FOSSIL RECORD: IMPLICATIONS FOR EVOLUTIONARY PATTERNS AND PROBLEMS IN DEEP TIME

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Evolutionary theory predicts that transformations in phenotypic characters involve a period of ancestral polymorphism wherein the probability of either the primitive or derived condition being expressed is relatively high. These periods of high variability circumscribed by changes in developmental potential may be extremely restricted in both time and space, especially when selection is strong, and may be limited to a single ancestral population. In such cases, the probability of sampling fossils from within one of these zones of variability is so low that the resultant variation is unlikely to directly influence broad patterns of evolutionary change as communicated on a taxonomically inclusive phylogeny. If, however, an evolving developmental network maintains its potential for high phenotypic variation over a significant period of geological time, then the probability of sampling fossils from within this zone increases, as does its potential influence on our perception of evolutionary history.

The hypothesis that extended zones of variability exist often enough to significantly affect our macroevolutionary view of the fossil record makes certain testable predictions. First, if the potential to express variation is controlled in part by phylogenetically informative transformations in the upstream architecture of the involved developmental pathways, then polymorphism levels should have phylogenetic structure when examined across a clade of extant species. Second, characters more recently evolved and thus diagnostic of less inclusive clades should express higher levels of polymorphism within extant species than characters that evolved at deeper positions on the tree. Third, as fossils are sampled successively closer in time and tree space to the evolutionary origin of a character, the probability increases that those fossils are drawn from within a zone of variability-a probability that should translate to marked homoplasy in the early history of that character.

Empirical data drawn from multiple extant vertebrate lineages support the conclusion that the first and second predictions are frequently met. In addition, a survey of tetrapod phylogeny reveals numerous characters that conform to the pattern of the third prediction indicating that conserved variability meaningfully affects our view of evolutionary history based on the fossil record. This hypothesis provides new opportunities for integrating morphology, development, systematics, and the fossil record to address long-standing problems in evolutionary biology.

Technical Session II (Wednesday, October 14, 2015, 8:00 AM)

PALEONTOLOGICAL, EMBRYOLOGICAL, AND MOLECULAR INSIGHT INTO THE DEVELOPMENTAL BASIS OF THE DISTINCTIVE MAXILLARY REDUCTION OF BIRDS (REPTILIA, AVES) AND EXPERIMENTAL RESTORATION OF A LARGE MAXILLARY REGION IN CHICKENS

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Recent work on the ontogeny and embryogenesis of the archosaur skull has revealed that the distinctively modified cranium of birds is the product of a combination of evolutionary and developmental influences. In its overall shape, it is foremost paedomorphic or miniaturized, but the rostral region is further transformed in several ways that differ from this generally juvenilized substrate. The premaxillary region is fused and greatly elongated, and the molecular mechanism behind this fusion and shape change has been the subject of some investigation. However, another striking characteristic of the avian skull is the enormous reduction of the maxillary bone and the maxillary region in general. For much of early embryonic life, this region develops separately, as the neural-crest-filled maxillary prominence, from the frontonasal structures that will become the premaxilla and other midline upper-jaw elements; and the developmental pathways active therein are also distinctive.

We undertook to investigate the nature of the reduced avian maxilla using alligators as a close archosaurian outgroup, and with reference to the fossil record and the development of other amniotes. Our paleontological results revealed a gradual diminution of the maxilla along the avian stem, with some acceleration very near to modern birds. Moreover, CT scans of embryos revealed that this reduction is associated with a truncation of the ancestral anterior maxillary ossification zone during late skeletal development. We posited that this truncation had an earlier cause and found that the maxillary prominences themselves are truncated in both neognath and paleognath birds, and that the expression of proliferative factors is also comparatively curtailed. To test the explanatory power of this correlative observation, we used small-molecule agonists to experimentally upregulate proliferative factors in the maxillary prominences of chickens and were able to generate a more ancestrally proportioned (according to geometric analysis) enlarged maxillary region on the affected side.

Technical Session I (Wednesday, October 14, 2015, 11:45 AM)

INSIGHTS ON LATE MIOCENE CLIMATE CHANGE AND REGIONAL UPLIFT IN MARAGHEH BASIN, EASTERN AZERBAIJAN PROVINCE, NORTHWEST IRAN REVEALED BY STABLE CARBON AND OXYGEN ISOTOPE ANALYSES OF FOSSIL HORSE TOOTH ENAMEL

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Stable isotope proxies were used to examine climate variability, including development of C_4 vegetation-based ecosystems, in northwest Iran during the Late Miocene. The approach was to use carbon and oxygen isotopic compositions of 15 bulk (whole tooth) and 211 serial tooth enamel samples from three species of horses (*Hipparion gettyi*, *H. matthewi*, and *H. campbelli*) from the Maragheh Basin, Azerbaijan Province, ranging in age from ~9 to <7.6 Ma. These paleoclimatic and paleoecological records provide insights on the effects of regional uplift on climate variation and the evolution of mammalian species. The Maragheh Basin is currently an arid steppe ecosystem and regional uplift has occurred throughout this region since the Early Neogene. Prior studies indicate that the Maragheh Basin was a woodland/grassland ecosystem throughout the Miocene. The serial carbon isotopic results suggest that C_4 grasses first appeared in the eastern Azerbaijan Province after ~8.9 Ma and disappeared from local ecosystems by ~8.2 Ma. These data support a shift to a cooler climate and tectonic uplift in the region after ~8.2 Ma. The bulk isotope data suggest a complex climatic history in the Maragheh Basin. There was a positive correlation between bulk $\delta^{13}C$ and $\delta^{18}O$ values prior to ~8.2 Ma. One explanation is that the climate may have become cooler and/or wetter, as indicated by shifts to relatively negative $\delta^{18}O$ values, meaning that grazed plants became less water-stressed, resulting in a contemporary negative shift in $\delta^{13}C$ values. Conversely, as $\delta^{18}O$ shifted to more positive values, indicating a change to a warmer/drier climate, plants became more water-stressed, thus resulting in increased $\delta^{13}C$ values. However, after ~8.2 Ma, bulk $\delta^{13}C$ and $\delta^{18}O$ values are negatively correlated. This suggests that the regional climate became cooler and drier after ~8.2 Ma; i.e., as the climate cooled (shifted to more negative $\delta^{18}O$ values), plants became water-stressed, as indicated by positive shifts in $\delta^{13}C$ values. An overall negative shift in bulk $\delta^{18}O$ values is also consistent with regional uplift. In addition, seasonality (based on serial $\delta^{18}O$ values) and average temperature (based on bulk $\delta^{18}O$ values) are negatively correlated from ~9 to <7.6 Ma, suggesting that as the climate became cooler and/or wetter, the regional climate became more variable. This may be a result of lowering atmospheric pressure as the region was uplifted, causing more variation in weather.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

COMPARISON OF UNGULATE AND SCIURID PALEOECOLOGY SUGGESTS SPATIAL AVERAGING IN OREGON LOCALITIES

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Relationships between mammal species and their preferred habitats are often used to reconstruct past ecology in fossil ecosystems. Ungulate herbivores, with dental morphology indicative of food preferences, are the most common terrestrial mammal group used in habitat reconstruction, but small mammals (which sample over a narrower geographic range) may offer a more sensitive and precise proxy. Modern fossorial sciurids favor open environments that facilitate burrowing (although a few taxa may tolerate intermediate habitats) while arboreal and gliding sciurids favor closed habitats. Terrestrial sciurids may occupy intermediate or closed areas. If large and small mammals are consistent in paleoecological signal, small mammals would provide alternate habitat indicators, facilitating habitat reconstruction in a greater variety of fossil ecosystems.

We hypothesized that sciurid taxa with open-habitat ecologies would be found in assemblages dominated by grazing ungulates rather than browsing or mixed-feeding ungulates. Similarly, assemblages containing sciurid taxa with closed-habitat ecologies would be dominated by browsing ungulates. An occurrence-based dataset of Oregon localities ranging in age from the Barstovian to the Holocene was compiled using the MioMap database. Ecological data was gathered from the literature and the Fossilworks Paleobiology database.

Preliminary results show that open-habitat sciurids frequently co-occur with browsing ungulates. Several localities support closed-habitat sciurids and grazing ungulates. This result indicates that these localities may be spatially averaged. It is possible for a locality's habitat to change over the period of fossil deposition and is likely given the patchiness of Miocene habitats. If this is the case, small mammals like sciurids may not provide a more sensitive and precise habitat indicator. Alternatively, the ecology of a taxon may be incorrectly reported and thus confounding our results, as many of the sciurid and ungulate taxa used in this study have not undergone dental microwear analysis. Analyzing occurrences in the context of a stratigraphically controlled framework or in comparison to paleosol type may shed light on this question.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

FIRST IDENTIFICATION AND DESCRIPTION OF THE GREAT PLAINS GIANT TORTOISE *HESPEROTESTUDO* CF. *H. ORTHOPYGIA* FROM THE EARLY PLIOCENE (HEMPHILLIAN) MEHRTEN FORMATION OF STANISLAUS COUNTY, CALIFORNIA

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Hesperotestudo is a genus of giant tortoise that existed from the Miocene to the Pleistocene of North and Central America and Bermuda. Literature for it in the United States is plentiful. However, in California this is limited to faunal lists, with no detailed descriptions. Here, we describe *Hesperotestudo* material from the upper Mehrten Formation (early Pliocene: Hemphillian) found at Modesto and Turlock Reservoirs 32 km east of Modesto in the northern San Joaquin Valley, California. Based on the University of California Museum of Paleontology collections, the Mehrten sites have the highest number and highest quality of *Hesperotestudo* specimens of all California sites. Additionally, most California sites are located outside the San Joaquin Valley. Only two localities approach the Mehrten's large quantity and only one locality is equal in quality. From the Mehrten sites there are 54 specimens total including 12 identifiable elements of plastron and 15 identifiable elements of carapace. This includes a mostly complete anterior plastron 436 mm wide, two pairs of left and right hypoplastra approximately 383 mm and 289 mm wide, and a crushed carapace and plastron from a juvenile 105 mm long and 93 mm wide. The largest Mehrten specimen, a peripheral, came from an animal with a carapace estimated to be over 120 cm long, similar in size to a Galapagos tortoise. Identification of the Mehrten specimens is based on comparison to the only two known California tortoise genera: *Hesperotestudo* and *Gopherus*. The Mehrten specimens are much larger than modern *Gopherus*, with a thicker shell (7 mm at their thinnest compared to 3 mm in *Gopherus)*, and more rounded free margin of the carapace. The pectoral scale is dramatically narrowed to 11.8 mm on the midline. This narrowing is a trait characteristic of *Hesperotestudo* while in *Gopherus* it is wider. In addition, the pygal is taller than wide in the referred Mehrten specimens (70 by 53.9 mm respectively) and *Hesperotestudo* while in *Gopherus* it is wider than tall. We place all Mehrten specimens in *Hesperotestudo* cf. *H. orthopygia,* a species best known from the Great Plains region, based on two lines of evidence: similarities of measurements of the entoplastron and pectoral scale to other *Hesperotestudo* specimens, and similarity in age (~5 Ma). Large non-burrowing tortoises are not very tolerant of frost conditions, indicating a relatively frost free climate in the early Pliocene of the northern San Joaquin Valley. This agrees well with the paleobotanical evidence from the Mehrten, in particular records of *Persea*, an avocado relative.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

MEASURES OF RELATIVE DENTARY STRENGTH IN RANCHO LABREA *SMILODON FATALIS* OVER TIME

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The Late Pleistocene megafaunal extinction of approximately 12,000 BP, included the demise of *Smilodon fatalis,* a hypercarnivore from the Rancho LaBrea deposits, which has been studied across time by looking at different deposits or pits to determine morphological size and shape changes and trends during this time. To better understand functional aspects of these changes, this study focused on a measure of jaw strength over time, which can give an indication of morphological changes within the jaw that cannot be seen using morphometrics. By radiographing dentaries, cortical bone (which is visibly opaque) provides bone strength in resisting bending forces while biting, and can be measured and used as an estimate of jaw strength with the jaw modeled as a hollow ellipse. Measurements were taken at repeatable locations within the dentary of the entire depth of the dentary, of the cortical bone, and of a standardized measure of cortical bone, which allows for the comparison between different individuals. Specimens included those of 4 different pits ranging from about 37 Ka to 13 Ka (just before the extinction event). No significant difference was found in the depth of jaws at any of the measurement points from any of the pits. However, significant differences were found in both the actual thickness of cortical bone, and the standardized thickness of cortical bone at the lower P4 between pit 13 (which had the lowest amount of bone) and pit 61/67 which had the highest. This gives support to other studies that have shown that individuals at pit 13 were under physiological and perhaps dietary stress, which may be reflected in their lower deposition of cortical bone. The opposite trend is seen in the individuals in pit 61/67, the most recent pit, which have been shown to be larger with more robust mandibles and gape. These further support findings that suggest that *Smilodon* did not appear to be morphologically most vulnerable right before its extinction.

Poster Symposia (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

VISUALIZING THE OLFACTORY IMPRINT WITHIN MAMMAL SKULLS: 3D IMAGING AND THE CRYPTIC CRIBRIFORM PLATE

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Deep in a mammal's skull lies a perforated cup of bone that separates the nasal chamber from the olfactory bulb. This cryptic feature is the cribriform plate (CP). Its myriad foramina usher the axons of olfactory sensory neurons on their path from the nasal turbinal bones to the brain. Because the CP is the sole crossing point for olfactory axon bundles in the neurocranium, the total area of CP foramina might be used as a proxy for relative olfactory innervation in a particular animal. Cribriform plate foramina area and overall CP size vary markedly across mammal species from disparate ecologies and likely reflect aspects of olfactory capacity. Until recently there was no method to quantify the cross-sectional area of CP foramina, but now with high-resolution CT scans and 3D imaging software we have designed novel digital methods to measure these minute features in dry skulls. By applying splines of coordinate points along the perimeter of CP foramina in virtual 3D skull models in Mimics 17.0 and then calculating the non-planar area of all splines in Rhinoceros 4.0, we are able to quantify the imprint that olfactory nerves have left in the bone. Additionally, where we once had to rely on direct linear measurements from actual skulls to approximate CP size, we have now developed a method to digitally calculate surface area. First, we fill in the CP foramina with virtual bone in 3D models then calculate the remaining generalized surface area in 3-Matics. These methods have allowed us to conduct wide comparative studies of the cribriform plate morphology in living mammals in the context of ecology, behavior and olfactory genomics. A promising dimension of this work will involve applying these imaging techniques to analyzing CP morphology in fossils. Because of its cryptic location in the nasal chamber, the cribriform plate is a fairly well-preserved feature of olfactory anatomy in fossil skulls. Now, with the help of novel, non-destructive digital methods, quantifying CP morphology may offer a first insight into the olfactory ecology of extinct mammals.

Grant Information

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Technical Session XVIII (Saturday, October 17, 2015, 2:15 PM)

COMMUNITY STRUCTURE OF NORTH AMERICAN MAMMALS DURING THE PALEOCENE AND EOCENE

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One of the larger turnovers in mammalian history occurred during the transition from the archaic communities of the Paleocene to the modern communities of the Eocene. The arrival of modern immigrants during the late Paleocene and early Eocene was followed by a decline in the abundance and diversity of archaic mammals. Both climate and/or competition with modern mammals have been proposed as potential causes behind the decline and eventual extinction of archaic mammals. Although the taxonomic turnover and the global climatic context are well known, the effects of the changing climate and faunal turnover on the ecological structure of North American mammalian communities is less well understood. We characterized community structure within 1 million year intervals as the distribution of body masses among species. We estimated body mass of 1220 species using lower first molar areas collected from the literature and our own measurements of museum specimens. Using a model-fitting approach, we separately identified six periods of stasis in community structure, community composition and global temperature as consecutive intervals with statistically homogeneous distributions of body mass, taxonomic composition, and oxygen isotopic data, respectively. We found that an initial change in community structure (occurring at 63 Ma) correlated with a change in taxonomic composition. Other shifts in community structure are coincident with changes in global temperature, suggesting climate played a role in the restructuring of communities. We confirmed the placement of community structure shifts by testing whether or not the body mass distribution of newly originating species significantly differed from the distribution of the previous interval. We also show multiple significant changes in community structure coincide with the arrival of modern mammals suggesting a gradual change in community structure. Non-metric multidimensional scaling showed that the communities were stable for most of the Paleocene while the communities of the Eocene showed progressive gradual change.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

PLASTERED: AN EXAMINATION OF UNORTHODOX JACKETING MATERIALS

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Specimen jackets are created with burlap, water, and plaster. During remote field work, however, these ingredients can occasionally be in short supply or absent and decisions need to be made on the viability of removing specimens. Several creative materials have been proposed and executed to supplement any missing supplies keeping with best practice methods. Various cloths; such as cotton/polyester t-shirts, denim jeans, and cotton socks are typically found in abundance in most field camps, but these materials are not suitable replacements for durable, easy-to-use burlap. Liquids, such as sports drinks or beer are familiar in many field packs or coolers; however, when substituted do not form reliable bonds with the plaster. If plaster is in short supply or unavailable, paper towels soaked in consolidant and mud that is impregnated with consolidant can be a safe substitute for a plaster specimen jacket in limited uses. Duct tape does not provide enough support and protection to safely transport specimens back to the lab and is not a viable solution. Since specimen jackets often reach large sizes, a jacket many require support braces made of tree branches, wooden 2 x 4s, or fence posts, although other materials can be used for a support brace when those supplies are not available. This study tests and examines past applications of various 'quick fix' solutions, and demonstrates the viability of each material in the creation of plaster specimen jackets to determine which solutions are safe for the fossils during transport, versus when it is better to leave the specimen in the field and return with proper supplies.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

FUNCTIONAL AND GEOMETRIC MORPHOMETRIC ANALYSIS OF A MIDDLE MIOCENE BANDICOOT (MARSUPIALIA, PERAMELEMORPHIA) SKELETON FROM THE RIVERSLEIGH WORLD HERITAGE AREA, AUSTRALIA

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The marsupial Order Peramelemorphia comprises four families: the extant Peramelidae (bandicoots), Peroryctidae (forest bandicoots of New Guinea), and Thylacomyidae (bilbies); and the extinct Yaralidae; with several fossil species of uncertain familial affinity designated as Peramelemorphia incertae sedis. Extant taxa (approximately 20 species) are characteristically omnivorous, small to medium sized (0.1–2.5 kg) semi-fossorial/fossorial marsupials with a quadrupedal bounding gait. They occupy a range of habitats in Australia and New Guinea from desert to rainforest. Twelve pre-Pliocene taxa are currently described on the basis of cranial and/or dental material, yet none is known from its postcranial skeleton.

In this study we use qualitative morphological and 2D geometric morphometric data to analyze a partial skeleton of a new species of bandicoot from a middle Miocene paleokarst deposit, AL90 Site, in the Riversleigh World Heritage Area, northwestern Queensland. This deposit has been U-Pb radiometrically dated at 14.7–15.1 Ma. The specimen preserves the skull, left and right dentaries, the fore-and hindlimbs, and elements of the manus, pes and axial skeleton. Cranio-dental morphology indicates the species lies outside crown-group Peramelemorphia. The estimated body weight of the new species based on predictive marsupial cranio-dental regression equations is approximately 250 grams. Dental morphology, particularly the absence of a well-developed metaconule on the upper molars, indicates a more insectivorous diet than extant bandicoots, more comparable to smaller modern dasyurids. Qualitative and metric analyses of the appendicular skeleton indicate a less-specialized postcranium than modern bandicoots, which possess numerous musculoskeletal adaptations for scratch-digging and /or fossorial behaviors. Most notable is the relatively gracile bones of the antebrachium of the fossil taxon which is in striking contrast to the short, robust forearm of many modern bandicoots. Collectively, these data indicate a more generalized niche for this species than crown group peramelemorphians and may support suggestions that archaic bandicoots filled an ecological niche later dominated by small dasyurids during the late Cenozoic.

Grant Information

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Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

NEW DATA FOR THE PALAEOBIOGEOGRAPHICAL HISTORY OF THE GENUS *PELOBATES* (AMPHIBIA, ANURA) IN ITALY

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Spadefoot toads (Pelobatidae, Anura) are quite rare in the Italian fossil record, being recorded only in the Late Pliocene of Arondelli (Piedmont Region, north-western Italy) and in the Early Pleistocene of Pirro 21 (Apulia, south-eastern Italy). Here we describe for the first time the abundant fossil remains from the Early Pleistocene fissure of Pirro 13 (Apulia, southern Italy) attributed to *Pelobates syriacus*, a toad currently living in the southeast of the Balkan Peninsula, Caucasus and Middle East. It is the first time that this species is reported in the Italian fossil record. In spite of this only fossil occurrence, *P. syriacus* is shown to have good dispersal abilities for toads, and dispersal routes to reach the Apennine Peninsula may have been favored by a lower level of the Adriatic Sea, furnishing new habitats suitable for spadefoot toads. Our finding is confirmation that the range of this species was broader in the past than at present. Noteworthy is that according to niche modeling, the potential ecological niche for *P. syriacus* is extended outside its known range, westwards in the Mediterranean (e.g., the Italian Peninsula) and northwards in the Pannonian Basin and north of the Black Sea and of the Caucasus in a similar way during glacial and interglacial periods.

Grant Information

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Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

COMPARATIVE ALLOMETRY OF FEMORAL CURVATURE IN GORGONOPSIAN VERSUS THEROCEPHALIAN THERAPSIDS

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The limb bones of many tetrapods exhibit curvature along the diaphyseal long axis. This curvature can have consequences for the ability of these bones to bear loads. Because the greatest bending stress on limb bones is typically derived from forces acting transverse to the shaft, large tetrapods often walk with straighter, more upright legs to reduce bending by redirecting transverse forces up the long axis of the bone. However, if limb bones are curved, forces transferred up the long axis will act at a distance from the shaft centroid, imposing a bending moment arm due to curvature that can elevate bending stress. We previously evaluated how this curvature-induced moment arm changes with increasing body size in the femora of gorgonopsian therapsids, a lineage in which the femur often exhibits a distinctive, sigmoidal (S-shaped) curvature perpendicular to the plane of knee flexion/extension. We found a pattern of negative allometry, such that larger specimens typically had less curved (i.e., straighter) femora, potentially helping to reduce bending stress if more upright posture were used at larger size. How common is this morphological stress-reducing mechanism among other therapsids? In this study, we evaluated femoral curvature for a wide size range of specimens classified as therocephalians, representing taxa more closely related to mammals. As in our analysis of gorgonopsians, we measured the femoral moment arm due to curvature as the distance between the line of action of forces acting along the long axis of the bone (from one articular surface to the other), and the midpoint along the diameter of the bone at its midshaft. In contrast to gorgonopsians, this moment arm showed positive allometry relative to femoral length in therocephalians; in other words, large specimens showed relatively greater femoral curvature. Even if some of the smaller therocephalian specimens in our sample represent juveniles that did not have sufficient time for characteristic curvature to develop, the curvature-induced moment arm commonly exceeds 10% of femoral length in larger therocephalians, but approaches only 5% of femoral length in larger gorgonopsians. Although some of the largest, basal therocephalian taxa may show femoral straightening similar to large gorgonopsians, it appears that reduction of bone curvature is not a uniform mechanism for reducing locomotor stresses across therapsids, and that the use of upright limb posture may have required many therocephalians to accommodate increased bending from axial forces.

Grant Information

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Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

POSTCRANIAL MORPHOLOGY OF EARLY EOCENE *CHOCTAWIUS* GIVES NEW INSIGHT ON THE RELATIONSHIP OF MICROSYOPIDS TO OTHER EUARCHONTANS

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Evidence for understanding relationships of microsyopids to other euarchontan mammals (primates, treeshrews, and colugos), has been limited to craniodental data with postcranial bones not previously recognized even from localities where teeth are relatively common. Screen washing efforts at the late Wasatchian (Wa5; ~52 Ma) UCMP locality V70246 in the early Eocene Main Body of the Wasatch Formation near Bitter Creek station, Washakie Basin, south-central Wyoming, have yielded many dental and postcranial specimens of euarchontans including omomyids (*Arapahovius*, *Anemorhysis*), an adapid (*Cantius*), a paromomyid (*Phenacolemur*) and microsyopids including *Microsyops* and a small bodied uintasoricine here recognized as a new species of *Choctawius* previously know only from the early Eocene of Mississippi and New Mexico. Dental specimens of *Choctawius* n. sp. (n = 150) are the most common of the euarchontans, including the first lower dentitions for the genus showing that it had an enlarged procumbent incisor, a dental formula of 1:1:3:3 similar to that of *Niptomomys*, relative proportions of i1, p3, and p4 distinct from *Niptomomys*, and upper molars with a less developed anterior cingulum than other species of *Choctawius*. Isolated tarsal bones referable to *Choctawius* n. sp. include astragali (n = 5), calcanei (n = 5), and a cuboid (n = 1) based on size, abundance, and diagnostic similarities to dentally associated tarsals of euarchontans including astragali with an extension of the trochlea onto the neck and confluent sustentacular and navicular facets, and calcanei with an anteroposteriorly aligned ectal facet, a distally extended sustentacular facet onto the body, a round and concave cuboid facet, and the absence of a fibular facet. *Choctawius* is unique among Paleogene euarchontans in having an astragalar trochlea that extends as far distally as the dorsolateral margin of the navicular facet and an extremely large peroneal tubercle on the calcaneus. Although these tarsals differ from those of extant dermopterans in some ways (e.g., a less round astragalar head), they are similar in having an astragalus with an anteroposteriorly long flexor fibularis groove, a calcaneus with a deep excavation of the calcaneocuboid facet on the plantar side, and a corresponding proximal process on the cuboid. *Choctawius* had a very mobile ankle typical for euarchontan mammals and a deep cuboid pivot to strongly stabilize the calcaneocuboid joint as in colugos, suggesting that microsyopids might share a closer relationship to Dermoptera than previously appreciated.

Grant Information
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Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

DETERMINING THE DRIVER BEHIND LARGE-SCALE ECOLOGICAL PATTERNS IN THE LATEST EOCENE–EARLIEST OLIGOCENE WHITE RIVER GROUP (USA): CLIMATE VERSUS GEOMORPHOLOGY

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Abundant evidence indicating significant late Eocene to early Oligocene cooling exists at many high and mid-latitude localities, but the presence and influence of such climate change on the iconic White River Group/Formation (WRG) of the Great Plains of North America is unclear. Faunal dynamics through the interval are variable, with reptiles showing significant ecological responses, whereas mammals appear minimally influenced. To date, the E–O cooling has most frequently been invoked to explain changes in WRG age environments and ecosystems, but the same faunal responses could also be caused by the progradation of a Distributive Fluvial System (DFS)-a likely model for WRG deposition. DFS progradation would predict a diachronous drying-upward trend (with associated faunal response), occurring earlier nearer to the apex of the system, whereas global climate change would produce synchronous cooling and drying across the WRG outcrop area.

To test these hypotheses we studied multiple aspects of the sedimentology and vertebrate faunas of the WRG in WY, NE, and SD in a new high-resolution stratigraphic framework, including: (1) measurements of stable isotope ratios from tooth enamel and evaluation of enamel use wear to characterize mammalian diets and address change in the water stress and vegetation of local environments; (2) diversity and abundance distributions to address changes in community structure relative to changes in environmental water stress; (3) species occurrence to address turnover; and (4) channel type, paleocurrent direction and sand:mud ratios to assess fit with the DFS model. Ecological and environmental data from the studied outcrops are most consistent with the DFS progradation as the primary driver, showing diachronous change occurring later to the east. Our multi-faceted approach has allowed us to better characterize this interval of change in the North American midcontinent, and suggests the need for more detailed examination of other terrestrial sequences for similar geomorphologically driven environment changes.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

SUBFOSSIL LIZARDS FROM THE GUADELOUPE ISLANDS: 30 000 YEARS OF SPECIES TURNOVER IN A LESSER ANTILLEAN ARCHIPELAGO

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A consensus now exists concerning the existence of a current mass extinction crisis affecting all organisms due to human impact on the biosphere. However, quantifying the effect of such a crisis on terrestrial vertebrates can sometimes be problematic in the case of extinctions that had occurred before the taxa were known and described by scientists. Such phenomena are frequent on islands because of the vulnerability of their endemic biotas that are often quickly eliminated by human habitat destruction and the introduction of exogenous competitors and predators. The only solution to obtain information about these extinct faunas is therefore to search for subfossil deposits containing osteological material, the last remaining evidence of their past occurrence.

My study focused on the subfossil lizards from the Guadeloupe archipelago. This archipelago is composed of six main islands from which I studied 30 sub-fossil deposits containing non-ophidian squamate remains. These deposits were both pre-Columbian human accumulations of consumed lizards and cave deposits mainly created by accumulation of regurgitated prey made by raptors, dated from Late Pleistocene (30 000 B.P.) until present. The goal of this work was to analyze the evolution of lizard species over time on these islands and investigate the impact of pre-Columbian (between 3000 BC and 1492 AD) and later European populations on the turnover of lizard assemblages.

Using a broad range of methodological tools (CT-scan, comparative anatomy, histology, morphometrics and geometric-morphometrics) my results provide a first description or new data concerning the members of three genera nowadays extinct on these islands (*Ameiva*, *Diploglossus*, *Leiocephalus*), new information about past occurrence and morphological changes through time of four other still-extant genera (*Anolis*, *Iguana*, *Mabuya* and *Sphaerodactylus*). My results also suggest or confirm that other taxa have only been recently introduced (*Iguana*, *Hemidactylus* and *Thecadactylus*). These data highlight the strong impact of modern human populations on these faunal turnovers. Indeed, they show that at least half of the native Guadeloupian lizards went extinct after the arrival of European populations, during the last centuries.

Technical Session IV (Wednesday, October 14, 2015, 3:00 PM)

NEW FOSSILS FROM NEW ZEALAND REVEAL THE AFFINITIES OF "*MAUICETUS*" *LOPHOCEPHALUS* AND SKELETAL PLAN OF EOMYSTICETIDAE: OLIGOCENE BALEEN-BEARING TOOTHED MYSTICETES (MAMMALIA: CETACEA)

BOESSENECKER, Robert W., University of Otago, Dunedin, New Zealand; FORDYCE, R E., University of Otago, Dunedin, New Zealand

The early evolution of toothless baleen whales (Chaeomysticeti) remains elusive despite a substantial record of Eocene–Oligocene archaeocetes and toothed mysticetes. Eomysticetids, a group of archaic longirostrine and putatively toothless baleen whales, fill in a crucial morphological gap between well-known toothed mysticetes (Aetiocetidae, Mammalodontidae) and more crownward Neogene toothless Mysticeti. A historically important but perplexing cetacean is "*Mauicetus*" *lophocephalus* (upper Oligocene Kokoamu Greensand, South Island, New Zealand; Duntroonian, 27.3–25.2 Ma). The discovery of new skulls and skeletons of eomysticetids from the Kokoamu Greensand and overlying Otekaike Limestone permit modern reinterpretation of "*Mauicetus*" *lophocephalus*. A new genus and species is represented by a partial skeleton (OU 22235; est. 6–7 m body length) including a nearly complete skull (1.9 m condylobasal length) with mandibles, tympanoperiotics, and cervical and thoracic vertebrae, ribs, sternum, and forelimbs from the Otekaike Limestone (Duntroonian), representing one of the most complete skeletons of a stem Mysticete yet discovered. "*Mauicetus*" *lophocephalus* is relatively similar and referable to this new genus. A new skeleton (OU 22081; Otekaike Limestone, Duntroonian) tentatively referred to "*Mauicetus*" *lophocephalus* includes a partial skull, mandibles, tympanoperiotics, and postcrania. This referred specimen surprisingly preserves an isolated partial tooth with a unique labiolingually flattened root, matching the flattened maxillary alveolar morphology of other Eomysticetidae (*Yamatocetus*, and new genus OU 22044). Phylogenetic analysis supports inclusion of these species within the Eomysticetidae alongside *Eomysticetus*, *Micromysticetus*, *Yamatocetus*, and *Tohoraata*, strongly supporting monophyly of Eomysticetidae and placement of the clade as sister to crown Mysticeti. This new eomysticetid possessed both baleen and possibly non-functional peg-like teeth, incipient rostral kinesis, a delicate archaeocete-like posterior mandible and synovial craniomandibular joint, suggesting it was capable of at most, limited lunge feeding in contrast to extant Balaenopteridae, and utilized an alternative as-yet unspecified feeding strategy. The dentition of Eomysticetidae, though likely vestigial, reflects the last known occurrence of adult teeth in baleen whales.

Grant Information
University of Otago Doctoral Scholarship; National Geographic Society

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

TAPHONOMY OF A K/PG MARINE BONEBED, MANTUA TOWNSHIP, NEW JERSEY

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The Main Fossiliferous Layer (MFL) of the Hornerstown Formation is a concentrated layer of marine K/Pg fossils preserved in heavily bioturbated glauconitic sediment. The origin of this assemblage has been hypothesized to be: (1) a reworked deposit; (2) a time-averaged deposit; or (3) a mass-death assemblage. Since 2012, we have excavated and collected all fossils from a 150 m^2 grid of the MFL, including sharks, fish, turtles, crocodilians, birds, and mosasaurs. Coprolites and plant material are also recovered. Several preservational trends are apparent. Most specimens are found as isolated skeletal elements or as an association of a few bones. However, articulated partial skeletons are also regularly found. Individual bones range in length from < 1 cm to ~31 cm, though a majority of fossils are less than 3 cm in length. A majority of the smaller skeletal elements are teeth, vertebral centra, fin spines, and bone fragments. Turtles are the most commonly occurring marine reptiles. Carapace and plastron plates are the most often preserved elements followed by upper limb bones, scapulae, and dentaries. Crocodiles are most frequently represented by vertebrae, upper limb bones, and skull/jaw elements. Cartilaginous and bony fish fossils include teeth, jaws, centra, and fin spines.

Bioerosion is common, being found on > 29% of skeletal elements. Most specimens exhibit minimal to no abrasion indicating a quiet depositional environment, minimal transport along the sediment surface, and/or minimal reworking. However, carcasses may have floated for a considerable distance before being deposited at this location as evidenced by the presence of terrestrial flora and fauna. Fossil breaks are typically transverse or oblique and likely occurred after fossilization due to post-burial compaction.

We hypothesize that many vertebrates went through a "bloat and float" stage during which scavenging and prolonged decay led to disarticulation of skeletal segments from the rest of the carcass. These bones, and eventually the carcass, sank to the sea floor where they were scavenged and/or colonized by a variety of organisms. Once deposited, these specimens appear to have experienced little to no transportation in traction or saltation. When combined with previous research, our taphonomic data adequately falsifies the reworking hypothesis. Of the remaining hypotheses, the prevalence of associated and articulated skeletons favors a mass death event over attritional accumulation. Ongoing taphonomic and sedimentological research may help validate this inference.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

INTRASPECIFIC VARIATION IN CRANIAL AND MANDIBULAR MORPHOLOGY OF THE EXTINCT RIVER DOLPHIN *PARAPONTOPORIA STERNBERGI* FROM THE UPPER PLIOCENE SAN DIEGO FORMATION, SOUTHERN CALIFORNIA, USA

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Parapontoporia sternbergi is an extinct species of river dolphin. It has been distinguished from two closely related extinct species, *Parapontoporia pacifica* and *Parapontoporia wilsoni*. The differences distinguishing these taxa served as a basis for the establishment of *P. sternbergi* as a separate species. This study tests the validity of recognizing *P. sternbergi* as a distinct species based on examination of intraspecific variation in the cranial and mandibular morphology of fossil specimens.

This study utilized specimens from collections at the San Diego Natural History Museum and the Natural History Museum of Los Angeles County. Specimens included three complete skulls of *P. sternbergi* and 13 complete skulls of the closely related river dolphin, *Pontoporia blainvillei*. The skull characters that define *P. sternbergi* as a species were identified as regions of focus. Variations of these characters are quantified by the following 15 skull measurements: left and right zygomatic process length, neurocranium width and length, left and right temporal fossa width, left and right temporal fossa height, left and right orbital length, width of rostrum at base, rostrum length, zygomatic width, width of rostrum at midpoint, and total length. Measurements were taken on each of the 16 specimens.

For each of the skull measurements, mean measurements were calculated for *P. sternbergi* (n=3) and *P. blainvillei* (n=13). Separate t-tests were conducted (1 for each skull measurement), testing for a significant difference between the *P. sternbergi* and *P. blainvillei* means. Each *P. sternbergi* mean measurement was tested against the corresponding mean measurement on *P. blainvillei*. The 2-sample t-tests revealed that nine of the 15 skull measurements resulted in p-values less than 0.05. This indicates that more than half of the skull characters of *P. sternbergi* are significantly different from those of *P. blainvillei*, suggesting that there are significant morphological differences in both river dolphins, supporting their recognition as separate species.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

POSTCRANIAL ANATOMY AND PHYLOGENETIC AFFINITIES OF *TANIUS SINENSIS* (ORNITHOPODA; HADROSAUROIDEA) FROM THE LATE CRETACEOUS OF CHINA

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Tanius sinensis, one of the first non-avian dinosaurs named from Asia, is known from a very complete associated skeleton preserving the caudal cranial bones, numerous vertebrae, major portions of the girdles, and exemplars of all major fore- and hind limb bones. The holotype is from the Jiangjunding Formation in China, considered to be Late Cretaceous in age. In spite of its late temporal context, current phylogenetic studies place *T. sinensis* as one of the few non-hadrosaurid hadrosauroids to survive into the latest Cretaceous, along with *Bactrosaurus johnsoni* and *Gilmoreosaurus mongoliensis* (Iren Dabasu Formation, China), at a time when none are recognized from North America. However, this assertion depends on resolving its phylogenetic affinities that rely on a better understanding of its anatomy, which has not been the subject of a thorough re-examination since 1929. Furthermore, the presence of a remodeled fibro-lamellar primary cortex and absence of an external fundamental system suggest a likely immature state for the holotype. Here we focus on the postcranial anatomy of *T. sinensis* and review its phylogenetic systematics.

Overall, the postcranial anatomy of *T. sinensis* is typical for hadrosauroids: strongly opisthocoelous cervical vertebrae, moderately developed deltopectoral crest (almost half of the humeral length), well-developed supra-acetabular process, arcuate fourth trochanter, completely enclosed femoral extensor tunnel, well-developed cnemial crest, and hoof-shaped pedal unguals. Of particular note is the caudal fusion of the medial and lateral femoral condyles forming a secondary tunnel, like the extensor tunnel. Such a condition is not seen in other hadrosauroids and may be autapomorphic.

Revisions of phylogenetic characters indicate unrecognized derived morphologies in the postcranial skeleton of *T. sinensis* shared with hadrosaurids: long dorsal vertebral spines and almost parallel dorsal and ventral margins of the scapular blade. Given these and other modifications to the matrix, *T. sinensis* shows a complex of characteristics that are both derived and primitive. This generates considerable character conflict resulting in a large polytomy with *Bactrosaurus*, *Claosaurus*, *Gilmoreosaurus*, *Jintasaurus*, *Levnesovia*, *Nanningosaurus*, *Probactrosaurus*, *Shuangmiaosaurus*, *Tanius*, and hadrosaurids (including *Telmatosaurus*). Despite this uncertainty, our results serve to emphasize the need for a better understanding of variation among non-hadrosaurid hadrosauroids, in particular ontogenetic variation.

Technical Session I (Wednesday, October 14, 2015, 9:15 AM)

THE EFFECTS OF SUBSTRATE, BODY POSITION, AND PLASTICITY ON THE MORPHOLOGY OF RUMINANT UNGUALS

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Ungual morphology is closely linked to substrate because of its proximate functional role in locomotion. However, ungual morphology may also be affected by weight distribution, biomechanical interactions, and plastic response to substrate conditions. To improve our understanding of ungual ecomorphology, we analyzed the relationship of morphology and these factors. This study quantifies the effects of substrate on ungual shape variation at the scale of the individual, the population, and the species across extant members of the suborder Ruminantia. Ruminants, which have reduced the number of digits to two, have eight weight-bearing toes. Each toe potentially supports a different proportion of total body mass and has different biomechanical interactions with substrate. Our first aim is to quantify morphological differences within an individual and to assess patterns related to substrate. Skeletal elements not only have a genetic component to their morphology, but they also plastically remodel in response to environmental forces. This remodeling may enhance the form-substrate relationship, but may also bias morphological studies that use zoo animals because captive animals traverse harder, man-made substrates. Our second aim is to analyze the degree of ungual shape difference between wild and captive ruminants. Three homologous landmarks and 100 semilandmarks were placed around the ungular plantar surface and subjected to 2D geometric morphometric methods in twenty-five species from dry, wet, ecotone (i.e., variable), and mountainous substrates. Shape differences were assessed using standard errors and randomization tests. Within-individual results show that taxa from wet or ecotone tend to have the highest variation between digits. Ungual shape is statistically different ($p = 0.009$) between captive and wild individuals; the trend in captive unguals is to be broader, have increased overall curvature, and increased anterior rounding. In addition, the most variation is seen in species that naturally frequent variable terrain. Taken together, these analyses show that the relationship between ungual morphology and substrate is more complex than thought. Species living on wet/ecotone substrates tend to have variable within-individual ungual morphology, which may be due to requirements of weight distribution and support during locomotion over unstable terrain. However, raising these species on uniform substrates can cause them to plastically adapt to simplified terrain, further affecting ungual shape variation.

Romer Prize Session (Thursday, October 15, 2015, 8:30 AM)

THE PHYLOGENETIC RELATIONSHIPS AND BIOGEOGRAPHY OF HYAENODONTIDA: USING THE AFRO-ARABIAN RECORD TO EXPAND CHARACTER AND TAXON SAMPLING

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Hyaenodontida is a diverse clade of terrestrial carnivorous mammals, whose members have been found in the Paleogene of Europe, North America, Asia, and Afro-Arabia. Recent work on hyaenodontidan systematics has led to multiple competing hypotheses for relationships between Afro-Arabian species and Laurasian species. Much of this controversy centers on the phylogenetic position of early Paleogene Afro-Arabian hyaenodontidans like *Boualitomus* and *Lahimia*, which have been recovered deeply nested within Hyaenodontida, thereby implying multiple, lengthy ghost lineages. In this study, new material from the Fayum Depression of Egypt was added to the largest morphological character matrix ever assembled to analyze the phylogenetic relationships of Hyaenodontida. Maximum parsimony analysis and Bayesian phylogenetic inference recovered two distinct clades that converged on hypercarnivorous dental morphology: Hyainailourinae, which includes *Pterodon* and *Megistotherium*; and Hyaenodontinae, which includes *Hyaenodon* and *Propterodon*. These clades are supported by new dental, cranial, and postcranial characters. Using these methods, *Lahimia* and *Boualitomus* are again recovered as deeply nested within Hyainailourinae, but Bayesian tip-dating instead places these taxa near the base of Hyainailourinae. Multiple biogeographic methods were applied to the topology recovered by the tip-dating analyses, and all support an Afro-Arabian origin for Hyainailouridae and a Laurasian origin for Hyaenodontinae, with the root of Hyaenodontida being either Asian or Afro-Arabian. This study suggests that there was an early Paleocene dispersal from either Afro-Arabia to Asia or from Asia to Afro-Arabia, followed by early Eocene dispersals of Hyainailouridae from Afro-Arabia to Europe, and of Teratodontinae from Asia to Afro-Arabia. This study provides an evolutionary context for the Afro-Arabian hyaenodontidan fauna before Afro-Arabia was invaded by Carnivora in the late Oligocene, and it provides a biogeographic hypothesis that can be compared to the dispersals of primates and rodents across the Tethys during the early Paleogene. This character matrix will be expanded to study the position of Hyaenodontida in Eutheria and used to study changes in body size and locomotion in the most diverse lineage of carnivorous mammals besides Carnivora.

Grant Information

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Romer Prize Session (Thursday, October 15, 2015, 8:45 AM)

RECONSTRUCTING THE DIVERSITY OF NASAL ANATOMY AND AIRFLOW IN DINOSAURS WITH IMPLICATIONS FOR PHYSIOLOGY AND ECOLOGY

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Many dinosaurs enhanced their nasal passages from the plesiomorphic condition, suggesting strong selection for one or more of its functions. To determine which functions I surveyed representatives of major dinosaur clades using nasal cavity expansion as a proxy for nasal passage enhancement. Expansion tended to correlate positively with body size, suggesting that nasal thermoregulation may have been the primary driver. To test this I reconstructed the airways of representative dinosaurs using the fossils coupled with comparative studies on extant diapsids (birds, crocodylians, and lizards). I used computational fluid dynamics to model airflow through these airways. Flow patterns in the extant clades revealed associations of air movement to gross nasal structure. All extant taxa had noses with small airway calibres (0.5–5mm) conducive to heat transfer. Similar patterns were observed in mammals suggesting that the biophysical limitations of nasal passage function largely overrides any potential phylogenetic pull. Using these data I compressed the airways of my dinosaur models, simulating space occupied by nasal glands, blood vessels, associated nervous tissue, and mucosa. Restoring mucosal thicknesses to dinosaur airways greatly changed flow patterns in the nose, producing results more in line with extant taxa. Fidelity of nasal passage reconstructions was proportional to the extent of hard-tissue boundaries. Ankylosaurs and pachycephalosaurs provided the highest fidelity reconstructions whereas the less restricted airways of theropods and sauropods produced less confident reconstructions. Heat flow across the nasal passages was analyzed using estimates for resting respiration and body temperature. I discovered that the convoluted nasal passages of ankylosaurs provided heat and water savings on par with extant animals. Pachycephalosaurs had less effective air conditioning capacity when soft-tissues were not incorporated, whereas the addition of soft-tissues (including respiratory turbinates) greatly increased air conditioning ability and restored olfactory flow. Heat flow across theropod nasal passages suggested intimate interactions between the relatively small airways of theropods, and their much enlarged antorbital sinuses. The results of my analyses indicate that the nasal passages of dinosaurs were effective heat exchangers and that elaborations of the airways or associate structures (e.g., antorbital sinus) acted to compensate for the increased heat loads that would have accompanied large body size.

Grant Information

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Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

A PRELIMINARY REPORT ON THE TURTLES FROM THE LATE MIOCENE OF CENTRAL PANAMA

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Fossil turtles were recovered from three late Miocene estuarine–marine assemblages in central Panama. The Chagres Formation (~7.0–6.0 Ma) preserves small marine turtles of the family Cheloniidae. The Alhajuela Formation (late Miocene) includes

representatives of the Podocnemididae, Trionychidae, Testudinidae, and Cheloniidae. Turtles from the Gatun Formation include the Kinosternidae (upper member, ~9.6–9.0 Ma), Cheloniidae (middle member, ~11.0–10.2 Ma), Geoemydidae, and Pleurodira (lower member, ~11.8 Ma). The kinosternid from the Gatun Formation as well as previously reported fossils of the *Kinosternon scorpioides* complex from the late Miocene of Honduras (~9–6.6 Ma) represent the oldest records of kinosternines in Central America prior to their subsequent dispersal into South America after final emergence of the Isthmus of Panama. Based on family-level classification, the turtle fauna from the Alhajuela Formation is nearly identical to that of the early Miocene Culebra Formation (~21.0–19.0 Ma) from the Panama Canal Basin and suggests that this family-level assemblage was stable for ~10 million years. Such faunal stability might be unexpected when considering hypotheses of early isthmus closure and/or shoaling and narrowing of the Central American Seaway during the middle Miocene. Non-marine turtles represented in the late Miocene of Panama appear to be North American and Old World in origin and as of yet no South American terrestrial or freshwater endemics are represented, suggesting that a biogeographic barrier was still in existence between North America and South America during the late Miocene.

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Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

REVISION OF CANIFORM DIVERSITY FROM THE LITTLE BADLANDS AREA (OLIGOCENE) OF NORTH DAKOTA

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The reported vertebrate fauna of the Brule Formation within North Dakota is largely based on preliminary faunal lists presented without detailed discussion. An effort is underway to refine our knowledge of that fauna, beginning with a thorough review of the caniforms collected in the Little Badlands area (Stark County, North Dakota) and held within the North Dakota State Fossil Collection. Caniforms previously reported from this area include *Brachyrhynchocyon* (=*Daphoenus*) *dodgei, Daphoenus* sp., *Hesperocyon gregarious,* and *Osbornodon renjiei*. This study confirms that the canid *H. gregarious*, which is represented by dozens of specimens, was the most common component of the caniform fauna. A single skull is referred to the amphicyonid *Daphoenus vetus*, marking the first occurrence from North Dakota. Another first report from North Dakota, the canid *"Mesocyon" temnodon*, is based on a well-preserved skull, lower jaws, and the most complete postcranial skeleton yet referred to that species. An isolated m1 is referred to *O. renjiei*, the type specimen of which is also from the Little Badlands area. A robust, yet small (p1–m2 length 37.1 mm) lower jaw likely representing an undescribed species is referred to Arctoidea, though its exact affinities remain uncertain. The carnivoran *Palaeogale sectoria* is also documented here for the first time. The previously reported presence of *B. dodgei* was not confirmed during this study. However, additional caniform diversity is indicated by specimens that do not match any of the taxa named above, but are too fragmentary to definitively assign to a specific taxon. All of these taxa (except *D. vetus*) and most of the caniform specimens were recovered from the Fitterer Ranch area within the Little Badlands, likely as a result of increased collection efforts focused on that area over the years. These results provide support for the hypothesis that a large portion of the vertebrate fauna from the Brule Formation of North Dakota remains unreported. Elucidating that diversity will facilitate better correlation between these sediments and those exposed throughout the northern Great Plains region.

Technical Session XI (Friday, October 16, 2015, 9:00 AM)

RE-EVALUATION OF PROMONTORY ARTERIAL DOMINANCE IN EARLY PRIMATES

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Although variation in cranial arterial presence, route and development has been shown to provide indications of phylogenetic relationship in primates, information on relative area of the promontorial and stapedial bony canals has never been comprehensively quantified. Among fossil euprimates, some genera (notably *Mahgarita, Notharctus,* and *Rooneyia*) have been described as resembling extant haplorhines in exhibiting a promontorial canal that is substantially larger than the stapedial canal. We compared adapiforms and omomyiforms to a sample of 22 extant euarchontan species using microCT scan data on canal dimensions and endocranial volume (ECV). Images of arterial pathways were created using Avizo 7.1 software. Cross-sectional area was measured for the internal carotid canal and its two major branches: the canal for the promontory artery and the canal for the stapedial artery. Each canal was measured in three places along its length; average area was taken for each canal. We then calculated the ratio of stapedial to promontorial canal area. Among the extant lemuriforms in our sample (which excludes cheirogaleids) this ratio ranges from 0.48–2.59, while species of *Tarsius* are significantly different with an average ratio of 0.11. Treeshrews are strepsirrhine-like, with ratios ranging from 0.64–1.16. Sampled adapiforms (*Cantius, Notharctus, Smilodectes,* and *Adapis*) and some omomyiforms (*Omomys* and *Necrolemur*) are most similar to extant lemurs and treeshrews, while *Rooneyia* is tarsier-like. To compare promontorial canal development among euarchontans, we regressed canal diameter against ECV. Treeshrews, tarsiers, and anthropoids resemble each other in this relationship, whereas strepsirrhines have a greatly reduced canal for their ECV. The fossil primates in our sample resemble living treeshrews and haplorhines with the exception of *Adapis*, which demonstrates some reduction in promontorial canal area relative to ECV. This study supports the hypothesis that presence of both a large stapedial canal and a large promontorial canal is primitive for euprimates. Extant strepsirrhines appear to be derived in reducing both branches relative to ECV (but with more emphasis on promontorial reduction), while extant haplorhines are derived in reducing the stapedial branch alone. Most fossil primates exhibit the plesiomorphic condition except *Rooneyia* and *Adapis*, which are more haplorhine- and strepsirrhine-like (respectively). We find no evidence for haplorhine affinities of adapiforms in the carotid canal system.

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Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

MORPHOSOURCE: AN OPEN-ACCESS, PROJECT-BASED WEB ARCHIVE FOR RESEARCHERS, MUSEUMS, AND PUBLIC TO SHARE AND ACCESS 3D MORPHOLOGICAL DATASETS

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One of the most exciting opportunities that comes from an increasing reliance on three dimensional (3D) digital data in studies of morphology is the potential for improving researcher and public access to relevant comparative samples. MorphoSource is the first project-based data archive developed for storing, collaborative sharing, and distribution of microCT scans, 3D surface renderings, and digital photographs of specimens (http://www.morphosource.org/). The site has been active since April 2013. At the time of this writing it includes over 250 registered participants from across the globe. In terms of datasets, it currently hosts 5,356 files representing 'raw' microCT volumetric data; mesh files (stl, ply) from laser scans, structured light, photogrammetry, or microCT; and 2D digital photographs. These files represent 1,735 repository-vouchered specimens from 51 institutions. These user contributed holdings are growing rapidly. Data on the site is protected by creative commons restrictions as customized by each contributing researcher (data author) according to his/her needs, concerns, or third party agreements (e.g., with museums). Most data published on the site can be immediately downloaded by registered users. Other datasets can be released for downloaded upon request by data authors who retain rights to grant third party access. This framework serves the interests of both physical repositories (museums) and data authors by tracking use statistics on datasets. Such statistics provide evidence of collection value and magnify impact of researcher-collected data. Datasets currently have unique identifiers that must be cited in publications using them. MorphoSource also provides an avenue for DOI registry of certain datasets. This framework supports digital outreach and education by hosting datasets that can be used by K-12 and STEM educators and college faculty alike. Several educational datasets are already available for use in the Paleoteach (http://www.paleoteach.org/) initiative based at the University of Florida. Even without datasets organized to match curricula, using Morphosource, the public can explore anatomical diversity in a way never before possible, visualizing in 3D any of thousands of museum collection specimens.

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Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

DIETARY VARIABILITY AS INFERRED FROM STABLE CARBON ISOTOPES IN WHITE-LIPPED PECCARIES: A CAUTIONARY TALE REVEALED FROM HAIR AND ENAMEL TISSUES

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Stable isotope analysis of mammalian enamel is often used to provide information regarding an organism's paleodietary niche. However, this practice is less commonly used to decipher the dietary niche of extant species, as it is invasive and must be completed post-mortem. Instead, stable isotope analysis of hair is more commonly employed. Both stable carbon isotopes of enamel carbonate ($\delta^{13}C_{enamel}$) and hair ($\delta^{13}C_{hair}$) provide information regarding the diet and foraging habitat during the time of tissue formation. While fractionation factors between the two proxies and corresponding diet have been well documented, the degree of dietary variability recorded in enamel as compared to that of hair remains less understood. As the geochemical analysis of enamel tissue is necessary for paleodietary studies, and the majority of modern studies examine the isotopic composition of hair, it is important to better understand how enamel and hair record dietary variability in extant mammalian populations.

Here, we analyzed stable carbon isotopes of hair and enamel tissues from white-lipped peccaries (*Tayassu pecari*) from seasonally inundated/wetland savannas and rainforests in South America. We found no significant difference in $\delta^{13}C_{enamel}$ values from peccaries residing in savannas as compared to rainforests (i.e., the Brazilian Pantanal versus the inland Atlantic Forest, respectively), despite notable differences in ecosystem productivity. However, mean $\delta^{13}C_{hair}$ values are significantly greater in the savannas ($p<0.0001$). The total $\delta^{13}C$ ranges of sampled white-lipped peccary populations are similar between tissue types, with Atlantic forest individuals varying by 1.5‰ in both hair and enamel, while Pantanal peccaries varied by 2.4‰ (hair) and 2.6‰ (enamel). Enamel values may be subject to increased time averaging and dampening of the original isotopic signature due to enamel formation but provide a more complete picture of average dietary behavior. In contrast, hair may record the diet of individuals over a more discrete time period yet neglect to capture the total range of an individuals diet (without continuous re-sampling of individuals). While paleontologists are reliant on $\delta^{13}C_{enamel}$, it is important to recognize how tissue choice can influence dietary interpretations and

comparisons of fossil enamel to modern hair should be interpreted cautiously. Further, interpretations of paleodiet from solely enamel should be interpreted as a minimum estimate of dietary variability.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

COMPARING TOOTH MACROWEAR IN A JUVENILE AND ADULT SPECIMEN OF *GORGOSAURUS LIBRATUS:* CHANGES IN FEEDING BEHAVIOR THROUGHOUT ONTOGENY IN TYRANNOSAURIDS

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An understanding of how paleopathologies occur can shed light on the behavior of extinct animals, and inform theories on how they might have interacted with their environment and contemporaries. More so than coprolites, microwear, or bite marks on the bones of prey, the study of macrowear in the teeth of articulated carnivorous dinosaurs provides direct evidence of feeding behavior for a particular specimen over an extended period of time. Following recent speculations on the diet and social dynamics of tyrannosaurid dinosaurs, macrowear in the teeth of two specimens of *Gorgosaurus libratus,* one juvenile and one adult, were compared in order to document any change in feeding strategies through ontogeny. Four major types of tooth wear were present in the two specimens: enamel spalling, longitudinal facets, tip wear, and barrel-shaped puncture marks. Enamel spalling is most likely reflective of traumatic feeding events or reduced enamel integrity due to continuous use after damage, and is presented in both specimens. However, the adult teeth were dominated by tip wear, in contrast to the juvenile teeth, which presented numerous examples of longitudinal wear facets. This is hypothesized to reflect an ontogenetic change in the feeding behavior of *Gorgosaurus*, from shearing and slicing of meat with high levels of tooth occlusion in young, to the more commonly accepted puncture and pull method in adults. This change is concomitant with an increase in bite force as the jaw grows throughout life, and may reflect a change in diet, and even ecological niches between juvenile and adult tyrannosaurids. At the very least, it shows that juveniles and adults processed carcasses in different ways.

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Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

A JUVENILE *HYPACROSAURUS ALTISPINUS* (DINOSAURIA: HADROSAURIDAE) BONEBED FROM THE HORSESHOE CANYON FORMATION (UPPER CRETACEOUS) OF ALBERTA, CANADA

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The Bud Nelson Bonebed, a monodominant *Hypacrosaurus altispinus* bonebed, is located in southern Alberta, Canada in the Horseshoe Canyon Formation. Although the University of Alberta discovered it in 1965, it has not been described. Approximately 50 elements have been recovered from the site. The minimum number of individuals is four late juveniles and one sub-adult or adult, based on humeri. The material is assigned to *H. altispinus* using four well-preserved jugals: the ventral margin is acutely angular and there is a lack of a mid-ventral constriction. Five dentaries and a surangular comprise the remainder of the known cranial material. Although details of the original collection are scarce, the material was found disarticulated. Cranial bones are represented by a dominance of right elements whereas postcranial elements show no dominance. Forelimb bones represent the highest number of elements in the bonebed, with the majority of these being humeri. Theropods are represented in the bonebed by shed teeth. The presence of puncture marks on some of the hadrosaur bones indicates scavenging.

The Bud Nelson Bonebed is significant for its high proportion of juveniles. Juvenile hadrosaur bonebeds are not common, especially for *Hypacrosaurus altispinus* which is typically found as isolated individuals or elements. There is only one other unpublished small bonebed that contains elements from this dinosaur and surprisingly the material also belongs to juvenile specimens. There is no evidence that the Bud Nelson assemblage represents a nesting ground. In contrast, three juvenile-dominated *Hypacrosaurus stebingeri* bonebeds are known from the Oldman Formation of Alberta and the upper Two Medicine Formation of Montana. These sites have eggs and baby remains as well as juvenile material at one of the sites in Montana.

The Bud Nelson Bonebed and the unpublished bonebed are the only evidence of communal or crèche behavior in *H. altispinus* into the late juvenile stage. Adult-dominated *Hypacrosaurus* bonebeds are unknown but are common for other hadrosaurs, such as *Edmontosaurus*. This could indicate different behavior among hadrosaur taxa, or bias in preservation. The higher proportion of juveniles suggests that the Bud Nelson Bonebed represents a catastrophic mass death assemblage.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

NEW SPECIMENS AND MORPHOLOGY OF THE LOWER JAW OF THE LATE CRETACEOUS METATHERIAN *EODELPHIS* MATTHEW, 1916

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The stagodontid metatherian genus *Eodelphis* is currently known from two species, distinguished by subtle differences in their dentition and size: *E. browni* and the more robust *E. cutleri*, the purported ancestor of *Didelphodon*, the largest North American mammal of the Mesozoic. Here we present two new, nearly complete jaws of *Eodelphis* from the Judithian-age Judith River and Two Medicine formations of Montana that shed light on the ontogeny and ecology of this taxon. Both specimens display characters diagnostic of *E. browni*, including an anterior second premolar (p2) alveolus approximately equal in size to the posterior p2 alveolus (when a double-rooted p2 is present) and a directly anterior position of the posterior root of the third premolar relative to the anterior root of the first molar. However, the teeth are larger than those previously reported from other specimens of *E. browni*. Although size has been traditionally considered as a diagnostic character among *Eodelphis* species, our results may indicate a greater variation in size within *E. browni* than previously thought. One specimen displays an interesting pattern of differential tooth wear in its molar series. The fourth molar (m4) has considerably less wear than the other molars, lending support to the idea that the m4, as in many other marsupials, was the last in the series to erupt. This wear pattern is also consistent with the hypothesis of changing tooth functionality, and by extension, feeding ecology, with ontogeny in stagodontids, with juveniles primarily using molar shearing to process food, gradually transitioning to crushing their food as wear on the cusps and crests accumulate over time to create broad crushing platforms. This wear pattern is thought to start at the anterior portion of the molar series and move posteriorly as teeth erupt during development. The molar series thus forms a broad, relatively flat surface, with the exception of the m4. Due to the existing dental morphology, this specimen may represent a younger adult in a transitional stage of feeding ecology trending towards a more durophagous diet. In comparison, the other specimen described here, although larger in overall size, does not display the same degree of wear in its molar series and seems to retain shearing function. This may indicate that this is a younger individual than the first specimen described here or this individual has not changed its feeding ecology regardless of ontogeny.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

CARNIVORA FROM THE RATTLESNAKE FAUNA (EARLY HEMPHILLIAN, LATE MIOCENE) OF OREGON

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The Rattlesnake Formation of eastern Oregon is an early Hemphillian site (~7.5 – 7.05 Ma) recording a diverse mammal fauna from a mixture of sagebrush steppe and woodland environments. The initial description of the Rattlesnake fauna was published in the early 1900s, and there have been few updates since then. Here we provide a comprehensive revision of the Rattlesnake carnivoran fauna, including addition of several species, revised identifications of previously described taxa, and description of new fossil material from several noteworthy species. New additions to the fauna include a canid, *Borophagus pugnator*; a mephitid, *Pliogale*; an ischyrictine mustelid, *Plionictis*; a machairodont felid, *Rhizosmilodon*; and a puma-like feline. Previously undescribed dental material allows identification of *Machairodus* cf. *catacopsis*. Notable new fossil material includes additional elements of the type specimen of *Indarctos oregonensis,* which were collected more than 100 years after its initial discovery. Also of significance are the earliest and first western records of the recently described *Rhizosmilodon*, as well as the first maxillary remains of this taxon. The occurrence of *Pliogale* represents the first skunk described from the fossil record of Oregon. As has been noted previously, the Rattlesnake Formation contains some of the earliest North American occurrences of immigrant taxa from Asia, such as *Simocyon*, *Indarctos*, *Plionarctos*, *Lutravus*, and *Machairodus*. With a total of 14 species, the Rattlesnake fauna is the most diverse carnivoran fauna of its age in North America. The diversity of carnivorans present in the Rattlesnake Formation is likely due to the mosaic environment preserved at the site, climate shifts through time, and its geographical placement near carnivore dispersal routes.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

NEW SPECIMENS OF THE THYREOPHORAN DINOSAUR *SCUTELLOSAURUS LAWLERI* FROM THE LOWER JURASSIC KAYENTA FORMATION OF NORTHERN ARIZONA

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Ornithischia originated during the Late Triassic but did not diversify until the Early Jurassic, before becoming the dominant group of terrestrial herbivores throughout the rest of the Mesozoic Era. While rare in Upper Triassic strata, the group had achieved a global distribution by the Early Jurassic, with members of Heterodontosauridae, Neornithischia, and Thyreophora present in Lower Jurassic strata worldwide. The oldest ornithischian fossils from North America have been found in the Silty Facies of the Kayenta Formation in northeastern Arizona. These include the thyreophoran *Scutellosaurus lawleri*, an unnamed heterodontosaurid, and osteoderms and rib fragments tentatively attributed to the thyreophoran genus *Scelidosaurus*.

I report here new ornithischian dinosaur material collected from the Lower Jurassic Kayenta Formation along the Adeii Eechii Cliffs of northern Arizona between 1997 and 2000 by field parties from the Vertebrate Paleontology Laboratory (TMM) at the University of Texas at Austin. Among this new material are two disarticulated associated skeletons of *Scutellosaurus lawleri* (TMM 43663-1 and TMM 43664-1), each preserving anatomy that is poorly known or not previously reported for the taxon, including the nasal, maxilla, lacrimal, postorbital, quadratojugal, squamosal, opisthotic, scapula, ilium, and metatarsus. TMM 43663-1 represents an individual of similar size as the holotype (MNA V175), while TMM 43664-1 represents a somewhat larger individual. These specimens have both been compressed taphonomically, making their removal from the surrounding matrix in their field jackets difficult without risk of damage to the fossil bone. Both specimens were mechanically prepared until risk of damaging the fossil bone was deemed too high, at which point the specimens were scanned at The University of Texas High Resolution X-ray Computed Tomography Facility. This approach results in three-dimensional volumetric models of individual bones generated by removing matrix from the surface of the fossil bone digitally, revealing otherwise obscured anatomy and exposing bone not visible on the surface of the specimens. In addition to these associated skeletons, several dozen other fragmentary specimens of *Scutellosaurus lawleri* have been identified, which increases the known sample size for the taxon. Several relatively large isolated indeterminate ornithischian fossils have also been recovered, which may indicate that ornithischian diversity in the Kayenta Formation is greater than is currently understood.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

PTEROSAUR TRACKS, TERRESTRIAL LOCOMOTION, AND PHOTOGRAMMETRIC ICHNOLOGY

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The fossil record of pterosaurs ranges from Late Triassic (Norian) to the latest Cretaceous (Maastrichtian). Despite the tremendous diversity of skeletal adaptations, there appears to be relative conservatism in quadrupedal terrestrial locomotion (i.e., erect, parasagittal gait) preserved in the ichnological record. While pterosaur body fossils are relatively well understood (with over 100 taxa recognized) only 4 ichnogenera and 11 ichnospecies of pterosaur tracks are known from less than 60 tracksites (ranging from Oxfordian to Maastrichtian) worldwide. *Pteraichnus* (with 8 ichnospecies) is the most prevalent ichnogenus and is primarily represented by small- to medium-size tracks from Late Jurassic and Early Cretaceous assemblages in North America and Europe. These tracks are often found in large numbers in marginal marine deposits that suggest congregation of individuals in shoreline habitats. However, ichnotaxonomy of pterosaurs is relatively immature and more work is needed to refine ichnological and ichnotaxonomic descriptions (along with standardized measuring methods), as it is likely that variation in track data is partially due to differing measurement and documentation techniques. The often subtle, low relief, and small size of many pterosaur tracks requires a very precise method for capturing 3D data. A properly collected and processed close-range photogrammetric (CRP) project can create a high fidelity surface with low noise that supports precise, submillimeter measurements, detailed morphometric volume comparisons, and other analyses. CRP image collection may be conducted for locations of various sizes, exposures, and orientations of track-bearing surfaces. This 3D documentation allows for a more objective understanding of ichnotaxomic variation, as well as the recordation of novel ichnites reflecting the kinetics of a variety of movements and activities (e.g., running, swimming, foraging, landing, flocking). Abundant Late Jurassic pterosaur tracksites are located in central Wyoming on Federal Public Lands. Exposures of the Sundance and Morrison formations around Alcova and Seminoe reservoirs yield hundreds of tracks and trackways of the conspecific ichnotaxa *P. saltwashensis* and *P. stokesi*, which have been studied for nearly 40 years, including CRP documentation over the past 15 years. The large volume of tracks in Wyoming yields an extensive dataset that provides valuable insights into pterosaur ichnotaxonomy, diversity, behavior, ichnofacies distribution, trackmaker identity, and paleoecology.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

ACTUALISTIC EXPERIMENTAL MODEL FOR THE PRESERVATION OF SKIN IN EXTINCT ARCHOSAURS

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In 1914, Barnum Brown reported the first dinosaurian skin impressions, associated with skeletal remains of *Corythosaurus*. Since then, fossilized dinosaur skin impressions continue to be found. Here we propose a model for dinosaur skin preservation, based upon a series of actualistic experiments with varying skin types in different environments. Archosaur skin consists of both alpha keratin and beta keratin; the latter is more resistant to degradation. Mammal skin has only alpha keratin. We predict, therefore, that archosaurian skin will persist longer than mammal skin.

We designed actualistic experiments to test three hypotheses. First, we test the hypothesis that archosaur skin is more resistant to degradation than skin comprised only of alpha, represented by mammals. Second, we tested the influence of epidermal appendages (hair, feathers, and osteoderms) on preservation. Finally, we tested environmental factors, comparing skins in sterile water to skin in a model lacustrine environment. All specimens within the sterile water eventually formed a biofilm after three to four weeks. In the lacustrine environment, results show that microbial growth does not occur in archosaurian skin as rapidly as in mammal skin. Mammal skin demonstrates confluent fungal growth after 2 weeks in the model lacustrine environment, while biofilms were slightly slower to develop; archosaur skins show minimal visible change until the third week, when biofilm formation is evident. In conjunction with biofilm growth, the epidermis sloughs off of the dermis. By the fifth week the dermis becomes a white paste upon contact from sampling. Presence of osteoderms did not affect preservation over the course of this experiment. Feathered skin was altered more than non-feathered skin. In all cases skin in model lacustrine environments degraded more rapidly than that in sterile water.

We propose that these experimental data may elucidate patterns of degradation in archosaurian skin preserved in the Cretaceous rock record. Based upon our finding of rapid dermal degradation while the epidermis remains intact, we predict that dinosaur skin should separate from the skeletal element, and may be found in isolation. We also predict that feathers (beta keratin only) may persist longer than skin, consistent with the observation that skin is rarely observed in dinosaurs with feathers.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

AN EARLY CAMPANIAN MAMMALIAN FAUNA FROM THE BIG BEND REGION OF TEXAS

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The Lowerverse Local Fauna is a diverse Early Campanian (c. 80–82 Ma) microvertebrate assemblage known from a single site in the lower shale member of the Aguja Formation near Big Bend National Park, Texas. The fauna includes chondrichthyan and osteichthyan fishes, amphibians, lizards, dinosaurs, birds, and mammals. Mammals are represented by more than 320 teeth and tooth fragments of "symmetrodonts," multituberculates, and therian mammals. The spalacotheriid *Symmetrodontoides* is represented by several teeth from different loci. At least six multituberculates are present, including ? *Janumys*, *Paracimexomys*, *Cedaromys*, *Cimolodon*, *Cimolomys* and *Meniscoessus*. Tribotherians may be represented by ? *Picopsis* and ? *Palaeomolops*. Several marsupials are present, including *Iugomortiferum*, *Alphadon*, and the pediomyid *Aquiladelphis*. Eutherians are represented by *Paranyctoides*. A single unusual tooth is similar to the enigmatic South American *Fergliotherium*.

Unique aspects of the Lowerverse mammalian assemblage may reflect its southern paleolatitude, but it also differs significantly from the younger Terlingua Local Fauna, known from the upper shale member of the Aguja. While the two share the endemic taxon *Palaeomolops*, the presence of others such as *Symmetrodontoides*, ? *Picoposis* and ? *Janumys*, not known from the Terlingua Fauna, indicates that the older Lowerverse Fauna is quite different. Although North American Late Santonian (Aquilan) and Middle Campanian (Judithian) mammalian faunas are well known, only two localities have thus far yielded probable Early Campanian mammals (lower Wahweap Formation of Utah, and Menefee Formation of New Mexico). The Lowerverse fauna represents a third assemblage, and will be useful in refining the boundary between Aquilan and Judithian North American Land Mammal Ages.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

ENAMEL MICROSTRUCTURE IN ORNITHOCHEIRID PTEROSAURS

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The enamel microstructure of reptiles is well known. Among Archosauria, it has been examined in detail in numerous dinosaurs, crocodiliforms, early crurotarsans, and phytosaurs. The microstructure of these teeth can be species-specific, especially for derived herbivorous dinosaurs with specialized dentitions, and may reflect differences in developmental history in addition to diet. However, enamel microstructure has not been well described in pterosaurs, an ecologically diverse clade of Mesozoic archosaurs with considerable variation in external tooth structure. In this study, we describe the enamel microstructure of ornithocheirid pterosaur teeth for the first time in order to better understand variation in the clade and how it might relate to diet in archosaurs. Teeth of two previously described morphotypes (A and B) of ornithocheirid pterosaur teeth from the Kem Kem beds of Morocco were examined using SEM and thin sections. Overall, the enamel in both morphotypes is very thin, and is often worn away to expose dentine. The enamel ridges on the teeth of morphotype A are formed from differing crystallite heights, to a maximum of 200 microns in thickness. The columnar basal unit layer is about 100 microns high, and the outer half of the enamel is composed of parallel crystallites with longitudinal lines of incremental growth. This type of enamel is suggested to be resistant to wear and abrasion. The enamel microstructure of morphotype B is relatively simple. Ranging between 30 and 50 microns in thickness, the enamel is composed of simple, poorly developed columnar units with rare divergence lines. This type of enamel is suggested to be better suited to resisting cracking and bending.

The enamel microstructure of morphotype A most closely resembles that of the basal archosauromorph *Trilophosaurus*, while the microstructure of morphotype B most closely resembles that of *Revueltosaurus*. These new data on pterosaur microstructure were incorporated into a larger analysis of enamel microstructure evolution in Archosauria based on ancestral state reconstruction of five enamel characters and 71 taxa from all major clades. The ancestral state reconstruction reveals extensive convergence, and that tooth enamel microstructure characters appear to have little phylogenetic utility for determining broad taxonomic classifications. The two types of enamel in pterosaurs are highly convergent with other archosaur taxa, and there is considerable variation within closely related species in Pterosauria.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

A BASAL BAENID TURTLE PROVIDES INSIGHTS INTO THE AQUATIC FAUNA OF THE EARLY CRETACEOUS (APTIAN) CEDAR MOUNTAIN FORMATION OF WEST-CENTRAL UTAH

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Turtles are rare components of the Cedar Mountain Formation. Here, we report on a basal baenid turtle preserved in a single bonebed located about 10 m above the base of the Cedar Mountain Formation's Yellow Cat Member, which is no older than 125 Ma (early Aptian). A minimum of five individuals were preserved in three closely spaced clusters. Aside from a single lungfish tooth plate, all bones from the site pertain to a single taxon that is interpreted as a new species of the baenid *Trinitichelys*.

This turtle is represented by a complete skull, isolated and associated shell elements, and other postcranial elements that allow a nearly complete reconstruction of the skeleton. Differences from *Trinitichelys haitii* include the presence of a more triangular snout, a more dorsally facing external narial opening, a larger exposure of the prefrontal on the skull roof, and a narrower triturating surface. This taxon adds support to the interpretation that *Trinitichelys* is a basal baenid.

The bonebed was preserved in a reddish-brown, silty mudstone matrix that was deposited in a moderately drained floodplain. Minute mandible marks and burrows in the bones indicate insects harvested flesh and bone, indicating at least a brief episode of subaerial exposure prior to burial. Locally, equivalent stratigraphic levels contain a femur of a neochoristodere, a fin spine and gut content casts of the spiral valve of hybodont sharks, gar scales, and fish teeth (including lungfish plates) and gastropods, all indicative of links to perennial freshwater bodies. These sites provide the most diverse aquatic fauna known from the Aptian-aged sequence of the Cedar Mountain Formation.

Technical Session II (Wednesday, October 14, 2015, 11:15 AM)

A NEW, LARGE, NON-PTERODACTYLOID PTEROSAUR FROM A LATE TRIASSIC INTERDUNAL DESERT ENVIRONMENT WITHIN THE EOLIAN NUGGET SANDSTONE OF NORTHEASTERN UTAH, USA INDICATES EARLY PTEROSAURS WERE ECOLOGICALLY DIVERSE AND GEOGRAPHICALLY WIDESPREAD

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Body fossils of tetrapods are extraordinarily rare in the Late Triassic–Early Jurassic desert sand erg composed of the Navajo/Nugget/Aztec formations which covered >2.2 million km^2 of the western USA. We previously reported on a wealth of tetrapods, including multiple individuals each of a coelophysoid, a drepanosauromorph, two sphenosuchian taxa, and two sphenodontian taxa. All are preserved along the shoreline of a Late Triassic oasis in the Nugget Sandstone at the Saints & Sinner Quarry (SSQ). Recently, we discovered a non-pterodactyloid pterosaur at the quarry, represented by a partial uncrushed, associated/articulated skull imaged via micro CT. The premaxillaries are spoon-shaped rostrally; the maxilla is a simple bar with a needle-like nasal process, the suborbital jugal/quadratojugal blade is high; the nasal is a short, narrow rectangle; and the fused frontals are wide with a moderately high, tripartite sagittal crest. The lower jaws are complete, with a long, slender dentary terminating rostrally in a downward-bend with a ventral expansion, a short postdentary complex and a short retroarticular process. The quadrate-articular joint is well above the tooth row. At least three, widely spaced, conical teeth are in the premaxilla; maxillary teeth are mesiodistally long (3 widely-spaced mesially and 7 close together distally); and on the dentary there are two apicobasally high, widely-spaced mesial teeth and ~20 small, multicusped, low-crowned distal teeth. The frontals and lower jaws are extensively pneumatized.

With a 170 mm-long lower jaw, this is two times larger than other Triassic pterosaurs and only the second indisputable Triassic pterosaur from the Western Hemisphere (the other is from Greenland). This is the only record of desert-dwelling non-pterodactyloids and it predates by >60 Ma all known desert pterosaurs. Whereas most pterosaurs are known from fine-grained marine or lacustrine environments, and other Triassic forms are smaller, the SSQ specimen shows that early pterosaurs were widely distributed, attained a large size, and lived in wide range of habitats, including inland deserts far (>800 km) from the sea. Finally, the SSQ pterosaur corroborates the Late Triassic age of the fauna based on drepanosaurs because pterosaurs with multicusped teeth are presently known only from the Upper Triassic.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

NEW SHARP-NOSED CROCODILES (*MECISTOPS*) FROM THE MIO-PLIOCENE OF THE LAKE TURKANA BASIN OF KENYA AND THE TRANSITION FROM BROAD TO SLENDER SNOUTS IN CROCODYLIDS

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Living sharp-nosed crocodiles (*Mecistops cataphractus*, which is a complex of at least two cryptic species) are found throughout western and central Africa. Fossils from the East African Rift Valley dating back to the late Miocene have been referred to *M. cataphractus*, but close examination reveals at least two new species, and possibly three, in the Mio-Pliocene sequence of the Lake Turkana Basin of Kenya that document the transition from the broad snout seen in most crocodylids to the long, tubular, gharial-like snout diagnostic of modern *Mecistops*. The oldest is from the late Miocene Lower Nawata Formation. Exclusion of the nasals from the naris and a long anterior ramus of the ectopterygoid support a close relationship with *M. cataphractus*, but its snout is plesiomorphically triangular. A second form, from the Plio-Pleistocene Koobi Fora Formation, has a substantially narrower snout, though not to the same degree seen in living forms, and the snout is not as elongate. Attenuation of the mandibular symphysis is apparent from the Nawata form and specimens from the early Pliocene Kanapoi Formation; the symphysis extends to behind the fifth alveolus in most living *Crocodylus*, but to behind the sixth in the Nawata and Kanapoi forms. It extends to the seventh or eighth in extant *Mecistops*. In the Kanapoi form, the alveoli are more widely spaced, and the fourth alveolus is not as enlarged. A similar symphysis is known from *Crocodylus nkodoensis* from the Mio-Pliocene of Uganda; this might until recently have been sufficient to refer the Kanapoi form to the same species, but the symphyses of western and central African *M. cataphractus* are very similar, rendering the value of symphyseal length by itself as a diagnostic tool problematic. These fossils suggest that osteological features typically associated with the tube-snouted condition, such as separation of the nasals from the naris, may correspond more with snout narrowing (stenorostry) than with snout elongation (longirostry).

Grant Information
US National Science Foundation

Technical Session XVIII (Saturday, October 17, 2015, 1:45 PM)

A SIMULATION-BASED EXAMINATION OF THE RESIDUAL DIVERSITY ESTIMATES AS A METHOD OF CORRECTING FOR SAMPLING BIAS

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The influence of sampling biases on estimates of species richness through geological time is a great concern of palaeontologists, and multiple methods have been used to correct for them. Subsampling methods have been extensively examined, both with simulation studies and empirical data. However some datasets, particularly those with low sample sizes such as in terrestrial vertebrates, are not suited to subsampling, and alternatives have been developed. One method is the residual diversity estimate, a modelling approach which seeks to remove the signal of a chosen sampling proxy from the data by calculating deviations from a linear relationship between proxy and diversity. Despite having been widely applied to palaeodiversity studies, the residual diversity estimate has yet to be tested in a simulation environment. One difficulty with such a test is that the simulation has to not only carry out random taxon deletion to represent incomplete sampling, but simulate sampling in such a way that a sampling proxy may be extracted from the model in order to calculate the residual diversity. Here, a novel approach is used to examine the efficacy of this method. Taxa and an associated phylogeny were simulated using a birth-death model, and a parameter was added representing dispersal of the taxa between areas in simulated space. The simulated space in each time bin was divided into formations and localities, which were removed at random to represent incomplete sampling, and also to provide counts of sampling proxies used in calculation of the residual diversity estimate. The data was also used to construct taxic (no sampling correction) and phylogenetic (including ghost lineages inferred from the phylogeny) diversity estimates for comparison. The phylogenetic diversity estimate consistently outperforms the residual and taxic diversity estimates, even when errors are introduced into the phylogeny. When the quality of sampling is reduced, the correlation of all three diversity estimates with the original data decreases, but that of the phylogenetic diversity estimate decreases at a slower rate, implying that it is more robust to poor sampling than the residual diversity estimate. The residual diversity estimate performs best when the chosen sampling proxy is forced to be the greatest influence on sampling. A recent update to the residual diversity estimate, incorporating polynomial relationships between diversity and proxies, performs poorly, often showing a weaker correlation with the original data than the uncorrected taxic diversity estimate.

Technical Session VI (Thursday, October 15, 2015, 8:45 AM)

JAW SUSPENSION OF THE XENACANTH *ORTHACANTHUS TEXENSIS* – WHAT PHYLOGENETIC INFORMATION CAN CHONDRICHTHYAN JAWS PROVIDE?

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Sharks and their allies are often treated as 'primitive' vertebrates, serving as theoretical placeholders for the ancestral traits of modern gnathostomes. New fossil information changes this paradigm, and shows us that today's sharks are actually a highly derived group of fishes. However, chondrichthyan phylogeny and systematics is still very much in flux, especially the relationships of extinct taxa, both relative to the crown group (modern sharks, rays, and chimaeras) and to each other. In the past, many of these phylogenetic relationships were based on dental characters, due to the relative abundance of fossil teeth compared with poor preservation of cartilaginous anatomy. However, data from the cranium and other cartilaginous features are increasingly being used to determine phylogenetic relationships, particularly among ancient chondrichthyan groups such as xenacanths and 'ctenacanths'. The phylogenetic position of xenacanths is particularly controversial, with conflicting opinions about their relationship to modern sharks and rays. Although the cranium and jaws of *Orthacanthus texensis* have previously been separately described, a complete three-dimensional specimen from the Texas Permian (MCZ 12872) has never been properly addressed. This specimen represents an articulated cranium and jaws. Well-preserved fossils of *O. texensis* can provide new phylogenetic information about these sharks. Additionally, MCZ 12872 provides important information about jaw suspension in *O. texensis* and other 'paleostylic' fishes. Combined with existing morphological information, the new data provide further evidence for an extensive chondrichthyan stem group and the derived nature of modern sharks and rays.

Technical Session I (Wednesday, October 14, 2015, 10:15 AM)

MACROSCOPIC ENAMEL INDICATORS OF POPULATION-WIDE FOOD STRESS IN MODERN, PLEISTOCENE, AND HOLOCENE UNGULATES

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Enamel defects result from impaired enamel deposition and/or mineralization due to metabolic stress. Dental enamel hypoplasias (DEH) are often used as indicators of systemic stress, such as malnutrition and disease, in archaeological and paleontological records. However, relatively little work has been done on their frequency in food-limited extant wild populations. Previous work showed that DEH frequency is correlated with population density in cervids using several decades of data from modern populations (moose, *Alces alces* in Isle Royale National Park; elk, *Cervus canadensis* in Yellowstone National Park; red deer, *C. elaphus* on the Isle of Rum). While all three populations suffered documented periods of food stress, juvenile moose from low-density areas incur DEH at higher frequencies than either *C. canadensis* or *C. elaphus* raised under extreme food limitation. Instead of DEH, red deer and elk more often show evidence of impaired enamel maturation (hypomineralized enamel) in addition to excessive tooth wear (scratched incisors, broken teeth from osteophagy). Studies of living ungulates have linked DEH prevalence to extreme caloric deprivation and two stressful events of early life: birth and weaning. The timing of enamel formation relative to these events likely accounts for the observed differences in DEH among genera. The developmental periods of moose tooth crowns overlap and all teeth are nearly complete by the end of the calf's first winter; thus many teeth have experienced both events. By contrast, several crowns in *Cervus* continue to form during the animal's second year of life, and consequently exhibit fewer DEH but more post-weaning food stress in the form of impaired tooth mineralization and subsequently chipped enamel. Birth and weaning appear more likely to cross the threshold necessary to produce DEH than spring/summer food restriction. These data underscore the importance of evaluating living taxa prior to making paleoecological inferences. Based on the above, we can conclude that some Late Pleistocene and Early Holocene moose populations from the Fairbanks area were subject to stress below levels experienced by stable modern moose populations. This likely reflects low population densities and adequate resources. In contrast, samples of some Pleistocene *Cervus* are comparable to the Yellowstone elk from documented periods of starvation. In addition, Pleistocene *Bison* from the Fairbanks area incurred DEH at levels

comparable to those recorded at two Holocene kill sites (Early Holocene: Folsom NM; Late Holocene: Buffalo Creek WY).

Grant Information
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Technical Session VII (Thursday, October 15, 2015, 4:00 PM)

CONVERGENT EVOLUTION IN HORNED DINOSAUR CRANIAL ORNAMENTATION (ORNITHISCHIA: CERATOPSIDAE) REVEALED BY A NEW MAASTRICHTIAN CHASMOSAUR

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Ceratopsid (horned) dinosaurs are an iconic group of large-bodied, quadrupedal, herbivorous dinosaurs, restricted to the Late Cretaceous and, until recently, western North America. Easily recognized by their cranial ornamentation in the form of nasal and postorbital horns and frill (capped by epiossifications), these structures show high morphological disparity and also represent the largest cranial display structures to evolve. Despite their restricted temporal and geographic occurrence, this group has one of the best fossil records within Dinosauria, showing a rapid diversification in horn and frill morphology. A new genus and species of chasmosaurine ceratopsid is described based on a nearly complete and three-dimensionally preserved cranium recovered from the uppermost St. Mary River Formation (Maastrichtian) of southwestern Alberta. This new taxon exhibits many unique features of the frill, and is characterized by a large nasal horncore, small supraorbital horncores, a dorsally offset median epiparietal, and a series of massive and pentagonal paired epiparietals. Cranial morphology, particularly the epiossifications, suggests close affinity with the late Campanian/early Maastrchian taxon *Anchiceratops*, as well as with the late Maastrichtian taxon *Triceratops*. A median epiparietal necessitates a reassessment of epiossification homology, and results in a more highly resolved and simpler phylogeny than previous studies. Results indicate a deep split within Chasmosaurinae into a Campanian *Chasmosaurus*-clade and a Maastrichtian *Triceratops*-clade, with this new taxon in a polytomy at the base of Triceratopsini.

Most surprisingly, this new taxon exhibits a suite of cranial ornamentations that are superficially similar to Campanian centrosaurines, including de-emphasis on the supraorbital horns, and an increased emphasis on the nasal horn and epiparietals. This indicates both exploration of novel display-morphospace in Chasmosaurinae, especially Maastrichtian forms, and convergent evolution in horn morphology with the recently extinct Centrosaurinae. This marks the first time that evolutionary convergence in horn-like display structures is demonstrated between dinosaur clades, a pattern similar to fossil and extant mammals.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

A CASE STUDY OF LIVE-TWEETING IN PALAEONTOLOGICAL FIELD RESEARCH

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The presentation and interpretation of Alberta's rich fossil heritage is a major component of the mandate of the Royal Tyrrell Museum of Palaeontology. Palaeontology itself enjoys a coveted position as a 'gateway science', with the ability to increase both the public appetite for science as well as science literacy. Much of the public interest in palaeontology is focused on the discovery phase that takes place during fieldwork. However, communicating the processes involved with palaeontologic fieldwork has often proved problematic for museums.

The advent of social media has changed how museums interact with the public, and opened doors to new and exciting ways of scientific communication. In the summer of 2014, a pilot project was launched to test both the logistical feasibility and public interest in live-tweeting a dinosaur excavation by museum palaeontologists. The highlighted fieldwork focused on an ongoing research program investigating variation and evolution of horn dinosaurs, and largely involved excavation of two ceratopsian bonebeds in Dinosaur Provincial Park, Alberta. Tweets were sent live from palaeontologists in the quarry via the Royal Tyrrell Museum's account (@RoyalTyrrell) as well as that of Caleb Brown (@Brown_Caleb_M) using the hashtag #LiveFromTheField.

Tweets mainly documented the discovery, mapping, and excavation of bones-focusing on processes and research goals, but also focused on prospecting, camplife, and the modern flora and fauna of the Canadian badlands. The program was successful on many fronts. Over the course of the 40 days, 92 tweets were sent, which were retweeted and favorited 906 and 1075 time respectively. Feedback from the public came in the form of questions as well as comments indicating both interests and a desire for more tweets. Several traditional media outlets (television, print, and radio) also picked up on the twitter campaign and resulted in increased visibility for both the fieldwork and museum. Based on the results from 2014, the Royal Tyrrell Museum's live-tweeting of field research will continue for the 2015 fieldwork season.

Preparators' Session (Thursday, October 15, 2015, 10:45 AM)

A RELATIVELY INEXPENSIVE METHOD TO PRODUCE GOOD QUALITY PHOTOGRAMMETRIC MODELS OF VERTEBRATE MICROFOSSILS IN THE 1–2 MM SIZE RANGE

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I have developed a protocol to produce photogrammetric models of vertebrate microfossils, in the 1–2 mm size range, using relatively inexpensive hardware and readily available software. Many institutions are likely to already have access to suitable equipment and the necessary software. The microscope and microscope accessories I use are manufactured by Dino-Lite and consist of: a 5 MP Extended Working Distance digital microscope (model no. ADL7013MTL); a Rigid Table Top Pole Stand (MS35B); and an Adjustable Staging Holder (MSAK815). The cumulative retail price for these three items is approximately $1,200 US. With respect to the hardware, the key to this protocol is the adjustable stage, which consists of a small, manually-rotated turntable that can be used to change the orientation of a pin-mounted specimen along three axes relative to the microscope. A dual gooseneck illuminator is also required to provide indirect illumination.

Before any photographs can be taken the specimen must be whitened with ammonium chloride. This classic photographic technique serves two purposes: it improves the contrast and detail apparent in each photograph; and most importantly eliminates surface reflections on the specimen.

The limited depth of field, at the high magnifications involved, requires the use of focus-stacked images. Two to four hundred photographs, each one a focus-stacked composite composed of between 10–20 individual photographs taken at various angles relative to the specimen, are necessary to achieve good results. A series of scripts is then used to automate the focus-stacking of the composite images in Adobe Photoshop. Once focus-stacking is complete the composite images are loaded into VisualSFM where a point cloud is generated. The point cloud file can then be imported into Meshlab to create a texture mapped surface model.

Currently, this is a labor intensive process that would not be practical to use to digitize large collections. It is useful in creating digital models of important or unique specimens, such as types, that can then be made available online for reference, research, and educational purposes.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

THE FIRST RECORD OF NOASAURIDAE (THEROPODA) FROM THE ADAMANTINA FORMATION (CAMPANIAN-MAASTRICHTIAN), BAURU GROUP, BRAZIL

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Noasauridae is a small abelisauroid clade composed of eight species (without *Elaphrosaurus gautieri*, whose phylogenetic placement is still dubious and regarded as basal ceratosaur by some authors). The sole purported noasaurid from Brazil are isolated teeth referred to *Masiakasaurus*, from the Alcântara Formation, São Luís Basin (Cenomanian). Here, we describe the first osteological record of a noasaurid from Brazil composed of an isolated mid-cervical vertebra (DGM 929-R) that was also submitted to CT-Scan to access internal structures. The specimen comes from an abandoned quarry located on the outskirts of Santo Anastácio city, where the upper sequences of the Adamantina Formation crop out. The vertebra is elongated (ratio length/height of the centrum around 3.55) and low (ratio cotyle height/neural arch around 1.363). The remaining structure of the neural spine is located on the anterior half of the vertebra. Comparisons with *Noasaurus leali*, *Masiakasaurus knopfleri*, *Laevisuchus indicus* and *Dahalokely tokana* reveal similarities based on the parallel transverse processes, with the zygapophyses forming a straight line, and triangular diapophyses. These features differ from abelisaurids that present an anteroposteriorly compact centrum and the transverse process forming a curve between the zygapophyses. The CT-Scan revealed the internal structure of the centrum, formed by an array of rounded cavities, with sizes varying from 5-12 mm in length and 3.0-5.45 mm in height; septal thickness around 1-2 mm; and a pair of camerae in the middle of centrum, with foramina connecting them to pleurocoels located at the lateral surface of the centrum. The neural arch is extremely pneumatizated with developed diverticullae in the infradiapophyseal fossae and camerae. These characteristics are remarkably similar to the polycamerate pattern, as recognized in sauropod specimens. Those pneumatic features are also similar to those found in some birds, mainly considered as camellate. We assumed the polycamerate nomenclature because of the lack of detailed and systematic studies regarding the pneumatic variation of internal structures among avian specimens. Regarding the abelisauroids from Brazil, the Bauru Group yielded several remains, most of them being interpreted as small- to medium-sized individuals. DGM 929-R corroborates not only the presence of different sized abelisauroids in this country, but also suggests a larger diversity of this theropod clade in the upper sequences of the Bauru Group than previously recognized.

Grant Information
FAPERJ E-26/102.409/2013, CNPQ 304780/2013-8

Symposium 1 (Wednesday, October 14, 2015, 3:45 PM)

DINOSAUR DYNASTIES: LARGE THEROPOD TURNOVER IN THE MID-CRETACEOUS AS REVEALED BY A NEW PHYLOGENY OF TYRANNOSAUROIDS AND NEW FOSSILS FROM UZBEKISTAN

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Theropod dinosaurs are among the most iconic predators of prehistory, with several clades independently reaching enormous sizes (>10 meters in total body length, >1 ton in estimated mass). These clades iteratively filled apex carnivore roles during the Jurassic-Cretaceous, but little is known about when and why there were turnovers between different large theropod groups at the top of the food chain. One of the most puzzling transitions occurred in the mid-Cretaceous, when the previously diverse allosauroids were replaced by tyrannosauroids in North America and Asia. We constructed a comprehensive new phylogenetic analysis of tyrannosauroids (28 ingroup taxa, 366 characters), which is a combination of the two largest previously published datasets plus many new taxa and characters. Salient results include a monophyletic group of proceratosaurids at the base of the tree (including the large-bodied *Yutyrannus* from the Early Cretaceous of China), an intermediate grade of Early-mid-Cretaceous taxa including *Eotyrannus* and *Xiongguanlong* (which were moderate in size, at 3-4 meters in estimated length), the Campanian *Bistahieversor* falling immediately outside of

Tyrannosauridae (the derived subclade including colossal forms >10 meters in length), and a tyrannosaurid position for the long-snouted alioramins. Few taxa in the phylogeny, however, are from the critical mid-Cretaceous interval. New cranial material from the Turonian (ca. 94-90 Ma) Bissekty Formation of Uzbekistan provides an unprecedented look at a tyrannosauroid from this gap. Small basal tubera and a diamond-shaped ventral process of the supraoccipital demonstrate its close affinities with *Xiongguanlong*, from the Aptian-Albian of China. CT-based reconstruction shows that it has a foreshortened endocranium with an enlarged cerebrum, more like a maniraptoran than the elongate S-shaped endocasts of derived large-bodied tyrannosaurids. The new Uzbek fossils, the phylogeny, and recent study of allosauroids from the mid-Cretaceous of Asia and North America paint an emerging picture of the mid-Cretaceous theropod turnover and the rise of tyrannosauroids. Tyrannosauroids spent the first ~80% of their history mainly as small-to-mid-sized predators, lived alongside larger allosauroids deep into the mid-Cretaceous, and then relatively suddenly assumed large size and ecological dominance around the beginning of the Campanian, but only in Asia and North America, as other groups filled the top predator role in Europe and the southern continents.

Grant Information
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Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

THE VERTEBRAL COLUMN OF ODONTOCETE CETACEANS: THE EVOLUTION OF DEVELOPMENT

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Terrestrial mammals are diversely adapted to many environments, but the organization of their vertebral columns varies within tight limits. The uniform presence of five vertebral series or modules, each with distinctive morphology and count, indicates the existence of developmental constraints on the evolution of the vertebral column. The earliest whales must have inherited the component column series and developmental constraints of their terrestrial ancestors. The Eocene transition from limb-based to axial-oscillatory locomotion by archaeocetes was marked by the loss of the sacral series and by the origin of the fluke. The post-Eocene modification of the cetacean vertebral column was in many ways as radical as that of archaeocetes. We tested the hypothesis that neocetes exhibit a reorganized column with a combined torso (= lumbar + anterior caudal) developmental module. We evaluated seven major odontocete subgroups for patterns of centrum shape and length, meristic increase and decrease, and growth during ontogeny. Fetal vertebrae are sub-equal in length, but become regionally differentiated during ontogeny. Transitions in growth rates between adjacent regions reflect boundaries of developmental environments, and thus of modules. We used segmented regression to identify developmental / modular boundaries at different ontogenetic stages. Sequential increases in the number of breaks allowed the identification first of the primary division of the column, and then of subsidiary units. Surprisingly, shape, count, and growth analyses indicate that mysticetes, physeterids, and ziphiids retain archaeocete column patterning: the primary column subdivision is at the precaudal / caudal boundary. In contrast, delphinids have a midcolumn torso module with an inverse relationship between count and centrum length, suggesting the independence of somitogenesis and body axis patterning. This innovation may have been critical to conserving the postcranial dimensions typical of oceanic cruisers, an overt example of 'the control of development by ecology.' A subset of derived delphinids additionally exhibits a novel prefluke module in the tail.

Grant Information
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Technical Session X (Friday, October 16, 2015, 8:30 AM)

EVOLUTION OF THE FORELIMB MUSCULATURE IN EARLY THEROPODS: EVIDENCE FOR THE ACQUISITION OF NEW PREDATION STRATEGIES

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The bauplan of early theropods–small-bodied, carnivorous bipeds–has been thought to characterize the common ancestor of all dinosaurs as well as many non-dinosaurian dinosauromorph taxa. However, discovery of new dinosauromorph taxa and ambiguity in the phylogenetic position of some early dinosaurs (e.g., *Eoraptor*) has caused uncertainty in the primitive diet of dinosaurs and suggested the possibility that omnivory characterized the early history of the clade. Although diet is usually inferred based on craniodental morphology, the forelimbs of bipedal early dinosaurs and non-dinosaurian dinosauromorphs also may have had an important role in food acquisition. To investigate the functional evolution of the forelimbs, phylogenetically-based reconstructions of the musculature were used in combination with close examination of the osteology to compare patterns of the muscular and bony morphology among early dinosaurs and non-dinosaurian dinosauromorphs. Many similar features characterize the forelimb musculature of early dinosaurs and non-dinosaurian dinosauromorphs, suggesting that they likely shared similar functional roles relating to food acquisition, grooming, or intraspecific interactions. However, early theropods exhibit improved mechanical advantage of the humeral extensors compared to that found in more basal taxa, which likely reflects adaptations for the apprehension of large prey relative to their body size. This trend is continued among more crownward taxa (e.g., *Dilophosaurus* and basal tetanurans), which exhibit increasing robustness of the musculature and joints associated with specializing in large prey. Although they possess some features relating to large prey capture, the earliest theropods (e.g., *Tawa*, coelophysoids) also retained gracile limbs and a higher degree of freedom at the joints of the forelimb, which are features suited for the capture of smaller, more agile prey. The presence of intermediate characteristics in the forelimbs of these taxa indicates that they were mixed-prey specialists, just beginning to acquire the ability to take on larger prey. Furthermore, the distribution of muscular characters in the forelimbs of other early dinosaurs and non-dinosaurian dinosauromorphs is consistent with a specialization in the capture of small prey relative to their body size, whether exclusively as carnivores or as a portion of an omnivorous diet.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

THE SYSTEMATIC POSITION OF THE SABER-TOOTHED AND HORNED GIANTS OF THE EOCENE: THE UINTATHERES (ORDER DINOCERATA)

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Ever since their discovery in the American West in 1871, the saber-toothed horned uintatheres, belonging to the order Dinocerata have defied placement on the mammalian tree. Previous researchers have suggested a wide range of relationships to insectivores, rodents, condylarths, proboscideans, pantodonts, and South American xenungulates. Utilizing a large dataset of characters downloaded from Morphobank, the two best known Middle Eocene uintatheres species *Uintatherium anceps* and *Eobasileus cornutus* were added to a large character matrix of 4,541 morphological characters sampled across 86 other mammalian taxa. Parsimony analysis was performed using nearest-neighbor interchange in Mesquite, as well as search algorithms using TNT to find the most parsimonious placement of Dinocerata among other mammals.

Uintatheres were found to be most closely related to the xenungulate *Carodnia vieirai* (together as Uintatheriamorpha). If the molecularly supported Afrotheria clade is held together, Uintatheriamorpha is positioned within Laurasiatheria (Liptyphla, Pholidota, Carnivora, Perissodactyla and Cetartiodactyla) excluding Chiroptera. The most parsimonious tree using TNT search algorithms split the Afrotheria clade across Mammalia, and resulted in the placement of rodents, proboscideans, hyraxes and sirenians among a polyphyletic ungulate clade including uintatheres. In light of molecular data for living mammals, Uintatheres were found within a monophyletic ungulate clade and not closely related to Afrotheria. The Early Paleocene North American *Protungulatum donnae* is considered the most primitive member of a monophyletic clade that includes Condylarthra, Meridiungulata, Dinocerata + Xenungulata, Perissodactyla, and Cetartiodactyla. Morphological similarities between proboscideans, sirenians and uintatheres are likely convergent adaptations. Uintatheres group within other mesoaxial-grade ungulates, including perissodactyls, phenacodont condylarths, and South American ungulates, suggesting an interchange between North and South America during the Early Paleocene, and isolation of Africa. Uintatheres share the following synapomorphies with other mesoaxial ungulates: 1) presence of hooved distal phalanges, 2) weight bore principally by third metacarpal as central axis of the fore and hind foot, 3) loss of the centrale bone (with no indication of fusion with scaphoid), and 4) lack of a deep cotylar fossa on the astragulus. The nearest living relatives of uintatheres are rhinos, horses and tapirs.

Colbert Prize (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

DENTAL MICROWEAR ANALYSIS IN SOUTH AFRICAN RODENTIA AS AN ENVIRONMENTAL PROXY

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Dental microwear has proven useful for reconstructing the diets and paleoenvironments of extinct mammals. Yet, few studies have focused on separating the effects of food and environ on microwear patterning. To better understand these effects, we selected three sympatric species with differing diets, all commonly found throughout Lesotho and the Free State Province of South Africa, to see if the specific diets of these rodents remain independent within the microwear from other environmental influences, such as exogenous grit. In particular, we looked to see whether (1) dietary differences between taxa within a specific locality can be observed in the microwear; (2) differing environmental factors play a role in microwear pattern; and (3) seasonality is reflected in microwear signal. Using a blue-light scanning confocal profiler, we examined the lower second molars of *Mastomys coucha* (n = 37), *Micaelamys namaquensis* (n = 45), and *Rhadomys pumilio* (n = 57) specimens from the Nama-Karoo Shrublands, Dry Highveld Grasslands, and the Lesotho Highlands at 150x magnification for the presence of microwear on the occlusal surfaces. Scale-sensitive fractal analysis (SFFA) methods were then applied to obtain quantitative data for statistical comparisons: a general linear model was used with species, diet, and habitat as the factors and SFFA attributes (rank-transformed data) as the variables. Multivariate tests indicated significant differences in microwear textures between species within given habitats. There was also significant variation between environments for both the *M. coucha* and *M. namaquensis* subsets. In particular, specimens from the Dry Highveld Grassland, in which plant coverage remains relatively uniform despite season, stood out from the more variable regions analyzed (Karoo and Lesotho). Individual analyses of variance and pairwise comparisons were used to identify the specific sources of significance as needed. A sampling bias restricted seasonal analysis to the *R. pumillio* and grassland samples, and no significant variation was found within this limited sphere. Overall, results suggested that for these rodents, microwear varies by physical environment, but this effect does not swamp diet-related differences. Studies such as ours are capable of parsing the different effects, suggesting that rodent dental microwear can be an effective environmental proxy and can provide insights into the paleoecology of micromammals.

Technical Session VII (Thursday, October 15, 2015, 1:45 PM)

INTRASPECIFIC VARIATION IN LATE CRETACEOUS NODOSAURIDS (ANKYLOSAURIA: DINOSAURIA)

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Sources of morphological variation (dimorphism, individual variability, ontogeny, and pathology) can obfuscate taxonomic variation. This is true for Late Cretaceous nodosaurid ankylosaurs, for which several complete, well-preserved skulls and postcrania are known. Although a generalized taxonomy has been accepted for about 25 years, new specimens show mixtures of features considered diagnostic for more than one taxon. Because these taxa are well-accepted and overlap temporally and geographically, they are

good candidates for testing intraspecific variation in dinosaurs. This was done by quantitatively testing taxonomic characters a priori with bivariate and clustering analyses. A character-specimen matrix was coded for a parsimony analysis to aid in taxonomic referrals. Because many phylogenetic characters are based on relative proportions or shapes, taphonomic distortion is problematic for this group. Nevertheless, four taxa are valid: *Edmontonia longiceps*, *E. rugosidens*, *Panoplosaurus mirus*, and *Denversaurus schlessmani,* the latter two more derived. Compared to contemporaneous North American ankylosaurids, nodosaurid taxa do not correlate as well with their stratigraphic distribution. A posteriori character analysis reveals that *Panoplosaurus* has a shortened skull and rounded cervical/pectoral osteoderms. *Denversaurus* and *Panoplosaurus* share inflated cranial sculpturing with visible sulci between individual elements. *Denversaurus* has a relatively wider anterior snout. The clade shows some overall evolutionary trends: doming of the skull over the orbits, thickening of the vomer and closure of prevomer foramen, encroachment of sculpturing over the anterior temporal bar, shortening and widening of the snout, etc. Use of proportional character data is common in dinosaur systematics, often subjectively. This study demonstrates that quantitatively testing such characters increases their repeatability and clarifies taxonomic decisions.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

ENAMEL PATTERNS AND SURFACE MORPHOLOGY OF THE LOWER FIRST MOLARS OF *LEMMISCUS CURTATUS* (RODENTIA: ARVICOLINAE)

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Fossils of arvicoline rodents frequently are used as biostratigraphic and biochronologic tools in Pleistocene sediments. The justification for their use in biostratigraphy is their inferred rapid morphological evolution that results in a distinctive dental morphology that permits species-level identifications in fossil deposits. The sagebrush vole, *Lemmiscus curtatus*, has a diagnosable lower first molar morphology that permits assessment of the molar evolution through the Pleistocene. However, morphologic features of the dentition can be difficult to adequately assess, because the different character states are not necessarily discrete. Likewise, the characters are almost impossible to score on specimens that have broken occlusal surfaces. Some researchers previously used the unbroken, unerupted, ventral portion of the rootless molars to assess these characters, but it is not clear if such an approach is justifiable. We used microCT scans in combination with two-dimensional (2D) morphometrics to assess the differences between occlusal surfaces and unerupted ventral surfaces of lower molars, from both fossil and extant specimens of *L. curtatus*. Our 2D morphometric approach uses 10 landmarks as anchor points and 80 sliding semi-landmarks that are evenly spaced to form an outline of the tooth. The results of the 2D approach indicate that occlusal and ventral morphologies each have distinct mean morphotypes, although there is minor overlapping of occlusal and ventral surfaces in morphospace. Morphological disparity is highest for the unerupted ventral surfaces, but overall disparity is similar between occlusal and ventral surfaces. Higher disparity for ventral morphologies indicates that assessing ventral surfaces may suggest a different evolutionary signal than that portrayed by the occlusal surface. It is not yet clear the degree to which diagnostic features vary both on the occlusal or ventral surfaces. Based on a limited sample size our current interpretation is that it may be necessary to use the ventral surface to assess discrete morphological characters thought to be diagnostic of *Lemmiscus*. These preliminary results underscore a need for a larger sample size and continued work to include data from mid-molar and 3D morphometrics in order to adequately assess the discrete features of the molars and the total range of potential variation found in *L. curtatus*.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

A CAMPANIAN-AGED LACUSTRINE DEPOSIT ON A VOLCANIC MAAR IN THE AGUJA FORMATION, BREWSTER COUNTY, TEXAS

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A pond/lag deposit atop a volcanic maar deposit, near the Aguja/Javelina (Campanian/Maastrichtian) contact, just north of Big Bend National Park (72.6 ± 1.3 Ma) has yielded fragmentary, though abundant, turtle, dinosaur, mollusk (gastropod and bivalve), gar, and wood material. The fossils occur as either as a surficial lag or are embedded in several centimeter thick lamina only in the uppermost 0.20 meters of the 12 meter thick eruptive sequence. The maar deposit is thinly bedded (ca. 0.5 to 2.0 cm) pyroclastic debris containing poorly to moderately vesicular, angular, olivine, and plagioclase basaltic ash and lapilli intermixed with sand- and mud-sized Aguja lithic fragments. Pond sediment was already cool when the fossils were originally buried and was likely derived from a more distant eruptive center. The co-occurrence of turtle bone, wood, gar scales, bivalves, and gastropods suggests that a pond formed at the top of the 'last' eruptive sequence where skeletal material and wood were reworked into the uppermost beds. Over 95% of the plant material recovered is palm wood, but silicified/carbonized dicot twigs are present. Highly weathered dinosaur long bone fragments (none larger than 12 x 5 cm) and a single ceratopsian(?) sacral centrum have been found, constituting < 5% of the recovered bone.

Though lacustrine deposits have been described from the Aguja and Javelina Formations before, this exposure is highly atypical as it is associated with a maar eruptive sequence and the exposures are so spatially restricted that it does not demonstrate 'standard' lacustrine facies. Similar, though younger, eruptive maar deposits occur further south in Big Bend National Park at Peña Mountain but what may be lacustrine facies have no fossils.

Chelonians are represented by carapace and plastron fragments, none larger than 7 x 5 cm with few smaller than 2 x 2 cm. Taxa identified include different species of *Aspideretes*, *Baena*, *Bothremys, Basilemys*, and *Adocus*. Other taxa may be present but have not yet been identified. None of the fragments appear to have bite marks. Unlike the extremely weathered dinosaur bone, all turtle bone appears freshly broken and has not undergone transport. All mollusk and plant material also appears to have been deposited in situ.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

PRELIMINARY OSTEOHISTOLOGY OF THE TYPE SPECIMEN OF *NIOBRARASAURUS COLEII* (DINOSAURIA: NODOSAURIDAE) AND COMPARISON WITH POTENTIAL JUVENILE MATERIAL

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Osteohistology has become a powerful tool in determining the metabolism and life histories of many extinct species. There are several instances where a taxon has been shown to be a distinct growth stage of an altogether different taxon. However, few studies have investigated the osteohistology and ontogeny of nodosaurids due to the fragmentary, isolated nature of many nodosaur fossils. This study presents new research into the bone histology and ontogeny of nodosaurids by examining the known specimens of *Niobrarasaurus coleii* (Dinosauria: Nodosauridae) from the Late Cretaceous Smoky Hill Chalk of Kansas. The osteohistology of representative elements from the type specimen are compared to a second specimen to study possible ontogenetic differences. The type specimen, FHSM VP-14855, is represented by four nearly complete limbs, most of the pelvic girdle, and numerous associated osteoderms. The second specimen (FHSM VP-13985) consists of only the right radius and ulna of an individual half the size of the type. Based on the smaller size alone, previous studies refer to FHSM VP-13985 as a juvenile *N. coleii*. The elements selected for the description of the type specimen osteohistology are the radius, ulna, humerus, femur, tibia, and an osteoderm. The radius and ulna of FHSM VP-13985 were also selected to determine if there are ontogenetic differences between the two specimens. Initial cuts of the ulna and radius of FHSM VP-13985 show a well-defined compact cortex with cancellous bone in the medullary cavity. The ulna has particularly cancellous, fragile bone in the medullary cavity, while the radius has a larger, permineralized medullary cavity. The FHSM VP-14855 ulna shows solid bone through the midshaft. This may be a result of the bone being laterally crushed or an indication that the FHSM VP-14855 ulna was much more ossified than the FHSM VP-13985 elements. These preliminary cuts indicate a definite difference between the two specimens. Further investigation will focus on the shape and density of vascular canals, specific bone tissue, and growth marks to elucidate the ontogeny of *N. coleii*. This will contribute to the understanding of nodosaurid osteohistology in general and lends support to using this technique to determine species relationships and taxonomic placement.

Grant Information
Western Interior Paleontological Society - Karl Hirsch Memorial Grant, Pending - Kansas Academy of Science - Student Research Grant

Technical Session X (Friday, October 16, 2015, 10:15 AM)

DICHOTOMOUS EVOLUTION OF TOOTH GROWTH AND REPLACEMENT STRATEGIES IN HERBIVOROUS DINOSAURS

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Herbivory evolved multiple times in Dinosauria, albeit through different adaptive pathways. Ornithischian and saurischian clades, such as iguanodontians, ceratopsids, and sauropodomorphs, independently developed complex dental batteries and exhibit phylogenetic trends of increasing tooth replacement rate to accommodate greater reliance on dentition. Therizinosaurians, a clade of coelurosaurian theropods, also exhibit ecomorphology consistent with facultative herbivory, yet computed tomographic imagery and gross observation of in situ replacement teeth suggests an alternate strategy of reduced reliance on dentition for food processing. Here we assess tooth growth and replacement rate in Therizinosauria using von Ebner lines in dentin and lines of incremental growth (LIG) in the enamel of early diverging and specialized therizinosaurians. LIGs have been identified as circaseptan growth lines analogous to daily lines in dentin, and despite exceptional microstructural preservation in enamel, no direct comparisons of replacement rates have been made between these tissues. Our study tests the efficacy of LIGs as suitable indicators of relative tooth replacement rates in theropod dinosaurs and contrasts the tooth replacement strategy of Therizinosauria with that established for other herbivorous dinosaurs.

We sampled isolated teeth of the basalmost therizinosaurian *Falcarius utahensis*, as well as a probable dentary tooth of *Suzhousaurus megatherioides,* a large-bodied, specialized therizinosauroid. We made three thin sections from each tooth, imaged the slides using a Nikon Eclipse Ci-POL petrographic microscope, then vacuum-coated the slides with roughly 5 nm of Au-Pd to aid in conductance and reimaged using a Jeol JSM-6010LA scanning electron microscope. Clearly defined LIGs are distributed throughout the teeth of both taxa. Mean increment width is 6.4 µm in *Falcarius* and 1.7 µm in *Suzhousaurus*. Based on LIG density and number, tooth growth and replacement rate was slower in *Suzhousaurus* than in *Falcarius*, even when accounting for crown volume. Our data indicate that reduced reliance on oral food processing is a strategy adopted early in the evolutionary history of Therizinosauria and that intensified in at least some specialized members. Gross observation of dentition in ornithomimosaurs and oviraptorosaurs suggests reduction of replacement rates is widespread in theropods occupying the omnivory/herbivory spectrum and correlates with the repeated evolution of rhamphothecae in the avian line.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

MODELING ECOLOGICAL ASSOCIATIONS AND HABITAT PREFERENCES OF HORNED DINOSAURS: A CASE STUDY USING THE CERATOPSIAN FOSSIL RECORD

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In our continuing endeavors to understand the role ecology plays in evolution, we have incorporated taxon-free (trait-based) approaches to understand the environmental context in which novel morphologies evolved. While these approaches have been

primarily employed for recent or extant species, the methodologies can also be utilized for similar studies of extinct lineages through deep time where there is a robust fossil record, relatively well-resolved phylogeny, and well-described environmental characteristics of occurrence formations. In this project, I am testing for environmental associations among the Ceratopsia. Ceratopsians represent a diverse group of dinosaurs that spread across the northern hemisphere during the Cretaceous, attaining their maximal taxonomic and morphologic diversity during the Campanian. The coexistence of both basal small-bodied taxa and derived large-bodied taxa in North America raises intriguing questions about ecological segregation and habitat preference. I created a comprehensive database of fossil occurrences (49 genera) from the Paleobiology Database and a review of primary literature. I then created a rank-index for three environmental variables: temperature (1 = cooler to 6 = tropical), precipitation (1 = arid to 6 = humid/wet), and paleoenvironment (1 = coastal to 5 = upland/inland) based on published interpretations of dinosaur-bearing formations (DBFs). A specimen occurrence was scored for each variable based on its presence in a given DBF and an abundance-average was taken for each genus. Results indicate significant differences between chasmosaurines, centrosaurines, and basal ceratopsians for temperature ($p = 0.02$), precipitation ($p = 0.0002$), and paleoenvironment ($p = 0.003$). Chasmosaurine ceratopsids had a preference for wetter, coastal habitats while the smaller-bodied basal ceratopsians preferred drier, more inland habitats, and centrosaurines preferring cooler temperatures, but more intermediate in terms of environment and precipitation. These results provide the framework for testing additional macroevolutionary hypotheses because they present a model of ecological context for these organisms and whether or not morphological traits (e.g. horns and frills, dentition) or other features (e.g., body size) evolved in response to changes in the environment.

Technical Session I (Wednesday, October 14, 2015, 8:15 AM)

NO BONE UNTURNED: DETECTING HARD TISSUE SYNAPOMORPHIES FOR BOVIDS (ARTIODACTYLA, MAMMALIA) THROUGH TOTAL EVIDENCE ANALYSES OF MORPHOLOGY AND MITOCHONDRIAL, NUCLEAR, AND ANCIENT DNA

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Great effort has recently been made toward understanding the effects of the frequent lack of soft tissue preservation during fossilization on phylogenetic inference, but the paucity of hard tissue morphological synapomorphies for some clades has led to preferential use of soft tissue or molecular characters to infer relationships. In the Artiodactyla, family membership is often determined by presence of a particular type of cranial appendage (e.g., horns, antlers, ossicones, or pronghorns), making it difficult to resolve the position of fossil taxa when the appendages are not preserved or when taxa lack cranial appendages entirely. This has resulted in an emphasis on molecular data in artiodactyl phylogenetics and the consequent exclusion of the many known fossil taxa from these analyses. For Bovidae, a diverse artiodactyl clade that radiated rapidly in the Miocene, analyses using hard tissue characters alone have produced many conflicting proposed relationships. To determine if hard tissue synapomorphies for bovids can be identified on a well supported phylogeny, I performed a total evidence analysis of 134 morphological characters, 11 nuclear genes, and complete mitochondrial genomes for 138 bovids (including four fossil taxa, two of which are represented by mitochondrial ancient DNA), representing one of the largest samplings of Bovidae and using the most comprehensive dataset in a single analysis to date. Only two hard tissue characters were uncovered as synapomorphies for all Bovidae, but several hard tissue synapomorphies provided strong morphological support for the monophyly of several bovid tribes, such as a lack of contact between the premaxillary and the nasal bones in Reduncini and an absent or small metastyle on the third molar in Caprini. This integrative phylogeny substantially improves on past efforts to determine interrelationships of the bovids through the combination of morphology with mitochondrial and nuclear DNA from extant and extinct taxa. Identifying hard tissue morphological characters that serve as bovid synapomorphies is an essential step toward assigning enigmatic or incomplete fossils to the correct group and for incorporating more fossils in phylogenetic studies, which are key improvements in building accurate phylogenies to study evolution in this diverse, ecologically important clade.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

FIRST EVIDENCE OF A SMOOTH-INCISOR SICISTINE (RODENTIA: DIPODIDAE) IN NORTH AMERICA FROM THE CABBAGE PATCH BEDS OF WESTERN MONTANA

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Sicistine rodents (birch mice), relatives of the extant Eurasian *Sicista*, are found throughout western North America during the Oligo-Miocene. The arrival of *Plesiosminthus clivosus* in North America from Asia marks the beginning of the Arikareean North American Land Mammal 'age'. The paraphyletic genus *Plesiosminthus* (including *Schaubemys* but not *Megasminthus*) is currently the only known genus of Sicistinae in the Arikareean of North America. This small brachydont rodent is diagnosed in part by a grooved upper incisor. Several isolated grooved incisors from Colorado, South Dakota, and Nebraska have been referred to *P. clivosus,* whose cheek teeth have been found at the same localities as these incisors. The Arikareean-aged Cabbage Patch (CP) beds of North America (Renova Formation) preserve a very large sample (over 100 specimens) of sicistines teeth and partial jaws representing at least two taxa as evidenced by both cheek teeth and upper incisors.

In addition to numerous grooved incisors recovered throughout the beds, one exceptional specimen, which includes the associated remains of at least three individuals, preserves smooth incisors associated to upper cheek teeth along with several complete lower dentitions, partial skulls, and postcranial elements. The cheek teeth of this specimen are morphologically very similar to those of *Plesiosminthus clivosus*. They differ only in the position of the anteroconid of the lower first molar. Our phylogenetic analysis of sicistines including *P. clivosus* and the CP material supports the hypothesis that the CP material is not a member of the genus *Plesiosminthus* by lacking the groove of the upper incisor, an unambiguous synapomorphy for the genus. The CP specimen falls as the sister taxon to the genus with which it shares a similar morphology of the anteroloph of the upper first molar. The CP material also differs from *Parasminthus*, a small smooth-incisor sicistine known from Eurasia, by the absence of a double protoloph and a posterior concavity between the hypocone and posteroloph of the upper molars. The presence of a new sicistine taxon bearing smooth-incisors suggests an additional immigration from Asia to North America during the early Arikareean and brings into question the systematic affinities of *Plesiosminthus clivosus*.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

A NEARLY COMPLETE SPECIMEN OF *HYPOSAURUS ROGERSII* (CROCODYLOMORPHA, DYROSAURIDAE) FROM THE LATE CRETACEOUS-EARLY PALEOGENE OF NEW JERSEY

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The longirostrine crocodylomorph *Hyposaurus rogersii* is the only dyrosaur known from North America. Partial remains have been recovered only from the Maastrichtian-Paleogene Hornerstown Formation of New Jersey and the age equivalent basal Clayton Formation of Alabama. Most of the *H. rogersii* material previously collected has consisted of isolated bones, although a few associated remains of partial skulls, vertebrae, limb elements and osteoderms have been recovered.

In the autumn of 2011, a team from the New Jersey State Museum collected the most complete skeleton of *H. rogersii* ever recovered. It was excavated from the basal Hornerstown Formation at the classic Inversand locality in Gloucester County, New Jersey. The closely associated but un-articulated remains allow, for the first time, a full description of the morphology of *H. rogersii*. The specimen (NJSM 23368) consists of a nearly complete skull and mandible including 29 whole or partial in-situ teeth. The axial skeleton includes the proatlas, atlantal neural arch pedicles, axis with odontoid process, and 4 additional cervical vertebrae. Also recovered were 12 dorsal, 1 sacral and 13 caudal vertebrae, 9 cervical and 26 thoracic ribs, 6 haemal arches and numerous small fragments of gastralia. The appendicular skeleton includes the left scapula, coracoids, humeri, radii, ulnae, ischia, ilia, pubes, femora, tibiae, and fibulae. Additional appendicular bones include radiales, calcanei, left astragalus, 7 metapodials and 16 phalanges including a single ungual. Additionally 73 osteoderms were recovered. The preservation is exceptional, and both skull and mandible have been physically reconstructed in the lab, using Paraloid B-72 in acetone as adhesive and consolidant. The only major elements missing from the skull are the left premaxilla, the anterodorsal portion of the left maxilla and the palatines.

Of particular interest is a prominent area of damage on the ventral right dentary, between the fourth and fifth alveoli, suggestive of a puncture. The medial edge of the puncture is tangential to the mandibular symphysis, and the cavity measures 1.7 cm long, 1.1 cm wide and 1.3 cm in depth. Several crocodylomorphs and at least two species of chondrichthyan are known from the Hornerstown Formation that could have produced a bite mark of this magnitude. Since there are no other bite marks or signs of scavenging on the bones, this puncture and the missing anterior left maxilla suggest a fatal defensive wound that pierced and fractured the dentary and shattered the maxilla.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

FAUNAL ANALYSIS OF THE RECENTLY DISCOVERED EOCENE BACTRIAN HILL, REPO MAN AND ROSE CREEK LOCALITIES OF THE CYPRESS HILLS FORMATION, SASKATCHEWAN, WITH ADDITIONS TO SWIFT CURRENT CREEK LOCALITY

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Three recently discovered localities in the Cypress Hills Formation (CHF) provide new information about the Eocene–Oligocene transition (about 33.9 million years ago). This interval is characterized by a shift from warm, humid conditions to cooler and more arid conditions. The invasion of grasslands and a loss of forest cover worldwide is strongly associated with increasing aridity. Mammals in the CHF from this interval are poorly studied, with many known only from isolated teeth and fossil assemblages isolated to areas that lack superposition. Although fossils from the late Eocene and early Oligocene from CHF were first discovered in 1833, fieldwork has been somewhat limited, with little work conducted during the last 30 years. Recent efforts, however, have resulted in the discovery of several new late Eocene localities including the Bactrian Hill, Repo Man, and Rose Creek localities. There have also been new additions made to the well-studied middle Eocene Swift Current Creek locality, which include mammals such as *Centetodon* cf. *C. aztecus*, *Didelphodus serus, Domnina* sp., *Herpetotherium innominatum, H. marsupium, Ibarus ignotus, Janimus mirus, Metanoiamys fugitivus, Microparamys solidus, Nyctitherium serotinum*, *Peradectes californicus, Scoricidae* sp. and *Wallia scalopidens* that support a Uintan age for this locality. The twelve mammals identified from the Bactrian Hill locality include *Adjidaumo* sp., *Heliscomys hatcheri*, *He. ostranderi*, *He. vetus*, *Leptomeryx* sp., *Leptomeryx* cf. *L. yoderi*, *Lepotomus* sp., *Leptictis haydeni*, *Leptictis* sp., Leptictidae sp. indeterminate, *Prosciurus relictus* and *Sciurus vetustus*, and indicate a Chadronian age for this locality. Furthermore, as *P. relictus* has not been found in Chadronian assemblages before, this may extend the known range of this species. Taxa found at Rose Creek correlate to a middle Chadronian age, and include *Agnotocastor praetereadens, Ardynomys occidentalis, Centetodon chadronensis, Cylindrodon galbreathi, Heliscomys ostranderi*, *H. hatcheri, Megalagus brachyodon, Palaeolagus temnodon* and *Paradjidaumo trilophus*. Discoveries from the

Repo Man locality include *Adjidaumo minutus*, *Domnina gradate, Heliscomys vetus*, *Paradjidaumo trilophus* and *Leptomeryx* sp. These taxa indicate a Chadronian or Orellan age for this locality. Collectively, these discoveries provide a better understanding of the patterns of mammalian evolution across the Eocene-Oligocene boundary in Saskatchewan, and have extended the ranges of several taxa that were previously unknown in these ages.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

EVOLUTIONARY TRENDS IN *VAGACERATOPS* (ORNITHISCHIA: CERATOPSIDAE) AND THE STATUS OF *KOSMOCERATOPS* IN THE UPPER CRETACEOUS (CAMPANIAN) DINOSAUR PARK FORMATION OF ALBERTA

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Chasmosaurinae spans the entire depositional history of the Dinosaur Park Formation (DPF) of Alberta, and currently includes *Chasmosaurus belli*, *C. russelli, Vagaceratops irvinensis*, *Mercuriceratops gemini*, and *Pentaceratops aquilonius*. The addition of the latter two taxa in 2014 significantly increased the known diversity of this subfamily in the DPF.

The previously referred *C. belli* skull YPM 2016 has a straight posterior frill margin adorned with 10 epiparietals (EPs). This suite of characters is diagnostic of *V. irvinensis*, whereas other *Chasmosaurus* specimens have a variably embayed margin adorned with 6 EPs. However, YPM 2016 differs from *V. irvinensis* specimens in that its four medial EP pairs (EP1–4) are dramatically shorter, and its parietal fenestrae are relatively longer. These morphological differences are here interpreted as representing evolutionary change within *V. irvinensis*, as YPM 2016 is approximately 300 000 years older, occurring in the lowermost Dinosaur Park Faunal Zone (DPFZ 1), while other specimens of this taxon are from the uppermost zone (DPFZ 3). The rugose mounds above the orbits in YPM 2016 and other *V. irvinensis* specimens (CMN 41357 and TMP 1987.045.0001) are also here interpreted as representing resorbed postorbital horncores, as similar structures occur in mature specimens of *C. belli*.

Kosmoceratops sp. is purportedly represented in the DPF by a specimen previously referred to *Chasmosaurus* sp. (CMN 8801). This referral was based on their shared possession of a weakly hooked rostral, a posteriorly inclined narial strut, a ventrally-restricted septal flange, a triangular-shaped triangular process, a posteriorly situated nasal horncore, and a completely roofed-over frontoparietal fontanelle. The shape of the rostral, inclination of the strut, and position of the horncore in CMN 8801 are all within the range of variation of other *Chasmosaurus* specimens, and are likely attributable to individual differences. The septal flange and triangular process in CMN 8801 are incompletely preserved, but would have been more dorsally expansive and square-shaped, respectively, as in *Chasmosaurus*. Finally, CMN 8801 does possess a transversely expansive frontoparietal fontanelle, as in *Chasmosaurus*, but it is infilled with sediment. Therefore, we conclude that *Kosmoceratops* is not represented in the DPF, but is instead restricted to southern Laramidia (Utah). Current chasmosaurine diversity in the DPF appears to have been overestimated.

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Technical Session XII (Friday, October 16, 2015, 9:45 AM)

RE-EVALUATION OF *APHANIZOCNEMUS LIBANENSIS* - TO BE OR NOT TO BE A DOLICHOSAUR

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Aphanizocnemus libanensis is a small monotypic lizard from platy limestones deposited in patch reef lagoons stretching across the Tethyan platform from North Africa to Europe (Cenomanian; Upper Cretaceous). The sole specimen is articulated and nearly complete, though the skull was destroyed during collection. The original description placed the taxon within the Varanoidea as a member of the aquatic Dolichosauridae. Re-examination suggests that characters cited as supporting varanoid-dolichosaur affinities are misinterpreted, i.e., an intramandibular joint, a character diagnostic of pythonomorphs (the group including the Dolichosauridae, Serpentes and the Mosasauria), is actually a break in the dentary associated with the considerable damage to the skull. The single frontal omits this animal from the Varanoidea, which have paired frontals, and the shape of the frontal-nasal suture indicates that the nasals are broad and robust, unlike the splint-like condition seen in dolichosaurs. In addition, though we recognize variability in the shape of the parietals of dolichosaurs, the exceptionally large parietal of *Aphanizocnemus* is far wider and more extended than seen in any dolichosaur, which have posteriorly narrowed parietals far longer than they are wide. The morphology of the scapulocoracoid (rounded, semicircular) and the neural spines (low, posteriorly directed) are common to many squamates, and like many other features of the specimen, i.e., the unfused, simple girdles; the reduced, flattened limbs; the shorter hind limb; and the poorly ossified tarsus, are likely tightly linked to aquatic adaptation. The hallmark feature of the specimen is the strongly regressed tibia, which is short and flat, with unclear articular surfaces. Limb reduction is a characteristic of the Pythonomorpha, but it is also common to numerous families within Squamata, including the Scincomorpha. We hypothesize here that the genus *Aphanizocnemus* is not a varanoid, nor in fact an anguimorph, but may represent a new form of aquatic scincomorph, a group not previously recognized as having evolved aquatic adaptations.

Technical Session VI (Thursday, October 15, 2015, 10:30 AM)

ECOLOGICAL AND PHYLOGENETIC CONSTRAINTS ON THE DENTAL MORPHOLOGY OF SHARKS

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One of the major appeals of investigating disparity dynamics in the fossil record, compared to traditional assessments of taxonomic richness, is predicated on the assumption that morphology is ecologically relevant. However, this assumption is rarely tested, largely because direct extant comparators are often difficult to identify, resulting in ambiguous and unconstrained links between morphology and ecology (ecomorphology). Here we adopt modern sharks (Selachimorpha) as a model to explore the ecological (dietary) and phylogenetic nature of dental variation. Based on a dietary dataset of 150 extant sharks, including information on the relative importance of different dietary components from gut contents (e.g., fish, cephalopods, and marine mammals) and a geometric morphometric analysis of dental shape (n=42; upper toothrow), we apply a series of multivariate and phylogenetic comparative approaches to test whether feeding ecology served as a primary driver of selachimorph dental morphology.

Ordination of diets based on a correspondence analysis reveals major axes of variation related to molluscivory and zooplanktivory. Third and fourth axes partition diet in relation to the size of both the predator and prey (large vertebrates vs. small invertebrates). Correlation with shark size was robust even within a phylogenetic context ($p<<0.05$), indicating a role of body size in partitioning some shark diets. Over 95% of the morphometric variation could be explained in six (of 41) axes. Despite a strong phylogenetic signal in several of the dietary and morphometric axes, both standard and phylogenetic canonical correlation analyses recovered significant associations between diet and morphology. Broad teeth infer a dietary preference for large vertebrates, pointed and/or multicusped implicate zooplanktivory, and some feeding on cephalopods, and lower-crowned teeth indicate a predisposition towards harder food-types (e.g., molluscs and crustaceans). Pending further data collection, the recovery of such correlations question the long-held notion that sharks are feeding generalists and demonstrate that shark dental morphology is an indicator of diet, particularly when compared to body size. Phylogeny, although associated with all data-types, does not diminish the ecological signal thereby supporting the hypothesized causal relationship between feeding ecology and morphology, with major implications for reconstructing ecological diversity patterns across the 400 million years of shark evolution.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

NEW INFORMATION ABOUT THE ANATOMY AND PHYLOGENETIC RELATIONSHIPS OF *SKORPIOVENATOR BUSTINGORRYI* (THEROPODA, CERATOSAURIA) FROM THE UPPER CRETACEOUS OF NEUQUÉN PROVINCE, PATAGONIA, ARGENTINA

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Skorpiovenator bustingorryi (MMCh PV 48) from the Huincul Formation (Cenomanian) of Neuquén province, Patagonia, Argentina is one of the best-represented abelisauroid theropods ever found. After years of technical preparation, we conducted an osteological analysis of the specimen, allowing the recognition of many anatomical cranial and postcranial traits. As in other ceratosaurs, the opening for the basisphenoid recess is teardrop-shaped. A trait shared with other abelisaurids like *Carnotaurus* and *Majungasaurus* is the presence of a slight ventrally pronounced median bulge on the posteroventral surface of basioccipital. As in *Carnotaurus* and *Abelisaurus* the tips of paraoccipital processes are dorsolaterally projecting, contrasting with the laterally projecting processes seen in *Majungasaurus*. The anterodorsal border of the neural spine of the axis is convex as in *Carnotaurus*, different from the slightly concave condition in *Majungasaurus*. The ventral margin of the mid-sacral centra is strongly dorsally arched, as in *Carnotaurus*, contrasting with the straight margin observed in *Rajasaurus*. The femoral fourth trochanter is a moderately elevated crest as in *Ekrixinatosaurus* and *Aucasaurus*, but not the strongly reduced process observed in *Rahiolisaurus* and *Majungasaurus*. The popliteal fossa of the femur is traversed by the infrapopliteal ridge between the medial condyle and tibiofibular crest, as in *Carnotaurus, Quilmesaurus* and *Ekrixinatosaurus,* contrasting to the smooth condition seen in *Rajasaurus*. Metatarsal III is T-shaped in proximal view, as in *Aucasaurus*, lacking the strong caudal buttress seen in *Majungasaurus* and *Rahiolisaurus*. We incorporated the revised scoring of the holotype and other South American abelisaurids (220 modified scorings in total) in an existing matrix of 40 taxa and 326 morphological characters. The analysis was run in TNT (1.1), giving 20 most-parsimonious trees of 742 steps. A consensus tree was obtained, excluding the highly fragmentary and poorly known *Tarascosaurus*, 'Pourcieux' and 'La Boucharde' abelisaurids. *Skorpiovenator* was recovered deeply nested in a small clade of other Cenomanian-Turonian abelisaurids from Patagonia (including *Ilokelesia* and *Ekrixinatosaurus*), sister group of Carnotaurini. Notably, all the South American abelisaurids are recovered as members of the clade Brachyrostra, with the Indian-Malagasian Majungasaurinae as its sister group.

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Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

ONTOGENETIC DEVELOPMENT AND INTRASPECIFIC VARIABILITY OF BONE MICROSTRUCTURE IN PENGUINS, WITH IMPLICATIONS FOR PALEOECOLOGICAL INFERENCE

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Birds have colonized various ecological niches during their evolutionary history. Besides the acquisition of flight, several lineages independently adapted to the aquatic environment and developed swimming and diving capabilities. Over the past years, an

increasing number of papers focused on the diversity of long bone microstructure in aquatic birds in light of their diverse locomotor strategies. Some studies attempted to reconstruct the evolution of aquatic adaptations in a given lineage, based on the bone microstructure of fossil taxa, without referring to a comparative set of modern taxa. These works often drew ecological deductions from one or two limb bones of a single specimen. However, the ecological signal contained in bone microstructure is known to vary between skeletal elements. Bone microstructure can also be affected by other factors (besides lifestyle), which have often been overlooked in paleoecological inferences, including individual age, reproductive status, nutritional status, etc.

Studies on intraspecific variability, as well as bone microstructural development during ontogenesis are rare in the field of comparative bone histology. However, such works are essential for the choice of standard parameters for bone description and structural analyses and for drawing rigorous paleobiological inferences.

In the present study, we sampled all major long bones of several hatching, juvenile and adult specimens of the king penguin (*Aptenodytes patagonicus*), in order to assess the extent and the causes of limb bone microstructural variability during ontogenesis.

Histomorphometric observations reveal that, for a given skeletal element, the microstructure and the compactness vary greatly during ontogeny. The limb bones undergo an intense remodeling episode during the juvenile molt. Moreover, the limb bones examined show different developmental patterns during the individual's life and osteosclerosis affects mostly the stylopod and the zeugopod in *Aptenodytes patagonicus*. Finally, for a given long bone, even adult specimens exhibit variability in compactness.

This work is intended to constitute a comparative basis for the histological study of extinct sphenisciforms (and other diving birds), and thus provide a better framework for paleobiological and ecological reconstructions.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

THE FIRST NEARLY COMPLETE JUVENILE *PENTACERATOPS*, FROM THE UPPER CRETACEOUS KIRTLAND FORMATION (HUNTER WASH MEMBER), SAN JUAN BASIN, NEW MEXICO

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Here we describe an exceptionally small skeleton of the ceratopsid dinosaur *Pentaceratops sternbergi* discovered in the Hunter Wash Member of the Kirtland Formation in the Bisti/De-Na-Zin Wilderness Study Area, San Juan County, New Mexico, USA. *Pentaceratops sternbergi* is an index fossil of the Late Campanian Kirtlandian land-vertebrate 'age' and is found almost exclusively in the Upper Cretaceous Kirtland Formation (Hunter Wash Member) of the San Juan Basin, New Mexico. The specimen described here (New Mexico Museum of Natural History P-68578) is partially articulated and consists of nearly all cranial and postcranial elements. Aided by the fact that there is no evidence of any other ceratopsid dinosaurs in the Hunter Wash Member of the Kirtland Formation, we confidently assign this small chasmosaurine dinosaur to *Pentaceratops sternbergi* based on the diagnostic parietal and squamosal bones. The median ramus of the parietal is slender with a U-shaped posterior margin. The right and left squamosals have subtriangular-shaped episquamosals fused along the outer margins. Length measurements of the humerus (460 mm), ulna (405 mm) and femur (670 mm) show that this animal was just over half the size of a mature adult *Pentaceratops*. The only other record of a subadult *Pentaceratops* (San Diego Museum of Natural History 43470) is from the Williams Fork Formation in northwestern Colorado and consists of disarticulated and incomplete cranial elements. This nearly complete subadult skeleton of *Pentaceratops sternbergi* provides important insight into the ontogeny of the genus.

Technical Session X (Friday, October 16, 2015, 9:15 AM)

A SUBADULT *TYRANNOSAURUS REX* AND ITS BEARING ON THE *NANOTYRANNUS* HYPOTHESIS

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In 2002, a rare, surprisingly complete, and partially articulated skull and skeleton of a subadult tyrannosaurid (BMRP 2002.4.1) was collected by the Burpee Museum (Rockford, IL) from the Hell Creek Formation in southeastern Montana. We refer the skeleton to *Tyrannosaurus rex* based on the presence of several autapomorphies of that taxon: a long caudolateral process of the nasal, extensive contact between the antorbital fossa and the nasal, and a narrow snout and wide temporal region that orient the orbital fenestrae forward.

The ~20 foot (6 m) -long skeleton gives an unprecedented view of an early growth stage of a dinosaur whose fossil record is dominated by adult skeletons. Evidence for its subadult growth stage comes from several lines of evidence, including size, relative development of hundreds of osteological features, and bone histology, which gives a chronological age of ~11 years. Based on a cladistic analysis of ontogenetic characters, BMRP 2002.4.1 was found to occupy a new growth stage, between a smaller juvenile (CMNH 7541) and a larger subadult (LACM 23845). With the addition of the new specimen, the early part of the growth series is more completely understood.

In this context, BMRP 2002.4.1 is important in testing recent claims of the validity of *Nanotyrannus lancensis*; the specimen is similar in many ways to the holotype of *N. lancensis* (CMNH 7541), which has been critically assessed and identified as a juvenile *T. rex*. The sequential position of these specimens in the growth series suggests that the similarities are the result of their relative immaturity, not autapomorphies of a novel taxon.

In a larger context, the growth changes seen early in *T. rex* ontogeny are also seen in the growth of all derived tyrannosauroids (*Bistahieversor* + Tyrannosauridae). This shows that ontogeny in this clade is highly conserved, specifically the gross differences between subadult and adult specimens.

Among other changes, our BMRP 2002.4.1 data suggest that in *T. rex*, maxillary and dentary tooth counts increase early in ontogeny before decreasing through adulthood; the lacrimal has a prominent horn at this growth stage, which is later lost to inflation in adults; and caudal neurocentral suture closure follows an anteriorward sequence. The specimen reveals a distinct feature of *T. rex*, where the humerus of BMRP 2002.4.1 is relatively long in contrast to subadult tyrannosaurids of similar growth stage. Finally, despite the discovery of this important specimen, a substantial gap in the growth series is seen between the gracile subadults and the robust adults.

Technical Session X (Friday, October 16, 2015, 8:45 AM)

NEW INFORMATION ON THEROPOD FORELIMB EVOLUTION FROM THE FOREARM AND MANUS OF *CERATOSAURUS NASICORNIS* (DINOSAURIA, THEROPODA)

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Recent studies of theropod forelimb evolution have focused on the unusual morphology of the manus in Ceratosauria as evidence for a shift in development and function at the node Averostra (Ceratosauria + Tetanurae). These conclusions rely heavily on the extremely reduced manus of *Limusaurus* and the assumption that its features are primitive for Ceratosauria. Yet other basal ceratosaurians offer significant morphological data that bears on these issues. Among them is *Ceratosaurus nasicornis* from the Late Jurassic Morrison Formation of the western U.S.A., although it has not been closely studied for nearly a century.

The forearm of the type specimen of *C. nasicornis* (USNM 4735) was recently removed from exhibit and re-prepared. This revealed important new morphological data, including a nearly complete metacarpal I. In detail, the ulna and radius are quite similar to those of *Dilophosaurus* and *Eoabelisaurus*, and lack almost all features that characterize derived abelisaurids. In the manus, *Ceratosaurus* exhibits shortened first phalanges, like derived abelisaurids, but retains primitive metacarpals that more closely resemble those of *Dilophosaurus*, *Berberosaurus*, and *Eoabelisaurus*. In particular, metacarpal I shows few differences from that of *Dilophosaurus*.

These new data are consistent with the placement of *Ceratosaurus* as close to (or within) Abelisauroidea but basal to *Eoabelisaurus*. Within Ceratosauria, digit reduction began in taxa that still retained most phalanges and unguals-and which therefore probably retained grasping as a primary, albeit reduced, function. More importantly, these data strongly indicate that the extremely reduced manus of *Limusaurus* is a derived condition that does not reflect the primitive state for Ceratosauria. Instead, basal ceratosaurs inherited a manus that was similar to that of more basal neotheropods. Thus, the proposed shift in manus digit identity during theropod evolution likely did not occur at Averostra, but later.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

SOUTH AMERICAN INMIGRANTS FROM THE LATE BLANCAN-IRVINGTONIAN DEPOSITS FROM MEXICO

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Field work carried out by the Centro de Geociencias, UNAM in the Tecolotlan basin, located 100 km southwest from Guadalajara city, is the second most important basin by the abundance of late Hemphillian fauna; the sequences have geochronologic dates that have shown a late Hemphillian age for the lower sequence (4.89 Ma).

In unconformity, the late Blancan–Pleistocene deposits are exposed in the San Buenaventura stratigraphic sequence, bearing South American immigrants, such as *Glyptotherium* and caviomorph remains, which were collected associated with camels and horses. The capybara material has been referred to the genus *Neochoerus*. The most significant material, a partial jaw with p4–m1, has the suture of the intermandibular joint below prism (Pr) I of p4, the incisor ends posteriorly in Pr III of m1, the masseteric ridge ends in Pr I of p4, and the fossa is located in the middle part of mI. A partial M3 with 12 simple plates has the anterior six plates with slight bifurcations in the labial side, and the posterior prism has a V shape; a complete m3 shows the anterior prism with a deep fissure, two isolated laminae and a Y-shaped posterior prism; and an incomplete m3 has the anterior prism with a deep fissure. The most important feature is in m2, the anterior prism has a V shape but the middle prism has been separated into two isolated plates.

The *Neochoerus* from Tecolotlán differs from *Neochoerus cordobai* of the early Blancan of San Miguel Allende basin, in the deepness of their fissures, and the middle prism of m2 that splits up on two separate laminae, a character considered an evolutionary step in capybaras. It has been stated that a species of capybara whose molars have dispersed elements, descended from another more remote species with these elements together. Based on this, the *Neochoerus* from Tecolotlan must be considered more progressive than *Neochoerus cordobai*. Comparison with the late Blancan–Irvingtonian jaws from El Golfo, Sonora, México, showed that both specimens share similarities, specifically in the m2, in the masseteric ridge and the fossa located in Pr II of m1 and the depth of the fissures. These similarities suggest that the late Blancan *Neochoerus* from Mexico, belongs to the same population, but differs from *Neochoerus dichroplax* because the posterior part of the intermandibular connection is located a half inch in front of the first prism of p4, a character present in young individuals, and is therefore considered ontogenetic; the m2 is composed of two prisms that are V-shaped in outline; and the specimen of Tecolotlán has a longer diastema.

Grant Information
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Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

REASSIGNMENT OF *MONTANAZHDARCHO MINOR* AS A NON-AZHDARCHID MEMBER OF THE AZHDARCHOIDEA

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The latest Cretaceous fossil record of pterosaurs is dominated by azhdarchids, despite various reports of non azhdarchid material from the Late Campanian and Maastrichtian. However, the only indisputable non-azhdarchid pterosaur material from the latest Cretaceous has been the single nyctosaurid humerus from the Gramame Formation of Brazil. This study presents evidence that *Montanazhdarcho minor* is a non-azhdarchid member of the Azhdarchoidea. *M. minor* was assigned to the Azhdarchidae based on diagnostic features of the humerus, shoulder girdle, and the partial cervical vertebra of the holotype MOR 691. The initial description focused mainly on the specimen's developmental maturity as assessed by paleohistology and its relatively diminutive size (2.5 m wingspan). Subsequent discoveries of postcranial material from thallasadromines, tapejarines, and azhdarchids have revealed that the postcranial features initially used to assign *M. minor* to the Azhdarchidae are synapomorphies for the more inclusive Azhdarchoidea clade. Phylogenetic analysis reveals that *Montanazhdarcho* possesses multiple characters that are shared by the Tapejarinae and Thallasadrominae: (1) a broad and well-developed tubercle at the ventroposterior margin of the coracoid; (2) a massive, distinct ulnar crest with a developed proximal ridge; (3) a strong boot-like ventral margin of the humeral head; (4) an ulna/radius as long or longer than metacarpal IV; an (5) a phalanx IV-1 that is as long or longer than metacarpal IV. The results of this study show that the Late Cretaceous pterosaur fauna was not entirely dominated by azhdarchids and recognizes important post-cranial characters that better define Azhdarchoidea. The reappraisal of *M. minor* as a non-azhdarchid member of the Azhdarchoidea also recognizes *M. minor* as the first known pterosaur of that clade found in North America, as well as one of the latest occurrences of the group.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

TEASING APART THE RELATIONSHIP BETWEEN ECOMORPHOLOGY AND GEOGRAPHIC DISTRIBUTION IN THE FOSSIL RECORD OF NORTH AMERICAN CANIDAE

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Quantifying geographic trends in extinct groups of organisms can be important for understanding the evolutionary success or failure of species, although it is difficult to do so because of inherent biases in the fossil record. In particular, analysis of the geographic distribution of species in association with ecomorphological data is important because it can reveal whether there are particular ecomorphs that tend to be more widespread in space than others. Here, we use the extensively sampled, well-studied, 40-million-year-old North American fossil record of the mammalian family Canidae to explore the association between ecomorphology and geographic distribution over evolutionary time. Do certain ecomorphologies, here defined by body size and dietary category, tend to be more geographically common, i.e., present in more localities? If ecological generalization allows organisms to occupy more sites, then we expect medium-sized mesocarnivores to be more common over the landscape than small or large hypo- or hypercarnivores. Using fossil occurrence data from the Fossilworks database and the Miocene Mammal Mapping Project, we quantified the locality coverage of over 100 North American canid species within 20 time slices in order to understand which particular ecomorphologies, if any, allow a species to be geographically common. We gauged locality coverage for each time slice by creating a North American grid system separated into half-degree cells and by calculating the proportion of all cells where a species was present. We then determined whether trends in body size and dietary category for species that were more common (present within more cells) also apply to those that were rare (present in only one or few cells). We accounted for taphonomic bias due to body size by analyzing commonness within three body size categories. While previous results have shown that Canidae has trended toward larger body size and hypercarnivory over time, our results indicate this trend occurs predominantly in relatively few species, but these species are present at more localities. In contrast, a larger number of species remained relatively small and mesocarnivorous, and these species are present at fewer localities, suggesting that generalization is the more successful strategy when success is measured only by taxonomic richness.

Preparators' Session (Thursday, October 15, 2015, 9:15 AM)

DESIGN AND USE OF A LARGE ADJUSTABLE TENT FOR DOING AIR ABRASIVE WORK ON LARGE DINOSAUR SPECIMENS

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Air abrasive machines have become an integral part of the fossil preparation lab over the past few decades. They are useful for detailed matrix removal on small and large fossils. Because they send very small particulate-sized dust into the air, the work must be done in a work chamber with a proper dust collection system attached. While most fossils are small enough to be air abraded in a standard issue work chamber, larger articulated specimens may need a custom made work chamber. Custom work chambers range in size from shoe box sized to complete room size.

In 2004, the Tate Geological Museum collected an articulated partial hadrosaur skeleton lovingly named "Dead Sheep 148" (DS-148). The skeleton was left articulated and a special sand-blasting tent was built to do the air abrasive work on a specimen that is roughly 8 feet long by three feet wide. The DS-148 Tent is made of PVC tubing, wood, glass, and assorted hardware. It is adjustable in many different dimensions so it can be used on other specimens, and can be shifted as work progresses along the specimen. As work was being done on the dinosaur, it sat on a sturdy table with wheels, so the table can also be moved under the tent. This presentation will cover how the tent was designed and made, how it is set up, its limitations and what could be done better the second time around.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

MAKING A PERMANENT BASE FOR A THIN FOSSIL USING EPOXY

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JODA 4771, as collected, was a large block of Clarno Formation, around 42 Ma, with only the hollow enamel of the upper tooth rows of a new brontothere species exposed. A huge amount of very hard rock was oriented over this thin, fragile specimen. As the rock was scribed away and the block got smaller, traditional plaster cradles were used to support it. Eventually, the block became extremely thin, and the plaster cradles were inadequate support. In a few places, the rock was only millimeters thick, and while uncovering the occlusal side of the teeth, a few holes were punched all the way through the matrix. Afraid to proceed any further for fear of losing the dimensions of the palate that had been preserved, it was decided to make a permanent base out of epoxy. Clear epoxy was chosen so the undersides of the teeth were still visible as originally preserved. The challenge then became how to construct the base without getting epoxy on the newly exposed occlusal surfaces. A number of trials were made using clay, carbowax, cyclododecane, and silicone. The best method was using brushable silicone employing a process much like molding the specimen. First, all undercuts and places where silicone could adhere were filled in with clay. Because the finished product is not being used to make a replica, claying can be done liberally without worry of masking the specimen's features. Brushable silicone was applied to the dorsal surface until thick enough and completely set. A temporary clay wall was constructed at the edge of the ventral surface. Then, the brushable silicone was extended up the wall to create a silicone reservoir that was tightly sealed to the fossil. Finally, the clear epoxy was poured into this reservoir to form a solid, level, permanent base. Embedded in its new stable foundation, preparation resumed without fear of the specimen breaking apart.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

THE EYES HAVE IT: BOUNDING ESTIMATES OF EYE SIZE IN DINOSAURS WITH SOFT TISSUE RECONSTRUCTION AND THE EXTANT PHYLOGENETIC BRACKET APPROACH

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The visual apparatus of extinct dinosaurs and their avian descendants is of clear relevance to their biology given the ubiquity of visual display structures and large orbits. Previous studies reconstructing dinosaur visual abilities involved either morphometric analysis of the scleral ossicles and orbital walls to make inferences about activity regime or estimates of visual fields from sculptures. However, many accessory soft tissues (e.g., muscles, nerves, glands) also occupy the orbit and impose additional constraints on eyeball size and location. These accessory tissues impact the function of the visual apparatus, but have been largely overlooked in past studies. Finally, the visual apparatus is functionally linked to the semicircular canals (SCCs) of the inner ear via the vestibulo-ocular reflex that functions to stabilize gaze by producing compensatory movements of the eye muscles in response to head rotation. Here, tests of the symmetry, alignment, and coplanarity of the eye muscles and SCCs in extant taxa provide critical insights into eyeball orientation in extinct taxa. High-resolution, iodine-enhanced microCT scans were taken of intact heads of nine avian species, two alligator specimens, and three squamate species. Soft tissues were segmented in Avizo and then modeled in Maya. Eyeball size was measured and compared to estimates using regressions of sclerotic ring diameter, optic foramen diameter, and other orbital metrics from the literature. Eyeballs of maximum, average, and minimum size that were estimated from the regression equations were modeled in Maya for each species. These estimated eyeball models were subsequently re-inserted into the respective orbital regions of the digitized skulls that include the segmented, accessory orbital soft tissues in situ. If the estimated eyeball models intersected with the accessory soft tissues and/or bones, then the predicted model from the regression equation was rejected based on the overestimation of eyeball size. The results indicate that reconstructing accessory soft tissues in the orbits of extant diapsids can provide upper limits on the regression equation estimates for eyeball diameter and axial length. Thus, optical parameters such as focal length and monocular visual field (which depend in part on eyeball size, shape, and position) may be modeled with more confidence. Together, models of visual fields based on optical parameters and estimates of eyeball orientation will inform reconstructions of dinosaur visual abilities in the next phase of this project.

Grant Information
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Technical Session XII (Friday, October 16, 2015, 11:00 AM)

A NEW LATE OLIGOCENE SQUAMATE FAUNA FROM GERMANY

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Late Oligocene squamates are very rare in European fossil deposits, resulting in significant gaps in our knowledge of the reptile faunas from the latest Paleogene. Here we report on new Late Oligocene fossil material from two German localities, Herrlingen 11 (MP 28) and Herrlingen 9 (MP 29). The material can be assigned to the following major clades: Gekkota, Lacertidae, Amphisbaenia, and Anguimorpha. Although very fragmentary, the gekkotan material appears to be more similar to lower Miocene forms such as *Euleptes* or *Gerandogekko,* rather than to lower Oligocene taxa like *Cadurcogekko,* as indicated by small size and morphology (e.g., tooth number, shape of Meckel`s groove). The amphisbaenian material is represented by two types; the first can be allocated to the modern genus *Blanus* based on tooth count and the presence of a small 4th and an enlarged 3rd tooth, which is a derived feature of the genus. Given that previously described upper Eocene fossils of *Blanus* are taxonomixally questionable, the Herrlingen material might represent the oldest known record of this clade. The second type has a marked tooth slope as typically seen in *Palaeoblanus*. The lacertid material consists of several amblyodont forms such as *Dracaenosaurus*, *Pseudeumeces* and *Mediolacerta*, as typically seen in other Oligocene deposits from Europe, but also

includes non-ambylodont taxa such as *Plesiolacerta*. Especially common among the material are anguimorphs, which are here represented by *Ophisaurus* and a form that appears identical to the French Oligocene taxon described as *Dopasia coderetensis*. Personal reinvestigation of the European Oligocene '*Dopasia*' (=*Ophisaurus*) shows that the taxa described as *D. frayssensis* and *D. coderetensis* are markedly different from the members of the clade *Ophisaurus* in the morphology of the posterior dentary region and that those taxa cannot be allocated to that genus, requiring a new generic name. The composition of the Herrlingen fauna is very similar to several Oligocene localities from France, but is especially significant because of the oldest record of the modern amphisbaenian genus *Blanus*, providing a minimum bound for molecular clock calibrations. Also, the resemblance of the gekkotan fossils to Miocene forms suggests potential faunal turnover prior to the Paleogene-Neogene transition.

Grant Information
Deutsche Forschungsgemeinschaft, Mu 1760/7-1

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

PTEROSAURS VS. BIRDS? A COMPARISON OF MORPHOSPACES CONSTRUCTED USING FUNCTIONALLY ANALOGOUS TRAITS

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The late Mesozoic saw the evolution of powered flight in birds and their subsequent radiation in the presence of pterosaurs. Whether this event led to competition between the two clades is a topic of great interest given that these are two of only three volant vertebrate groups. One means of testing for competitive interactions is comparing eco-morphospaces. Here, multivariate analyses of forelimb, hind limb, and lower jaw measurements are used to compare patterns of morphospace occupation. Unlike previous studies, the wing is divided into functionally analogous units rather than simply using homologous skeletal structures. For this purpose the lengths of the primary feathers were included in the avian data. The results show separation of the two clades due to the relatively longer jaws, shorter metatarsals, and shorter brachial region of pterosaurs. Comparison of the forelimbs by themselves again showed separation of birds and pterosaurs, with the former tending to have a relatively longer brachial region in relative terms. The importance of the other wing regions varied depending on whether metacarpal 4 of the pterosaurs was included within the antebrachial or distal wing regions. Wing lengths that are corrected for elbow flexion angle at full wing extension differ little from wing lengths calculated by summing the lengths of wing elements. However, there is reduced overlap in wing lengths between pterodactyloids and Aves due to the more obtuse angle of the elbow in the former. Examination of data from the Jehol Biota of China shows that large avians had similar wing lengths to small pterodactyloids, indicating that any ecological separation was not solely a function of size. These results indicate that comparison of analogous traits can provide further insight into key differences between taxa that are hypothesized to be ecologically similar.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

FIRST OCCURRENCE OF THE PLESIOCHELYID TURTLE *PLESIOCHELYS ETALLONI* FROM THE LATE JURASSIC KIMMERIDGIAN OF ENGLAND, UNITED KINGDOM

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Several groups of basal eucryptodire turtles (Plesiochelyidae, Thalassemydidae, and Eurysternidae) adapted to life in epicontinental seas during the Late Jurassic, representing the first radiation of eucryptodire turtles into marine environments, and are usually found in Kimmeridgian and Tithonian coastal marine deposits. Plesiochelyids and thalassemydids are generally associated with more open shallow marine environments. They have been numerously found in in northwestern Switzerland and in northwestern Germany. Turtles have also been reported from the Late Jurassic Kimmeridgian of England since the Nineteenth century. A beautifully preserved basicranium with partial otic chambers (NHMUK R3370) referable to *Plesiochelys etalloni* from the Kimmeridge Clay, southern England, United Kingdom represents the first occurrence of this plesiochelyid in England. The basicranium is characterized by a unique combination of traits, including a high dorsum sellae that does not overhang the sella turcica, a remarkable configuration known only in a group of Late Jurassic turtles traditionally referred to the Plesiochelyidae. The surface below the dorsum sellae is mostly vertical in *Plesiochelys etalloni* and *Plesiochelys planiceps*, which results in foramina anterius canalis carotici cerebralis opening a short distance in front of the level of the dorsum sellae, a condition present in NHMUK R3370. *Plesiochelys planiceps*, like all other plesiochelyids except *Plesiochelys etalloni*, lacks a completely ossified pila prootica. The presence of an entirely ossified pila prootica in NHMUK R3370 is the strongest argument to refer this specimen to *Plesiochelys etalloni*. *Plesiochelys etalloni* is a taxon previously recorded only in the Kimmeridgian of the Jura Mountains in Switzerland and France but now definitely also occurring in the Kimmeridge Clay of the UK. This is the first evidence that this taxon had a wider paleobiogeographic distribution than previously thought.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

NEW SPECIMENS OF *DICHOTODON BAJAENSIS* (SQUAMATA, BORIOTEIIOIDEA) FROM THE LATE CRETACEOUS OF BAJA CALIFORNIA, MÉXICO, REVEAL UNUSUAL TOOTH REPLACEMENT AMONGST LIZARDS

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Dicothodon bajaensis from the Campanian of El Gallo formation, Baja California (Mexico), has been previously described based on fragmentary teeth and dentaries. As a result of paleontological field work in the El Gallo Formation, new material of *D. bajaensis* has been recovered, including cranial fragments, lower jaws, anterior and posterior limbs, and vertebrae. This greatly expands our knowledge of this fossil lizard and makes it the second most complete lizard from the entire Mesozoic of North America. The new specimens include eight maxillae and five dentaries, all belonging to adults and sub-adults. The tooth count in both jaws is 15: in the upper jaw, there are seven conical anterior teeth and eight molariform posterior teeth; in the lower jaw, six conical anterior teeth and nine molariform teeth. Replacement teeth were found in both jaws inside circular and well developed resorption pits that are positioned lingually relative to the functional teeth. In the specimens in which replacement was observed, replacement teeth were similar in size to each other. Some specimens, however, lack functional pits and x-rays show that replacement teeth are entirely missing, indicating replacement had completely ceased in such cases. The absence of replacement explains the extreme wear at tooth apices observed in some presumably older individuals, and which does not occur in specimens where replacement was still active. *Dicothodon* is therefore inferred to have had arrested tooth replacement. Despite slowing down of replacement being reported in a few lizards, complete cessation of replacement of the posterior tooth series in late ontogeny is unknown amongst living forms. The only other lizard previously suggested to bear this replacement type is another Late Cretaceous borioteiioid, *Peneteius*. The pattern observed in *Dicothodon* and *Peneteius* seems to be intermediate between the typical lizard pattern, also described for *Bicuspidon*, and the one observed in *Polyglyphanodon*, which lacks replacement at least during their entire adult life. The new specimens provide important clues as to the evolution of the unique kind of dentition observed in North American borioteiioids.

Grant Information
PAPIIT IN 100913

Romer Prize Session (Thursday, October 15, 2015, 9:00 AM)

NON-ANALOG ECOLOGICAL STRUCTURE OF EARLY CRETACEOUS JEHOL MAMMAL COMMUNITIES

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Most mammalian taxa of the Lower Cretaceous Jehol Group of northeastern China are preserved as nearly complete fossil skeletons. This fossil record currently represents our best opportunity to move beyond the study of the autecology of individual species to analysis of Mesozoic mammal communities. Contextual information, such as abiotic factors and other biotic factors, is well constrained for the Jehol Group, enabling analysis of linkages between intrinsic and extrinsic factors that might have shaped the ecological structure of these ancient mammal communities. I quantified the ecological structure of two mammalian communities from the Jehol Group and 28 extant small-bodied mammal communities from tropical, arid, temperate, and cold environments from across the globe using diet, body size, and locomotor mode. I used the resulting dataset to compare ecological structure among the extant mammal communities with those from the Jehol Group. I used ecological and ecological diversity as parameters to characterize ecospace occupations for each mammal community. Results indicate that environmental factors play essential roles in shaping ecological structure of extant small-bodied mammal communities. In tropical regions, small-bodied mammal communities have more clustered ecospace occupations, reflected by low ecological disparity and high ecological diversity, in contrast with mammalian communities from arid and cold environments, which have more scattered ecospace occupations as reflected by high ecological disparity and low ecological diversity. Results also indicate that the ecological diversity and disparity of the two Early Cretaceous mammal communities are most comparable to extant small-bodied mammal communities from tropical and arid environments, respectively. The significantly different ecological structure of the extant small-bodied and Early Cretaceous mammal communities might be primarily due to sampling biases of the fossil record, non-analog Early Cretaceous environments, and/or evolutionary ecology differences of species compositions among extinct and extant mammalian communities.

Grant Information
Washington Research Foundation-Hall Fellowship, University of Washington; Burke Museum of Natural History and Culture Vertebrate Paleontology Fellowship

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

DESCRIPTION OF A NEW WUKONGOPTERID PTEROSAUR WITH A DIFFERENT TYPE OF PREMAXILLARY CREST FROM THE JURASSIC OF CHINA AND ITS IMPLICATIONS FOR ONTOGENY

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The Wukongopteridae comprises a group of long-tailed flying reptiles that combine typical characteristics of basal (non-Pterodactyloidea) and derived pterosaurs (Pterodactyloidea). To date, it contains three genera: *Wukongopterus*, *Darwinopterus*, and *Kunpengopterus*, and potentially also includes *Changchengopterus*. Although known from several specimens, there is still a general lack of knowledge about their anatomy, particularly changes during ontogeny. Here we report a new specimen (IVPP V17959) that can be referred to the Wukongopteridae based on the presence of a confluent nasoantorbital fenestra, elongated cervical vertebrae and a long tail. The skull and lower jaw are preserved laterally and exposed in left view, lacking the rostral tip. The premaxilla bears a low ossified crest, which is confined to the anterior part of premaxilla and possibly extends to the rostral tip. This differs from *Wukongopterus*, in which the anterior dorsal margin of the premaxilla is flat, *Darwinopterus,* which shows a bony premaxillary crest starting anterior to the nasoantorbital fenestra reaching the skull roof, and *Kunpengopterus*, which lacks a cranial crest. The nasal bears a ventral process formed by contralateral fusing elements. Although broken, it is clear that this process almost reaches the ventral margin of the nasoantorbital fenestra. This process differs from the short and inclined nasal process of *Darwinopterus* and *Kunpengopterus*. The postcranial skeleton of IVPP V17959 shows signs of an ontogenetically fully mature individual at the time of death, having several elements completely fused such as the scapula and coracoid, the proximal and distal carpal series, and the extensor tendon

process of the first wing finger phalanx. Besides that, opposite prepubes are in close contact with the suture between them partially open suggesting that they are about to fuse. Based on this specimen, it appears that the fusion of the prepubes occurs very late in ontogeny. The new specimen also increases the diversity of the Wukongopteridae and the non-pterodactyloid pterosaurs of the Yanliao Biota, suggesting that it was the most abundant pterosaur group represented in that region during the Jurassic.

Grant Information
National Basic Research Program of China, the Hundred Talents Project of CAS; and CNPq and FAPERJ (Brazil)

Romer Prize Session (Thursday, October 15, 2015, 9:15 AM)

SHIFT IN WEANING AGE SUPPORTS HUNTING-INDUCED EXTIRPATION OF SIBERIAN WOOLLY MAMMOTHS (*MAMMUTHUS PRIMIGENIUS*)

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Woolly mammoths disappear from the fossil record of mainland Siberia around 10 ka BP and then are lost globally around 4 ka BP. The causes of this continental extirpation and eventual extinction are still obscure, but current competing hypotheses implicate detrimental effects from hunting pressure and climatic changes during the Pleistocene-Holocene transition. Age of final weaning is a life-history landmark that is expected to change differently in response to predation and climate-related nutritional stress. African elephants (*Loxodonta africana*) wean calves later during multi-year droughts. This phenomenon provides a way to investigate nutritional status and environmental quality for fossil proboscidean populations. If reduced quality or quantity of food, the usual proximate causes of climate-induced stress, were forcing the decline of Siberian woolly mammoths, we would expect their average weaning age to increase toward the end of the Pleistocene. On the other hand, overhunting can accelerate maturation in populations. This suggests we might see the opposite pattern (decreased weaning age) if exploitation from humans was the primary pressure reducing proboscidean populations. Thus, the pattern of weaning age through time can be used to evaluate whether extirpation was more likely due to hunting or to climate change.

To establish a 'weaning signature' that could be detected in fossil tusk records, I serially analyzed nitrogen stable isotope composition ($\delta^{15}N$) of tail hairs from a mother-calf pair of African elephants at the Toledo Zoo, Ohio, to document changes associated with nursing and weaning. Data from this modern analog provided context for interpreting isotope profiles obtained from young woolly mammoth tusks. Using serial records of tusk collagen $\delta^{15}N$, I estimated weaning age for nine Siberian specimens from Taimir and Chukotka with accelerator mass spectrometry dates between 10 and > 41 thousand radiocarbon years BP. Most records display a gradual multi-year decrease in $\delta^{15}N$ values followed by an abrupt increase that appears to reflect short-term nutritional stress during the first year after being fully weaned. Using the spike in $\delta^{15}N$ as an indirect indication of final weaning, this analysis shows a decrease in weaning age from 7 to 4 years over this interval. This result corroborates hypotheses that implicate hunting by humans as the primary cause of woolly mammoth extinction.

Technical Session XVIII (Saturday, October 17, 2015, 2:45 PM)

DIFFERENT MECHANISMS OF BODY SIZE CHANGE DURING THE HYPERTHERMALS OF THE EARLY EOCENE

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Decreasing body size has been described as the 'third universal response' to warming. Examples include wide-spread size decreases in the early Eocene mammals of the Willwood Formation, Bighorn Basin, WY, at the Paleocene-Eocene Thermal Maximum (PETM), a well-known episode of geologically rapid, intense global warming. Nearly half of all Willwood FM mammal lineages were smaller during the PETM than before and/or after the event, compared with only 1–2 larger taxa. These changes occurred through the immigration of small species and the temporary dwarfing of lineages, probably via metabolic effects.

Two additional, smaller hyperthermals, ETM2 and H2, are also recorded in the Willwood FM ~2 million years after the PETM, providing the opportunity to test the universality of body size response to rapid warming. The geochemical signatures of ETM2 and H2 have been identified in the northern part of the Bighorn Basin. Previous analysis extrapolated their stratigraphic position to the southern part of the basin where dense mammal samples span each event. More than 32000 mammal fossils from >100 lineages are known from a 220-meter thick stretch of stratigraphic section along the Fifteenmile Creek that brackets and includes the ETM2 and H2 levels. From these specimens, the length and width of >7500 complete lower first molars were previously measured and natural log-transformed occlusal surface areas were calculated as a proxy for body size.

Mean molar area for the entire Willwood fauna is 10–20% smaller during ETM2 and H2 than before and after the events. The same pattern is exhibited in randomized, standardized subsamples of the data and the differences are statistically significant. This change is superficially similar to the decline in body size seen at the PETM, but detailed examination of individual lineages reveals different mechanisms. At ETM2 and H2, there are no documented immigrants and new species appearing through morphological innovation are both larger and smaller than their close relatives. Dwarfing is apparent in only a few lineages (*Cantius*, *Microsyops*). Instead, the overall size decreases at ETM2 and H2 are driven by shifts in (standardized, proportional) relative abundance, which favor the smaller species in eight of the 10 most common families. Many of these abundance shifts begin at Biohorizon B, a faunal event immediately preceding ETM2, and reverse after H2. Biohorizon B is a profound episode of faunal change apparently related to the onset of warming at the Early Eocene Climatic Optimum that sets the context in which ETM2 and H2 occurred.

Grant Information
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Technical Session V (Wednesday, October 14, 2015, 2:15 PM)

ASSESSMENT OF AGE RETROCALCULATION METHODS IN DINOSAUR GROWTH STUDIES: A CASE STUDY USING THE CENTROSAURINE CERATOPSID *CENTROSAURUS APERTUS* (CAMPANIAN)

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Growth curve reconstruction provides a quantitative assessment of dinosaur growth dynamics, but is challenging because it requires the estimation, or retrocalculation, of missing growth marks due to the ontogenetic remodeling of bones. Two alternative methods have been used for age retrocalculation: 1) section-stacking, in which cross-sections of differently-sized bones are overlaid, and 2) growth model fitting to a series of growth marks within a single bone that estimates the missing growth mark record from a best fit curve. Despite their fundamental differences, the influence of these retrocalculation methods in growth curve reconstruction has not been previously evaluated.

Here we assess the effect of different age retrocalculation methods on growth curve reconstruction using a population sample of the ceratopsid dinosaur *Centrosaurus apertu*s derived from a monodominant bonebed in the Oldman Formation (Campanian) of Alberta, Canada. A size series of humeri and tibiae were thin sectioned for histological analysis. Full sections for each limb bone were made at their minimum circumference, and the circumferences of the growth marks were traced and measured in imaging software. The circumferences were estimated to body mass using developmental mass extrapolation.

Using the model fitting method, all individuals are estimated to have lost no more than one growth mark. In contrast, section-stacking suggests that the largest individual (tibia) is suggested to have lost three growth marks. The Reconstructed growth curves are also vastly different. The model-based methods result in a best fit curve where juvenile growth was rapid. In contrast, section stacking results in a growth curve that has a prolonged low growth rate stage in the middle of the trajectory, a pattern undocumented in the average growth trajectories of extant vertebrates.

These differences appear to be driven by a high degree of growth variation in the sample. Asymptotic sizes range from 1300 kg to 2000 kg, and different maximum annual growth rates vary from 150 to 500 kg/year. Growth mark circumference at any given age is therefore highly variable, making sections difficult to align accurately. The variable growth pattern has also been observed in *Plateosaurus* and may be common in dinosaurs. Therefore, section-stacking age retrocalculation may be unreliable and should be used with caution.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

FIRST ORNITHOMIMID (DINOSAURIA) FROM THE DJADOKHTA FORMATION (CAMPANIAN) OF TUGRIKIN SHIRE, MONGOLIA

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Ornithomimosaurs are commonly found in the Upper Cretaceous beds of Mongolia, especially from the Bayanshiree (Cenomanian-Turonian) and Nemegt (Maastrichtian) formations. Although the Djadokhta Formation, stratigraphically positioned between these formations, is rich in dinosaur fossils and widely distributed in the central Gobi area, it has produced only two fragmentary ornithomimosaur skulls from the Ukhaa Tolgod locality, referred to Ornithomimosauria indet. In 1994, the Japan (Hayashibara Museum of Natural Sciences) – Mongolian (Institute of Paleontology and Geology, Mongolian Academy of Sciences) Joint Paleontological Expedition discovered the first ornithomimosaur from the Tugrikin Shire locality, which is dominated by *Protoceratops* and yields other dinosaurs such as ankylosaurs, *Velociraptor*, *Shuvuuia*, troodontids, and avialans. This specimen preserves the astragalus, calcaneum, distal tarsal III, and the complete pes, which bear important taxonomic characters. A phylogenetic analysis produced nine most parsimonious trees, and the strict consensus tree shows the Tugrikin Shire taxon is positioned within the clade Ornithomimidae, sharing one unambiguous synapomorphy (arctometatarsalian). The relationships of the Tugrikin Shire taxon, *Anserimimus*, *Gallimimus*, and the clade of North American taxa form an unresolved polytomy. This analysis detected five apomorphic characters for the Tugrikin Shire taxon: fossa on the anterior surface of the medial base of the ascending process of astragalus, metatarsal IV longer than metatarsal II, shallow extensor ligament pits on the dorsal surface of phalanges of digit IV, anteroposteriorly long pedal phalanges of digit IV, and well-separated proximal and distal articular surfaces of digit IV. This specimen has additional unique features as an ornithomimosaur, such as a robust distal end of metatarsal II, a laterally tilted medial condyle of phalanx IV-1, elongated and slender phalanges of digit IV, and ungual of digit II larger than the other two. These characters indicate that this is a new taxon. The discovery of the Tugrikin Shire taxon is also important for understanding the habitat of ornithomimosaurs. Ornithomimosaur remains, including those from Ukhaa Tolgod, have been hitherto found in fluvial and lacustrine sediments, but the depositional environment of the Djadokhta Formation at Tugrikin Shire is eolian. This indicates some ornithomimosaurs inhabited arid environments.

Grant Information
2011 Jurassic Foundation for collection visits

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

THE USE OF SEAL LIMB BONES (PHOCIDAE: CARNIVORA) IN TAXONOMY AND SYSTEMATICS: NEW INSIGHTS FROM MORPHOMETRIC ANALYSIS

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Phocidae (earless seals) are one of the most morphologically and ecologically diverse pinniped clades. Despite their present diversity, the evolution of the group remains poorly known. Many taxa have been described based on isolated humeri and femora, and it's uncertain how useful these elements are for diagnosing taxa. To assess the usefulness of limb elements in phocid taxonomy, we measured 17 variables for the humerus and 16 variables for the femur from 67 phocid specimens. Our sample size included representatives of every extant phocid genus, as well as data from isolated femora and humeri identified as belonging to five phocid taxa: the monachine (southern seal) *Acrophoca longirostris* and *Callophoca obscura*, and the phocine (northern seal) *Leptophoca amphiatlantica*, *L. lenis*, and *Phocanella pumila*. Principal Component Analysis (PCA) was performed separately on the humerus and femur datasets to identify major sources of morphological variation in the datasets. PCA plots of PC1 versus PC2 for both the humerus and the femur performed well at segregating phocine and monachine seals. Our PCA found that variation in PC1 was the result of differences in size of elements (~76% and ~77% for the humerus and femur respectively). For the humerus, PC2 reflected the width of the deltoid crest, and explained ~9% of the variation. For the femur, PC2 explained ~8% of the variation, and represented relative size of the condyles. Plots of PC1 versus PC2 performed well at segregating extant taxa by genus. When fossil taxa are included within the analysis, results largely supported previous taxonomic studies of fossil phocids. *Phocanella* clustered together and overlapped with extant phocine seals. *Acrophoca* clustered together within a region of overlap between monachine and phocines seals. *Callophoca* clustered together in the femur dataset but not the humerus dataset. This reflects variation in humerus size, a result of sexual dimorphism previously identified in this taxon. In contrast to the above taxa, *L. amphiatlantica* and *L. lenis* occurred within the phocine portion of the femur morphospace, but do not cluster together, suggesting that they may belong to different genera. Our results indicate that phocid humeri and femora contain diagnostic elements that may allow identification of taxa to at least generic level, and supports their usage in phocid taxonomy. Future work will expand our sample size to allow testing of diagnosability at the species level and lead to the creation of new characters for phylogenetic analysis.

Technical Session XVI (Saturday, October 17, 2015, 8:00 AM)

MICRO CT IMAGERY REVEALS A UNIQUE MANUS MORPHOLOGY WITH DIGGING/SCRATCHING ADAPTATIONS IN THE SAINTS AND SINNERS QUARRY (SSQ) DREPANOSAUR, NUGGET SANDSTONE (LATE TRIASSIC), NORTHEASTERN UT

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The SSQ, a shallow water shoreline interdunal lake deposit, is the richest vertebrate site in the erg system that covered the western US during the Late Triassic - Early Jurassic. Over 11 000 bones of coelophysoids, sphenodontians, pterosaurs, drepanosaurs and sphenosuchians have been recovered. The latter two groups are represented by multiple 3-dimensional, complete and nearly complete, skeletons.

The SSQ drepanosaur manus is broad with a reduced phalangeal formula [2-2(but see below)-2-2-2]. Digit I is short but functional with a strongly curved, thin claw. Unguals III-V are elongate with little curvature. The hypertrophied ungual II has an inverted Y cross-section with an immense vertical blade and broad, concave ventral surface. The proximal element of II is enlarged, broad, dorsoventrally flattened, and perforated by a foramen. This element occupies the equivalent space of the metacarpal (MC) and proximal phalanx in III-V. Whether this is a single element (MC or II-1) or the result of fusion of MC II and II-1 cannot be determined. A similar large element in the manus of the golden mole (*Eremitalpa*) results from fusion of carpal, MC II, and II-1.

Carpal morphology is also unusual. The elongated ulnare and intermedium form two of the four forearm elements. Distal carpal II is short, wide, and caps the proximal end of 'II-1'. A similarly shaped distal carpal is seen in digit III in the pygmy anteater *Cylopes didactylus*. Carpal II is fused with the proximolateral surface of MCI forming an L-shaped element. No other carpals are present. Basal drepanosaurs have five distal carpals indicating a reduction in the SSQ taxon. Some SSQ mani appear to preserve MC III-V in articulation with the proximal carpals (ulnare and intermedium) that have been modified into elongated epidopdials.

The scapulocaracoid (SC) and forelimb of the SSQ form have numerous features seen in fossorial and burrowing taxa (elongate unguals with low curvature, one hypertophied ungual, broad manus, >2 epipodial elements, short radius, plate-like ulna functioning as a large olecranon, pectoral elements narrow and located below the neck with scapulae meeting above the dorsal vertebrae) and are convergent with the SC and forelimb skeleton of moles. Other aspects of the drepanosaur skeleton preclude a burrowing habit; a long pointed skull, immense orbits, and a long, laterally compressed, deep tail with tall neural spines and elongate curved chevrons. We interpret the SSQ drepanosaur as a scratch digger that foraged in the soft sands along the vegetated margins of the interdunal lake.

Colbert Prize (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

RODENT DENTAL TOPOGRAPHIC ANALYSIS: THE PROMINENCE OF PREMOLARS

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Dental topographic analysis, the evaluation of teeth as landforms, is a holistic and homology-free method to quantify biological shape. Earlier studies have used Geographic Information Systems (GIS) tools, such as slope and patch count, to quantify tooth morphology, and these can be used to predict diet and infer other aspects of ecology for extant and extinct taxa. We applied dental topographic analysis to rodents, which are taxonomically, morphologically, and ecologically diverse. Ongoing work has generated a library of high-resolution µCT-scans for >200 extant North American rodent species. Using µCT-derived isosurfaces of lower cheek tooth rows for a trophically diverse subset (n = 26), we generated raster surfaces in ArcGIS to analyze each cheek tooth position individually. We extracted mean slope, aspect, surface curvature, and other variables to quantify the morphology of tooth crowns. Using discriminant function analysis (DFA) we attempted to segregate diet categories (folivore, rootivore, omnivore, granivore, frugivore, invertivore) based on the GIS variables. To analyze species with premolars and those without in the same morphospace, we excluded data for premolars from our initial analysis. Without premolar data, we had some success delineating invertivores and frugivores from other trophic categories based on a combination of molar slope and patch count but could not reliably classify species in other trophic categories. However, including premolar metrics (thus excluding rodents without premolars), we correctly classified all represented diets (rootivore, granivore, folivore, frugivore, omnivore) for 11/11 species with premolars using p4 and m1 slope average and curvature, m1 patch count, and m2 area. Mean p4 slope was most significant, with omnivorous and frugivorous species represented by the greatest average slope and rootivorous and granivorous species represented by the lowest. Considering the apparent adaptive value of p4 in diet, the loss of premolars and numerical reduction of the molar row in many rodent clades is intriguing. Continuing work is increasing sample size and taxon sampling to account for potential phylogenetic bias. We are also testing watershed and contour analyses as shape descriptors to improve overall diet prediction. In addition to reconstructing paleodiet in extinct rodents, we are using these results to explore cheek tooth reduction and premolar loss in rodents in the context of the North American rodent radiation and dental adaptation.

Grant Information
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Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

SECOND EUTHERIAN MAMMAL FROM THE CLOVERLY FORMATION (LOWER CRETACEOUS) OF MONTANA

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The Lower Cretaceous (Albian) Cloverly Formation of Montana and Wyoming has yielded a diverse assemblage of tribosphenic (therian) mammals, of which five have been formally recognized: two basal forms (*Argaliatherium robustum* and *Carinalestes murensis*), two metatherians (*Pappotherium pattersoni*, also known from the Trinity Group; and *Oklatheridium wiblei*), and the eutherian *Montanalestes keeblerorum*. Herein we record the presence of a second eutherian, known by associated remains representing the most completely known Early Cretaceous therian from North America. The fossil, revealed mainly by CT, is that of an immature individual and includes nearly complete dentaries and parts of both maxillae, along with various postcranial elements. Several of the teeth are deciduous, as indicated by unerupted successors; three molars (the last of which is incompletely formed and unerupted) and at least four premolars (the last of which, presumed p5, is partially formed and unerupted, lying beneath presumed dp5) are present. As in other early eutherians, p4 is lower and shorter than m1, the paraconid of lower molars is shorter than the metaconid, and the upper molar stylocone is small with the parastyle occupying a distinctly mesial position. Additionally, this new taxon shares with the basal eutherian *Holoclemensia* (from the Trinity Group) a large stylar cusp in the 'C' position and mesiodistal compression of the trigonid. Molar structure departs from the primitive pattern in having low, rounded, robust cusps; upper molar protocone and lower molar talonid are broad and well developed, and there is little height differential between talonid and trigonid. In these regards, this new eutherian resembles geologically younger Asiatic and North American zhelestids. This new find highlights the taxonomic and morphological diversity achieved by eutherians during the Early Cretaceous on this continent.

Grant Information
We thank NGS, NSF, and ACS for support of this research.

Technical Session III (Wednesday, October 14, 2015, 8:00 AM)

FIRST BONE RECORD OF TERRESTRIAL VERTEBRATES IN THE LOWER PERMIAN OF SOUTH AMERICA

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Captorhinids were Permian reptiles with distinctive ornamented anapsid skulls, commonly displaying dental adaptations for herbivory and durophagy. Despite having a cosmopolitan distribution, and being conspicuous in the Permian faunas of North America, the clade has never been reported in South America. Recent fieldwork in the

Pedra de Fogo Formation of the Parnaiba Basin in northeastern Brazil has yielded a new vertebrate fauna that inhabited an extensive tropical lacustrine system. This rock unit is best known for its petrified forests, and for hosting a marine ichthyofauna and the long-snout temnospondyl *Prionosuchus plummeri*, found near the basin's depocenter. The newly discovered vertebrates occur on the northern margin of the basin, in quarries near the city of Teresina, and include new temnospondyls, and the first record of the Captorhinidae in South America. One captorhinid specimen is represented by a natural mold of a right mandibular ramus. The anterior portion of the hemi-mandible is preserved, and exhibits most of the dentition, including incisiforms and a battery of three conical tooth-rows. A cranium of a second, smaller individual (skull length ~45 mm) that is still embedded in the matrix is exposed in dorsal view and displays the diagnostic ornamentation patterns of pits and sulci. Both the mandible and the exposed areas of the skull seem morphologically compatible with *Captorhinus aguti*, a common species from the Permian of southern USA. A third specimen that is tentatively referred to the Captorhinidae consists of a partial skull of a much larger individual. The roof of the left side of the tropibasic cranium minus the antorbital region is preserved in ventral view (partial skull length ~160 mm). This specimen falls within the size range of the North American species *Labidosaurus hamatus*. These reptiles represent the first record of amniotes in the Permian of the Parnaiba Basin. Captorhinids were important primary consumers in Permian ecosystems and their presence in the fossil forests of northeastern Brazil adds to the emerging picture of tetrapod communities in tropical Gondwana.

Grant Information
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Technical Session VI (Thursday, October 15, 2015, 9:45 AM)

NEW FOSSIL SCOMBRID (PELAGIA: SCOMBRIDAE) FISHES PRESERVED AS PREDATOR AND PREY FROM THE EOCENE OF SENEGAL

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Fossil fish material from the Lower Eocene Thies Formation in the region of Rufisque-Bargny near southeast Cap Vert Peninsula, Senegal, reveals predator-prey interaction between two scombrid fishes, the first ever described in the fossil record for the clade. The material is a part and counterpart concretion preserving nearly complete skulls of both predator and prey in 3-dimensions. The larger predator fish represents the second specimen of †*Auxides* (*Thynnus*) *huberti*, the only non-Tethyan representative of †*Auxides*. The smaller prey fish is a new genus and species, closely resembling *Scomber*. Several of the caudal vertebrae from the smaller prey fish are obscured near the area of the opercle and continuing into the pharynx of †*A. huberti*, indicating it was swallowed. Additionally, the smaller skull is partially enclosed within the abdominal ribs of †*A. huberti*. Among species of †*Auxides*, serrated pelvic fin spines are limited to †*A. huberti*. The new specimen has small, pointed teeth and a thickened, sickle-shaped first haemal spine. The first dorsal fin has 6-7 interneurals and associated dorsal fin spines. The bony dorsal and anal finlets begin immediately behind the second dorsal and anal fin respectively. Ventral corselet-like scales are present, a condition found in *Auxis* and *Thunnus*, but which differs from the type species of †*Auxides*. The caudal fin has gracile hemitrichia that surround the two posteriormost epineurals and the entire hypural plate proximally. The smaller prey fish differs from *Scomber* in possessing frontal bones that approach the midline anteriorly and long sigmoid shaped nasal bones that project further anteriorly from the frontal bone than the length of the nasal-articulating surface. The exceptional preservation of the prey fish and the second ever recorded occurrence of †*A. huberti* is the first direct evidence of scombrid feeding behavior and demonstrates that smaller 'mackerel-like' scombrids have been prey for larger tuna-like scombrids since at least the middle Eocene, as they are today. Furthermore, the area near Cap Vert, Senegal, represents a significant snapshot into early scombrid ecology, comparable to but certainly distinct from Monte Bolca.

Grant Information
National Geographic Society 8315-07 to M. O'Leary

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

A NEW PIPID FROG FROM THE MIOCENE OF ETHIOPIA

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Fossiliferous carbonaceous lacustrine strata within a 21.7 Ma volcanic crater in the Mush Valley, Ethiopia, preserve a nearly complete developmental sequence of clawed frogs (Xenopodinae). Adult skeletons were CT scanned and scored for phylogenetic analysis. Soft tissue preservation reveals larval characteristics, cranial nerves, body outlines through growth, and keratinous 'claws' in adults. The Mush anurans are assigned to a new taxon, based on autapomorphic character states including branching anterior processes of the nasal and posteriorlateral processes of the frontoparietals. The frog sample represents a breeding population, as evidenced by the presence of individuals representing multiple ontogentic stages. Snout-vent length variation within the adult sample indicates sexual dimorphism, as is seen in modern pipids, as well as multiple age cohorts. The anuran fossils were associated with a rich broadleaf floral community, indicating that the surrounding area was forested. Higher in the section, a tooth of the rodent *Diamantomys* and an anthracothere were recovered, both of which represent Oligocene holdovers in this fossilized Miocene landscape.

Grant Information
Earth Sciences department and ISEM at SMU, the Dallas Paleontological Society, the National Geographic Society, and the National Science Foundation

Technical Session VI (Thursday, October 15, 2015, 11:00 AM)

***TRISTYCHIUS*: ADVANCED JAWS IN AN EARLY ELASMOBRANCH**

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Powered suction feeding, facilitated by kinetic linkages between mobile components of the hyoid arch, mandibular arch, and skeletal supports of the gape margin, is widely considered to be a specialization first seen in Mesozoic fishes. Possession of a mouth that enlarges both anteriorly and laterally as the jaws snap open has long been associated with the evolutionary radiations of neopterygian fishes. The earliest secure evidence of such jaws in an osteichthyan is the semionotid *Acentrophorus* from the Late Permian. Here, we provide evidence that sharks achieved this system some eighty million years earlier. *Tristychius arcuatus* is a probable hybodontid stem-lineage elasmobranch known mostly from Viséan localities in the Midland Valley of Scotland. John Dick described several near-complete crania, including the braincase, jaws, hyoid and gill arch skeletons, from specimens preserved in ironstone nodules. These and previously unreported material have been CT-scanned, revealing cartilages retaining much of their in-life connectivity. Because of the richness of such data, reconstruction of the complete head skeleton of this meter-long shark has been straightforward. Unexpected features include presence of a large retroarticular process on Meckel's cartilage, the form of the hyoid articulation with the otic capsule wall, and the morphologies of the ceratohyal, basihyal, and labial cartilages. Dick's speculation about a sliding connection between the palate and the postorbital process is confirmed. Virtual renderings of the re-articulated head and jaws have allowed detailed modeling of three-dimensional movements of the jaws, labial cartilages, and hyoid arch throughout the mouth opening and closing cycle. The net result is unexpectedly similar to the jaw kinetics of a modern suction feeding orectolobiform shark. *Tristychius* is thus highly specialized, with a jaw mechanism that differs radically from those of all earlier and contemporary gnathostomes.

Grant Information
National Science Foundation grant DEB-0917922

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

THE FIRST EUTHERIAN MAMMALS FROM THE EARLY LATE CRETACEOUS OF NORTH AMERICA

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Putative eutherians have been described from the late Early Cretaceous (Albian, about 105 Ma) of North America, but relationships of included taxa remain unclear; undoubted eutherians belonging to recognized clades do not appear until the Santonian–Campanian, 20 million years or more later, despite major improvements in the fossil record. Herein we document the first occurrence of eutherians in the Turonian of North America, represented by isolated teeth from the Smoky Hollow Member of the Straight Cliffs Formation, southern Utah.

We recognize at least three groups of eutherians, including *Gypsonictops* sp., cf. *Paranyctoides* sp., and one or more unidentified form(s). *Gypsonictops* is represented by three specimens (Mx, P4, and p5); all are morphologically indistinguishable from the later Judithian and Lancian species, *G. hypoconus* and *G. lewisi*. Another taxon, known by less complete material (mx talonid) is identical in known respects to *Paranyctoides*, until now the only pre-Campanian eutherian from North America. Three large specimens (M3 fragment, Mx fragment, and a complete dp5) are comparable in size to large zhelestids (e.g., *Eoungulatum*, *Parazhelestes*) and *Cimolestes magnus*. Most informative of these is dp5, which is low-crowned and bears a broad talonid, and which closely resembles deciduous premolars of the much smaller Asiatic *Aspanlestes*.

The Smoky Hollow eutherians are significant in their temporal occurrence, near the middle of a 20 million year hiatus in the North American record. Furthermore, each of the three (or more) represents a group or taxon typical of later North American assemblages, showing that at least part of the faunal composition was established by or during the Turonian. Each also plausibly represents an Asiatic clade (*Paranyctoides*, recognized from both landmasses, is known from the Turonian of Uzbekistan), suggesting the possibility of intercontinental migration by the early Late Cretaceous.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

THE ARLINGTON ARCHOSAUR SITE, A UNIQUE URBAN EXCAVATION AS A SOURCE OF SCIENTIFIC EDUCATION AND PUBLIC OUTREACH IN TEXAS

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The Arlington Archosaur Site (AAS) is a unique ongoing urban excavation located within the large Dallas-Fort Worth metroplex. The AAS occurs within the mid-Cretaceous Woodbine Formation and preserves a coastal delta plain ecosystem. Researchers and volunteers continue to discover the fossil remains of dinosaurs, crocodilians, turtles, fish, amphibians, mammals, and plants, providing a rare glimpse into the fossil record of mid-Cretaceous ecosystems. Equally unique is the partnership between the private landowner, world-class museum, professional researchers, and volunteers that leverage their diverse perspectives and resources to achieve a host of scientific and educational goals. Proximity to large cities 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. The climate and large volunteer base allow for an expanded field season that accommodates amateur

enthusiasts, educators, and college students to participate in digs through the Fall, Spring, and Summer. All volunteers go through a rigorous training process including overburden removal, sediment screening, fossil excavation, mapping, and data recording. Much of this is accomplished inexpensively by volunteers using social media to inform, invite, and manage events on a regular basis. Over 5 years of activity at the AAS has built a group of highly trained, amateur volunteers who understand the importance of documenting and sharing fossils with academic institutions for the benefit of science and humanity. This unique location provides science education opportunities for underrepresented groups, is a resource for educators and students, and inspires stewardship of Earth's natural resources. Its urban accessibility and volunteer base create genuine scientific experiences, in the field and as classroom-contained projects, making science tangible to diverse populations and influencing future career paths. Public education and outreach efforts help raise awareness of the fossil record and encourage cooperative relationships between researchers and amateurs while promoting an appreciation of paleontology and lifelong learning within the community by participating in workshops, public lectures, STEM Fairs, and educator conferences. Much work remains to be done. The AAS provides a practical model for building amateur-professional partnerships that enhance public engagement and appreciation for science and paleontology.

Technical Session XIV (Friday, October 16, 2015, 3:45 PM)

PALEOBIOGEOGRAPHICAL IMPLICATIONS OF THE PARIETAL EYE, THROUGH THE PARIETAL FORAMEN, IN MOSASAURS

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The parietal eye (PE), the parietal foramen (PF), and the pineal body collectively form the pineal complex and is primarily used to maintain circadian rhythms, body temperature, and orientation in animals. In particular, the pineal complex generally becomes larger for animals living in high latitudes to better regulate these functions due to the generally cooler environments and lower intensity of sunlight. The pineal body of the leatherback sea turtle, *Dermochelys coriacea,* for instance, has an increased sensitivity to sunlight compared to lower latitude dwelling cheloniid sea turtles and is likely used to trigger seasonal migrations based on the amount of daily sunlight it receives. Similarly, high-latitude dwelling squamates (Reptilia) are more likely to have a PE and a larger PF compared to low-latitude lizards, presumably to better regulate their circadian rhythms, body temperature, and sexual reproduction cycles. This study is the first to determine the role of the PE in an extinct group of squamates. We compared the size of the PE, based on the PF, among five different genera of mosasaurs: *Clidastes, Mosasaurus, Platecarpus, Plioplatecarpus,* and *Tylosaurus*. If there was a correlation, then mosasaurs with a large PF should inhabit high latitudes compared to mosasaurs with a small PF. *Plioplatecarpus* had the largest PF followed by *Platecarpus*, *Mosasaurus, Tylosaurus*, and *Clidastes*. *Plioplatecarpus* had the highest paleolatitudinal distribution followed by *Tylosaurus*, *Mosasaurus*, *Clidastes*, and *Platecarpus*. There was a moderate support for the paleolatitudinal hypothesis among genera as *Plioplatecarpus* has both the highest paleolatitudinal distribution and by far the largest PF, however *Platecarpus* has the second largest PF but shares a similar northern paleolatitude range with the smaller PF-bearing mosasaur, *Clidastes*. The results also falsified the hypothesis for specimens within genera as there was no relationship between PF size and paleolatitudinal distribution. We suggest that *Plioplatecarpus* was able to exploit extreme latitudes (~78 degrees) due to their abnormally large PE and furthermore, used their PE as a tool to trigger seasonal migration similar to *D. coriacea.* However, we are still unsure why *Platecarpus* has a large PF despite sharing similar a similar paleolatitudinal range with *Clidastes.* Further research on the biogeographical effects of the pineal complex in modern reptiles can elucidate this conundrum as well as continued fieldwork establishing the true paleobiogeographical range for all mosasaurs.

Technical Session XII (Friday, October 16, 2015, 10:45 AM)

ANGUIMORPHA (SQUAMATA) AND THE IMPORTANCE OF FOSSILS

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Anguimorpha is a small but conspicuous squamate clade including monitor lizards (*Varanus*) and Gila Monsters (*Heloderma*), among others. Monstersauria (the *Heloderma* lineage) and Shinisauria (the *Shinisaurus* lineage) are anguimorph clades whose relationships are contentious. Two recent studies of global squamate phylogeny, one based on morphology and the other applying those morphological data to a combined analysis along with genetic data, have suggested that monstersaurs are polyphyletic. The morphology-only analysis also supports the traditional view that *Shinisaurus* is a xenosaurid rather than being part of Goannasauria (the *Varanus* lineage). Both studies excluded many possible monstersaur fossils (e.g., *Paraderma*, *Primaderma*, *Palaeosaniwa*), xenosaurids (*Restes*, *Exostinus*), and shinisaurs (*Bahndwivici*, *Dalinghosaurus*)-fossil taxa critical for reconstructing ancestral states. Using our own anguimorph data matrix (99 anguimorph species, 502 morphological characters, 5729 molecular characters) as a starting point, we mimicked the taxon and character samplings of the previous studies to test anguimorph phylogeny and recovered topologies similar to the ones recovered in those earlier studies. Our subsequent analysis that included the relevant fossils (including an Eocene fossil shinisaur skin, *Chianghsia*, those listed above, and others) recovered a holophyletic Monstersauria, shinisaurs as goannasaurs, and a monstersaur-anguid-xenosaurid clade. *Paraderma* and *Primaderma* were found to form the sister-group to higher monstersaurs, with *Gobiderma*, *Palaeosaniwa*, and a *Chianghsia-Estesia* clade being successively more proximal helodermatid outgroups. Fossil monstersaurs demonstrate the stepwise addition of morphological characters leading from a generalized 'necrosaur' condition to the highly derived *Heloderma* condition. Shinisauria (including the fossil skin) is united with goannasaurs by five cranial characters, one hemipenial character, and 30 unequivocal molecular characters. Closer examination of the 10 synapomorphies recently used to unite *Shinisaurus* and *Xenosaurus* shows that five are eliminated by deeper taxon sampling, three are based on erroneous characterizations of *Shinisaurus*, and two require further attention. *Estesia* and *Gobiderma* are monstersaurs. Shinisaurs are basal goannasaurs. We recommend the inclusion of as many fossils as possible in any phylogenetic analysis.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

VERTEBRATE FAUNAL CHANGE THROUGH TIME IN THE MIDDLE MIOCENE SITE OF LA VENTA, COLOMBIA

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The Colombian paleontological site of La Venta, located in the Magdelena River Valley, has provided a wealth of information about the endemic Middle Miocene Neotropical fauna. This geological sequence spans over 2 million years (13.5–11.6 Ma) with two major divisions: the La Victoria Formation and the Villaviaja Formation. While fossil collection has been conducted across all units, most previous efforts have focused on the Monkey Beds of the younger Villaviaja Formation. During the summers of 2013 and 2014, our team identified 25 previously undocumented fossiliferous localities spanning the entire geological sequence and also sampled seven previously known localities. From these sites, we collected nearly 1500 identifiable vertebrate fossils. Here we present our analyses of faunal composition and associations across all geological layers.

For all analyses, we used the number of individual specimens as a measure of faunal composition. Crocodylia and Testudines were most common in all units and made up over 50% of specimens collected in total; however, in several layers (unit below the Tatacoa Sandstone, Monkey Beds, Fish Beds, and Polonia Red Beds) they were found in smaller proportions. Across three points in the sequence, Osteichthyes made up at least 25% of the collected sample; these layers included the unit below the Tatacoa Sandstone found in the La Victoria Formation and the Fish Beds, La Venta Red Beds, and El Cordon Red Beds of the Villaviaja Formation. This is in contrast to all other layers sampled, where fish made up no more than 5% of the vertebrate sampled collected. Mammals made up at least 25% of the sampled fauna in four layers spanning the sequence with representatives of Notoungulata, Astrapotheria, and Litopterna (Meridiungulata) found in nearly every layer.

Of particular note are the shifting faunal associations, which indicate significant paleoecological change across the sequence. The unit below the Tatacaoa Sandstone showed a unique faunal composition and stood out as exhibiting a relatively large proportion of both Mammalia and Osteichthyes. In contrast, mammals were relatively rare in all other layers where fish were found in high proportion. Across all layers where Meridiungulata were common, Xenarthrans were also found. While work at this site is on-going, our results indicate ecological change across the sequence that has not been analyzed in previous faunal reconstructions of the site. These changes are likely in response to fluctuations in the proto-Magdelena River.

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Northeastern Illinois University's Summer Research Stipend, Grand Valley State University's CSCE Research Grant-in-Aid and Mini-Grant programs, and the NSF GRFP

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

RELATIONSHIPS AMONG WHITE RIVER TORTOISES FROM TWO LOCALITIES

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Tortoises from the White River Group of Nebraska and South Dakota have been extensively collected, and most large museums in the world house tortoises from the White River Group. These turtles have usually been assigned to *Stylemys*, and sometimes *Gopherus* or *Hesperotestudo,* but most of these early taxonomic assignments were made in the absence of a robust, widely accepted suite of diagnostic characters. Furthermore, while the specimens are readily available, using them in phylogenetic studies is problematic because most were collected without retention of precise stratigraphic information. As such, it has been impossible to study the evolutionary relationships among these tortoises through time. In order to gain a better understanding of the White River tortoises, seven specimens were collected with stratigraphic precision from Toadstool Park and Scotts Bluff National Monument (Nebraska). Preliminary cladistic analysis using a suite of diagnostic shell characters suggests that they all belong to the genus *Stylemys.* We have also observed a diminutive form, possibly a new species, that may reflect a reduction in size caused by the global cooling events of the early Oligocene.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

AN ARTICULATED SKELETON OF *CARCHARODON HASTALIS* (LAMNIFORMES, LAMNIDAE) FROM THE 'MONTEREY FORMATION', ORANGE COUNTY, CALIFORNIA

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Despite an abundance of specimens, there are few scientific studies on fossil sharks from California. Fossil shark teeth have been mentioned sporadically in papers concerning fossil birds or marine mammals from California, but descriptive studies are uncommon. We present an articulated fossil shark skeleton (OCPC 4618, from the John D. Cooper Center) that was collected during paleontological monitoring in 1992 from the 'Monterey Formation' diatomite in Laguna Niguel, California. OCPC 4618 includes vertebrae, dentition, and a brown film outlining the specimen that is believed to be calcified cartilage prisms. The preservation of OCPC 4618 is significant because, whereas isolated shark teeth are common in the fossil record, articulated shark specimens are rare. OCPC 4618 is identified as *Carcharodon hastalis* (white shark) by its teeth with rectangular root systems and triangular crowns. OCPC 4618 has lateral cusplets, a character that is also found in juvenile *Carcharodon carcharias*. Combined with the

small size of the specimen we hypothesize that OCPC 4618 is a juvenile and so provides a unique perspective on the ontogenetic morphological features of fossil white sharks.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

A NEW SPECIMEN OF THE ALLIGATOROID *BOTTOSAURUS HARLANI* FROM THE PALEOCENE OF NEW JERSEY, AND ITS PHYLOGENETIC IMPLICATIONS

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Two species of *Bottosaurus* have been described from the Late Cretaceous and Paleogene of New Jersey: *B. harlani* and *B. tuberculatus*. Both are based on poorly preserved types. The jaw of an alligatoroid (New Jersey State Museum 11265) from the Hornerstown Formation of New Jersey resembles the *B. harlani* type specimen in overall proportions. NJSM 11265 also includes a complete skull, preserving portions of the snout and the majority of the lower jaw and skull posterior to the snout. Postcranial material includes portions of all limbs and limb girdles as well as numerous osteoderms and vertebrae.

Bottosaurus harlani is diagnosed by the presence of tribodont teeth with dorsoventrally wrinkled enamel and mesiodistal carinae. Posterior teeth are mediolaterally compressed. It also preserves a distinct depression between the orbits, and aspects of the skull table – including constricted supratemporal fenestrae and a large trapezoidal dorsal supraoccipital exposure – similar to those of caimans.

A phylogenetic analysis was conducted using Winclada and TNT. The matrix included 138 crocodylian taxa and 189 characters. A strict consensus tree recovered *B. harlani*, including NJSM 11265, as a caimanine crocodylian. NJSM 11265 is included within Caimaninae due to the angular-surangular suture broadly passing along the ventral margin of the external mandibular fenestra. In this analysis, *B. harlani* has a sister-group relationship with the modern dwarf caimans (*Paleosuchus*). That a substantial stratigraphic gap separates *Bottosaurus* from *Paleosuchus*, which first appears in the Miocene, raises questions about this relationship. Further analysis of *Bottosaurus* and other Cretaceous-Paleocene alligatoroids will help illuminate the relationships among these forms and their living relatives.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

BIOMECHANICS OF THE AVIAN FEEDING APPARATUS

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Understanding jaw muscle morphology and cranial biomechanics of birds is essential to understanding feeding behavior and evolution in extant and extinct theropod dinosaurs. Avian clades are historically defined by their palate morphologies: paleognath birds possess horizontally flat, weakly kinetic palates whereas neognath birds have arched, tubular, flexible palates. Both clades evolved from a stock of theropod dinosaurs with their own, characteristic, vertically-oriented, thin palates. However, little is known about how these different palates and their attaching pterygoideus muscles behave biomechanically or how they evolved along the line to birds. This study compares the biomechanics of a sample of avian and non-avian theropods using 3D modeling techniques to discover new biomechanical characters and to test ecological and evolutionary hypotheses. Muscle attachment and physiological parameters were reconstructed in CT scan-derived, 3D models of ostrich, chicken, parrot, and *Tyrannosaurus*. 3D lever analysis was performed about multiple joint axes and bite points to determine the moments each jaw muscle contributes to bite force as well as forces about the jaw and other kinetic joints. We found distinct differences in M. pterygoideus function in which the muscles are not distinct openers or closers of the jaws in neognaths contrary to their sole roles in closing in other clades. The protractor pterygoideus muscles have prominent mediolateral resultants about the palatobasal joints in all clades. Finally, although the temporal regions of ostrich and neognaths are occupied by non-homologous muscles, these muscles were functionally convergent in their action about the jaw joints. These data show that high-resolution 3D models of the dinosaur feeding apparatus shed light on the biomechanics of the dinosaur-bird transition and the origins of avian kinesis.

Grant Information
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Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

POSTCRANIAL MORPHOLOGY OF *PONDAUNGIMYS ANOMALUROPSIS* (RODENTIA, ANOMALUROIDEA) FROM THE LATE MIDDLE EOCENE PONDAUNG FORMATION OF CENTRAL MYANMAR

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The Anomaluridae are an African rodent group also known as the 'scaly-tailed squirrels'. This rodent family is endemic to western and central equatorial Africa. All anomalurid species are strictly arboreal and, with a single exception (*Zenkerella*), are able to perform gliding flight. Anomalurids are represented by four living genera (*Anomalurus*, *Anomalurops*, *Idiurus* and *Zenkerella*).

The Paleogene fossil record for this group is poor. The oldest African anomaluroids known so far come from the late middle Eocene Bir El Ater locality of Algeria, the late middle Eocene Dur At-Talah deposits of Libya and the early late Eocene Birket Qarun 2 locality of Egypt. The only known occurrence of anomaluroids outside of Afro-Arabia is the late middle Eocene genus *Pondaungimys* from Myanmar. Later in time, this clade has been reported from the Oligocene of Oman and the Miocene of East Africa.

Paleontological expeditions conducted in the late middle Eocene Pondaung Formation of Myanmar have yielded an astragalus attributable to *Pondaungimys*. This fossil represents the oldest postcranial evidence for anomaluroids. Other postcranial bones of Paleogene anomaluroids have been reported from the late Eocene of Egypt and referred to *Kabirmys*. The postcranial morphology of this primitive anomaluroid has been described as generalized with many primitive features. The postcranial skeleton of *Kabirmys* shows no obvious gliding adaptations.

The astragalus of *Pondaungimys* lacks features present in living anomalurids and its overall morphology is more similar to those of early fossil rodents such as paramyids. Compared to extant anomalurids, it has a short neck and the lateral trochlea is not appreciably larger than the medial one. The astragalus of *Pondaungimys* lacks the distinctive adaptations found in extant anomalurids that are related to their commitment to strictly arboreal environments.

Grant Information
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Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

A NEW EARLY MIOCENE FOSSIL LOCALITY AT NAPAK, UGANDA (~20 MA)

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Early Miocene sediments associated with the extinct Napak volcano in northeastern Uganda have been prospected and studied since the 1950s. These localities have yielded well-preserved fossil assemblages that sample diverse mammalian communities, including catarrhine primates. All Napak localities are dated to ~ 20 Ma. Most of the known fossil localities are located on the volcanic remnant known locally as Akiism, but the larger remnant of Napak had not been extensively prospected.

Here, we report a new locality (Napak CCIV) that was discovered while prospecting on the northern slopes of the Napak volcanic remnant. NAP CCIV is associated with early stages of volcanism, and would have been located close to the base of the developing volcanic sequence. The fossils are derived from coarse fluvial and floodplain sediments deposited on a series of lahars that accumulated on the basement complex.

We used systematic surface collection, including transects, followed by localized excavations to collect vertebrate fossils. To date, we have collected 128 vertebrate specimens belonging to at least 12 taxa. The mammalian assemblage is similar to other Napak localities, except for a few important differences: (1) primates are relatively rare, and represented only by one or two possible postcranial elements; and (2) *Diamantomys luedertizi*, the most common rodent at all East African early Miocene localities has not been sampled, but other thryonomyoids are well represented. These preliminary findings suggest that NAP CCIV may be sampling a somewhat different habitat than other Napak localities at higher elevation on the volcano slopes. Aquatic taxa are very poorly represented, which is similar to other Napak localities that are also sub-aerially deposited.

Preliminary results from Napak CCIV corroborate our team's previous findings that there is some habitat heterogeneity between Napak localities. Future research will focus on analyzing plant and phytolith remains from the site, as well as analyzing mammalian tooth enamel isotopes in order to further elucidate the habitats sampled at NAP CCIV and compare the locality with other Napak localities and early Miocene sites from across East Africa.

Grant Information
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Technical Session VI (Thursday, October 15, 2015, 10:15 AM)

EVOLUTION AND DEVELOPMENT OF THE CHONDRICHTHYAN VERTEBRAL COLUMN: THE EMBRYONIC ORIGIN OF CENTRA

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The vertebral column is a defining feature of vertebrates, but it varies widely in its components and tissue types. Previous ancestral state reconstruction analyses indicate that separate components of the axial column complex evolved independently many times. Specifically, centra have originated independently in numerous gnathostome groups, fishes in particular, and the developmental processes regulating centrum formation vary accordingly. Teleost centra can form through sclerotomal cells migrating from the ventral somite, by bone matrix deposited by the notochord, or from both sources, while amniote centra develop exclusively from the sclerotome. Most of the available data on centrum development in gnathostomes come from osteichthyans, however. To broaden taxon sampling with respect to the embryonic origin of centra, we examined embryonic axial morphology, gene expression and sclerotome fate in a cartilaginous fish, the little skate (*Leucoraja erinacea*). Histological analysis of a series of stage 28-32 embryos, stained using haematoxylin and eosin, reveals a thickening of the fibrous notochord sheath prior to cartilaginous centrum formation. *In situ* hybridizations for the sclerotome marker *Pax1* show ubiquitous expression throughout the sclerotome as cells begin to migrate from the ventral somite. To investigate the embryonic origin of skate centra, we performed sclerotome fate mapping experiments. The ventral somite was labeled with the lipophilic dye CM-DiI prior to the emigration of sclerotomal cells from the somite, and DiI-labeled cells were subsequently identified both surrounding, and within, the notochord sheath and incipient centra seven weeks post-injection. These results suggest that chondrichthyan centra derive from sclerotomal cells, and, when taken

with data from other gnathostome models, that the sclerotome plays a key ancestral role in vertebral development.

Colbert Prize (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

TEMPORAL VARIABILITY IN THE DIETARY BEHAVIOR OF *CANIS DIRUS* AT THE RANCHO LA BREA TAR PITS

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The dire wolf, *Canis dirus*, ranged from Canada to South America during the Pleistocene and is one of the most frequently preserved carnivorans at the Rancho La Brea tar pits. As recovered specimens range from approximately 40,000 to 11,000 years before present (YBP), it is possible to assess how the morphology and diet of *C. dirus* changed over time, potentially in response to interglacial warming. Previous work documented a reduction in *C. dirus* skull size at Pit 13 (mean calibrated age of 16,192 YBP), potentially coinciding with or shortly after the Last Glacial Maximum. Understanding if and how the diet of *C. dirus* may have fluctuated in response to past climate change can help clarify carnivoran responses to long-term climate change and potentially reveal extinction implications.

Prior work has suggested that changes in morphology, especially skull proportion and size, may have been related to a decline of resource availability. Using dental microwear texture analysis (DMTA), a three-dimensional analysis that quantifies microscopic wear patterns on the chewing surface of teeth, we quantified the textural properties of food consumed by *C. dirus*. Specifically, we analyzed *C. dirus* teeth from three depositional units (Pits 61/67, Pit 13, and Pit 77, with mean calibrated ages of 11,581, 16,192, and 35,370 YBP, respectively) to test the hypothesis that the diet of *C. dirus* was more generalized during cooler glacial periods. Further, we clarified how the textural properties of food consumed by *C. dirus* may have correlated with changing climates, morphology, and tooth breakage throughout the late Pleistocene. Our data demonstrate that complexity is significantly greater at Pit 77 than at Pit 13 and 61/67, with no significant differences in complexity between Pits 13 and 61/67. These data suggest that *C. dirus* may have consumed more brittle objects (potentially including bone) ~35,000 YBP, as compared to the past ~11,000 to 16,000 YBP. In addition, we find that textural fill volume is significantly lower at Pit 13 as compared to Pit 77 and Pits 61/67, and that variances of individuals from each pit are all significantly different from one another (with Pit 13 having the greatest variance). Collectively, DMTA data suggests that *C. dirus* may have been more generalized in its dietary behavior during cooler glacial periods, while individuals from ~35,000 years ago likely consumed more brittle food items, such as bone.

Grant Information
This work was funded by NSF (EAR 1053839).

Technical Session XV (Saturday, October 17, 2015, 9:00 AM)

NEW MAMMAL FAUNAL DATA FROM CERDAS, BOLIVIA, A LOW LATITUDE NEOTROPICAL SITE THAT CHRONICLES THE END OF THE MIDDLE MIOCENE CLIMATIC OPTIMUM IN SOUTH AMERICA

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Many groups of South American mammals apparently underwent northward range contractions following the Middle Miocene Climatic Optimum (MMCO) including primates, porcupines (Erethizontidae), palaeothentid marsupials (Paucituberculata), and astrapotheres (a native ungulate group). Determining the precise timing of these shifts has been hampered by a scarcity of (1) early middle Miocene (Langhian) sites from tropical latitudes, and (2) late middle Miocene (Serravallian) sites from the Southern Cone. Cerdas, Bolivia (ca. 21° S) is one of only three sites of Langhian age that documents Neotropical mammal distributions near the end of the MMCO. Our team's recent fieldwork at the site recovered specimens from low in section that represent three groups previously undocumented at the site: a meat-eating metatherian (Sparassodonta), a proboscis-bearing ungulate (Astrapotheria), and a megatheriid sloth. Paleosols from this portion of the section are weakly to moderately developed, have compound and composite profiles, and preserve several types of ichnofossils including lined and unlined burrows, rhizohaloes, and rhizotubules. The sparassodont remains include the basicranium and most of the mandible of a species comparable in size to the hathliacynid *Cladosictis patagonica* from the late early Miocene of Santa Cruz, Argentina. However, several features suggest borhyaenoid rather than hathliacynid affinities including a jugular fossa, a non-pneumatized squamosal, and the lack of a hypoconulid on m4. The astrapothere remains consist of many tooth fragments with an unusual combination of features not typical of late early Miocene *Astrapotherium magnum* nor late middle Miocene members of the Uruguaytheriinae; these include relatively smooth premolar ectolophs and very large upper molar cingulae. A partial megatheriid sloth dentary preserving the last molariform likely pertains to a Megatheriinae, which suggests that this subfamily could have originated in lower latitudes and later spread into Patagonia. A newly discovered specimen of a horned armadillo (Peltephilidae) from Cerdas includes a partial articulated carapace that supports its identification as a new species. The osteoderms of this specimen are characterized by a surface texture of small tubercles and pits, a central longitudinal elevation (acute in cross section) surrounded by a deep, wide groove extending over most of the osteoderm, and depressions along the border arranged in a unique, radial pattern. Ongoing studies at Cerdas aim to place these mammals in a refined paleoenvironmental context.

Grant Information
This research was supported by the National Science Foundation (EAR 0958733 to D. Croft).

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

HOW CONSERVED IS NEUROANATOMY IN SNAKES? COMPARING THE ENDOCASTS OF A 32-MILLION-YEAR-OLD SNAKE AND ITS EXTANT RELATIVES

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Exceptional preservation of a 32-million-year-old snake from the White River Formation, WY, allows for the first thorough investigation of internal morphological details in a fossil snake skull. Here, the first endocast of a fossil ophidian is rendered using digital preparation of a high-resolution CT scan. The digital endocast provides a unique opportunity to observe brain evolution of a branch of boid snakes through direct comparison of an extinct taxon with two closely related extant species. With reference to the extinct White River taxon, the endocast morphologies of both *Lichanura* and *Ungaliophis* are remarkably similar. All of these endocasts exhibit classic snake-like features, including relatively large olfactory bulbs, cerebral hemispheres, optic tecta, and medullae, as well as a highly reduced cerebellum. There is also extensive mediolateral narrowing of the endocast at the level of the endolymphatic duct, which is a characteristic byproduct of the relatively large and internalized otic capsules in snakes. The cerebral hemispheres are well defined and little dorsoventral flexon of the endocast is present, giving it a true "reptilian" appearance. Notably, the dural venous sinus pattern is virtually identical in the fossil and extant endocasts. The near lack of change between these taxa over the last 32 million years indicates that the endocast morphology in this branch of Boidae is remarkably conserved.

Technical Session VII (Thursday, October 15, 2015, 2:30 PM)

FOCUSING ON THE FLOODPLAIN: VARIATIONS IN HADROSAURID BEHAVIOR, SOIL PROCESS, AND FOREST STRUCTURE OVER THE LATE CRETACEOUS LANDSCAPE OF WESTERN NORTH AMERICA

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Extensive terrestrial deposits of Late Cretaceous age provide a window into this greenhouse world that has allowed for detailed descriptions of past environments and ecosystems. In western North America, low-relief river and floodplain environments were located in basins to the east of Sevier Orogeny highlands and west of the Western Interior Seaway (WIS), with these environments extending north–south from Alaska to Mexico. Living in these river and coastal areas was a very diverse assemblage of plants and animals, including the most diverse dinosaur ecosystems described to date.

Despite all that is known about this time in western North America, there are some critical questions that remain unanswered. Focusing on ecosystems, a major question is how these forests were able to support such diverse associations of animals, particularly large herbivorous dinosaurs, given the absence of evidence for migratory behaviors. Considering climate, there is the question of how these environments are linked to the global carbon cycle, and what role they play in maintaining greenhouse climate conditions.

In this study, stable isotope ratios ($\delta^{13}C$ and $\delta^{18}O$) of hadrosaurid dinosaur teeth collected from a number of Campanian-aged localities along the WIS are used to investigate dinosaur niche partitioning, possible surface methane production, and the nature of the forest canopies. Isotope ratios of tooth dentine are altered by diagenetic processes taking place in soils/sediment, and thus provide information on these processes. In contrast, isotope ratios of tooth enamel preserve primary biological signals, and can be used to study animal diets, which in the case of hadrosaurids are trees of the floodplain forest.

High $\delta^{13}C$ of dentine (> +5 ‰) indicates that CH_4 production took place in certain soils on the floodplain and that this CH_4 was emitted to the atmosphere. This likely played an important role as a climate feedback that helped maintain greenhouse conditions. The existence of hadrosaurid tooth enamel with similarly high $\delta^{13}C$ suggests that these gases were incorporated into low-level forest vegetation before being eaten by the animals, thus providing evidence for the presence of closed-forest canopies on the floodplain. In addition, offsets in $\delta^{13}C$ of enamel for co-existing populations of hadrosaurids within the Kaiparowits Formation of southern Utah reveals significant offsets, which provides evidence of dietary niche partitioning amongst hadrosaurid sub-families within low-lying fluvial environments of southern Utah.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

ULNAR BUMPS OF *CONCAVENATOR*: QUILL KNOBS OR MUSCULAR SCARS? MYOLOGICAL RECONSTRUCTION OF THE FORELIMB OF *CONCAVENATOR CORCOVATUS* (LOWER CRETACEOUS, LAS HOYAS, SPAIN)

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The *Concavenator corcovatus* holotype (MCCM-LH 6666) is a skeleton of a carcharodontosaurid from the Las Hoyas fossil locality (Lower Cretaceous, Spain). This specimen shows unusual features, such as elongated neurapophyses of the dorsal vertebrae and a series of small bumps on the ulna.

The right ulna is completely preserved and all sides are visible, except for the medial side, which is hidden. The bumps are present on the posterolateral surface of the ulna. Three of them, located more laterally, are the most marked, and their separation is 6 mm. The two most distal bumps are posteriorly directed and their separation is from 10.6 to 16.7 mm.

These bumps are topologically homologous to the quill knobs of birds. Although quill knobs are generally situated on the posterior surface of the ulna, some taxa, such as *Gallinula,* develop these knobs on the lateral surface. Altenative hypotheses to explain

these bumps consist of their association to an intermuscular crest or an attachment scar for the insertion of an ulnar muscle.

A myological reconstruction of the forelimb of *Concavenator* is performed in order to test these hypotheses. The reconstruction is carried out based on the osteological description, anatomical comparison with extant taxa, and using the Extant Phylogenetic Bracket (EPB).

The insertions of M. triceps brachii (TB) and M. anconeus (AN), and the origin of the ulnar head of M. abductor pollicis longus (APL) are reconstructed on the ulna of *Concavenator*. The first is located on the posterior surface of the olecranon. The insertion site of AN is situated on the anteroposterior surface of the ulna based on EPB. The origin of APL is located on the anterior surface of the ulna.

The bumps are not located between these muscles. Thus, the hypothesis that the bumps could be an intermuscular crest is refuted. As for the second hypothesis, the bumps could be a muscle scar of AN. However, the insertion of this muscle is a fleshly attachment that produces a featureless surface, without osteological correlates.

In conclusion, the myological reconstruction does not provide any evidence supporting the hypothesis that the series of bumps can be interpreted as an intermuscular line or attachment scar. However, the existence of birds with quill knobs in the same position as the bumps of *Concavenator* inclines us to consider that this is, so far, the most parsimonious interpretation. This interpretation indicates the presence of skin appendages in *Concavenator*, preceding the wing feathers present in Maniraptora.

Grant Information
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Poster Symposia (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

RECONSTRUCTING THE EVOLUTIONARY BIOMECHANICS OF THE FELID POSTCRANIUM

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Felids (cats) span a wide range of body masses, from ~1 kg in the smallest extant species to >400 kg in some of the largest extinct species. Our analyses of body size across 39 species of living and extinct species suggest that this diversity evolved through either Brownian motion or a relatively simple 2-optimum OU process. Of particular interest is the observation that cats maintain the same crouched posture at all sizes, contrary to a biomechanical trend that terrestrial vertebrates' limbs become increasingly erect at larger body sizes. To explore this phenomenon, we combine dissection and finite element (FE) modelling to explore muscle properties and bone loading patterns across a range of felid species.

Using dissection, we measured the muscle properties for the appendicular skeleton of nine species of felids spanning a wide range of body sizes. The data showed that the masses and fascicle lengths of most hind limb muscles scale with positive allometry whilst only fascicle lengths for the lower forelimb scale with positive allometry. The other muscle measures for both limbs scale with isometry. Because cross-sectional area (a metric of force production) scales against mass$^{2/3}$, large felids become relatively weaker than their smaller relatives. These data, combined with CT and photogrammetry from the extant species, allowed for reconstruction of the muscles of extinct taxa, including the American cheetah (*Miracinonyx trumani*).

To test how previously observed, positively allometric trends in bone robusticity affect functional performance, FE models of limb and vertebral bones were validated using semi-physiological loads in a special loading rig and using digital image correlation to measure strains. Results show that the validation strain patterns in the experiments closely match those seen in the computer simulation and will allow for further study of bone stresses and strains across felidae using the data from dissections.

The combination of three-dimensional approaches for reconstructing the postcranial musculoskeletal system of living and extinct felids demonstrates that despite some muscle metrics scaling with positive allometry, larger cats become muscularly relatively weaker with increased size. This suggests that bone allometries and behavioural changes may be responsible for the maintenance of crouched postures. Future work will involve integrating the muscle data into musculoskeletal models with experimental gait data collected from a range of taxa to test this hypothesis.

Grant Information
Leverhulme Trust grant RPG 2013-124 to AG and JH

Technical Session IX (Thursday, October 15, 2015, 3:15 PM)

NEW DATA ON DINOSAUR FAUNAL TURNOVER AND EXTINCTION TIMING IN THE DINOSAUR PARK FORMATION (LATE CRETACEOUS: CAMPANIAN) OF ALBERTA, CANADA

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The Campanian Dinosaur Park Formation (DPF) is a transgressive alluvial-paralic unit in Southern Alberta famous for its high abundance of articulated dinosaur skeletons and bonebeds. High-resolution biostratigraphic data have revealed ornithischian faunal turnover within the ~1 million years of time represented by this 70 m thick unit. Previous studies have hypothesized that the presence of changes in the proposed discrete faunal assemblages represent community turnover through pulses of immigration and local extinction, with the possibility of anagenetic evolution within some lineages. Here we present new biostratigraphic data for DPF theropods (tyrannosaurids, ornithomimids, and deinonychosaurs) and updated biostratigraphic data for large herbivorous ornithischians. In order to better quantify faunal dynamics within the formation and test for discrete turnover-pulse events, we applied the 'Creeping-Shadow-of-a-Doubt' (CSD) method to abundant taxa in the DPF. This Bayesian method examines the prior occurrences of a taxon in order to estimate the probability of it being locally extinct at a given stratigraphic position, and provides the position at which it can reasonably be considered extinct versus merely unsampled.

Ornithischians follow a distribution pattern similar to previous studies, with hadrosaurs and ceratopsians experiencing multiple sets of turnover events throughout the DPF. In contrast, the theropods appear to experience less origination or turnover across the sampled interval, remaining relatively stable throughout the formation. The results of the CSD analyses infer extinction time of early-appearing large herbivorous taxa as offset by 15-30 m compared to their last appearance in section, and confirms turnover in this guild. However, the timing of herbivore origination within putative faunal zones is poorly coordinated, suggesting that these zones were not strongly coherent as ecological communities. Interestingly, theropods show little stratigraphic segregation and none of the sampled theropods could be inferred as extinct with high probability until above the sampled stratigraphic range of the DPF, despite the disappearance of some taxa within the strata. This suggests that herbivores were more sensitive to environmental changes and associated plant community turnover than carnivores were to changes in herbivore assemblages.

Technical Session X (Friday, October 16, 2015, 12:00 PM)

EXQUISITELY PRESERVED SPECIMEN OF *SAURORNITHOLESTES LANGSTONI* (THEROPODA, DROMAEOSAURIDAE) FROM DINOSAUR PROVINCIAL PARK, UPPER CRETACEOUS OF ALBERTA CANADA

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It was exactly a century ago when a field crew of the American Museum of Natural History collected an almost complete skull of a small theropod from what is now known as Dinosaur Provincial Park. This specimen became the holotype of *Dromaeosaurus albertensis*. *Velociraptor* and *Deinonychus* were eventually recognized as related forms, and the three animals were united in the Dromaeosauridae. *Saurornitholestes* was described by Sues in 1978, thereby becoming the fourth known dromaeosaurid, and the second from Dinosaur Provincial Park. It has turned out to be much more common than *Dromaeosaurus*, and isolated teeth and bones are frequently recovered in southern Alberta. There are also four partial skeletons of *Saurornitholestes*. Nevertheless, reasonably complete skeletons have remained elusive, and virtually nothing is known about the skull. The lack of truly diagnostic material has been problematic, and led one researcher to synonymize *Saurornitholestes* with *Velociraptor*. Although most workers on Dromaeosauridae do not accept this synonymy, *Saurornitholestes* has fallen into many different positions in recent phylogenetic analyses because of the incomplete knowledge of its anatomy. In 2014, an almost complete skeleton, including the skull, was collected from the west end of the Park. Like well-preserved specimens of *Velociraptor* from Mongolia, the specimen includes a furcula, an ossified sternum, sternal ribs and uncinate processes. Although similar in size to *Velociraptor*, the facial region of the skull is considerably deeper and wider. The enlarged raptorial pedal ungual II-3 is also relatively larger, and its strong curvature is accentuated by the preservation of the keratinous sheath. The new information allows reanalysis of its taxonomic position within the Dromaeosauridae, and supports the suggestion of at least two major invasions of Asian dromaeosaurid taxa into North America.

Technical Session XVII (Saturday, October 17, 2015, 4:00 PM)

TINY TITANOSAURS: PRIMARY GROWTH AND EARLY ONTOGENY IN A VERY YOUNG SAUROPOD FROM MADAGASCAR

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Even the largest sauropods began their lives as small animals, exhibiting an ontogenetic size difference between hatchlings and adults greater than that of any other terrestrial vertebrate. The lack of data for perinatal sauropods hampers our understanding of the strategies that allowed them to achieve such astounding changes in size. Here we describe a very young specimen of *Rapetosaurus krausei* that represents one of the smallest post-hatching sauropods yet recovered. The new juvenile specimen is represented by associated elements from the forelimb, hind limb, pelvic girdle, and vertebral column. Limb element lengths indicate that this very young juvenile stood ~ 35 cm tall at the hip and weighed as little as ~35 kg. In spite of its very small body size, limb elements do not exhibit significant differences from later stage juvenile and adult morphology and generally scale isometrically, as documented for other sauropod taxa.

Bone histological and microCT data indicate that perinatal *Rapetosaurus* grew very quickly, but that this fast growth coincided with an early onset of bone remodeling that extends into the mid-cortex of all sampled appendicular elements. Lines of Arrested Growth (LAGs) and annuli are absent, but an intracortical zonation not demarcated by LAGs may indicate a post-hatching growth hiatus and provide a lower limit for body size at hatching for *Rapetosaurus*. Remodeling may be related to a phylogenetic shift in titanosaur growth strategies, biomechanical loading, and/or to blood calcium homeostasis. Epiphyseal regions are comprised of zones of calcified cartilage perforated by canals lined with newly formed bone tissue. These zones are thinner than in other perinatal dinosaurs, and could indicate relatively slow elongation of limb bones, a pattern that would be inconsistent with observed rapid appositional growth and the frequency of secondary remodeling. These data, combined with the taphonomic and paleoenvironmental context of the Maevarano Formation, support the hypothesis that *Rapetosaurus* were nidifugous (precocial) and probably not reliant on significant postnatal parental care.

Grant Information
EAR-0955716

Poster Symposia (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

FRONTAL SINUS MORPHOLOGICAL DISPARITY IN CARNIVORA

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Mammal skulls contain up to four air-filled chambers called paranasal sinuses that develop in the frontal, maxilla, sphenoid, and ethmoid bones. Paranasal sinuses exhibit striking morphological disparity among mammals, but few studies have quantified sinus

morphology, and their function is poorly understood. Mammals appear to have gained and lost sinuses multiple times throughout their evolutionary history, but until recently, patterns in sinus morphology were difficult to study due to the fact that they are hidden inside skulls. I used non-destructive CT scanning to quantify frontal sinus morphology in the order Carnivora, and included skulls from 61 species representing 10 carnivoran families. Carnivorans offered an excellent comparative sample because they span a range of skull size and shape disparity, vary in ecology and diet, and literature suggests that frontal sinuses were gained and lost multiple times in this clade. I focused on frontal sinuses because they vary most in size and presence among species relative to other paranasal sinuses and are often well preserved in fossil skulls. I constructed volumetric models of frontal sinuses from CT scans using specialized visualization software and applied a novel technique called spherical harmonics to quantify three dimensional sinus shape disparity among species. Skull size and shape were quantified using three-dimensional geometric morphometrics. Allometry of sinus size and shape and skull size and shape were explored using linear and multivariate regression techniques within a phylogenetic context to test the hypothesis that sinuses form where bone is mechanically unnecessary. Results showed frontal sinuses were gained and lost multiple times across Carnivora and sinus morphology varies greatly among species. Sinus presence, size and shape related to external skull size and shape, and were also correlated with allometric differences in skull shape between families related to biomechanical function and ecology, which supports the hypothesis that frontal sinuses develop where bone is mechanically unnecessary. For some species, presence of frontal sinuses may also have enabled evolution of novel skull shapes, such as the dome-shaped frontals of durophagous carnivorans, which are an adaptation to produce proportionally large bite forces.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

BARSTOVIAN BATS (CHIROPTERA: VESPERTILIONIDAE) FROM THE MYERS FARM LOCAL FAUNA, NEBRASKA

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The Myers Farm (MF) local fauna was recovered in the early 1970s from UNSM locality Wt-15A, Webster County, Nebraska, in the Crookston Bridge Member of the Valentine Formation. The local fauna is late Barstovian (Ba2) in age. Wt-15A yielded one of the largest Neogene assemblages of bat fossils in North America, yet the bats have remained unpublished in the subsequent 40 years. The bats were the most abundant microvertebrates at Wt-15A and occurred in a limited interval of black and green sandy silt representing a quiet water association. The black silt is also apatite-rich and likely represents altered guano, and the bats probably roosted directly above the black lens. The bat fossils number about 1248 (number of identified specimens [NISP]), consisting of (in order of abundance) the ends of humeri and radii, dentaries, femora, isolated teeth, maxillae, and other skeletal elements. All pertain to Vespertilionidae: Vespertilioninae. The vast majority of specimens (1200 or 96% of NISP; minimum number of individuals = 83 by distal humeri) represent a new species of Antrozoini that is smaller than the three known members of the tribe: the extant species *Antrozous pallidus* and *Bauerus dubiaaquercus*, and the extinct *Anzanycteris anzensis*. Antrozoini genera are dentally similar but are distinguished by lower incisor count: *Bauerus* normally has three incisors with large i1–i2 and tiny i3 crowded between i2 and the canine cingulum (some individuals lack i3), *Antrozous* has uncrowded large i1–i2 only, and *Anzanycteris* has a large i1 and a small i2 (but the available incisor sample for *Anzanycteris* includes only the holotype specimen). Although the MF Antrozoini specimens lack the actual incisors, the incisive alveoli are preserved in many dentary fragments; there are consistently three lower incisive alveoli in a triangular configuration, with large i1 positioned forward, large i2 crowded posteriorly, and a small i3 crowded ahead of the i2. Thus the new species is referred to *Bauerus*. Postcranially the distal humerus of the fossil bat is more similar to that of *Antrozous*, lacking a tiny posterior tubercle near the olecranon fossa seen in *Bauerus*. The MF antrozoin represents a sister taxon to *A. pallidus* and *B. dubiaquercus*, possibly ancestral to both. Far less common bats of the MF fauna comprise small vespertilionids (44 elements; 3.5% of NISP) including a single bone of *Lasiurus* sp. and at least two species of *Myotis*, a larger and a smaller form. All MF bats pertain to adults with no unfused epiphyses on any of the major limb elements, suggesting that the assemblage does not represent a maternity colony.

Technical Session XII (Friday, October 16, 2015, 11:30 AM)

SKULL SHAPE SUPPORTS A TERRESTRIAL-FOSSORIAL TRANSITION IN THE EARLY EVOLUTION OF SNAKES THROUGH HETEROCHRONY

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The origin of snakes is a contentious topic with three competing hypotheses: aquatic, terrestrial or fossorial. The snake fossil record is poor with a few preserved complete skulls dated back to the Cretaceous. Phylogenies using discrete morphological data and including fossils are contradictory regarding the ophidian ancestor. Thus, alternative approaches that aid tracking down the lizard-snake ancestral transition are necessary. Comparisons of quantitative data such as skull shape of extant and fossil taxa but also ontogenetic trajectories of skull development are relevant alternative approaches. In this study, we analyzed for the first time more than 600 extant and extinct taxa representative of all major Squamata families using two- and three-dimensional landmarked-based geometric morphometrics. We also mapped a consensus phylogeny onto the morphospace and estimated ancestral shapes with Parsimony. Lastly, we traced 61 skull ontogenetic trajectories with principal component analysis. We first found that snakes and lizards occupy different parts of the morphospace, except for many convergent fossorial forms. Shape transitions are gradual and strongly linked with ecology. The first axis of variation largely accounts for changes in the braincase and quadrate. Interestingly, ancestral estimations recovered the most common ancestor of snakes as a small fossorial similar to *Anomochilus*, while Cretaceous snakes show intermediate skull shapes similar to boas and pythons. Ontogenetic trajectories of snakes and lizards are linear and overall parallel phylogeny in snakes. Young embryos of Alethinophidia have similar shape to terrestrial adult lizards and trajectories are clearly peramorphic. Adults and embryos of Scolecophidia are located at the base of lizard ontogenetic trajectories, likely indicating neoteny. Altogether, our data indicate that skull shape and ecology are strongly connected, supporting the hypothesis that modern snakes lineages originated from a fossorial snake ancestor through an early transition from terrestrial lizards. Lastly, natural selection fine-tuned skull ecological function upon variation generated by heterochrony.

Grant Information
Three-Year Research Grant from University of Helsinki; BCH start-up Grant from Biocentrum Helsinki; Startup package from Institute of Biotechnology

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

THE ATYPICAL MORPHOLOGY OF THE ATLANTO-OCCIPITAL JOINT OF *PROLIBYTHERIUM* (RUMINANTIA, MAMMALIA)

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Prolibytherium is a taxonomically problematic species known from the Miocene of North Africa, and newly recognized from Pakistan. We are reporting on an atypical morphological feature of the atlanto-occipital joint, using material derived from three skulls and a single atlas from Gebel Zelten of Libya, and a single braincase from Zinda Pir of Pakistan (18—16 Ma). Unlike other ruminants, the two occipital condyles are connected at the midline without a clearly visible fusion line. This is accompanied by an increase in bony material at the median plane, where the condyles are uniformly thick throughout. Moreover, there is a bony plate connecting the lateral margin of the condyle with the paroccipital process. The occipital condyles are oriented more posteriorly in the Libya specimens, with a thinner anterior surface, whereas the condyles are oriented laterally in the Pakistan specimen, with a fuller anterior midline section. The Pakistan specimen has specialized basioccipital tuberosities that connect at the midline. The tuberosities are sharp edged and posteriorly have small bony growths concentrated medially. In the Libya specimens, the tuberosities are taller and more prominent, and are slightly rostral, but are separated at the midline and lack the posterior growths.

The *Prolibytherium* atlas also has several specializations. The ventral arch is thickened, as is the dorsal surface. There is a concavity on the posterior articular facets, which articulate with the axis. In addition, the anterior edge of the dorsal and ventral lamina lacks the characteristic U-shape and instead is filled with bony material, forming a transverse ridge with a small notch at the midline ventrally. The alar wings are also larger than that of a typical ruminant.

We hypothesize that these specializations on the *Prolibytherium* atlanto-occipital joint have implications on the range of motion and support of the head and neck. The increased anterior surface area of the condyles and atlas increases the contact between these bones, allowing for stronger reinforcement of the head and neck during flexion. The atlanto-occipital motion appears to be concentrated centrally (rotation, flexion/extension), rather than laterally (side bending), which leads to speculation on the modes of fighting. One specimen each of *Giraffokeryx* and *Schansitherium* have approximated but not fused occipital condyles. All three of these taxa have four ossicones, suggesting that a specialized mode of fighting might relate to this occipital condylar morphology.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

ADDITIONAL RESEARCH AND TAXONOMIC RESOLUTION OF SALAMANDERS (AMPHIBIA: CAUDATA) FROM THE MIO-PLIOCENE GRAY FOSSIL SITE, TN

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The Gray Fossil Site (GFS) is a Mio-Pliocene (4.5-7 Ma) locality in the southern Appalachians boasting the most diverse pre-Pleistocene salamander fauna in North America. Previous work on isolated vertebrae has yielded *Desmognathus* sp., *Plethodon* sp., *Notophthalmus* sp., a Spelerpini-type plethodontid, and *Ambystoma* sp. Existing fauna (including *Alligator* sp., *Rana* sp., and neotenic *Ambystoma* sp.) support a perennial sinkhole lake, though greater taxonomic resolution could result in more precise paleobiological interpretations. Two new salamander specimens are presented by the current study. A nearly complete articulated ambystomatid allows for the inclusion of cranial characters in identification and appears most like modern *Ambystoma maculatum* in dentition and vertebral proportions. An isolated right vomer is consistent with a terrestrial Spelerpini-type plethodontid other than *Eurycea*. It appears most like modern *Pseudotriton* spp. and *Gyrinophilus porphyriticus* in possessing a postdentigerous process and similar dentigerous row morphology. If the two fossil specimens share similar ecological preferences as the modern taxa they resemble, it is unlikely they cohabitated the same pond. Modern *Pseudotriton* spp. and *G. porphyriticus* require multiple years to complete their aquatic larval stage; their presence could further support a perennial lake interpretation. Modern *A. maculatum* preferentially breed in vernal pools; confirmed identification could suggest local seasonal wetlands.

Preparators' Session (Thursday, October 15, 2015, 10:30 AM)

VIRTUAL *AQUILOPS*: DIGITALLY RECONSTRUCTING A TINY CERATOPSIAN

DAVIES, Kyle L., SNOMNH, Norman, OK, United States of America, 73072; STOWE, Garrett R., SNOMNH, Norman, OK, United States of America

Recently described, *Aquilops americanus* is the oldest named ceratopsian from North America. It is based on a partial, slightly crushed skull, predentary, and most of the left dentary. The remains represent an immature individual and is small by ceratopsian standards, with a skull length of less than 10 cm and an estimated body mass of about 2 kilograms. Prior to publication, the Oklahoma Museum of Natural History undertook to make an uncrushed reconstruction of the skull and jaws together with a life reconstruction of the animal for exhibit purposes. This was done virtually using ZBrush, a 3D sculpting program. Both skull and body were done as straightforward virtual

models. Phylogenetic analysis places *Aquilops* among basal Neoceratopsia. Accordingly, missing parts of the skull, where not present on either side, were reconstructed after structurally similar taxa also lying near the base of Neoceratopsia, especially *Auroraceratops* from China. The projected body, which lacks skeletal representation and hence is entirely conjectural, was similarly based on close relatives. Sculpting proceeded rapidly enough to send draft versions of the digital reconstructions to the authors describing the specimen prior to its publication, allowing corrections to be made and providing a basis for adjusting the published reconstruction of the skull and jaws. The virtual skull was printed out in 3D for final exhibition and also displayed with an Occulus Rift 3D visualization system using goggles on a temporary basis. Both models were placed on the museum's website as an interactive viewing experience.

Symposium 2 (Friday, October 16, 2015, 3:00 PM)

LAST GLACIAL MAXIMUM FOSSIL RECORD OF MAMMALS SHOWS STRONG MIS-MATCH WITH ECOLOGICAL NICHE MODEL HINDCASTS: ROOM FOR IMPROVEMENT?

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Studies have questioned the ability of ecological niche models (ENMs) to transfer knowledge about species distributions from one climate regime to another. This problem is an important one as the world struggles with predicting biological responses to ongoing anthropogenic climate change. ENMs could be used to predict future ranges if their results are transferable. We addressed this problem by comparing ENMs made on modern climate data to the Last Glacial Maximum (LGM; ~21 ka) fossil distributions of 55 extant species of mammals. Drawing from the FAUNMAP database, we selected species with well-sampled LGM ranges, distributed across ecological and phylogenetic diversity. We used MAXENT to create ENMs using the 19 standard bioclimatic variables derived from modern climate layers. We then hindcast those ENMs on a climate layer of the LGM created using the Community Climate System Model, resampled to 1-km resolution. Our initial results show no systematic concordance between fossil data and ENM hindcasts, with over half of species showing little to no overlap with predicted distributions. In the end, 23 species (42%) have little to no hindcast range, suggesting a strong mismatch between their LGM and modern environmental occupation. We are still refining our methodology, with the next steps being to explore other niche modelling approaches (GARP, RandomForest, ensembles), as well as additional climate datasets for both the modern and LGM. We also will incorporate the mid-Holocene as another alternate climate regime. We are working to develop an approach that integrates ENMs across fossil and modern data to improve predictions for conservation prioritization under future warming scenarios.

Technical Session XV (Saturday, October 17, 2015, 11:00 AM)

WHAT HAPPENED TO FUNCTIONAL DIVERSITY DURING THE LATE PLEISTOCENE MEGAFAUNAL EXTINCTION?

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Because no two species are equal, there is increasing interest in taxon free approaches to ecology like continuous indices of functional diversity. Important to conservationists and paleontologists is understanding how species loss alters functional diversity. Although there are many simulations that examine this relationship, there are few studies looking at real extinctions. By examining the 99 largest mammals in North America over the last 50,000 years, we can see how functional diversity changed throughout immigrations; introductions; and a massive, continental scale extinction.

I coded each species for 10 quantitative and pseudo quantitative functional traits covering mass; percentage diet; running, climbing, digging, and swimming abilities; and sociality. Presence/absence bins of 1,000 years were constructed based on species' first and last appearance dates. Using new methods I developed that allow for pseudo quantitative traits, species were placed in a multidimensional functional space and on a functional dendrogram both constructed from trait weighted interspecies Euclidean distances. For each time bin, I calculated species richness, dendrogram based functional diversity (FD), Functional Richness (FRic), Functional Dispersion (FDis), and Rao's Quadratic Entropy (RaoQ).

Though the Pleistocene extinction is clearly size driven, examining additional traits besides mass provides a much more nuanced picture of functional diversity change over the last 50,000 years. Both FD and FRic dropped precipitously during the megafaunal extinction. However, FRic, which is more susceptible to outliers like large mammoths, dropped far below values predicted by null models. FDis and RaoQ also decreased meaning that current species are more closely packed into a smaller functional space than previous faunas. The first species to go extinct were actually not those with distinctive trait values at the edge of functional space but instead those with average values and close functional equivalents that made them redundant. Surprisingly, many odd species with unusual trait combinations survive into the present, making extinct species no more functionally distinct on average than extant taxa.

This study represents the highest temporal, taxonomic, and functional resolution analysis of the terminal Pleistocene in North America to date while providing conservation ecologists with a much needed example of functional loss during a large extinction caused by humans and climate change.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

SCIENCE IN THE NEWS: ORGANIZING A SUCCESSFUL LECTURE SERIES FOR THE PUBLIC

DAVIS, Matt, Yale University, New Haven, CT, United States of America, 06520; SARRO, Richard, Yale University, New Haven, CT, United States of America; SCHREINER, Sarah, Yale University, New Haven, CT, United States of America; LELAND, Bryan, Yale University, New Haven, CT, United States of America; VAN DEN HONERT, Becky, Yale University, New Haven, CT, United States of America; ZWICK, Rachel, Yale University, New Haven, CT, United States of America

Yale Science Diplomats (YSD) is graduate student and post doc outreach organization dedicated to fostering a scientifically informed electorate. Along with other programs, we run a public lecture series at local libraries on breaking scientific advancements called Science in the News (SITN). Each lecture features three grad students or post docs speaking about recent, newsworthy science topics to a broad audience for around 15 minutes each. Topics are wide ranging and have included everything from Ebola and stem cells to dinosaurs and robots. The speakers develop communication skills through rigorous peer-based training and help excite and inspire young people about STEM career paths by putting a fresh face on science.

Each fall, YSD holds auditions for the spring's SITN series. Potential speakers can come from any discipline and are not required to be YSD members (although many join after their positive experience), but they must exhibit strong oral communication skills. A committee of YSD members chooses the best speakers and organizes them into three person groups covering complementary topics. Early in winter, all these groups come together and decide on dates and overall themes for their talks. YSD advertises their events heavily throughout the greater New Haven area with printed flyers, press releases, emails, and social media. Each group of three speakers is assigned a YSD coordinator who guides the team through a structured preparation schedule, helping them to improve their communication skills along the way. Rehearsals are critiqued by YSD members and former speakers so all talks are well polished before they reach the public. We solicit feedback cards from audience members after the talks to help us maintain quality and alignment with our mission statement.

SITN is very popular and is already expanding to several additional libraries in the New Haven area. Speakers have also visited local high schools to give adapted talks and hold Q and A's with students about careers in STEM. Additionally, we work with ABC-CLIO, an online textbook company, to transform the talks into viewpoint essays and background material that is distributed to schools worldwide. Using a recent grant, we'll develop our own educational material that can be packaged with videos of the talks online and used by teachers seeking exciting standards based lessons.

Grant Information
SITN is funded by Yale's Graduate and Professional Student Society, the Office of Graduate Student Life at the McDougal Center, the Center for Teaching and Learning, and the Yale Office of New Haven and State Affairs.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

SIGNIFICANT VERTEBRATE FOSSIL LOCALITIES DISCOVERED DURING CONTINUING PALEONTOLOGICAL RESOURCE INVENTORY AND MONITORING OF THE LATE TRIASSIC CHINLE FORMATION AT CAPITOL REEF NATIONAL PARK

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Through a systematic program of paleontological resource inventory and monitoring, the National Park Service (NPS) has been at the forefront of paleontological resource management on public lands. After more than a decade of work, initial inventories have been completed in many parks and the NPS has moved into a second phase which involves monitoring of known sites and targeted inventory of specific formations identified during preliminary surveys as having high potential for significant discoveries. Several formations, including the Triassic Moenkopi and the Jurassic Morrison formations, have been the subject of limited investigations that have provided baseline paleontological resource data for Capitol Reef National Park (CARE). Recently, the Utah Geological Survey (UGS) produced Potential Fossil Yield Classification maps of the park using newly updated geologic maps. In the spring of 2014, the UGS and NPS conducted 10 days of field inventory in the park, targeting the well-exposed rocks of the Late Triassic Chinle Formation. The Triassic Period and Triassic-Jurassic transition have been the focus of considerable research because this interval is thought to be associated with a major evolutionary radiation and subsequent extinction event associated with the rise of most modern terrestrial animal groups. Because the Colorado Plateau preserves so many rocks of this age, it has been one of the best places to study this interval, and CARE occupies a central location for correlating Chinle Formation rocks in Utah. Our work, which included measuring three detailed stratigraphic sections, is intended to dovetail with other investigations of these rocks in other places on the Colorado Plateau. Five members have been identified in CARE; these are, from oldest to youngest, the Shimarump, Monitor Butte, Moss Back, Petrified Forest, and Owl Rock; the Moss Back is recognized in the park for the first time during our work. Several informally named beds have also been recognized. Our survey resulted in the identification of over 80 new localities. Numerous vertebrate localities from the Chinle Formation were documented and placed in stratigraphic context. Vertebrate fossils found include the remains of phytosaurs, aetosaurs, metoposaurs, and lungfish.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

NEW FOSSILS OF THE RARE EARLY MIOCENE FLORIDATRAGULINE CAMEL *FLORIDATRAGULUS NANUS* FROM FLORIDA AND SOUTHERN CENTRAL AMERICA

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Floridatraguline camels are known from tropical and subtropical assemblages ranging from Panama (~9° N) to the northern Gulf Coast (~30° N). The oldest, "*Poebrotherium*" *franki*, is known from a single Oligocene fossil assemblage in Texas. The small-sized and poorly understood *Aguascalientia* has been reported from the late Arikareean North American Land Mammal Age (NALMA) (~20–23 Ma) of Texas and

Panama (Lirio Norte Local Fauna). This distribution of *Aguascalientia* supports the idea that there was a biogeographic connection between the Gulf Coast and southern Central America during the late Arikareean. By the Hemingfordian NALMA, floridatragulines (mainly represented by *Floridatragulus*) are known from the Gulf Coast with a single occurrence of *Aguascalientia* in southern Mexico. *Floridatragulus* has been reported from the Hemingfordian Thomas Farm fossil site in Florida (*Floridatragulus dolichanthereus,* and *F. barbouri*); *F. nanus* from the Hemingfordian Garvin Gully Local Fauna in Texas, and *F. hesperus* and *F. texanus* from Barstovian deposits from Texas. In the early Miocene Centenario Fauna (from the uppermost Culebra and Cucaracha formations ~19 Ma) in the Panama Canal basin, floridatraguline camels are represented by a small form of *Floridatragulus* tentatively identified here as *F. nanus*. The holotype (and only previously known specimen) of *F. nanus* is an m3. The taxon from Panama is smaller (~15%) than the holotype of *F. nanus*, and has the distinctive p2-p3 diastema of *Floridatragulus,* an m3 with a bi-lobed hypoconulid, relatively smaller intercolumnar pillars, and brachydont dentition. In addition, analyses of tooth dimensions for *Floridatragulus* from Thomas Farm, reveals the presence of a *F. nanus* sized taxon in the fauna. Compared to *F. nanus* from the type locality in Texas, the Thomas Farm dental remains are similar in morphology and in size (anteroposterior length m3 = 19 mm vs. 20 mm). Although present in Arikareean–Hemingfordian assemblages in the Gulf Coast, Panama, and Mexico, the apparent absence of *Aguascalientia* in the Hemingfordian Centenario Fauna in Panama could be related to changes in forest structure associated with variable influx of volcanic products.

Grant Information
Funded in part by the Panama Canal Project.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

TESTING THE ACCURACY OF FLIPPER OUTLINE RECONSTRUCTION FROM SKELETAL ELEMENTS IN EXTANT TETRAPODS WITH POTENTIAL APPLICATION TO PLESIOSAURS AND ICHTHYOSAURS

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The invasion of aquatic environments by tetrapods occurred independently several times across many different lineages, resulting in the convergent evolution of hydrofoil-shaped flippers. Shape is critical to the function of hydrofoils; however part of what forms this shape is the soft tissue, which is lost during fossil preservation. Consequently, studies of flipper shape and function in fossil taxa have simply assumed that the soft tissue envelope closely surrounds the bones, even though this is not the case in the flippers of some extant taxa. To address this problem, we developed two methods based on extant taxa to reconstruct the soft tissue margin from fossil bones. We used radiographs and preserved museum specimens of cetaceans, spheniscids, otariids, and cheloniids. Cetacean flippers were chosen for their diverse flipper shapes while still primarily used for steering and control. The rest were chosen to cover the gamut of flipper morphology used in underwater flight. In one method, a convex hull is delineated around the limb bones. This method is easy to implement and closely approximates flipper planform area for cetacean flippers but it does not preserve the curvature along the trailing edge of the flipper. The second method involves numerically interpolating through a variant of the convex hull, hereby termed the 'skeletal' hull. This method is more complicated and tends to underestimate the total area but it does preserve the curvature along the trailing edge. Both methods give equivalent estimates for the area and shape of hydrofoils used in underwater flight. The present study enables the soft tissue envelope surrounding the flippers of extinct taxa, such as plesiosaurs and ichthyosaurs, to be approximated for the first time and opens the door to more rigorous quantitative studies of flipper function in extinct taxa.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

ENDOCRANIAL ANATOMY OF *MADRYNORNIS MIRANDUS* (AVES, SPHENISCIFORMES), A CROWN-PENGUIN FROM THE EARLY LATE MIOCENE OF PATAGONIA

DEGRANGE, Federico J., CICTERRA (CONICET-UNC), Córdoba, Argentina; TAMBUSSI, Claudia P., CICTERRA (CONICET-UNC), Córdoba, Argentina

By studying the brain and inner ear anatomy of the early late Miocene (Tortonian, 11.6 - 7.2 Ma) crown penguin *Madrynornis mirandus* (MEF-PV100), it was our aim to find out more about the transition from stem to crown penguins. Previous phylogenetic studies show *Madrynornis mirandus* as closely related to the living Yellow-eyed Penguin and the crested penguins of the genus *Eudyptes*. The three-dimensional visualization of its endocranial anatomy in a comparative framework (stem and extant penguins and outgroups) reveals some shared characteristics with extant penguins while other features are shared with the stem penguins (Patagonian Miocene *Paraptenodytes* + Antarctic Eocene penguins). In *Madrynornis mirandus*, the brain is airencephalic, the wulst is less caudally expanded but more dorsally extended than in extant penguins, the optic lobes are cranially located but relatively less developed, the interaural pathway (the contralateral connection between the paired rostral tympanic recesses) is absent, the general pattern of the tympanic recesses is simple without cancellae, and the carotid anastomosis is X-type (similar to *Spheniscus*). Secondly, the telencephalon of *Madrynornis mirandus* is relativelly longer and narrower and the flocculi are stouter and more laterally disposed than in extant penguins. Because the posterior portion of the skull is broken, brain volume and consequently encephalization quotient, could not be estimated. *Madrynornis mirandus* also shows the retention of primitive morphologies such as large olfactory bulbs and a high olfactory ratio (35.7), suggesting higher levels of olfactory sensitivity than extant taxa. The latter may indicate exceptional smell sensory abilities that would be expected from predatory animals. These new data hold a high potential to learn more about the evolution of the brain in penguins.

Grant Information
CONICET (PIP 112 20130100059 CO) and UNLP N671

Technical Session XII (Friday, October 16, 2015, 10:15 AM)

PHYLOGENETICS AND PALEOBIOLOGY OF A LATE CRETACEOUS STEM IGUANIAN FROM MONTANA

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The Late Cretaceous record of Iguania is best documented from the Gobi Desert of Mongolia and is based on dozens of articulated crania, postcrania, and partial to nearly complete skeletons. Such a record is almost non-existent from contemporaneous deposits in North America where, until recently, few putative iguanian partial jaws recovered from vertebrate microfossil bonebeds are known. Discovery of two nearly complete fossil skeletons of a new iguanomorph (i.e., stem iguanian) from the Egg Mountain locality of the Two Medicine Formation, Montana, U.S.A., has substantially improved our understanding of the phenotype of an early North American iguanomorph and has allowed us to more fully assess its phylogenetic relationships and paleobiology. Our phylogenetic analysis incorporating morphological data augmented by computed tomography scans and three dimensional renderings recovered a sister-group relationship for the new taxon with Temujiniidae (*Temujinia ellisoni* + *Saichangurvel davidsoni*), a recently identified clade of Campanian-age iguanomorphs from the Djadokhta Formation of Mongolia. That relationship provides the first phylogenetic evidence supporting Cretaceous iguanian biotic interchange between Asia and North America and places a firm minimum estimate of iguanian dispersal into North America by the Late Campanian (~75.5 Ma).

Nearly all Late Cretaceous terrestrial squamate assemblages sampled from the Western Interior of North America occur within lowland floodplain depositional environments with some squamate clades (e.g., chamopsiids, anguids) being the taxonomically and/or numerically dominant forms. Conversely, the geological and paleontological evidence at Egg Mountain suggest the new iguanomorph inhabited a semi-arid environment and one more similar to the xeric environments inhabited by contemporaneous sister taxa from the Gobi Desert. Comparative dental morphology coupled with dietary information of extant pleurodontan iguanians suggests the new iguanomorph was insectivorous. Several extant pleurodontans prey on apocritans (wasps and bees). Given the nearly ubiquitous occurrence of wasp pupae cases at Egg Mountain, we hypothesize that this predator-prey interaction similarly occurred at that locality during the Late Cretaceous.

Grant Information
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Technical Session IV (Wednesday, October 14, 2015, 3:30 PM)

FILLING THE MIOCENE 'BALAENID GAP'-THE PREVIOUSLY ENIGMATIC *PERIPOLOCETUS VEXILLFER* KELLOGG, 1931 IS A STEM BALAENID (CETACEA: MYSTICETI) FROM THE MIDDLE MIOCENE (LANGHIAN) OF CALIFORNIA, USA

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Living balaenids (including bowhead and right whales) are large mysticetes that were the focus of intensive whaling for over 1000 years. Their worldwide populations remain precariously low, even after a long period of international protection, because of mortalities related to indirect human activities (e.g., entanglements and ship strikes). However, we know little about their evolution, with current phylogenetic studies differing significantly on the evolutionary relationships of balaenids and other crown and stem mysticetes. The earliest confirmed fossil balaenid is *Morenocetus parvus* Cabrera, 1926 from the early Miocene (Burdigalian) Gaiman Formation of Argentina. A considerable geochronological and morphological gap separates this taxon from nominal Pliocene balaenids known from Europe, Asia, and North America. This Miocene balaenid gap exacerbates problems of ghost lineages and long branch attraction that continue to vex mysticete phylogenetic systematics.

We report on a new specimen (SDNHM 99766) of *Peripolocetus vexillifer* Kellogg, 1931 collected from the middle Miocene (Langhian) Sharktooth Hill bonebed, from the Round Mountain Silt exposed near Bakersfield, California, USA. This new specimen, consisting of a complete neurocranium with attached petrotympanics, was collected from the same stratigraphic horizon as the type specimen (CAS 4370), consisting only of a fragmentary neurocranium, with an intact broken right petrosal, and an associated left tympanic bulla. The holotype was collected during bonebed quarries in the early 20th century and was originally described by Remington Kellogg as a species of cetothere s.l. Additional preparation of the type specimen, along with morphological features preserved in SDNHM 99766 show clear cranial and petrotympanic features (e.g., supraorbital process of frontal anteroposteriorly narrow and transversely elongate; short anterior lobe of tympanic bulla) that are balaenid synapomorphies. As a stem balaenid, *P. vexillifer* makes it possible to more accurately determine the taxonomic distribution of plesiomorphic and apomorphic character states within this lineage and to develop hypotheses concerning character evolution and the divergence history of crown balaenids. Inclusion of SDNHM 99766 in a comprehensive mysticete phylogenetic analysis provides new character data that supports not only the monophyly of the Balaenidae clade, but also the monophyly of the more inclusive Balaenoidea clade (Balaenidae + Noebalaenidae).

Technical Session XIII (Friday, October 16, 2015, 3:45 PM)

ACCOUNTING FOR SCALING ISSUES IN THE ESTIMATION OF GROWTH RATE SUGGESTS ENDOTHERMY IN NON-AVIAN DINOSAURS

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Growth is spatially complex and temporally variable, and its rate depends on the tissue, organ, or organism in question, complicating the estimation of growth rates in extinct animals and their comparison among taxa. Records of growth are commonly preserved in fossilized hard tissues as periodically formed incremental lines such as lines of arrested growth in bones. Tissue formation rate has been estimated as the amount of material added between lines divided by the inferred periodicity of the lines, and then scaled up or down to allow comparison among organisms that grow on different timescales. However, because each incremental line itself represents some time of zero growth, conversion from the period between the incremental lines (e.g., a year) to a finer timescale (e.g., a day) results in an underestimate of growth rate. Rates scaled in this way are especially underestimated for faster-growing, larger animals and animals for which the period of zero growth is a larger fraction of the periodicity. An analogous scaling problem occurs in comparisons of sedimentary and evolutionary rates, wherein inferred rates tend to be inversely related to the interval over which they are measured. This problem can be accounted for if the duration of the zero-growth period is known, or by modeling that period over a range of reasonable durations. I use the latter approach to estimate daily growth rates in non-avian dinosaurs from annual lines of arrested growth in their bones. Accounting for the approximately six months of paused growth expected for non-avian dinosaurs living in strongly seasonal environments, scaled daily growth rates fall within the range of those observed in extant placental mammals, generally lower than those of extant birds and higher than those of fish and reptiles. Phylogenetically informed regressions against body size further demonstrate similar daily growth rates among non-avian dinosaurs and placental mammals. These results suggest that non-avian dinosaurs were metabolically similar to modern placental mammals.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

INTRODUCING DINOSAURS TO NAVAJO MIDDLE SCHOOL STUDENTS

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The Navajo Nation, the largest and most populous Indian reservation of the United States, is situated in the Four Corners Area of the American Southwest and overlaps the San Juan Basin of northwestern New Mexico, a geologically and paleontologically rich area. Many Native students of the Four Corners area of northwestern New Mexico are deeply connected to the landscape and deeply concerned about environmental issues, yet Native American students are the most underrepresented group in the STEM disciplines. According to statistics provided by the National Science Foundation, only about 1% of Native American Students pursue the sciences.

We have been providing opportunities to Native students of the Four Corners area to learn about the sciences through cooperative learning in which we apply a differentiated instruction approach. We have been incorporating content from ongoing vertebrate paleontological research being undertaken in the area in order to engage learners. Our targets for these activities are Native American middle schools (grades ranging from 6th to 8th grade) on the Navajo Reservation near the New Mexico – Arizona border north of Gallup, New Mexico.

Topics of research that we have brought to the classroom are diverse and include discovery and description of new dinosaurs, research patterns of diversity and extinction of animals across the Cretaceous - Paleogene boundary, and investigation into how terrestrial ecosystems have changed through geologic time and in response to climate change.

Outreach activities typically include a PowerPoint presentation on New Mexican Dinosaurs (attracts the auditory and visual learners), hands-on interaction with fossil specimens including dinosaur bones, molds and casts, and a micro-vertebrate fossil picking station (attracts the kinesthetic learners). Response to these activities from students and teachers has been extremely positive.

Grant Information

NSF grant to Williamson (EAR – 1325544), BLM grants to Williamson (Challenge Cost Share, America Great Outdoors, National Landscapes and Conservation System)

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

APPLICATIONS OF REACTION-DIFFUSION MODELS TO ANALYSIS OF FOSSIL CHONDRICHTHYAN DEVELOPMENT

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Repeating geometrical spatial patterns of pigment and calcified elements are commonly observed in studies of vertebrate development. Recent molecular work and mathematical simulation of different biological systems have shown that some of the seemingly intricate spatial patterns can be explained by underlying reaction-diffusion (R-D) systems, in which simple interaction rules of hypothetical morphogens produce elaborate patterns over large spatial and temporal scales. Understanding the effects that R-D parameter changes have on the outcomes of R-D model simulation is a step toward understanding the underlying physiological dynamics of, and character conceptualization in, complex spatial systems lacking developmental data, such as fossils. Fossil organisms may exhibit mosaic trait data not found in the extant taxa to which R-D models are most commonly applied, and so provide an overlooked source of data for modeling. We therefore apply R-D models to dermal denticle and fin spine ornament development in fossil chondrichthyans. The utility of R-D models for inferring processes from fossil organisms, and the role of fossils in refining biological R-D model formulations, are discussed.

Grant Information

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Technical Session XIV (Friday, October 16, 2015, 1:45 PM)

THREE-DIMENSIONAL VISUALIZATION OF THE BERLIN ICHTHYOSAUR STATE PARK FOSSIL BEDS FROM TERRESTRIAL LIDAR DATA

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Terrestrial LiDAR (Light Detection and Ranging) is a nondestructive technique that uses the reflection of laser impulses off surfaces to create point cloud data sets. Although terrestrial LiDAR has been applied extensively in the fields of neotectonics and mine surveying, the application of this technology to the study of in situ vertebrate fossils has not been fully evaluated. We collected georeferenced three-dimensional data on a large in situ thanatocoenosis of the enormous Late Triassic ichthyosaur, *Shonisaurus popularis*. The fossil beds are exposed in outcrops of the Carnian/Norian Luning Formation and are protected by a permanent shelter, the "fossil house", at Berlin Ichthyosaur State Park in Nye County, Nevada. The beds are approximately 25 x 15 fifteen meters and expose at least nine partially articulated adult specimens. A Maptek 8800 LiDAR unit was used to collect point data in the form of Cartesian coordinates with associated color intensities. A total of seven high-resolution (1 mm point spacing) scans captured the beds from multiple angles. Additional stations captured the building interior, exterior, and additional site features at lower resolution.

The 1 mm resolution of the *S. popularis* remains demonstrated by the LiDAR point cloud is suitable for analysis of gross bone structure in the organisms and represents a viable and efficient means of digitally capturing large in situ fossil sites, particularly for large bodied organisms. LiDAR imaging allows for the accurate measurement and analysis of spatial relationships between the skeletal elements. LiDAR datasets also provide an important baseline for conserving in situ fossil exhibits and evaluating disturbance or deterioration of exposed fossils and their protection measures (e.g., retaining walls, shelters). Recent and future improvements in LiDAR technology (increasing resolution, spectral data) will establish this underutilized tool as an important resource for field study of vertebrate fossils. Integration with other digitization techniques with complementary strengths and weaknesses which have been concurrently collected by our research group and collaborators (structure light scanning, photogrammetry) remains a technically challenging but important goal in creating rich three-dimensional datasets from large in situ fossil assemblages.

Symposium 2 (Friday, October 16, 2015, 2:15 PM)

MAMMALIAN RESPONSES TO CLIMATE CHANGE: LESSONS LEARNED FROM BOTH 'DEEP-TIME' EXPERIMENTS AND MODERN ECOLOGICAL STUDIES

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Climate change can alter species distributions, abundances, and interactions. Despite decades of research focus, long-term experiments can be logistically challenging and limited in the amount of time they capture. The fossil record provides critical data to assess the effects of past climate and environmental change on mammalian taxa by extending the temporal scale at which we can ask questions pertaining to competition, long-term responses to environmental change, and conditions facilitating species-level extinctions. For example, examining mammalian responses to Pleistocene glaciations can clarify how mammals may respond to current climate change. Paired with modern studies that assess mammalian responses to current climate anomalies, we can also help reveal how living mammals are responding to extreme climate events and recording their environment-using tools that can be applied to fossil taxa.

Here, we compiled new and published data to assess the effects of Pleistocene climate change on mammalian diets (medium to large herbivorous mammals) as inferred from stable carbon isotopes and dental microwear textures. Results reveal that mammalian dietary responses are variable: 1) those with less specialized dietary niches are often able to alter their isotopic range and/or shift their diet to incorporate different proportions of C_4 resources with changing climates; 2) dietary responses are typically constrained by morphology-mammals with lower crowned teeth demonstrate lower dietary variability (at the individual level) and are less likely to alter their diet with changing climates; and 3) dietary generalists may in fact be composed of individual dietary specialists and confer short-term and long-term benefits from this 'Jack of all trades and master of all (not none)' strategy, including greater species longevity. Lastly, by conducting modern studies of short-term dietary responses to extreme drought events, modern taxa (i.e., *Macropus giganteus* and *Macropus fuliginosus*) reveal dramatic dietary shifts to include less-preferred food resources (e.g., more woody material, as inferred from significantly greater complexity of dental microwear textures) during periods of extreme aridity. Collectively, these data reveal that mammalian dietary niches are not necessarily conserved over time, can change over fairly short-time intervals, and dietary generalism may be more nuanced and constrained by morphology. Further, we can draw on these 'lessons-learned' to assess how extant mammals may respond to changing climates.

Grant Information

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Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

REAPPRAISAL OF THE FOSSIL SEAL *PHOCA VITULINOIDES* FROM THE NEOGENE OF THE NORTH SEA BASIN, WITH BEARING ON THE GEOLOGICAL AGE, PHYLOGENETIC AFFINITIES, AND LOCOMOTION OF A NEW DIMINUTIVE MIOCENE PHOCINE SPECIES

DEWAELE, Leonard, Ghent University, Ghent, Belgium; AMSON, Eli, University of Zürich, Zürich, Switzerland; LOUWYE, Stephen, Ghent University, Ghent, Belgium; LAMBERT, Olivier, Royal Belgian Institute of Natural Sciences, Brussels, Belgium

Since the species's initial establishment in 1871 and detailed description in 1877, the fossil phocid *Phoca vitulinoides* remained largely unstudied for more than 140 years! Furthermore, whereas the type material of *Phoca vitulinoides* was previously recognized

as comprising two distinct species (mostly based on a size argument), the number of specimens from the Neogene of the Antwerp area (southern margin of the North Sea Basin) assigned to this taxon substantially exceeds all other fossil seal taxa from the North Sea. A reinvestigation is thus needed.

Spurred by the discovery of several partial postcranial skeletons (including humeri, femora, the sacrum, tibiae and multiple vertebrae) that recently entered the collection of the Royal Belgian Institute of Natural Sciences, the current study clarifies multiple aspects of our knowledge of the original material of *Phoca vitulinoides*, with an emphasis on the smaller morphotype that represents an unnamed species.

First, the stratigraphical interval occupied by this new species is redefined. Originally assigned to the early Pliocene disused 'Scaldisian' stage, the species is now identified in Miocene layers, either from the lower beds of the Deurne Sands Member (middle to late Tortonian) or just below. At least part of the previously recognized Pliocene records may in fact be isolated bones reworked in the gravel at the base of the subjacent Zanclean Kattendijk Formation.

Second, our cladistic analysis points towards a closer phylogenetic relationship of the new species to the genus *Pusa* than to *Phoca*. Only tentatively proposed in the past, this assignment is robustly supported in the current analysis (with high Bootstrap and Bremer Support values). The smaller size, shallow gluteal fossa of the innominate, and highly raised greater trochanter of the femur are the most prominent characters distinguishing the new species and extant species of *Pusa* from *Phoca.*

Finally, the renewed anatomical description reveals some important osteological characters correlated with limb musculature and locomotion. A large humeral head, weakly developed lesser tubercle compared to the greater tubercle, and deep insertion scars for the supraspinatus and infraspinatus muscles on the humerus suggest an increased mobility and a more intensive use of the forelimb as compared to most other phocines.

Similarly, a greatly enlarged greater trochanter of the femur, a strongly concave patellar facet on the femur, and a strongly developed popliteal surface on the tibia suggest an energetic use of the hind limb during swimming.

Grant Information
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Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

PRINCIPLES OF INTEGRATED COURSE DESIGN APPLIED TO COLLEGE COURSES ON VERTEBRATE PALEONTOLOGY AND EVOLUTION

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College science courses can be made more effective if the goals of the course are determined before making decisions about content. Effectiveness here is evaluated both as the success of student learning as well as the perceived significance that a course has had on the student's long-term intellectual perspective. The principle of 'backward design' emphasizes that lecture content, lab activities, and assessments are added after planning for the long-term goals of the course.

Learning goals are the overarching ideas that a student will know or understand about a body of knowledge. Goals themselves cannot be assessed directly, so they need to be aligned with one or more objective measures that a student can achieve to demonstrate mastery. Goals that lead to significant learning can fall into several categories, including foundational knowledge, application of content, integration with other concepts, learning how to learn, and other realms. Workflows and other resources will be shared to show how to redesign a course using the principles of backward design.

I will demonstrate the implementation of these principles in two courses, a traditional lecture-and-lab course in vertebrate paleontology and a hybrid (i.e., technology-enhanced) course in biological evolution. For undergraduates, paleontological ideas can be framed in narratives. Students think about how the vertebrates solved problems related to predation, terrestriality, flight, or recovery from extinctions while still keeping a phylogenetic context. In the case of the hybrid evolution course, the instructor's task is to think through which evolutionary processes and patterns are best explored online in learning modules and which are better learned in a face-to-face setting. In our course, students responded positively to online simulations to explore population genetics but preferred in-person discussion of the *Origin of Species* and more recent scientific literature.

Colbert Prize (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

ECOMORPHOLOGICAL CONVERGENCE OF THE SEMICIRCULAR CANALS IN *ANOLIS* LIZARDS

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The semicircular canals, found in the inner ear, are a significant functional component of the vestibular system, responsible for sense of balance in all jawed vertebrates. It has been demonstrated that semicircular canal morphology is highly correlated with the agility and locomotory characteristics of animals in life. This relationship has made it possible to use comparative methods to reconstruct such biological characteristics in fossil species. Unfortunately, the majority of research has been focused on mammals, making it difficult to make any confident ecological reconstructions in non-mammalian fossil species.

Having received decades of attention as a model for understanding adaptation and evolution, *Anolis* lizards present a uniquely convenient model for studying the morpho-functional relationship of the semi-circular canals. This is for two reasons: first, anoles demonstrate strong morphological convergence into six distinct 'ecomorphs', which are well characterized by their morphology and ecology; and second, the phylogeny and biogeography of anoles are well understood. Together these properties provide a strong backbone for the study of the semicircular canals in an evolutionary context.

Representatives of all six ecomorphs from the four large islands of the Greater Antilles were micro-CT scanned, and the semicircular canals segmented out and rendered in 3D. Canal shape was then quantified using semilandmark-based 3D geometric morphometrics. The relationship between canal shape, size and phylogeny were determined using regression and sum of squared change respectively, and the effect of ecomorph on canal shape determined using Procrustes ANOVA, with and without a phylogenetic correction. Results demonstrate that ecomorph is the strongest determining factor of overall canal shape, describing over 50% of shape variation ($R^2 = 0.517$, $p = 0.002$). Conversely, phylogeny does not govern patterns of canal shape ($p = 0.1$) and size is only weakly correlated ($R^2 = 0.086$, $p = 0.004$).

Our analysis of the semicircular canal system in *Anolis* confirms a strong link between canal shape and ecomophology, and demonstrates the plasticity of the vestibular system to ecological pressures. These findings provide a strong basis for future exploration of the morpho-functional diversity of the vestibular system in lepidosaurs, including quantitative reconstruction of the paleobiology of fossil forms.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

'*DISSOROPHUS*' *ANGUSTUS* (TEMNOSPONDYLI, DISSOROPHOIDEA) AND INCREASING VARIABILITY OF DISSOROPHID OSTEODERMS

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Restudy of the type and only known specimen of the dissorophoid temnospondyl '*Dissorophus' angustus* from the Early Permian of north central Texas confirms its validity as a distinct species. It is diagnosed by the autapomorphies of a bluntly tipped anterior projection of the tabular portion of the supratympanic flange of the otic notch, an ilium with two pairs of vertical ridges along the medial side, ventral flanges on both external and internal osteoderms, and a transition from an anterior set of a double row of alternating external and internal osteoderms to a posterior single row of overlapping external and internal osteoderms. The ventral flanges of the internal osteoderms for vertebrae seven and eight are bifurcated into a narrow portion along the anterior side of the neural spine and a wider flat portion along the posterior side of the neural spine. The anterior portion of the ventral flange is absent from the internal osteoderm above vertebra nine and all succeeding vertebrae, but the posterior portion is retained. Osteoderms of the external series have a narrow, bluntly tipped ventral flange between a pair of neural spines. The double row of osteoderms consists of a dorsal external series overlapping and alternating with a ventral internal series. An apparent change from a double to single series of osteoderms is due to a shift in the pattern of contact between the two series beginning at the internal osteoderm above the ninth vertebra. This internal osteoderm overlaps the next external osteoderm, and the same pattern of an osteoderm overlapping the next posterior one, regardless of whether it belongs to the internal or external series, continues for the remainder of the preserved osteoderms. Phylogenetic analysis places '*Dissorophus*' *angustus* in a polytomy with *Dissorophus multicinctus* and four species of *Broiliellus*. Consequently, there is no support for this species belonging to *Dissorophus* or as an intermediate between this genus and *Broiliellus*. Presence of ventral flanges on osteoderms of the external and internal series potentially links this species with *Cacops aspidephorus* (flange on external series), *Broiliellus* (flange on a single presumably internal series), and *Dissorophus multicinctus* (flange on internal series with bifurcation of flanges on anterior osteoderms) yet the phylogenetic analysis failed to support any clear association. *'Dissorophus' angustus* provides another example of increasing variation in the anatomy of dissorophid osteoderms and their decreasing phylogenetic and taxonomic relevance.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

IMPLICATIONS OF CENOZOIC MICROVERTEBRATE ASSEMBLAGES FOR THE FORMATION OF THE MODERN NORTH AMERICAN FRESHWATER ICHTHYOFAUNA.

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Fish microvertebrate assemblages described from four Cenozoic North American Western Interior formations were used to inform our understanding of the transition from the Late Cretaceous freshwater fish fauna to the modern North American ichthyofauna. These assemblages were recovered from the southern Saskatchewan mid-Miocene Wood Mountain and Eo–Oligocene Cypress Hills formations, as well as the middle and early Eocene Bridger and Wasatch formations of Wyoming. Both Canadian assemblages are highly diverse, typical of lowland, well-oxygenated and varied floodplain environments, and indicate warm-temperate to subtropical climates at time of deposition. The Wyoming assemblages, although also indicative of warm environments, are relatively less diverse. However, these indicate that the early Paleogene ichthyofauna of North America was similar to that of the Late Cretaceous.

The assemblages were compared with one another and with other previously described assemblages, in order to reconstruct the evolution of the North American freshwater fish fauna through the Cenozoic, from the Mesozoic to the present. The formation of the modern fauna appears to have been relatively uninfluenced by the K-Pg transition, but to have occurred in two phases instead, one in the mid-Paleogene and the other in the late Neogene. The turnover from Late Cretaceous ichthyofaunas, rich in osteoglossiforms and clupeomorphs, to a taxonomically near-modern fauna seems to coincide with the increase of seasonality in North America between the middle and late Eocene. By the middle Neogene, the faunal composition of the continent had become modern, although the ichthyofauna was still markedly different from that of modern times in that the Miocene Saskatchewan assemblage would now be considered typical of the southern U.S.A., and was unlike the salmoniform-rich ichthyofauna that would now be found at such latitudes. This probably indicates that the modern latitudinal gradient in faunal composition was formed more recently, concurrent with-and therefore possibly caused by-the late Neogene climatic cooling trend, which culminated in the Plio-Pleistocene glaciations.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

USING AVIAN, REPTILIAN, AND MAMMALIAN DATA TO TRACK THE EVOLUTION OF VISION IN SAUROPOD DINOSAURS

DODSON, Peter, University of Pennsylvania, philadelphia, PA, United States of America, 19104; LI, Liguo, University of Pennsylvania, philadelphia, PA, United States of America; SALLAN, Lauren, university of Pennsylvania, philadelphia, PA, United States of America

While multiple studies have focused on the visual acuity of theropods, including modern birds, few have examined other groups of dinosaurs. Vision-related traits in sauropods-such as orbit size, corneal area, and visual field-could be assumed to resemble their Mesozoic theropod relatives due to common ancestry. However, sauropods were large terrestrial herbivores that fed primarily on ground plants or trees, and may have been subject to different selective pressures. It is possible that sauropod visual traits were more similar to herbivorous birds and mammals currently filling such niches, and/or herbivorous reptiles and birds, than predatory theropods. Here, we estimated the visual capabilities of sauropods based on measurements of over 50 extinct and extant avian, reptile, and mammal intact heads and skulls. We focused on herbivorous taxa but included carnivorous taxa for reference and to gauge trait differences related to ecology. In all skulls, we measured orbit length, width, and depth and skull length; for the intact heads we additionally measured corneal and eyeball diameters. Our observations and measurements, as well as statistical data, indicate that birds have corneal diameters > 50% but < 80% of their respective orbits; in reptiles, corneal diameters are close to orbit diameters. Mammals have a range of values between those of birds and reptiles. Some herbivorous birds, such as *Struthio camelus*, evolved relatively small eyeballs, likely because of reduced need for visual identification of food. This is the opposite of carnivorous birds, such as Strigiformes, whose members possess extraordinarily large eyeballs. The orbits of *Giraffa* and *Camelus* present laterally expanded caudal margins, highlighting laterally extensive views focused on the horizon. We selected *Mamenchisaurus*, *Camarasaurus*, and *Diplodocus* as primitive models for sauropods. With dorsoventrally elongate skulls and caudally reduced nostrils, *Mamenchisaurus* and *Camarasaurus* have prominent, large orbits that are enlarged both dorsoventrally and laterally. These two sauropods may have been restricted to rostral, long-distance binocular fields of view with large lateral ranges. In contrast, *Diplodocus* bears a comparatively small orbit located farther caudally. Tentatively we draw conclusions for binocular fields of view and concentrations on horizontal view range in sauropods. Our results suggest that some sauropods converged on visual traits common to herbivorous mammals, while others were more similar to ground-dwelling herbivorous birds.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

***SCHANSITHERIUM*: NEW INSIGHTS ON A LATE MIOCENE GIRAFFIDAE FROM GANSU, CHINA**

DOMALSKI, Rebecca, NYIT-COM, Old Westbury, NY, United States of America, 11568; HOU, Sukuan, Institute of Vertebrate Paleontology & Paleoanthropology, Beijing, China; DANOWITZ, Melinda, NYIT-COM, Old Westbury, NY, United States of America; SOLOUNIAS, Nikos, NYIT-COM, Old Westbury, NY, United States of America

New evidence suggests a close relationship amongst *Schansitherium tafeli* and *Samotherium* species. *Samotherium* species were more widespread and sampled from localities ranging from Spain all the way to Gansu and Shanxi, China. However, *Schansitherium* was more local, occurring mostly in the late Miocene of Gansu. To date, *Schansitherium* has not been properly figured or described. A number of newly discovered relatively complete skulls from Gansu have enabled us to better understand *Schansitherium* and assign it to its closest relative within the Giraffidae.

Character analysis revealed that the *Schansitherium* skull is most similar to that of *Samotherium boissieri* (Palaeotraginae), with one notable difference: *Samotherium* species possess one pair of simple ossicones. The characteristic that makes *Schansitherium* unique is the atypical morphology of its ossicones. This taxon possesses two pairs of ossicones, which share a common base on each side and are located superior to the orbit. The ossicones are smooth-surfaced and conical in cross section; with the posterior pair displaying planar wear facets distally like Palaeotraginae. When present, the epikouron (secondary bone growth) forms elongated streaks. The apex of the anterior pair of ossicones has interesting morphologies: (1) apical small growths (bumps) which are all clustered together, (2) two horizontal wavy laminations proximal to the apical bumps, and (3) two apical growths forming a Y; with one shaft directed anteriorly and one posteriorly. The anterior branch is smoother and the posterior contains multiple small bumps. The more proximal anterior growth shows wavy horizontal layering.

Palaeotraginae, Bohlininae, and Giraffinae primarily have two ossicones, while Giraffokerycinae and Sivatheriinae possess two pairs. The similarity of cranial features, including the ossicones seen in specimens of *Schansitherium* and *Samotherium,* is strong. It is likely that *Schansitherium* was a basal Palaeotraginae and has inherited the two pairs of ossicones from a presently unknown taxon similar to members of Giraffokerycinae or Sivatheriinae. Therefore, we hypothesize that *Samotherium* and other Palaeotraginae have lost this anterior pair of ossicones.

Technical Session XVIII (Saturday, October 17, 2015, 3:15 PM)

ENVIRONMENTAL HETEROGENEITY OF A LATE MIOCENE EAST AFRICAN LANDSCAPE: INTRODUCING NEW MAMMALIAN FAUNA AND INTEGRATING MULTIPLE PALEOECOLOGICAL METHODS AND MODERN FOREST ECOLOGY TECHNIQUES IN THE MPESIDA BEDS, BARINGO, KENYA

DOMAN, JESSAMY H., YALE UNIVERSITY, New Haven, CT, United States of America, 06511; COUTROS, PETER R., YALE UNIVERSITY, New Haven, CT, United States of America

We formally describe the late Miocene Mpesida Beds (Baringo, Kenya), which at 7–6.3 Ma capture a crucial time period for hominid evolution, climate change and biotic events in Africa, yet have been neglected paleontologically. Renewed prospecting alongside improved dates and stratigraphy of 12 sites across 50 miles^2 has nearly doubled the total faunal count and contributed new taxa previously unknown in the region. Mpesida has yielded the earliest sub-Saharan record of numerous taxa including members of Primates, Proboscidea, Carnivora and Lagomorpha.

Increasingly sophisticated modelling methods are being applied to community structure and dietary adaptations to predict the habitats likely available to extinct mammals. Yet whether one can indeed apply modern fauna-flora associations to their extinct counterparts needs to be more rigorously tested. We assess how mesowear, body mass estimations, stable isotopes and mammal community structure compare side-by-side. By overlaying detailed fossil mammal community data upon the new stratigraphic framework, we parse out specific, contemporaneous habitats on a heterogeneous landscape. Through this we question how the paleoecological signatures of localized ecosystems differ from those at the regional level.

Mpesida affords a unique opportunity to test how well these proxies hold up due to the presence of independent sources of paleoenvironmental data in the form of a large body of macrofloral evidence – including an in situ fossil forest where trees are preserved in growth position by volcanic ash dated to 6.37 Ma. We apply modern forest ecology techniques to mapped tree positions to project tree heights and analyze the spatial distribution of the trees, reconstructing a dense, lowland rainforest, and allowing inferences of faunal inhabitants and dispersal agents. Using regressions derived from correlations between modern mammal communities and arboreal cover, the Mpesida mammal assemblages predict 70% heavy tree cover in the south of the study area but less than 1% 20 miles to the north. We find that in the absence of macrofloral evidence, canopy cover would likely be underestimated when based on stable isotopes, mesowear, and community structure alone, suggesting there are no strict modern analogs for Miocene forest ecosystems. However, using the known presence of different types of wooded habitat in late Miocene Baringo (deciduous woodland, rainforest and riparian woods) we suggest ways one might use the fossil mammal record to differentiate between such habitats.

Grant Information

This work was supported by the Quaternary Research Association; Paleontological Society; Yale Institute for Biospheric Studies; and the MacMillan Center.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

TEACHING THE 'E WORD': SCIENCE ANXIETY IN OKLAHOMA EDUCATORS

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In 2015, the state of Oklahoma began implementing the new Next Generation Science Standards (NGSS) in public schools. The reaction to this change has been mixed, with teachers being both optimistic and nervous about creating effective lessons to teach to the new standards. Original ethnographic research indicates that elementary and middle school teachers in the state are uncomfortable teaching many science concepts. We attribute this to several factors: (1) a lack of exposure to science in their professional development and training; (2) barriers to teaching science concepts with an inquiry-based (hands-on) approach; and (3) a concept we call "science anxiety", which is a learned and cumulative sense of self wherein individuals feel incapable of doing, learning, or engaging in science. Science anxiety is a function of identity, meaning that it is affected by factors such as socioeconomics, health, socialization (race, class, gender), ideology, and opportunity. The present project has involved creating a collection of vertebrate paleontology specimens and offering free outreach to Oklahoma educators in order to help them prepare for NGSS in their classrooms, as well as alleviate their science anxiety via the use of science objects. We test their level of science knowledge, their sense of self-efficacy in teaching science, and their attitudes toward certain factors of NGSS, most specifically teaching evolution. Confidence and ability to teach evolution is tested and improved through the implementation and enjoyment of the "gateway science", paleontology.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

AGE, DEPOSITIONAL ENVIRONMENTS AND PALEOECOLOGY OF ALASKA'S OLDEST DINOSAUR FOSSILS FROM THE JURASSIC NAKNEK FORMATION

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Geological mapping in the 1970s resulted in the serendipitous discovery of a dinosaur tracksite on a remote mountainside in southwestern Alaska. Although the site has been known for over 35 years, the exact age of the track-bearing unit was equivocal and the tracks have never been formally studied. Recently, the site was relocated by the University of Alaska Museum and detailed geological and paleontological data was collected for the first time. The track-bearing unit occurs in the Indecision Creek Sandstone Member of the Upper Jurassic Naknek Formation in the Peninsular terrane. The tracks occur at the upper surface of a 7.5 m thick, trough cross-bedded sandstone package, which occurs at the top of a series of coarsening-upward successions that are interpreted as shallow marine offshore to upper shoreface successions. Overlying the track-bearing sandstone is a succession of coastal plain sediments that transition upward into shallow marine deposits. Biostratigraphic control is provided by the presence of the bivalve *Buchia mosquensis* in shallow marine strata above and below the trackway, indicating a late Kimmeridgian to middle Tithonian age. Palynological assemblages are consistent with a Late Jurassic age and bisaccate and monosaccate pollen grains are more common in coal facies, indicating the presence of coniferous forests. Marine invertebrate assemblages from the upper Naknek Formation indicate relatively cool settings consistent with deposition at a high paleolatitude. The prints are exposed in outcrop as true tracks on a near-vertically inclined bedding surface. At least 18 individual prints were visible at the time of discovery, but some have subsequently been lost to erosion. The prints are uniformly sized and have a maximum length of 17 cm. Complete prints are tridactyl, the

digits are relatively long and narrow, and phalangeal and claw impressions can be discerned. Based on overall size and morphology, the tracks are attributable to a small- to medium-sized theropod dinosaur with an approximate hip height of 0.8 meters. The tracksite is significant in being the first record of Jurassic dinosaurs in Alaska as well as the oldest documented occurrence of Dinosauria in the state, predating by approximately 50 million years dinosaur tracks from the Cretaceous Nanushuk Formation on Alaska's North Slope.

Technical Session XVI (Saturday, October 17, 2015, 9:30 AM)

NEW CLADES AND CHARACTERS IN BASAL CROCODYLOMORPH PHYLOGENETICS

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Crocodylomorphs were the only crocodile-line archosaurs to survive the end-Triassic extinction event and parsing out their early evolution is a critical step in studies of post-extinction recovery. Early taxa were terrestrial predators of predominantly small-body size that are typically recovered as a paraphyletic grade with respect to Crocodyliformes. In order to better place all basal crocodylomorph taxa into a phylogenetic context, we have reevaluated the anatomy of several well-known taxa and conducted the first phylogenetic analyses to include newly discovered specimens.

We further prepared and reevaluated the holotype specimen of *Dromicosuchus* in light of newly recovered, more complete early crocodylomorph remains, resulting in revisions to the anatomy as previously described. Certain hind limb materials originally referred to *Dromicosuchus* are now recognized as aetosaurian. Other elements noted to be absent have been identified, including the interclavical and quadratojugal. Moreover, detailed analysis of several well-preserved specimens (e.g., NCSM 13733, CM 29894, etc.) indicates that parsing out the complex articulations of the antorbital and postorbital regions of basal Crocodylomorpha require scrutiny via computed tomographic (CT) imagery. For example, the maxilla-jugal-lacrimal contact in many taxa appears to be interdigitated and the nature of the quadratojugal may be more laminar and anteroventrally extensive than previously thought.

With this new information, we conducted a phylogenetic analysis of 42 taxa (17 crocodylomorph OTUs) and 242 characters (60 MPTs, 651 steps), which resulted in a well-resolved Crocodylomorpha with large-bodied taxa, including the newly named *Carnufex carolinensis* and the fragmentary *Redondavenator*, representing the earliest diverging members. The analysis also recovered a basal clade composed of *Dromicosuchus*, *Hesperosuchus*, and several other specimens, united by a deep, well-defined antorbital fossa, and a medial tuber on the proximal head of the radius. Specimens previously referred to "*Hesperosuchus*" (YPM 41198, CM 29894) did not group together in a clade with the holotype specimen of *Hesperosuchus agilis* (AMNH 6758). The analysis also found *Terrestrisuchus* and *Dibothrosuchus* as sister taxa. Detailed morphological examination and phylogenetic analysis of basal Crocodylomorpha is essential for our understanding of trait evolution and ecology in Triassic and early Jurassic taxa and in improving outgroup choice in phylogenetic analyses of early Crocodyliformes.

Technical Session XVIII (Saturday, October 17, 2015, 3:30 PM)

QUANTIFYING THE HABITAT PREFERENCES OF LARGE MAMMALS IN PLIOCENE-PLEISTOCENE EASTERN AFRICA USING ESTIMATED FRACTION WOODY CANOPY COVER

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Accurately identifying the habitat preferences of extinct taxa is important for understanding how ecological and evolutionary mechanisms functioned in the past. Previous studies have inferred habitat preference from proxies such as functional morphology, stable isotopes, dental wear, and/or habitat preferences of extant relatives. These measures, however, are all **indirect** habitat indicators and do not measure the **direct** association between a taxon of interest and its inhabited environment. Understanding the link between a taxon and its habitat is especially important because taxonomic composition of fossil assemblages is often used to reconstruct the paleoenvironments in which they occurred. Here, we quantify the type and range of habitats occupied by fossil large mammal genera based on their observed associations with sites of varying woody canopy cover in the geological record. We jointly analyzed an online pedogenic carbonate database with published records of fossil large mammal abundances from eastern African sites divided into two 1 Myr time bins: 3.5–2.5 Ma (Pliocene) and 2.5–1.5 Ma (Pleistocene). One Myr time-averaged bins were justified to explore the full range of sites/habitats that were occupied by each genus. Stable carbon isotope values were transformed into fraction woody canopy cover for each site. We calculated weighted 25th, 50th (median), and 75th quartiles of fraction woody cover associated with each genus, where weights were a function of genus abundance found at each site with a given woody cover value. Weighted medians represent the fraction woody cover preferred by each genus, and the 25th and 75th quartiles represent the diversity of habitats preferred. Results show that many genera are associated with the types and ranges of habitats as predicted by other proxies, although some are unexpected. Pleistocene habitat preference is not a predictable function of Pliocene habitat preference ($r = 0.053$), demonstrating that many genera exhibit the capacity for high ecological plasticity or niche evolution at the scale of our analyses. These results caution against reconstructing paleoenvironments using strict taxonomic uniformitarianism. Nevertheless, there is a lot of noise in comparing mammal and pedogenic carbonate data because they likely record paleoecological information at different spatio-temporal scales. Researchers therefore need to be mindful about the scale of their paleoecological analysis and how this determines their proxy of choice and vice versa.

Grant Information
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Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

DERIVED PACHYCEPHALOSAURID SQUAMOSALS (ORNITHISCHIA: MARGINOCEPHALIA) FROM THE UPPER DINOSAUR PARK FORMATION, SOUTHERN ALBERTA

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Pachycephalosaurids are a group of bipedal ornithischians with a poor fossil record due in part to taphonomic bias against small body size. Taphonomic and phylogenetic studies predict a much greater diversity in this group than presently recorded. The thickened bones of the cranial dome, which are preferentially preserved, provide most of the evidence documenting diversity, given the distinctive bony ornamentation along the margins of the dome. Here we report on two nearly complete pachycephalosaurid squamosals from the uppermost Dinosaur Park Formation (DPF) that represent new derived taxa from a poorly sampled interval within the unit. The first specimen was found in Dinosaur Provincial Park (DPP) in the Lethbridge Coal Zone (LCZ), the uppermost informal subdivision of the DPF. The other specimen was collected approximately 10 km southeast of Manyberries in an outcrop chronostratigraphically correlative with the LCZ.

Both specimens exhibit a high degree of doming anteromedially and lack a supratemporal fenestra. The diagnostic squamosal ornamentation includes a linear primary row of large, subconical nodes along the dorsal region of the posterior squamosal bar and at least one prominent corner node. These features resemble the squamosal ornamentation in *Prenocephale prenes* and *Sphaerotholus* spp. In the DPP specimen, the posterior squamosal bar maintains a constant depth in lateral view but slopes at a significant ventrolateral angle in posterior view. It differs from *Prenocephale prenes* and *Sphaerotholus* in the presence of a second linear row of smaller nodes medial to the corner node. The Manyberries specimen differs from the first in the posterior squamosal bar, decreasing in depth laterally as in *S. buccholtzae* but unlike *P. prenes*. In addition to the aforementioned nodal rows, two enlarged corner nodes are positioned on the posterior surface of the squamosal bar immediately ventral to the primary node row. This arrangement of squamosal nodes closely resembles the condition in *Homalocephale*.

Preliminary phylogenetic analysis suggest that the new taxa are most closely related to *Sphaerotholus* spp. and may represent the most derived pachycephalosaurids currently known from the Belly River Group. Taxa from the LCZ are likely younger and from paleoecologically distinct habitats compared to pachycephalosaurids in the Dinosaur Park Formation, providing further evidence of faunal turnover.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

NEUROANATOMY, ENDOCASTS, AND THE EVOLUTION OF BRAINS AND BEHAVIOR IN BIRDS

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Brain endocasts are often used to make inferences about the neuroanatomy and behavior of extinct species. In birds, these endocasts have been shown to be relatively faithful representations of the external morphology of the brain. Avian brain evolution is complex, and an increase in the size of the same structure on the brain endocasts of two different taxa could be due to very different changes in neuroanatomy. To date, no study has systematically examined the extent to which the details of internal brain anatomy are reflected on the endocasts of birds. To assess the fidelity of the endocasts and underlying brains of extant birds, cadaveric specimens were soaked in Lugol's iodine, a solution that differentially stains soft tissues. These specimens were then CT scanned, and the data were examined for internal neural structures that could be visualized with this contrast-enhanced imaging technique. Identification of neuroanatomical structures was aided by histological work on avian brains done by other authors. Determining which structures are best resolved with this technique is imperative to building a broad taxonomic sample, as decisions on which species to add in future studies will be informed by the ability of this approach to yield information on their neuroanatomical specializations. Results of the pilot study show that components of the tectofugal and thalamofugal visual pathways are clearly discernable, indicating that this approach may be most informative when applied to birds with visual specializations. The goal of the broader study, however, is to establish patterns of brain evolution within the whole clade, and thus a wide taxonomic sample will be used to establish the critical link between functional neuroscience and the brain endocast within the bony skull. Establishing clearer relationships between endocast morphology and internal brain structure and function will allow avian endocasts to better serve as neurological proxies, allowing assembly of larger extant samples, which will in turn better constrain the inference of soft tissues and potentially behavior in extinct birds and their immediate nonavian dinosaur relatives.

Grant Information
National Science Foundation grant IOS-1050154

Preparators' Session (Thursday, October 15, 2015, 11:30 AM)

THE GLOVES ARE OFF-SPECIMEN DETERIORATION THROUGH COMMON HANDLING PRACTICES

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Fossil specimens in collections are routinely handled with bare hands. Aside from some type material, most collection policies do not prescribe the use of gloves, even though deterioration of the outer surface of fossils is frequently observed. This deterioration can be especially pronounced if specimens are handled for long periods at a time, e.g. during preparation projects. In paleontology, archaeology, rare book collections, and other fields dealing with scientific objects, gloves prevent oils and other substances from interacting with specimens and are widely deployed. These routine protective measures, however, are rarely implemented in fossil collections.

Damage to specimens by simply touching them is generally not a process that can be observed immediately. It often takes repeated handling over days to decades for damage to accumulate and be visible to the naked eye. Recent observations of specimens within teaching and research collections demonstrate that the outermost surface of a fossil can

be substantially altered through deposition of oils, salt, and other substances from our skin. Furthermore, whether during the preparation process or regular handling, surrounding matrix can be transferred onto the specimen contributing to abrasion by particles that stick to the oils from our skin. This can be especially problematic with light colored bone and a darker matrix that tints bone easily, for example [illegible]matite. Accelerated wear and deterioration of the outer cortex of specime[illegible] c[illegible]erved when handled with bare hands as opposed t[illegible]ittle to n[illegible]ea[illegible]o[illegible] [illegible]m[illegible]s [illegible]at are handled with gloves.

Withdrawn

The use of gloves [illegible]s t[illegible] transf[illegible] [illegible]minar[illegible]nd [illegible]as[illegible] m[illegible]erials onto the specimen. [illegible] should be used on specimens [illegible] handling, e.g., very small specimens [illegible] not recommended for use during preparatio[illegible] burns when coming into contact with cyanoacryl[illegible] gloves should be distributed to anyone needing to handle del[illegible] in collections, or when otherwise appropriate. Latex gloves should not [illegible]considered, because of potential allergic reactions. If the use of gloves is impractical, or not wanted, care should be taken to only handle specimens with clean, dry hands. Hygiene practices similar to those in the food and medical industries should be employed with frequent washing of hands with soap when appropriate.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

CARNIVORANS FROM THE IRRAWADDY SEDIMENTS (MYANMAR; LATE MIDDLE MIOCENE TO EARLY PLEISTOCENE) AND THEIR CHRONOLOGICAL CHANGES

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We report discoveries of carnivorans from the Irrawaddy Sediments. The sediments are widely exposed in the central part of Myanmar, and its age has been estimated from the late Middle Miocene to Early Pleistocene mainly based on biostratigraphic correlations with the Siwalik fauna. The occurrences of mammals from the Irrawaddy sediments were limited mostly to large ungulates during the last century. Intensive expeditions in the recent decade improved understandings on biostratigraphic position of each fauna within the Irrawaddy sediments and revealed presence of carnivorans.

An amphicyonid has been collected from the Tebingan locality, near the basal horizon (late Middle Miocene or Late Miocene) of the Irrawaddy sediments. This large endemic amphicyonine form is one of the last occurrences of the family in Southeast Asia.

The Chaingzauk fauna (around the Miocene/Pliocene boundary) yields the most abundant carnivorans: two species of primitive hyaenid (*Ictitherium*), a running hyaenid (*Hyaenictis*), two machairodontine felids (*Metailurus*, *Machairodus*), and a large ursid (*Agriotherium*). The fauna consists of medium to gigantic forms; sampling biases seem to influence collection of carnivorans as well as those of other mammals. All the carnivoran genera have cosmopolitan distributions, and the occurrences from Myanmar fill their geological gap at Southeast Asia within Eurasia.

A tooth of herpestid (*Urva*) and a dental fragment of viverrid (?Viverrinae) have been collected from the Gwebin fauna (Late Pliocene to the earliest Pleistocene). This first record of herpestid in the Pliocene and Early Pleistocene of Asia confirms that mongooses had already dispersed into Southeast Asia from South Asia by the Late Pliocene. The Sulegon locality is another area covered by stratigraphically younger sediments. Presences of additional taxa, a small felid and a large hyaenid, are suggested from postcranial bone specimens.

This discovery of diverse carnivorans from the Irrawaddy sediments fills geographical and/or chronological gaps of carnivoran distributions in Southeast Asia. Although each carnivoran assemblages is obviously influenced by sampling biases, the comparisons among carnivoran assemblages indicate faunal turnover of carnivorans at the family or subfamily level from the late Middle Miocene to the Early Pleistocene of Myanmar.

Grant Information
JSPS KAKENHI Grant No. 26304019 (to Takai), 15K05330 (to Egi)

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

FEEDING TRACES ON *PTERANODON LONGICEPS* (REPTILIA: PTEROSAURIA) BONES FROM THE LATE CRETACEOUS (CAMPANIAN) MOOREVILLE CHALK IN ALABAMA, USA

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Pterosaur remains are exceptionally rare in the Late Cretaceous marine chalks of Alabama, and the few specimens in the Alabama Museum of Natural History and McWane Science Center collections are typically very fragmented. Here we report the occurrence of three metacarpals of *Pteranodon longiceps* from the Mooreville Chalk (Campanian, ~80 million years old) of Dallas and Greene counties, Alabama. Two of the three specimens preserve evidence of post mortem feeding by marine scavengers. Specimen RMM 3274 from Greene County exhibits serrated tooth marks typical of sharks, such as *Squalicorax kaupi* whose teeth are found in abundance in the Mooreville, that are present across the outer surface of the bone. A second *Pteranodon* specimen, ALMNH 2014.1.200 also exhibits weak serration marks on the surface of the bone. A second set of larger, unserrated tooth marks, unlike those of any contemporary shark species, is also present. These tooth marks compare favorably with the tooth spacing and morphology of a small to moderate-sized saurodontid fish, such as *Saurodon* or *Saurocephalus*.

In both instances, feeding traces appear to be scavenging events due to the lack of any healing or bone remodeling. During the Campanian, Dallas and Greene Counties, Alabama, represented a shallow-marine ecosystem forming part of the Mississippi Embayment. It is hypothesized that both specimens represent *Pteranodon* individuals that either fell into marine waters or were washed out from nearshore areas and then scavenged by chondrichthyans and osteichthyans. This type of behavior has been recorded in other taxonomic groups from Alabama during the Late Cretaceous. The fragile, hollow bones of *Pteranodon* however, make their preservation in the fossil record much more rare.

Colbert Prize (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

FIRST ANALYSIS OF TUSK GROWTH RATE AND SEASON OF DEATH OF A SOUTH AMERICAN GOMPHOTHERE

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Excavations at El Trebal 1 near Santiago, Chile in 2011 revealed late Pleistocene-age channel fill deposits containing the skull and tusks of an adult gomphotheriid (*Notiomastodon platensis*). A sample was excised from near the proximal end of the tusk to evaluate the last years of life and assess season of death. The sample was broken into several pieces during the extraction process but contained a nearly continuous sequence of dentin from the pulp cavity surface to the cementum-dentin junction. Life history information was extracted from the sample using a battery of analyses including microCT scanning, thin-sectioning, and serial isotope sampling. In transverse sections derived from microCT data, the dentin shows somewhat regularly-spaced abrupt transitions from zones of high x-ray attenuation to adjacent zones of low attenuation. These transitions have been interpreted as corresponding to the boundary between winter and spring in proboscideans from North America and Asia. However, analyses of approximately weekly incremental features in transverse thin section show regular seasonal variation in dentin apposition over a period encompassing two full microCT density cycles. This is the first documented occurrence of semiannually recurring CT features in a proboscidean; such features may correspond to the timing of different growing seasons during the year. Both $\delta^{13}C$ and $\delta^{18}O$ values also show a slight drop (~1‰) concurrent with the microCT feature located in the middle of the final two years of life. Within the tusk sample, we were able to observe four years of life, including the year in which the individual died. Complete years prior to death show an average of 10.4 mm of appositional growth, which is comparable to growth rates measured in tusks of healthy male mammoths and mastodons from North America. Judging from thicknesses of complete annual growth increments in the last years of life, death appears to have occurred in the late summer to early fall, unusual for a natural death.

Technical Session I (Wednesday, October 14, 2015, 8:45 AM)

TRAUMATIC INJURY IN *PROMERYCOCHOERUS* (FAMILY MERYCOCOIDODONTIDAE, ORDER CETARTIODACTYLA)

EMERY, Meaghan, University of Oregon, Eugene, OR, United States of America, 97405; WARRICK, Douglas, Oregon State University, Corvallis, OR, United States of America; DAVIS, Edward, University of Oregon, Eugene, OR, United States of America

Promerycochoerus was a genus of large-bodied oreodonts that lived in North America during the Oligocene and Miocene. The genus is characterized by thickened, hooked, and laterally expanded zygomatic arches which may be sexually dimorphic. Male-male competition behaviors in extant sexually dimorphic artiodactyls like wrestling, head-butting, and biting can affect bone structure. We hypothesize that the expanded zygomatic arches of *Promerycochoerus* served a role in male-male competition. We evaluated 42 complete to semi-complete *Promerycochoerus* crania for osteopathies and found that 54% of them showed some sign of traumatic injury, including ovoid puncture marks with and without signs of healing (17%), partial overgrowth of bone on the jugal and squamosal (13%), bone remodeling (17%), and malunion of the zygomatic arches (13%). All of the injured individuals have at least one partly healed injury, indicating they survived their encounters.

All healed osteopathies we examined were associated with the postorbital processes and the zygomatic arches. In modern camelids a significant portion of the jugular vein and maxillary artery runs between the zygomatic arch and the braincase. We speculate that the posteriorly expanded section of the zygomatic arch in *Promerycochoerus* provided protection for this vulnerable blood supply. Undamaged portions of the zygomatic arch in *Promerycochoerus* preserve posteriorly-directed muscle scars that do not have a clear analog in modern artiodactyls. These muscles may have connected to the enlarged processes of C2 or the thoracic vertebrae. If so, *Promerycochoerus* would have possessed powerful neck musculature that could have facilitated head-butting or wrestling.

We found that puncture marks on *Promerycochoerus* were largely circular or semi-lunate, and up to 10.9 mm in diameter. Most of these punctures were shallow, but a few specimens had punctures that broke completely through the bone. *Promerycochoerus* canines are semi-lunate with a flat posterior surface, and average 15.27 mm in width and 14.98 mm in length but taper significantly up the crown, placing them within the appropriate size class for most of the puncture marks examined. Only two specimens had puncture marks on the skull that were not on the zygomatic arches, and only four had puncture marks without noticeable signs of healing. The uniformity of puncture mark placement and pattern of re-healing over an individual's lifespan indicates regular, survivable attacks may not have been the exception, but a normal part of life for *Promerycochoerus*.

Grant Information
Field Museum of Natural History Research Grant, FMNH
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Thomas Condon Award, University of Oregon

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

REVISION OF EOCENE ANTARCTIC CARPET SHARKS AND GROUND SHARKS (CHONDRICHTHYES, ORECTOLOBIFORMES, CARCHARINIFORMES)

ENGELBRECHT, Andrea, University of Vienna, Vienna, Austria; KRIWET, Jürgen, University of Vienna, Vienna, Austria; MÖRS, Thomas, Swedish Museum of Natural History, Stockholm, Sweden; REGUERO, Marcelo, Museo de La Plata, La Plata, Argentina

Seymour Island (Antarctic Peninsula) is known for the wealth of its Paleogene cartilaginous and bony ichthyofauna. Eocene marine vertebrate remains are common in the sediments of the La Meseta and Submeseta formations. Most vertebrate remains recovered up to now are isolated teeth of elasmobranchs. So far, 24 species of chondrichthyans belonging to 15 families have been described. The distribution of cartilaginous fishes is very patchy throughout the La Meseta and Submeseta formations. Generally, diversity is very low in TELMs 1 to 3 (late Paleocene–early Eocene). The highest diversities can be found in TELMs 4 and 5 (early–middle Eocene), where a predominantly cold-adapted chondrichthyan fauna seemingly emerges, indicative of a temperate marine habitat with some warm water elements like orectolobiform and carchariniform sharks. Consequently, these sharks are considered to be immigrants into the Southern Ocean during the Eocene.

For the first time, abundant new elutriated teeth of carpet and ground sharks from TELMs 4 and 5 (early–middle Eocene) of Seymour Island are available, allowing for a detailed analysis of the taxonomic composition of these shark groups in the Southern Eocene during gradually cooling conditions. Up to now, only two extinct species of carpet sharks (*Pseudoginglymostoma* cf. *brevicaudatum*, *Stegostoma* cf. *fasciatum*) and two fossil species of ground sharks (*Carcharhinus* sp., *Scoliodon* sp.) have been described from the Eocene La Meseta Fm, Seymour Island. Their species assignment however, remains ambiguous. Here, we present new material of the four currently known but also new records of carpet and ground sharks of the La Meseta and Submeseta formations on Seymour Island enabling a revision and taxonomic assignment of these sharks. Interestingly, the diversity of carpet and ground sharks in the Eocene of the Southern Ocean shortly before establishment of the Antarctic convergence is larger than previously assumed, depicting interesting faunal relationships.

Colbert Prize (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

PALAEOTHENTID MARSUPIALS (MAMMALIA: PAUCITUBERCULATA) FROM THE MIDDLE MIOCENE LOCALITY OF QUEBRADA HONDA, BOLIVIA

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During the Oligocene and Miocene, paucituberculatan marsupials were a significant and abundant component of most South American mammal communities, with over 60 species identified from this interval. These extinct paucituberculatans were much more diverse than modern forms, occupying ecological roles filled by rodents, eulipotyphlans, and primates on other continents. Nevertheless, during the middle Miocene, paucituberculatans abruptly declined in diversity, leaving only seven morphologically stereotyped extant species in a single family (the Caenolestidae), all of which are currently restricted to cool-temperate habitats in southern Chile and the Andes Mountains. The most speciose extinct paucituberculatan clade is the Palaeothentidae, which is last recorded at late middle Miocene sites in Colombia, Bolivia, and possibly Argentina. Here, we describe six new and seven previously undescribed specimens from one of these areas, the late middle Miocene site of Quebrada Honda, Bolivia. These specimens include (1) the first identified lower dentitions of *Acdestis maddeni*, (2) two new species of *Palaeothentes*, and (3) a third new species representing a new genus. The lower dentition of *A. maddeni* differs from other members of this genus in having a longer m1 paracristid and a reduced, single-rooted m4. The two *Palaeothentes* species from Quebrada Honda demonstrate that this genus survived into the late middle Miocene. One of these species is distinguished by a well-developed anterior cusp on P3 and the absence of an anterior trigonid crest on m1; the other is distinguished by its incomplete postcristid. The third new species differs from species of *Palaeothentes* and all other palaeothentids in having the unique combination of a straight entocristid on m2, a curved entocristid on m3, a cristid obliqua that is mesially directed towards the protoconid, and an m4 that is proportionately smaller than in palaeothentines but larger than in decastines. The relatively high taxonomic and ecomorphological diversity of palaeothentids at Quebrada Honda prior to their extinction is surprising given that clades tend to exhibit relatively low diversity before going extinct. This suggests that the extinction of these marsupials was relatively rapid, particularly considering the group's wide geographic distribution just prior to its extinction.

Grant Information
This research was supported by the National Science Foundation (EAR 0958733 to D. Croft) and the National Geographic Society.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

WEAR BIOMECHANICS IN THE SLICING DENTITION OF THE GIANT HORNED DINOSAUR, *TRICERATOPS*

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Herbivorous reptiles rarely evolve occluding dentitions allowing for the mastication (chewing) of plant matter. Conversely, most herbivorous mammals possess occluding teeth with complex tissue architectures that self-wear to complex morphologies for orally processing plants. Dinosaurs stand out among reptiles in that several lineages acquired the capacity to masticate. In particular, the horned ceratopsian dinosaurs, among the most successful Late Cretaceous dinosaurian lineages, evolved slicing dentitions for the exploitation of tough, bulky plant matter. Here we show how *Triceratops*, a nine-meter long ceratopsian, and its relatives evolved teeth that wore during feeding to create fullers (recessed central regions on cutting blades) on the chewing surfaces. This unique morphology served to reduce friction during feeding. It was achieved through the evolution of a complex suite of osseous dental tissues rivaling the complexity of mammalian dentitions. Tribological (wear) properties of the tissues are preserved in ~66 million year old teeth, allowing creation of a sophisticated three-dimensional biomechanical wear model (the first for a slicing dentition) that reveals how the complexes synergistically wore to create these implements. These findings, along with similar discoveries in hadrosaurids (duck-billed dinosaurs), suggest that tissue mediated changes in dental morphology may have played a major role in the remarkable ecological diversification of these clades and perhaps other dinosaurian clades capable of mastication.

Grant Information
NSF EAR 0959029 to GME and MAN

Technical Session XI (Friday, October 16, 2015, 10:15 AM)

THE EVOLUTION AND DEVELOPMENT OF HOMININ TOOTH SIZE

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The variation in molar tooth size in humans and our closest relatives has strongly influenced our view of human evolution. The reduction in overall size, and disproportionate decrease in third molar size, have been noted since Darwin, and have been attributed to reduced selection on the dentition due to changes in diet or the acquisition of cooking. The systematic pattern of size variation along the tooth row has been described as a 'morphogenetic gradient' in mammal and more specifically hominin teeth. However, the underlying controls of relative tooth size have not been well understood, with hypotheses ranging from a morphogenetic field to the clone theory. In this study, we make the first comprehensive examination of the morphogenetic gradient in hominin primary postcanine teeth (deciduous premolars and permanent molars). Tooth sizes of modern humans were represented by the averages of at least 59 populations for each molar, and eight populations for deciduous premolars. These were compared with data from 289 specimens of 13 species of fossil hominins, including the genera *Ardipithecus*, *Australopithecus*, *Homo*, *Kenyanthropus* and *Paranthropus*. Here we show that the inhibitory cascade, an activation-inhibition mechanism that affects relative tooth size in mammals, generates patterns equivalent to a morphogenetic gradient. Multiple regression of tooth proportions with absolute size of the first molar shows that the inhibitory cascade pattern, including a reversal of the direction of the morphogenetic gradient, explains the majority of variation in tooth size proportions in hominins (weighted average $R^2 = 0.65$). We conclude that the inhibitory cascade mechanism produces the default tooth size patterning for primary postcanine teeth in mammals, including hominins. Based on the relationship of changing inhibitory cascade patterning with size, we can use the size of a single tooth to predict the sizes of the remaining four primary postcanine teeth in the row for most hominins. *Ardipithecus* appears to be the largest outlier in this relationship among hominins, showing larger posterior molars than predicted for the size of the first molar. Our study shows the major influence of this developmental patterning mechanism in the evolution of the unique proportions of human teeth.

Grant Information
Australian Research Council (A.R.E.), Academy of Finland (J.J.), Wenner-Gren Foundation (K.K.C.), National Science Foundation (K.S.P.)

Technical Session VII (Thursday, October 15, 2015, 3:45 PM)

A NEW CENTROSAURINE CERATOPSID FROM THE OLDMAN FORMATION (MIDDLE CAMPANIAN), ALBERTA, CANADA, AND THE EVOLUTION OF CERATOPSID NASAL ORNAMENTATION

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The fossil record of ceratopsids between the occurrence of their proximate sister taxa in the Turonian and the beginning of their well-documented radiation from the late Campanian of North America onwards (between approximately 90 and 77 Ma) is poor, with only seven taxa described from this early period in their evolution. We describe a new taxon of a highly adorned basal centrosaurine from the lower part of the Oldman Formation (middle Campanian, approximately 78-79 Ma), Alberta, Canada. Almost 200 bones derived from virtually all parts of the skeleton, including numerous well-preserved specimens of the parietosquamosal frill were collected from a medium-density, monodominant bonebed. The new taxon is apomorphic in having epiparietals at loci 2 and 3 developed as broad-based, pachyostotic processes that are strongly procurved anterodorsally to overhang the parietal fenestrae. Although the morphology of the nasal is incompletely known, it clearly had large, upright nasal ornamentation located close to the orbits, which represents the oldest occurrence of a prominent nasal horn in Ceratopsia.

The most inclusive phylogenetic analysis of centrosaurine ceratopsids to date was conducted to assess the systematic position of the new taxon. The analysis resulted in 18 most parsimonious trees, with the new centrosaurine recovered as the sister taxon of *Sinoceratops zhuchengensis* in all of the most parsimonious trees. This clade forms a polytomy with *Xenoceratops foremostensis* and a much larger clade that includes *Centrosaurus apertus* and Pachyrhinosaurini. Overall, the topology within Centrosaurinae is very similar to that recovered in recent analyses, with *Diabloceratops* recovered as the sister taxon to all other centrosaurines, and a *Nasutuceratops* +

Avaceratops clade and *Albertaceratops* forming successive sister taxa to the more derived centrosaurines, including the new taxon. Basal centrosaurines, including *Diabloceratops* and *Nasutuceratops*, have weakly developed and ridge-like nasal ornamention. Given the phylogenetic position of the new taxon within Centrosaurinae, an enlarged nasal horn is hypothesized to have arisen independently at least twice in ceratopsid evolution.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

MOLAR MORPHOMETRIC DISPARITY REFLECTS PHYLOGENY MORE THAN DIET IN EARLY EOCENE PRIMATES

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The size and cusp shape of molars are commonly used as a proxy for body size and a primary tool for identification in the fossil record. However, does overall molar morphological disparity reflect inferred diet or evolutionary relationship? Early primates are an ideal group in which to examine this question, as both diet and evolutionary relationships have been well characterized. This study uses geometric morphometrics to quantify lower first molar shape changes between co-occurring early Eocene primates from the Wasatch Formation, Greater Green River Basin, Wyoming. We analyzed data from the lower first molar of 74 specimens, representing seven genera from three families (2 adapids, 4 omomyids, and 1 microsyopid). All specimens were photographed and digitized with 10 landmarks representing distinct cusp features in occlusal view. Principal Component Analysis (PCA) was run to quantify general shape patterns in morphospace, and Canonical Variates Analyses (CVA) were run on factors such as genus, locality, centroid size, and time bin. Results of the CVA show that locality and time bin are not significantly discriminated. Because locality is not significant, we can reject taphonomic bias on shape in favor of more biologically relevant correlations. Genus level CVA shows significant disparity between families and overlap between closely related genera. The more disparate groups are also more distantly related, suggesting a strong correlation between morphological disparity and evolutionary relationship. Additionally, overlap of taxa with similar inferred diets exists, but it cannot be strongly distinguished from phylogeny. Although other characteristics such as size and enamel structure are important distinguishing features among taxa, morphometric disparity based on cusp position most strongly reflects phylogeny. Future studies involving a temporal component in looking at shape trends as well as coexisting taxa may provide more insight into the influence of diet and phylogeny on tooth morphology in these mammal groups.

Poster Symposia (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

QUANTITATIVE INFERENCES ON THE LOCOMOTOR BEHAVIOR OF EXTINCT SPECIES: NEW INSIGHTS FROM 3D SURFACE GEOMETRIC MORPHOMETRICS APPROACHES

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Inferences of function and ecology in extinct taxa have long been a subject of interest because it is fundamental to understand the evolutionary history of species. In this study, we use a quantitative approach to investigate the locomotor behavior of *Simocyon batalleri*, a key taxon of the ailurid family. To do so, we use 3D surface geometric morphometric approaches on the three long bones of the forelimb of an extant reference sample. Next, we test the locomotor strategy of *S. batalleri* using a leave-one-out cross-validated linear discriminant analysis (LDA). Our results show that *S. batalleri* is included in the morphospace of the living species of musteloids. However, each bone of the forelimb appears to show a different functional signal suggesting that inferring the life-style or locomotor behavior of fossils can be difficult and dependent on the bone investigated. These results highlight the importance to study the whole skeleton, at least where possible, and to be careful in inferring life-style when studying isolated bones, even when using quantitative methods as was done here. Our results also show that some bones better capture functional signal than others, which implies that some bones can be more informative for inferring locomotor and behavioral strategies in extinct species. For example, the humerus appears to be a good indicator of aquatic and semi-fossorial adaptations, the ulna for the arboreal and semi-fossorial adaptations, and the radius for arboreal adaptations based on our LDA analysis. This highlights the importance of studying, where possible, a maximum of skeletal elements to be able to make robust inferences on the life-style of extinct species. Finally, our results suggest that *S. batalleri* may be more arboreal than previously suggested. This fossil ailurid shared its habitat with other larger carnivorans, such as the sabre-toothed felids *Machairodus aphanistus* and *Promegantereon ogygia*, or the lion-sized amphicyonid *Magericyon anceps*. In this context it seems reasonable that a generalised carnivoran such as *S. batalleri*, lacking large canines and being smaller than other large members of the predator guild, developed strong climbing abilities for escape from these larger species, but likely also for some foraging on trees.

Preparators' Session (Thursday, October 15, 2015, 8:45 AM)

THE RIGGING TECHNIQUES IMPLEMENTED FOR THE DE-INSTALLATION OF THREE CHALLENGING PLAQUE MOUNTS AT THE SMITHSONIAN INSTITUTION NATIONAL MUSEUM OF NATURAL HISTORY

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During the planning stages of the de-installation of exhibits at the Smithsonian Institution National Museum of Natural History, we identified three specimens that presented unique challenges. Typical de-installation challenges include layers of plaster, and aging adhesives and consolidants, but these three specimens had their own challenges and required new strategies for removal.

Both *Edmontosaurus* and *Albertosaurus* were plaque mounts located on a platform approximately 25 feet from the exhibit hall floor. The obvious challenges of these two specimens were the sheer size, weight and logistics of removing them from the current exhibit location. In addition to the specimens themselves, there were challenges with floor loading restrictions and earthquake damage. The presence of asbestos in the wall directly behind the two plaques meant that material could not be disturbed.

Xiphactinus was another plaque mount that was located roughly 30 feet from the exhibit hall floor and 5 feet above a ramp that connected the mezzanine in the dinosaur hall to a geology gallery containing the Hope Diamond. The original plan was to use material handling lifts to remove the plaque from the wall while being supported by the ramp or to use a spider crane from the floor below to lift the specimen from the wall and over the ramp to the gallery floor below. Given that the floor would not support the point load of the crane and the specimen we could not use this method. The ramp suffered damage during the 2011 earthquake that ended up closing the ramp and mezzanine to the public and rendering it unstable to lift from.

After identifying all of these challenges, we developed a method for removing the specimens. We created a custom modular system with various components that could be interchanged and used in all 3 rigging procedures. The safety of those performing the work and the preservation of the specimens were our first considerations. Through coordination, planning, and preparation, these three specimens were successfully lowered to the ground for shipping and storage.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

QUANTIFYING VARIATION IN THE OLIGOCENE EQUID *MIOHIPPUS* (MAMMALIA, PERISSODACTYLA) OF OREGON

FAMOSO, Nicholas A., University of Oregon, Eugene, OR, United States of America, 97403

As many as eight species of the equid genus *Miohippus* have been identified from the John Day Formation of Oregon, but no one has yet quantified the variation in these horses. Consequently, I compared the John Day *Miohippus* to ecological analogs as well as phylogenetically related taxa, both extinct and extant, to gain a better understanding of their variation. I compared variation of the anterior-posterior length and transverse width of upper and lower teeth of the John Day *Miohippus* to that of *M. equinanus*, *Mesohippus bairdi*, *Equus burchelli*, and *Tapirus terrestris* using *Z* tests of their coefficients of variation (*V*). None of the *Z* tests were significant, indicating that the variation seen in the John Day *Miohippus* is not significantly different from any of the populations of other perissodactyls examined in this study. Additionally, I examined the hypostyle condition, which has been used to diagnose species of *Miohippus*. Hypostyle condition was found to be related to the stage of wear using an ordered logistic regression. In the end, only one species of equid in the Turtle Cove strata can be identified and I therefore recognize *Miohippus annectens*, the genotype and first species described from the region, as the sole species known from Turtle Cove Fauna.

Grant Information

I would like to thank the Geological Society of America GeoCorps America program, which supported me while conducting research at John Day Fossil Beds National Monument.

Symposium 2 (Friday, October 16, 2015, 2:45 PM)

ASSEMBLING ECOSYSTEMS DURING GLOBAL WARMING: MEGAFAUNAL COLONIZATION AND SUCCESSION IN GLACIATED NEW YORK AFTER THE LAST GLACIAL MAXIMUM

FERANEC, Robert S., NY State Museum, Albany, NY, United States of America, 12230; KOZLOWSKI, Andrew L., NY State Museum, Albany, NY, United States of America

Determining how species assemble within ecosystems is of crucial importance for community ecology and understanding how taxa relate ecologically and evolutionarily. Further, due to on-going climate change it appears critical to identify how faunal communities establish and develop. Having knowledge of how species assemble permits predictions of species compositions for certain areas in the future, and allows for more informed conservation efforts. Many studies examining species assembly have focused on modern communities and have yielded important insights. Many of these analyses focus on community assembly on islands, and it may be uncertain how these studies scale up to continents or how relevant these data relate to periods of more significant climate change. Here we examine the colonization of megafauna into previously glaciated areas of New York State (NYS) after the Last Glacial Maximum (LGM) to assess how species assemble in continental ecosystems during a time of significant global warming. We test the hypothesis that species show preference for particular habitats. Twenty–five thousand years ago, nearly all of NYS was covered by the Laurentide Ice Sheet (LIS), and recession of the LIS opened the landscape for colonization. For our study, we generated and analyzed nearly 50 accelerator mass spectrometry (AMS) radiocarbon dates from species within NYS including caribou (*Rangifer tarandus*), giant beaver (*Castoroides ohioensis*), mammoth (*Mammuthus* sp.), mastodon (*Mammut americanum*), peccary (*Platygonus compressus*), and sloth (*Megalonyx jeffersonii*). Preparation of samples followed standard techniques, and analyses were performed at the National Ocean Sciences AMS (NOSAMS) facility. Bayesian analysis of the radiocarbon dates in species with more than 10 dated individuals (i.e., caribou, mammoth, mastodon), showed that caribou and mammoth colonized glaciated NYS no later than 15,000 cal BP, while mastodon arrived no later than 14,000 cal BP. Supporting our hypothesis, these dates coincide with the establishment of particular habitats. Caribou and mammoth appear with the development of tundra habitat, and mastodon appears once spruce taiga is established. Dates for the extirpation of all megafauna are more recent than 12,500 cal BP. These data imply that colonization of NYS after the LGM resulted from species tracking preferred habitats, and their extirpation was near the beginning of the Holocene shortly after human

colonization. This study informs how mammals colonize habitats and assemble within ecosystems during periods of substantial global warming.

Technical Session XVI (Saturday, October 17, 2015, 11:45 AM)

FROM EGGS TO HATCHLINGS: NEST SITE TAPHONOMY OF AMERICAN CROCODILE (*CROCODYLUS ACUTUS*) AND BROAD SNOUTED CAIMAN (*CAIMAN LATIROSTRIS*)

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The nesting behavior in extant animals can potentially serve as either an analog or as a taphonomic model for the interpretation of reproduction habits in extinct organisms. Past studies have examined birds with open nests and nest-bound altricial young, and turtles with buried clutches and precocial young. However, no taphonomic research covers crocodilian nests which, as archosaurs with buried clutches and precocial young, may be reproductively closer to dinosaurs than turtles and even birds. Here, we taphonomically describe five American crocodile (*Crocodylus acutus*) nests at Turkey Point, Florida and eleven broad snouted caiman (*Caiman latirostris*) nests in the Santa Fe and Chaco provinces of Argentina. Surveys focus on eggshell fragment orientation, density, distribution, and nest composition of successfully hatched nests. While assisting young, female *Crocodylus acutus* excavate triangular or flask-shape holes into organic-rich sandy clay, scattering eggshell and membranes in a semi-circle around the trace. These sites often include mollusk shell debris, limestone pebbles, and cobbles. Depths range from 20-45 cm, whereas excavations measure 50-80 cm in diameter. Average eggshell orientations from outside the egg chamber favor concave down (n = 997, 62.1%). *Caiman latirostris* nests differ from the American crocodile in that they construct mounds of predominantly plant debris in forested areas with organic-rich soil or on vegetation islands in marshes. Nests range from 1.2-1.6 m in diameter, with a height of 30-60 cm. Most eggshell occurs within and atop the open chamber and the area between the nest and water. Average eggshell orientations within the egg chamber favor concave up (n = 270, 62.3%), not including 7 partial eggs found inside, whereas those outside of the chamber are nearly evenly distributed, with 52.2% (n = 209) concave up. Eggshell orientation values observed outside the egg chamber in both these crocodilians differ from the 60:40 up:down ratio in both bird and turtle nests, as well as the 20:80 ratios of hydraulically transported shell. The distribution and orientation in these crocodilian nests largely resulted from hatching assistance and transportation of young by adult females. The exposed eggshell orientations differ from dinosaur eggshell 60:40 distributions from Devil's Coulee and Augusta, yet the chamber distributions match. Exposed eggshell distributions appear to be unique to crocodilians and may be used to identify localities near a nesting chamber possibly generated by the hatching assistance of parents.

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Technical Session IV (Wednesday, October 14, 2015, 2:00 PM)

FLOCCULAR COMPLEX LOBE SIZE DOES NOT CORRELATE WITH VERTEBRATE ECOLOGY AND BEHAVIOR

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The floccular complex lobes (FCL), housed in the FCL fossa of the prootic and periotic, are part of the cerebellum. Several experimental studies have shown that the FCL integrate visual and vestibular information, responsible for the vestibulo-ocular reflex, smooth pursuit and gaze holding. Thus, over the last decades multiple paleoneurological studies have been extrapolating these results to infer a causal relation between FCL size and behavior of extinct forms.

We analyzed braincase endocasts of a representative sample of Mammalia (48 species) and Aves (60 species) rendered using tomographic segmentation techniques. We tested statistical correlations between the floccular complex volume, ecology and behavior that could support previous paleobiological assumptions. The data were analyzed using three models of trait evolution and covariance structures (Pagel's Lambda Model, Brownian Motion Model and Grafen's Rho Model) to produce phylogenetic generalized least-squares regressions. Phylogenic trees were built and all branch lengths were set to one. Our results convincingly demonstrate that: 1) there is no correlation between relative FCL volume and body mass; 2) there is no correlation between relative FCL and optic lobe size in birds; 3) average relative FCL size is larger in diurnal than in nocturnal birds but there is no statistically significant difference in mammals; 4) feeding strategies do not correlate with FCL size; 5) locomotion type is not correlated with relative FCL size in mammals.

We conclude that the cerebellum is a highly plastic structure and may be adapted to control different functions across different taxonomic levels. For example, the european mole (*Talpa europaea*) which is fossorial and practically blind, has relatively larger FCL fossae than do bats, which are highly maneuverable, and comparable to the value of African gliding rodents (Anomaluridae) or the flying phalanger (*Petaurus* sp.). Therefore, until further experiments are done, we recommend that ecological and behavioral traits of extinct animals should not be inferred based on the relative size of FCL fossae. Alternatively, we here suggest that the evolution of FCL fossae relative size variations might be better explained by factors such as anatomical trade-offs or other developmental constraints. It has not escaped our notice that further research is needed to challenge several other paleoneurological hypotheses that are simultaneously widely accepted and narrowly tested.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

THE IMPORTANCE OF PHYLOGENY IN TEMPORAL AND REGIONAL DIVERSITY AND DISPARITY DYNAMICS

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It is often not straightforward to determine which macroevolutionary processes are influencing changes at different scales of diversity. Most studies that focus on past, current, or predicted changes in diversity use a phylogenetic context without a phylogenetic diversity framework. Bridging that conceptual gap can help produce a more coherent understanding of diversity patterns and can be more useful when integrated with new dimensions (e.g., time). To understand how extinction and origination affect measures of taxonomic (taxic), phylogenetic (sensu Faith's diversity), and morphological diversity, I performed 2D geometric morphometric analysis on the skulls of modern monitors and some fossil relatives to quantify and compare morphological diversity. I tested this using a phylogenetic framework alongside taxonomic and phylogenetic diversity on a molecular tree both temporally and spatially. Monitor lizards are a good model for these shape analyses because they are morphologically conservative, but regionally variable in diversity. Because the extant varanid tree contained only originations, I also analyzed taxonomic and phylogenetic diversity through time on simulated trees and a modified fossil canid phylogeny to quantify the effect of extinctions on these measures. To understand how phylogenetic diversity and taxonomic diversity compare temporally, I performed analyses on whole trees as well as trees modified to represent designated time bins. All statistical analyses showed that although taxonomic and phylogenetic diversity can be strongly correlated, they often diverge. This indicates a significant shift in tree geometry, especially during the extinction of evolutionarily deep (and thus vital) lineages. For example, fossil varanoids fall well within the range of extant morphological variation, but the geographic region of least taxonomic (but relatively high phylogenetic) diversity today has the greatest shape disparity both early in the lineage and today. These results suggest that in order to understand the evolutionary consequences and causes of diversity shifts, we cannot just look at diversity today or one metric alone. Origination and extinction can have disparate effects on morphological and phylogenetic diversity. As a consequence, trying to understand extant and past diversity without the power of a phylogenetic diversity analysis may result in the loss of a wealth of information on the effects of originations and extinctions on tree geometry and dynamics.

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UCMP Doris O. and Samuel P. Welles Fund, UC Berkeley Department of Integrative Biology Summer Research Grants, and the UCMP Claire Englander Student Prize.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

CARBON STABLE ISOTOPE COMPARISONS OF LATE CENOZOIC EQUIDS FROM MEXICO: A FIRST APPROACH TO ASSESSING THEIR DIET THROUGH TIME

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Vertebrate Paleontology in Mexico spans some 150 years, from an early start carried out by foreign paleontologists (e.g., E.D. Cope, H. F. Osborn, W. Freudenberg), to its present stage with a small, but very active native community loosely associated to paleontologists from many countries. The development has been quite uneven, so that some groups (e.g., mammals and dinosaurs) have been more attended than others; likewise, some epochs/periods (e.g., Pleistocene and Tertiary), have received more attention than others; and geographically there is a strong bias toward the Trans-Mexican Volcanic Belt and the Central Plateau morphotectonic provinces.

Understandably then, in some disciplinary areas Vertebrate Paleontology is mature enough, so that research avenues other than the taxonomic could be fruitfully pursued. An instance is Late Cenozoic mammals, whose $\delta^{13}C$ isotope relations have recently begun to be studied to infer the diet of certain Pliocene and Pleistocene taxa. However, studies of selected lineages spanning different ages have not been attempted.

In this study we establish the diet of equids from different ages, and compare them to detect time-related traits or patterns, and discuss their paleoebiological significance. The equids involved are: (a) *Cormohipparion* sp., *Merychippus* cf. *sejunctus,* and *Pliohippus* sp., Barstovian of Oaxaca State, Sierra Madre del Sur; (b) *Astrohippus stocki*, Hemphillian of Guanajuato State, Central Plateau; and (c) *Equus conversidens*, *Equus* sp., Hidalgo State, Trans-Mexican Volcanic Belt.

Our results show that the Barstovian equids largely fed on C3 plants, and the Hemphillian horse species had a mixed C3/C4 diet, as did the Pleistocene ones. Such results indicate that during the Barstovian C3 plants were the chief (perhaps only) food stuff of horses in Mexico (at least those of the southeast); whereas in the Hemphillian, C4 plants were the dominant source of food, inducing a significant diet shift in the horses of this age (at least those from Central Mexico). C4 plants remained as an important component of Pleistocene horses' diet. The Hemphillian diet shift disclosed by the Mexican horses, is coeval to the inception and spread of C4 plants, which is already well documented in temperate North America.

Technical Session II (Wednesday, October 14, 2015, 9:15 AM)

LATE EVOLUTIONARY ORIGIN OF MODERN AVIAN FLIGHT FEATHERS IN MESOZOIC STEM GROUP BIRDS

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The geometry of feather barbs (barb length and barb angle) determines feather vane asymmetry and vane rigidity, which are both critical to a feather's aerodynamic

performance. Here, we describe the relationship between barb geometry and aerodynamic function across the evolutionary history of asymmetrical flight feathers, from Mesozoic taxa outside of modern avian diversity (*Microraptor*, *Archaeopteryx*, *Sapeornis*, *Confuciusornis* and the enantiornithine *Eopengornis*) to an extensive sample of modern birds. Contrary to previous assumptions, we find that barb angle is not related to vane-width asymmetry; instead barb angle varies with vane function, whereas barb length variation determines vane asymmetry. We demonstrate that barb geometry significantly differs among functionally distinct portions of flight feather vanes, and that cutting-edge leading vanes occupy a distinct region of morphospace characterized by small barb angles. This cutting-edge vane morphology is ubiquitous across a phylogenetically and functionally diverse sample of modern birds and Mesozoic stem birds, revealing a fundamental aerodynamic adaptation that has persisted from the Late Jurassic. However, in Mesozoic taxa stemward of Ornithurae and Enantiornithes, trailing vane barb geometry is distinctly different from that of modern birds. In both modern birds and enantiornithines, trailing vanes have larger barb angles than in comparatively stemward taxa like *Archaeopteryx*, which exhibit small trailing vane barb angles. This discovery reveals a previously unrecognized evolutionary transition in flight feather morphology, which has important implications for the flight capacity of early feathered theropods such as *Archaeopteryx* and *Microraptor*. Our findings suggest that the fully modern avian flight feather, and possibly a modern capacity for powered flight, evolved crownward of *Confuciusornis*, long after the origin of asymmetrical flight feathers, and much later than previously recognized.

Grant Information
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Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

THE BULLDOG FISH: AN UNUSUAL TELEOSTEAN FOSSIL FISH FROM THE MUHI QUARRY (CRETACEOUS: LATE ALBIAN-EARLY CENOMANIAN) OF MEXICO

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The Muhi quarry (state of Hidalgo, Mexico) is a fossil Lagerstätte that continues to produce an ever-growing diversity of ichthyofauna. Many species and genera that have been described up to this point are endemic to the Cretaceous fossil fish localities of Mexico. One such fish is described here. Eleven specimens were collected, four of which are complete or nearly complete and several specimens appear to be juveniles. It is the fourth most common fish found at the quarry. *Enchodus zimapanensis,* an *Eubiodectes*-like ichthyodectiform, and a small acanthomorph fish are more common.

The bulldog fish, as it has been nicknamed, has an elongate body with a head that is deeper than that of the body. Standard length averages 150 mm. The average length of the head is 33 mm. The depth of the head is almost equal to its length. Measuring from the back of the neurocranium to the base of the preopercle, the average depth is 30 mm. What gives the fish its bulldog-like appearance are the very deep infraorbital bones, which cover the suspensorium, and the deep opercular bones. The deep cranium causes the mouth to be angled superiorly, adding to its bulldog-like appearance. The pectoral fin is in a low position on the body. The pelvic fin is located on the anterior third of the body. Besides the head, another unusual feature is that the dorsal fin originates posterior to the anal fin. The caudal fin is deeply forked and has a stegural.

So far, most of the fish taxa described from the Muhi quarry have been placed in known orders. Despite being well preserved, this fish has yet to be assigned to any order. The shape of the skull and its jaws superficially resemble that of an ichthyodectiform fish, but the presence of a stegural places it within the euteleosts.

Technical Session XVI (Saturday, October 17, 2015, 11:00 AM)

A REVIEW OF THE GENUS *ARARIPESUCHUS* (MESOEUCROCODYLIA) FROM THE CRETACEOUS OF GONDWANA

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The genus *Araripesuchus* is one of the most representative taxa of the Cretaceous of Gondwana, comprising six formally described species to date: *A. gomesii*, *A. wegeneri*, *A. patagonicus*, *A. buitreraensis*, *A. tsangatsangana*, and *A. rattoides*. These widespread animals can provide valuable information about the Cretaceous paleobiogeography and the early evolution of Mesoeucrocodylia. However, their phylogenetic affinities and taxonomic status are still controversial. An extensive review of the morphology and systematics of *Araripesuchus* species, including two unpublished Brazilian specimens (MN 7061-V and SMNK PAL 6404), provided new information and more comprehensive diagnoses for these crocodyliforms. A set of well-defined characters, such as a slit-like notch at the premaxilla-maxilla suture, external surface of the premaxilla mostly smooth, presence of neurovascular foramina opening posterior to the narial fossa, premaxillary teeth 1 to 4 aligned in a diagonal row, and presence of a buccal emargination on the maxilla, are observed in all species but the fragmentary *A. rattoides*. The Moroccan specimens (CMN 41893 and UCRC PV3) have no diagnostic features supporting this taxon as an *Araripesuchus* species. MN 7061-V is regarded as a new specimen of *A. gomesii* on the basis of at least one new diagnostic character (dentary buccal emargination ornamented with tiny foramina), whereas SMNK PAL 6404 shows several unique traits (extremely short posterodorsal processes of the premaxillae, robust rod-like anterodorsal processes of the premaxillae, premaxilla completely lacking ornamentation, enlarged foramen aëreum on the posteromedial surface of the quadrate medial condyle, fan-shaped dorsal process of the ectopterygoid, diminutive symphyseal teeth, fossa for the pronator teres muscle separated from the insertion area for the flexor digitorum longus on the medial surface of the distal humerus) and cannot be assigned to any known *Araripesuchus* species. Cladistic analyses using a novel data matrix (666 morphological characters) for Crocodylomorpha (107 ingroup taxa) were performed with the software TNT. The most parsimonious hypothesis shows all *Araripesuchus* species within Notosuchia, and comprising a monophyletic Uruguaysuchidae clade along with *Uruguaysuchus aznarezi*, *A. rattoides* and MPCA PV 236 as sequential sister-taxa. The Uruguaysuchidae is sister to the 'advanced notosuchians', and *Libycosuchus* is sister to this former group. A second large notosuchian clade unites peirosaurids, sebecids, and mahajangasuchids.

Symposium 1 (Wednesday, October 14, 2015, 3:30 PM)

A PERSPECTIVE ON THE MID-CRETACEOUS FROM A DINOSAURIAN HIGH LATITUDE GREENHOUSE ECOSYSTEM, NORTH SLOPE, ALASKA

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The Albian-Cenomanian Nanushuk Formation crops out over much of the central and western North Slope of Alaska, and varies in thickness from ~1500 m in the west to ~ 250 m in the northeast. The Nanushuk Formation records a succession of complexly intertonguing marine and nonmarine strata interpreted as shelf, deltaic, strandplain, fluvial, and alluvial overbank deposits, that prograded from west to east along the axis of the Colville foreland basin with an additional south to north component in the area that now makes up the east-central Brooks Range foothills. The Nanushuk Formation is present throughout most of the northern foothills belt and subsurface of the central and western North Slope coastal plain, where it is dominantly marine lower in the section and becomes a mix of nonmarine and marine facies in the upper part.

Preliminary work in the western and central regions of the North Slope of Alaska have produced isolated discoveries of both body fossils and trace fossils attributable to dinosaurs from fluvial, alluvial, and deltaic settings. More specifically, the ichnological remains are attributed to large and small theropods, and bipedal and quadrupedal ornithischians, while skeletal elements are attributed to ornithopods. Furthermore, palynological and megafloral remains are common that, along with coals and paleosols, provide paleoenvironment and paleoclimate data. These reconnaissance discoveries from nonmarine sections illustrate the great potential of the Nanushuk Formation to produce valuable insights into the structure, dynamics and climate of an ancient high-latitude greenhouse terrestrial ecosystem across the North Slope coastal plain.

Grant Information
Explorers Club, National Science Foundation

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

CRANIAL DIVERSITY OF MAMMALS: PAST AND PRESENT

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Over the past 65 million years or so, placental mammals have evolved a great diversity of cranial morphologies, presumably associated with different locomotor, feeding, sensory, cognitive, and habitat-related adaptations. Using geometric 3D morphometrics, we examined patterns of cranial diversity among a large sample of nonvolant, extant and extinct placental mammals, including Primates, Xenarthra, Artiodactyla, Perissodactyla, Carnivora, Lagomorpha, Rodentia, Hyracoidea, Scandentia, Pholidota, Sirenia, and Cetacea. When only extant terrestrial taxa are considered, Primates and Xenarthra show the greatest cranial diversity, reflecting mainly differences in neurocranial size and shape, and snout length. In contrast, other orders, including extant Carnivora and Artiodactyla show less cranial diversity. In addition, Primates are particularly distinctive, showing little morphological overlap with other taxa in overall cranial form whereas there is extensive overlap among taxa from most other orders.

There is little clustering of cranial forms by gross dietary habits (carnivory, frugivory, folivory, grazing), independent of phylogeny. However, when extant aquatic taxa of different orders are added to the analyses, they all lie in a unique area of morphospace despite their different phylogenetic relationships.

The addition of extinct fossil taxa does little to change the relative size or position of the morphospace occupied by Primates. The morphospace occupied by living and fossil Primates is largely within that of extant Primates. However, adding fossil taxa of other orders often drastically changes their relative size and positions in cranial morphospace.

Grant Information
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Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

A THREE-DIMENSIONALLY ARTICULATED PROBABLE OVIRAPTOROSAUR FROM THE HELL CREEK FORMATION OF MONTANA

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In 2006, the Museum of the Rockies (MOR) collected a nearly complete theropod dinosaur skeleton (MOR 9722) from the Hell Creek Formation, Montana, approximately 10 meters below the K/Pg boundary. MOR 9722 remained unidentified until 2013, when the iron-rich concreted sandstone blocks in which it was preserved were reassembled by the authors. The skeleton is approximately 1.5 to 2 meters long, preserved articulated in three dimensions, and comprises a nearly complete vertebral series (preserved in opisthotonic posture), ribcage, gastral basket, sacrum, ilia, partial pubes and ischia, partial tibia, articulated right tarsals and proximal metatarsals, partial forelimb, and many partial phalanges and unguals of the pes and manus. However, many bones have been weathered away leaving natural molds in the hard rock. The specimen is tentatively identified as an oviraptorosaur and compares favorably with material recently described as the new taxon *Anzu wyliei*, based on the following observations: non-triangular and recurved pedal unguals and a recurved gracile manual ungual, arctometatarsalian metatarsals, anteriorly oriented pubes, and the sharply curving L-shape of the ischium.

MOR 9722 is one of only five reported oviraptorosaur skeletons from the Hell Creek Formation, and is currently the most complete specimen. It also may be the stratigraphically highest known oviraptorosaur specimen yet reported and as such, was the latest known surviving member of its clade. MOR 9722 may be especially useful for paleobiological analyses that require a high level of completeness and three-dimensional articulation, such as biomechanics, physiology, studies on extinction, possible biomolecular research, and with its intermediate size, ontogeny. For this reason, the challenging preparation of the specimen has not yet commenced to incorporate any requirements specific for future research, and we invite advice as to how the specimen might best be prepared to benefit these kinds of analyses. We anticipate that high-powered CT scanning and photogrammetry will facilitate access to encased bones and the negative space of molds, making possible a full description of the specimen.

Technical Session XI (Friday, October 16, 2015, 12:00 PM)

AN ORIENTAL PROVINCE SMALL-MAMMAL FAUNA FROM THE MIOCENE OF SOUTH CHINA

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Miocene age vertebrate faunas in South China generally are not widely known. This part of China, roughly that region south of the Yangtze River, contrasts biogeographically with North China. The distinction is partial, because complex topography and history of uplift in Yunnan and adjacent areas has led to mixed but diverse assemblages. Late Miocene, Baodean land mammal age faunas are well known in North China, but in the south, Late Miocene small mammals are well-documented only for the Yunnan hominoid localities near Yuanmou and Lufeng. Here we describe a new small mammal fauna of latest Miocene age from Shuitangba, a locality representing wet habitat with abundant fish and wading birds, and preserving both a monkey and an ape. The fossiliferous sediment is dark brown to black silty clay, locally with gastropods and molluscs, and it preserves cranial as well as postcranial remains, generally disassociated. Dominant among the small mammals are murid rodents and shrews. Several skulls and jaws of a large rat-like murid and a smaller mouse have been retrieved, and jaws of the large mole shrew *Anourosorex* make this the most common insectivoran. The extinct mole *Yunoscaptor* is also common. Interesting, given the moist habitat setting, is the presence of the rabbit *Alilepus longisinuosus*. As for some modern leporids, *Alilepus* may not necessarily be an indicator of nearby open terrain. There are two species of bamboo rat, which today are moist, wooded habitat elements. Isolated teeth of a flying squirrel, tree squirrel, and hamster were recovered by screening. The hallmark of the Shuitangba fauna is its beaver. Originally thought to be a species of the Late Miocene genus *Sinocastor*, it instead resembles a new beaver from Thailand. This beaver lineage, at extraordinarily low latitude for the family, is one of several elements shared by Miocene localities of the Oriental Biogeographic Province, underscoring small mammal distinction from the Palaearctic Province to the north.

Grant Information
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Technical Session XII (Friday, October 16, 2015, 11:15 AM)

NEW DIVERSE EARLY EOCENE SNAKE ASSEMBLAGE FROM TADKESHWAR LIGNITE MINE, WESTERN INDIA

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A diverse snake fauna has been described from the early Eocene Cambay Formation of the Vastan lignite mine, Gujarat, western India, among which early colubroid caenophidians were the most remarkable. Here we describe a new snake assemblage from the approximately contemporary nearby Tadkeshwar mine situated about 10 km south-west of Vastan. As at Vastan, the material from Tadkeshwar is represented only by vertebrae. There are several species in common with Vastan, such as the small madtsoiid gen. et sp. indet. that possesses a haemal keel, the co-occurring palaeophiids *Palaeophis* sp. and *Pterosphenus* sp., the same indeterminate boid, and *Thaumastophis missiaeni* (Caenophidia incertae sedis). However, the most abundant snakes in Tadkeshwar are the madtsoiids. Among them is a new giant madtsoiid that exhibits morphology broadly similar to *Gigantophis* and *Madtsoia*. However, it differs in having dorso-ventrally compressed vertebrae with oval cotyles and condyles and a strong notch on the posterior part of the neural arch. The major axis of the prezygapophysis is transverse in dorsal aspect and the parapophysis is very developed and extends beyond the lateral extremity of the prezygapophysis. The haemal keel is absent. While the composition of the Tadkeshwar fauna, like that from Vastan, is reminiscent of the early Eocene of Europe, the large madtsoiid suggests a Gondwanan paleogeographic origin. Indeed, such large madtsoiids are known only from the Late Cretaceous and Paleogene of South America, Africa and the Indian subcontinent, and the late Paleogene and Neogene of Australia. More importantly, the snake assemblage from Tadkeshwar indicates that Laurasian taxa of European affinities were still mixed with relict taxa from Gondwana during the early Eocene before or near the India-Asia collision.

Grant Information
National Geographic Society, Leakey Foundation, Wadia Institute of Himalayan Geology, Belgian Science Policy Office

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

THE DENTAL HISTOLOGY OF THE EARLY DINOSAUR *COELOPHYSIS BAURI*

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Research on dinosaur teeth has focused primarily on function and external morphology. Most studies use shed teeth, which typically only consist of the crown tissues enamel and dentine. As a result, the full suite of root tissues that attach teeth to jaws remain virtually undocumented in dinosaurs. Identification of these tissues would allow for comparisons with other amniotes for evidence of homology and establish a baseline for comparisons among dinosaurs. In order to approximate the ancestral tooth attachment tissues in dinosaurs, histological thin sections were prepared from a partial skull of *Coelophysis bauri*. As an early theropod dinosaur, *C. bauri* is an ideal candidate for examining dental tissues near the base of the dinosaur clade. These tissues could then be compared to other amniotes, including *Alligator mississippiensis*, early eureptiles, stem amniotes, and mammals.

The thin sections revealed that *C. bauri* possessed three attachment tissues that are homologous across amnniotes: cementum, periodontal ligament, and alveolar bone. A band of clear, acellular cementum lines the dentine of the tooth root. A thin layer of cellular cementum was present and perforated by extrinsic Sharpey's fibers extending across its full thickness. The impressions created by Sharpey's fibers indicate the presence of a periodontal ligament. The non-mineralized periodontal ligament occupied a narrow gap between the cementum and alveolar bone. In between teeth were zones of more mature alveolar bone that may be part of the interdental plates commonly found in theropods. Fragments of dentine found in these zones suggests the alveoli have shifted in position over time. Reconstruction of the timing of tissue development from teeth at different stages in the jaw allowed for the first sequence of tooth development documented in a dinosaur. Reconstructions of the tooth development sequence help to establish the relative timing of tissue development and the growth directions of the attachment tissues. Following this sequence shows that replacement teeth originated on the lingual side of the jaw and migrated labially towards the functional teeth, eventually intruding into the alveoli and resorbing portions of their roots. The sequence also shows that alveolar bone in *C. bauri* is deposited centripetally in a resorption pit to form the functional alveolus.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

TACTILE FACED THEROPODS

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For decades whether or not theropods had lips has been a hot topic for paleontology and paleoartists. Did they have lizard like 'lips' or were they lipless like an alligator? One of the arguments for lips are the numerous foramina on the premaxilla, maxilla and dentary. These foramina are theorized to have supplied nerves for the lips and muscles. The lips serve several functions: in squamata, the 'lips' protect the labial oral glands, hold food and retain water. In mammals, the 'lips' are for communication, food manipulation and water retention. Looking at extant animals, we can determine if theropods had lips. Both mammals and squamates have a limited number of foramina on the maxilla and dentary, which supplies nerves for their 'lips' and muscles, as well as nutrients. More importantly, the bone texture of the premaxilla, maxilla, and dentary is smooth in both mammals and squamates. This is caused by the constant interaction of soft tissue rubbing against the skull bones. Previous investigations have not taken this bone texture into account. Theropods have a rugose bony texture and numerous foramina, which indicates a lack of soft tissue for lips and facial muscles. This is best seen in the antorbital fenestra. Bones textures on the inside of the fenestra are smooth, which indicates the soft tissue has some movement, while the outside bone is rugose. There is a groove that extends from each foramina and it extends toward the jaw line. The foramina also have smaller grooves that extend in the opposite direction. This is best seen in older individuals. Crocodilians also have several foramina and a more rugose bone texture. The foramina do supply nerves for the facial region, which makes the face a tactile sense organ. The best use for this tactile face is for feeding/hunting in murky water. Another suggestion is theropods had a rhampotheca. In extant avians, the foramina supplies nutrients for a rhampotheca. Where the rhampotheca attaches in extant avians, the bone texture is smooth, i.e., the beak and claws. Therefore the skull elements in theropods with rough bone texture were incapable of having a rhampotheca. It is the conclusion of this study, using extant taxa as a baseline, that theropods lacked lips/facial muscles and a rhampotheca. This is based on the rough bone texture on the bone surface, which is in contrast to the smooth bone texture of animals with lips/muscles. It is also inferred that theropods had a tactile face similar to that in crocodilians.

Technical Session IV (Wednesday, October 14, 2015, 3:45 PM)

AN EARLY MIOCENE DOLPHIN FROM NEW ZEALAND EXPANDS THE RANGE AND DIVERSITY OF *NOTOCETUS*-LIKE PLATANISTOIDS

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A new early Miocene dolphin from New Zealand provides a southwest Pacific record for basal platanistoids with well-developed maxillary protuberances. Specimen OU 22670 lies crownward of *Otekaikea* and *Waipatia*, as a sister taxon of the Squalodelphinidae + Platanistidae, thus adding to the early diversity of Platanistoidea.

The dolphin is from the marine Mount Harris Formation (probably outer shelf; Altonian local stage, Burdigalian) of Awamoa Beach, Otago. The cranium is superficially similar to *Notocetus vanbenedeni*. It is high, with a narrow frontal on the vertex and a medially projecting nasal. There is a prominent dorsal infraorbital foramen posteromedially where the maxilla steepens near the vertex. Each bilateral maxillary protuberance is raised, rounded, and parasagittally oriented, overlying a frontal with a thick protruding preobital angle. The frontal has a small ventral fossa for a presumed orbital lobe of pterygoid sinus. The dorsal roof of each temporal fossa has a large frontal

window, exposing the maxilla within a ring of frontal. Similar features occur variably amongst species of *Notocetus*, *Zarhachis* and *Pomatodelphis*.

This is the first report of a New Zealand platanistoid with the maxillary protuberances that are presumed precursors to more elaborate maxillary-facial crests as seen in *Squalodelphis* and *Zarhachis*. The dolphin expands the southwest Pacific record of platanistoids beyond the named archaic Chattian to basal Aquitanian species of *Waipatia* and *Otekaikea*. Further, the source unit, Mount Harris Formation, has produced other as-yet unprepared concretionary Cetacea that may help understand the 'Aquitanian gap' in cetacean history.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

A SMALL THEROPOD DINOSAUR FROM THE AGUJA FORMATION (UPPER CRETACEOUS), BIG BEND NATIONAL PARK, TEXAS

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Previous researchers have speculated that dinosaurs exhibited regional biogeographic provinciality in North America, though these determinations have been based largely on the distribution of the far more common herbivorous ceratopsian and hadrosaurian dinosaurs. Evidence for endemism among the various herbivorous dinosaurs has become widely accepted, and it would seem reasonable to hypothesize that the theropod dinosaurs could exhibit similarly pronounced provinciality. Remains of theropod dinosaurs however are remarkably scarce and usually very fragmentary in Upper Cretaceous strata of Big Bend National Park. Most taxa have been identified or named based on dental elements alone, or on isolated finds consisting of no more than one or two bones. The identification and description of Big Bend theropod taxa from more substantive skeletal remains is therefore critical to recognition of distinct theropod biogeographic provinces in western North America during Campanian time. Parts of an associated postcranial skeleton of a small theropod dinosaur recently collected from the uppermost Aguja Formation is the most complete example thus far recovered in Big Bend. The specimen exhibits some unique features, but is compatible with identification as either Troodontidae or Dromaeosauridae.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

DANGERS OF LOW SAMPLE SIZE IN STUDIES OF SAUROPOD DINOSAUR SPECIES DIVERSITY: A MORRISON FORMATION CASE STUDY

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Sauropod dinosaur diversity studies are based frequently on relatively few partial skeletons of each species. Character states used in phylogenetic analyses are often treated as discrete even though many likely feature continuous variation. Small sample sizes result in an unlikelihood that individual species in purported multi-taxic genera represent approximations of reproductively isolated populations of such large animals.

The Morrison Formation contains an important sauropod fauna with a relatively abundant record of animals (8-19 species; diplodocoids and Macronaria) with which to look at this problem. Such high species diversity estimates as 19 are unlikely based on several factors: 1) rigorous tests of phylogenetic hypotheses are undermined by use of necessarily subjective and statistically unquantified characters, opening up the possibility that such hypotheses are documenting mostly individual variation within samples that in fact represent fewer species; 2) inadequate sample sizes result in even quantified characters, which may lie on a continuum of values yet appear separate, having potentially no statistical significance; and 3) assumption of high but realistic primary productivity for the Morrison suggests that for herbivores of 10+ tonnes, living in what was for them an ecologically fine-grained environment, sauropod diversity should be assumed to be minimized for what are currently form taxa.

Problems with sauropod classification are demonstrated by the Morrison fauna. Characters used to differentiate among species of diplodocoids and camarasaurids, for example, have never been statistically demonstrated to fall out into significant groupings (i.e., representing species) within a genus. Thus, species assignments within genera of Morrison sauropods, although ostensibly based on autapomorphies, do not necessarily represent statistically defined morphological variants. Given the low sample sizes, the identification of a character differentiation between species does not necessarily equate to its significance.

Recommendations for addressing this problem include quantification of all character states through measurements, ratios, and/or morphometric shape analysis and their graphic and statistical presentation. Only after such analyses have graphically and statistically demonstrated the morphological differentiation within a genus (i.e., discrete 'populations' within the sample, what might then be considered species) should phylogenetic analysis proceed on those species level groupings.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

RESTORING *DREADNOUGHTUS*: USING LATTICE DEFORMERS IN AUTODESK MAYA TO RETRO-DEFORM FOSSILS FROM AN EXCEPTIONALLY COMPLETE TITANOSAUR

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As often occurs with fossilized bones, several preserved elements of *Dreadnoughtus schrani* exhibit significant taphonomic deformation. Such deformation introduces error into attempts to use digitized fossils for volumetric mass estimation or paleo-art life restoration. For example, within the dorsal vertebral series, the variation in directionality of deformation between adjacent elements resulted in widely varying centra shapes and orientations of pre- and postzygapophases, such that the vertebrae cannot be articulated together. Several methods exist for producing two-dimensional landmark-based images of retro-deformed elements, such as various reflection and averaging methods or algorithmic symmetrization. However, to be useful for volumetric mass estimation or life restoration, these images must then be translated into retro-deformed 3D models. All preserved elements of *Dreadnoughtus* have been scanned with a laser surface scanner. Using shape predictions arrived at by two-dimensional retro-deformation methods, morphological input from the preserved elements of closely related titanosaurs, and adjacent or equivalent elements of *Dreadnoughtus,* the 3D digital models of the fossilized bones can be retrodeformed into bone elements capable of articulation. The lattice deformer tool in Autodesk Maya enables changes to be tracked and undone. A three-dimensional grid is overlain around and through the object. Alterations to the shape of the object are reflected as alterations to this lattice structure, resulting in visualization of shape differences similar to grid systems used in geometric morphometric analyses. Retrodeformation is an imperfect process, but improves results for certain types of research and outreach. Techniques such as reflection and averaging, and algorithmic symmetrization, combined with the lattice deformer tool, provide a powerful method to enhance the value of virtual skeletal data.

Technical Session XI (Friday, October 16, 2015, 11:30 AM)

PALEOENVIRONMENTAL FRAMEWORK OF RODENT COMMUNITY EVOLUTION IN THE MEADE BASIN (SW KANSAS, USA) OVER THE LAST 4.5 MILLION YEARS

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Understanding the origin of modern communities is a fundamental goal of ecology, but reconstructing the history of communities of species with durations of $103–10^6$ years requires data from the fossil record. Few studies have bridged the gaps between the observational timescales and methodologies of ecology and paleoecology to achieve a comprehensive view of the long-term evolution of specific modern communities. We are using early Pliocene to latest Pleistocene local faunas and associated sediments in the Meade Basin and modern soils and rodents in the area to examine the role of environmental change in the emergence of the modern community over the last 4.5 Myr. Here we describe a suite of paleoenvironmental proxies measured on modern surface soils and on paleosols that range in age from early Pliocene to mid-Pleistocene through the Meade sequence. We estimated mean annual precipitation (MAP) from the elemental composition and rock magnetic properties of modern surface soils and five paleosols. Values from surface soils range from 550–830 mm/yr, which is generally higher than the modern value of ca. 592 mm/yr. The MAP estimates from paleosols vary between wetter and drier periods, suggesting temporal variability with no long term trend. We estimated warm season temperature and $\delta^{18}O$ of soil water using carbonate clumped isotope paleothermometry on pedogenic carbonate nodules from six paleosols. Temperature estimates range from 17–24° C with no trend and are broadly similar to modern mean annual (14° C) and warm season (24° C) temperatures locally. Estimated soil water $\delta^{18}O$ values increase through time, suggesting aridification may play a role in the long-term evolution of the regional grassland ecosystem and the local rodent community. We used compound specific carbon isotope analyses of plant-derived *n*-alkanes and *n*-alkanoic acids in modern soils and 11 paleosol samples to examine the abundance of C_4 grasses and to complement the existing paleosol carbonate isotope record. In the modern soils, $\delta^{13}C$ of *n*-alkanoic acids reflect standing C_4 biomass better than *n*-alkanes. In paleosols, $\delta^{13}C$ of *n*-alkanoic acids suggests more C_4 biomass and less variability in C_4 biomass than co-occurring carbonates, possibly reflecting differences in time averaging for different proxies. Intervals with abundant wood charcoal have very low $\delta^{13}C$ values, and provide evidence for habitat heterogeneity. Our results provide an environmental framework in which to examine the evolution of rodent community structure in SW Kansas in terms of diet and body size distributions.

Grant Information
NSF EAR Earth-Life Transitions

Symposium 2 (Friday, October 16, 2015, 4:00 PM)

UNTANGLING THE ECOLOGY OF A MIXED-FEEDER: INDIVIDUAL BIOLOGICAL VERSUS ENVIRONMENTAL CONTROLS ON GAZELLE DIET IN A KENYAN SAVANNA ECOSYSTEM AND IMPLICATIONS FOR CONSERVATION

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Mammalian mesoherbivore mixed-feeders are often a diverse and numerically important clade in grassland ecosystems, and yet their ecology is generally understudied. This includes basic questions about the relative controls of individual biology versus environment (resource availability) on dietary variability. We must understand the nature of mixed-feeding before we can address issues related to habitat conservation, and sensitivity to resource availability. We focused on the Grant's gazelle (*Nanger granti*), an abundant antelope in East African savannas. We examined dietary records derived from C and N stable isotope analyses (n = 627) of horn, hair and feces from 34 adults from a single population. Isotopic data were coupled with both detailed demographic information for each animal, and environmental records from the region. Since gazelles are classified as mixed-feeders, we expected their diet to reflect changes in resource availability, such as seasonal pulses of C_4 grass. We quantified dietary changes using the difference in $\delta^{13}C$ values of C_3 plants, and C_4 grasses. As well, we used the difference in $\delta^{15}N$ values of N_2-fixing *Acacia* trees, and non-fixing herbs/forbs, to estimate the relative contributions of C_3 plant types to diet.

Our dietary findings were divided into three categories-within population and among tissues, within individual and among tissues, and within individual and within tissue. Within population analysis of multiple tissues showed that the relative importance of forage types in gazelle diet varied systematically with the length of time represented by each tissue. We designated *Acacia* trees as a permanent fallback diet source, herbs/forbs as a persistent maintenance source, and C_4 grasses as a preferred ephemeral source. Within individual analysis of multiple tissues revealed that while lifetime average diets were similar (10–30% C_4 grass), gazelles responded differently to a pulse of C_4 grass availability (20–70% C_4 grass). Within individual temporal analysis of horn serial samples found that male diets correlated with a major environmental event (drought), while female diets did not. We also used patterns of variability in horn chronologies to identify four types of mixed-feeders within the population. These designations will be combined with demographic records to understand how individual gazelles experience episodes of environmental stress, such as drought. The number of severe droughts has increased in Kenya over the past decade, and detailed dietary data aid wildlife management and conservation decisions.

Romer Prize Session (Thursday, October 15, 2015, 9:30 AM)

CLIMATE AND MACROEVOLUTION DRIVE TRENDS IN NORTH AMERICAN CENOZOIC MAMMAL PHYLOGENETIC COMMUNITY ASSEMBLY

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A primary goal in ecology is to develop a unified theory that can disentangle drivers of biodiversity through both space and time. In North America, low latitude animal communities are comprised of distantly related species (phylogenetic evenness) while high latitude communities are comprised of closely related species (phylogenetic clustering). Ecologists invoke competitive exclusion and abiotic filtering to explain evenness and clustering, respectively. However, the impacts of long-term processes, such as speciation and extinction, on phylogenetic community structure (PCS) are largely unknown. To develop predictions for PCS change through time, I simulated communities under both pure birth and birth-death models and allowed per lineage rates of speciation and extinction to vary. To measure changes in PCS as the simulated communities evolved, I used the Net Relatedness Index (NRI), which is a measure of sample standardized mean pairwise distances among species in a community. Under a pure birth model, communities showed phylogenetic clustering; as new species were added average relatedness among species increased. Under a birth-death model, communities showed phylogenetic evenness. Loss of species led to a decrease in average relatedness among species. Further, increasing macroevolutionary rates increased the rate of PCS change. I predicted that real communities should therefore show clustering during diversification and evenness during extinction. To verify these predictions using the fossil record, I studied PCS change in extinct North American ungulates by creating composite phylogenies that included 142 perissodactyl and 208 artiodactyl species. The phylogenies were time-scaled using dates of first and last occurrences and parsed by accepted subdivisions of the North American Land Mammal Ages (Barstovian through Rancholabrean). The relatedness of temporally co-occurring perissodactyl and artiodactyl species decreased significantly with global climate cooling ($\delta^{18}O$ (‰)) from the mid Miocene to the Pleistocene due to high rates of extinction following the mid-Miocene climatic optimum. Overall, I show that community structure is not only shaped by biotic interactions and abiotic filtering, but also by changes in speciation and extinction rates as they are mediated by climatic changes. Studying trends in phylogenetic community structure through time might also illuminate factors that have led to the formation of communities as we know them today.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

OVER THE SEA TO SKYE: HUNTING FOR HEBRIDEAN MIDDLE JURASSIC FAUNAS

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Fossils of dinosaurs, marine reptiles, and other Mesozoic vertebrates are rare in Scotland despite over 150 years of collecting dating back to the activities of the legendary Hugh Miller. Nevertheless, the Inner Hebrides of Scotland boasts one of the most complete sequences of Middle Jurassic sedimentary rocks in the world. Rocks of this age crop out from as far north as the Shiant Isles in The Minch, east of the Isle of Harris, to the southern coast of Mull. But it is the sediments on the Isle of Skye and the nearby smaller islands of Eigg and Raasay that are best known for their invertebrate and vertebrate fossils. These Mesozoic sediments were deposited in two individual fault-bounded basins, the Sea of the Hebrides Basin (Trotternish Peninsula) and the Inner Hebrides Basin (Strathaird Peninsula). Fragmentary remains of chondrichthyans, actinopterygians, marine reptiles, stem mammals, lissamphibians, and squamates together with articulated remains of an early turtle have all been previously well documented. Of particular note is a specimen of a docodont, which may be a new species and comprises much of the postcranium, making it one of the most complete docodonts ever found. Tantalizing bones and footprints of dinosaurs have been found in several Early–Middle Jurassic units, making the Isle of Skye one of the rare places in the world to yield dinosaurs from this under-sampled time interval.

A major new initiative to document the Middle Jurassic of Skye is reported here. This is being led by PalAlba, a consortium of paleontologists representing Scottish universities and government institutions. More recent discoveries hint at a more diverse marine vertebrate fauna, including a three dimensionally preserved pachycormid fish, plesiosaurs represented by several new vertebral remains, and ichthyosaurs represented by several specimens. Among the latter is the holotype of *Dearcmhara shawcrossi*, a non-ophthalmosaurid neoichthyosaurian indicating that small bodied archaic ichthyosaurs continued to thrive in Europe in the Middle Jurassic. Furthermore, an atoposaurid crocodylomorph, possibly attributable to *Theriosuchus*, is also described. In addition to theropod and sauropod teeth, other dinosaurian skeletal elements have now been recovered including a short series of stegosaur caudal vertebrae. Many of these specimens were collected by amateurs and donated to museum collections, a cooperative relationship essential to the preservation of Scotland's fossil heritage.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

FAUNAL COMPOSITION AND PALEOENVIRONMENTS OF THE ARUNDEL CLAY (POTOMAC GROUP, LOWER CRETACEOUS)

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The Arundel Clay facies of the Potomac Group represents one of the only vertebrate-bearing deposits in the Lower Cretaceous Atlantic coastal plain. Vertebrate fossils from the unit have been known for more than 150 years; a reasonably well-known assemblage has accumulated through the decades, but thus far formal descriptions have mainly concentrated on the dinosaurs and mammals. Here we describe a moderately diverse faunal assemblage from Dinosaur Park in Prince Georges County, Maryland (USNM 41614). This assemblage consists of 306 disarticulated macro- and microfossils that are largely composed of teeth and scales (89%). Faunally, this assemblage is represented by two hybodont shark species, multiple semionotid fishes, one species of dipnoan, one species of turtle, three families of neosuchians, six species of dinosaur, and two species of mammal. Combined with the historical collections for this unit, these new additions to the fauna show that the Arundel was a far more robust and diverse ecosystem than previously envisaged, broadly similar in composition to contemporaneous units of western North America (e.g., the Cloverly Formation, WY and MT; Trinity Group, OK and TX). The Arundel assemblage differs, however, from many other Lower Cretaceous sites in that it is dominated numerically by *Hybodus* and goniopholidid crocodylomorphs, which together comprise 58% of the entire data set. Similarly, this sample lacks lissamphibians and lepidosaurs entirely. Traditionally, the Arundel has been interpreted as a facies of fluvial origin, deposited in a freshwater system of stranded channels or oxbows. Based on faunal composition (specifically the ecological diversity and abundance data), together with published geological and sedimentological evidence, we propose that at least some of the Arundel facies was deposited in close proximity to the Atlantic Ocean, possibly within the brackish waters of a coastal swamp or marsh. This interpretation is similar to the conclusions of multiple early geologic studies that have reconstructed the Arundel as a transitional, paludal environment.

Technical Session VII (Thursday, October 15, 2015, 3:00 PM)

ANAGENESIS AND ONTOGENY OF HADROSAURINE DINOSAURS IN THE CAMPANIAN (LATE CRETACEOUS) WESTERN INTERIOR OF NORTH AMERICA: TWO NEW TRANSITIONAL TAXA FROM THE JUDITH RIVER FORMATION OF MONTANA

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The Hadrosaurinae are a diverse clade of dinosaurs that were abundant across the Campanian Western Interior of North America, and are thus an ideal group for studying high-resolution evolutionary trends. Here I present two new hadrosaurine taxa from the Judith River Formation, Kennedy Coulee, Montana (equivalent to the lower Oldman Formation, Alberta). Phylogenetic and geometric morphometric analyses, combined with recalibrated radiometric dates, demonstrate that the new taxa form morphologic and stratigraphic intermediates within the lineages of *Gryposaurus* and *Acristavus-Brachylophosaurus*. The new species of *Gryposaurus* is from a monodominant bonebed of at least ten individuals and three size classes: juvenile, subadult, and adult. Its dentary tooth width and the shape and position of its nasal crest are morphologically and stratigraphically intermediate between *G. latidens* (lower Two Medicine Formation) and *G. notabilis* (lower Dinosaur Park Formation). In the stratigraphically lowest *Gryposaurus* species, *G. latidens*, the nasal crest is low and anterodorsal to the posterior narial fenestra. The nasal crest becomes progressively higher and more posteriorly located in stratigraphically younger species. A similar trend occurs ontogenetically; small specimens have relatively anteriorly located low nasal crests that grow dorsally higher and migrate posteriorly in larger specimens of the same taxon. The new genus of brachylophosaurin has a short posteriorly-oriented nasal crest hypothesized as an intermediate evolutionary state between the stratigraphically lower (lower Two Medicine Formation) crestless *Acristavus* and the stratigraphically higher (middle Oldman Formation) *Brachylophosaurus*, with its wide posteriorly elongated crest. The nasal crest of *Brachylophosaurus* elongates posteriorly ontogenetically. Histologic analysis demonstrates that the holotype of the new genus is relatively more mature than the largest *Brachylophosaurus* specimen, so its smaller crest size is not due to the ontogenetic status of the holotype. Thus, in *Gryposaurus* and *Acristavus-Brachylophosaurus* lineages, directional trends in nasal crest morphology are observed both through ontogeny and between stratigraphically separated non-overlapping taxa, suggesting that the new taxa are transitional members of anagenetic lineages, and that the evolution of cranial display structures in hadrosaurines proceeds by heterochrony.

Grant Information
Geological Society of America, Ameya Preserve, N. Myhrvold, D. Sands, E. Short, D. Wagoner, Royal Ontario Museum, University of California Museum of Paleontology

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

THE PTEROSAURIAN PELVIS: AN ANALYTICAL VIEW OF MORPHOLOGICAL DISPARITY AND IMPLICATIONS FOR LOCOMOTOR EVOLUTION

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Pterosaurs achieved powered flight through a series of unique adaptations and are one of only three groups of vertebrates to become truly volant. Despite this, their flight and its tradeoffs with terrestrial locomotion remain poorly understood. Where birds have completely separated their limb girdles into specialized locomotor modules, bats have been unable to do so, with a corresponding loss in terrestrial performance. The function of the pelvis sits at the heart of this debate, but it too has been understudied. Pterosaurs have modified the basic triradiate amniote pelvis, extending the ilium into elongate processes both anterior and posterior to the acetabulum.

While pterosaurs are now generally accepted to move quadrupedally on the ground, many hypotheses exist regarding the diversity of gaits and terrains exploited across Pterosauria and how this may be correlated with the shifts in body plan found at the base of the monofenestratans and of the pterodactyloids. Early attempts to bring comparative anatomy to bear upon the topic have been largely descriptive of pelvic shape across the clade. I attempt to rectify this by providing a geometric morphometric analysis of a phylogenetically diverse sample of pterosaur pelves.

Using landmark-based methods, shape was captured at the bone margins and acetabulum, with a view to capturing surfaces available for muscle attachment. These landmarks were analyzed using principal components analysis (PCA). Principal components 1 and 2 distinguish well between genera, reducing possible concerns over the role of taphonomy and ontogeny in determining shape. It is not apparent whether the lack of a phylogenetic trend across shape space is due to small sample size or a high degree of evolutionary plasticity, highlighting the need for a greater sample size.

However, with this support for a biological signal in the data, subsequent steps can be made that focus on biomechanical and locomotor analyses using detailed anatomical observations. We can then try to identify how pelvic disparity might have led to a diversity of locomotor styles in this most unique taxon.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

ECOLOGICAL TRENDS AND REPLACEMENT IN THE CARNIVOROUS MAMMALS OF AFRICA ACROSS THE PALEOGENE/NEOGENE BOUNDARY

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There were no carnivorans in Africa in the Paleogene, and instead the creodonts were the sole group of carnivorous mammals during that time. Carnivorans immigrated into the continent at the beginning of the Miocene, when Africa became geographically linked to Eurasia, and creodonts went extinct soon after. No one has ever looked at trends in body size and ecology in creodonts in Africa both before and after this event. This investigation looked at evolutionary trends in African creodonts and compared them with what has been found during the decline of creodonts in North America. The analyses used size, as measured by molar area, and degree of carnivory, as measured by relative blade lengths and shape of the carniassial teeth. Although there is a large gap in the the fossil record of Africa in the late Oligocene, some interesting trends were observed. Paleogene creodonts (represented almost exclusively by taxa from the Fayum Depression) were relatively disparate in terms of size and degree of carnivory, with values for both measures spread across all taxa looked at in this study. When carnivorans appear and become a common part of the African fauna they are extremely disparate in both factors, but by this time, so were the creodonts, with both being represented by small and large hypercarnivorous and omnivorous forms. But by the middle Miocene, the only creodonts remaining were large and hypercarnivorous. This implies that one of two things happened: 1) carnivorans competitively replaced creodonts extremely rapidly, far more quickly than has been observed across the Eocene of North America; or 2) some factor other than competition with carnivorans, such as climatic change, drove the creodonts to extinction. If it is the first case, some characteristic of creodonts made them particularly susceptible to replacement by carnivorans, such as naiveté or a reproductive disadvantage. Better collections in the key late Oligocene period may help tease out these possibilities.

Technical Session XIX (Saturday, October 17, 2015, 2:45 PM)

THE EVOLUTION OF REGENERATIVE CAPACITIES AND PREAXIAL POLARITY IN LIMB DEVELOPMENT - INSIGHTS FROM PALEOZOIC AMPHIBIANS

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Among extant tetrapods, salamanders are unique in showing a reversed, preaxial polarity in patterning the skeletal elements of the limbs, and in displaying by far the highest capacity of regeneration among tetrapods, including full limb regeneration. These features are particularly striking since tetrapod limb development otherwise has been shown to be a highly conservative process and the deviation from it in salamanders has classically been regarded as derived for urodeles. It remains elusive if and how the capacity to regenerate limbs in salamanders is evolutionarily and mechanistically linked to the aberrant pattern of limb development. New data from the fossil record show that preaxial polarity in limb development was not only present in the derived temnospondyl dissorophoid *Apateon*, but also in the coeval basalmost dissorophoid *Micromelerpeton* and the stereospondylomorph *Sclerocephalus*. This suggests an early evolution of preaxial polarity in limb development in the lineage leading towards modern amphibians. Moreover, the capacity to regenerate limbs was also demonstrated in *Micromelerpeton*, based on a pattern of abnormalities distinctive for irregular regeneration. However, new insights from the lepospondyl lineage indicate that limb regeneration may also have been possible in 'microsaurs' in addition to tail regeneration that included the re-establishment of caudal vertebral segments, otherwise only seen in salamanders among extant tetrapods. Ontogenetic data from 'microsaurs' indicate that contrary to temnospondyls, they likely had postaxial polarity in limb ossification. Recent molecular studies have revealed that salamander orphan genes are playing a central role in both preaxial polarity and regenerative capacities of extant salamanders. When combined, the molecular and fossil data allow for a deep time perspective on limb development and regeneration and indicate that this link likely evolved in the temnospondyl lineage leading to modern amphibians, but that the capacity to regenerate body parts was probably the plesiomorphic condition for tetrapods.

Grant Information
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Technical Session XVII (Saturday, October 17, 2015, 2:00 PM)

WHY SAUROPOD POSTAXIAL CERVICAL VERTEBRAE ARE ALWAYS OPISTHOCOELOUS: PROXIMALLY-CONCAVE VERTEBRAL CENTRA CONFER GREATER STABILITY UNDER ROTATION

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Sauropod dinosaurs include the largest and longest-necked terrestrial vertebrates. The long, cantilevered necks of sauropods required stabilization against dislocation by their own weight, which would otherwise have catastrophic consequences for the animal. One stabilizing mechanism was the presence of concavo-convex joints between vertebral centra, which prevent dislocation without inherently sacrificing mobility. For the cantilevered necks of sauropod dinosaurs, there are two possible polarities for concavo-convex joints with respect to the fixed end (the body), only one of which is observed in the fossil record. Sauropod postaxial cervical centra are invariantly opisthocoelous (i.e., anteriorly convex, posteriorly concave); that is, the convex end of each centrum faces away from the body. Although the strength of convexity varies serially and among taxa, polarity does not. Several sauropod lineages also exhibit concavo-convex joints in the proximal portion of the tail. In all but one species, the centra are procoelous (i.e., anteriorly concave, posteriorly convex). Thus, in both the neck and the tail, the concave articulations face proximally, towards the body, and the convex articulations face away from the body. These are mechanically equivalent with respect to the direction of loading.

What explains this near-universal polarity in concavo-convex joints in sauropod necks and proximal tails? The center of rotation (COR) of a concavo-convex joint is located within the condyle, which means that joint polarity affects where that point is with respect to the fixed end. For proximally-concave centra like those in sauropod necks, this means the COR is in the more stable, proximal centrum rather than in the mobile, distal centrum. As a result, the more distal centrum (and remainder of the cantilever) will tend to stay in joint when it is rotated. In contrast, with the opposite polarity (i.e., proximally-convex centra) the COR is in the distal centrum, which rotates about a point within itself. This configuration allows the condyle to rotate outward and away from the body, increasing the risk of disarticulation. These behaviors were verified using physical models of concavo-convex centra suspended in articulation. Proximally-convex centra can only be stabilized at small angles of rotation or by proximal muscle insertions that compromise the mechanical advantage of the muscles. Sauropod cervical opisthocoely and caudal procoely are intrinsically stable across a greater range of angles and muscle insertion sites.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

CLADISTIC ANALYSIS OF *PENTACERATOPS* SPECIMENS FROM THE SAN JUAN BASIN, NEW MEXICO

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Pentaceratops is a Late Campanian ceratopsian known from the San Juan Basin in New Mexico. The recovery of many nearly complete skulls places *Pentaceratops* as an intermediate form to *Chasmosaurus* and *Triceratops*. Specimen descriptions and cladistic analyses are based on partial skeletons and composite specimens. Additionally, some specimens have been reclassified, leading to taxonomic confusion. To date, no cladistic analysis has been executed using individual specimens. The goal of this study is to code four specimens tentatively assigned to *Pentaceratops* to test the validity of their assignments. These specimens are not used in other cladistic analyses due to fragmentary material. The Museum of Northern Arizona specimen, MNA Pl. 1747, is used as the defining specimen for the genus. Redescription based on additional preparation since the initial description of the specimen reveals MNA Pl. 1747 to be the most complete *Pentaceratops* skull known. Results from the cladistic analysis indicates not all tested specimens can be confidently assigned to *Pentaceratops*. Results also suggest the possibility of a misidentified ceratopsian taxon from the San Juan Basin.

Colbert Prize (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

A DIGITAL RECONSTRUCTION OF THE SKELETON OF MIDDLE PALEOCENE *APHRONORUS ORIELI* (PANTOLESTA: PENTACODONTIDAE) AND PALEOBIOLOGICAL INTERPRETATIONS

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Fossils of *Aphronorus orieli* from the middle Paleocene (earliest Tiffanian; ~62 Ma) Bangtail Locality in the western Crazy Mountains Basin, Montana, include the best-known postcrania recovered for the enigmatic 'proteutherian' family Pentacodontidae. These include fore- and hind- limbs, pelvis, portions of the axial skeleton, dentognathic material, and three relatively complete crania. We scanned the Bangtail *Aphronorus* fossils at Duke University's microCT facility and digital models of each element were created in order to allow more meaningful morphological measurement as well as a skeletal reconstruction. The locomotor behavior of *A. orieli* is also interpreted using a dataset of skeletal indices from small-bodied extant mammals of known locomotor mode. Seventeen of the indices that were found informative in distinguishing extant taxa by locomotor mode could be calculated from measurements of *A. orieli* fossils. Of these, 12 were calculated from forelimb measurements, and these appeared to be the most informative in distinguishing among locomotor modes when the indices were examined by region. Discriminate Function Analysis (DFA) was used to calculate the maximum separation between locomotor groups in multivariate space and then predict the locomotion of *A. orieli*. DFA was restricted to indices representing the forelimb to avoid

over-parameterization. The analysis was successful in classifying 65.7% of the extant taxa by locomotor mode, however the majority of errors were between terrestrial and arboreal classifications. *A. orieli* was classified as fossorial or semi-fossorial with 84.8% posterior probability. This agrees with qualitative assessment of the postcranial anatomy, which appears in some respects to resemble that of the generalized semi-fossorial early palaeanodont *Escavododon*. DFA did not support a semi-aquatic adaptation for *Aphronorus* as often argued for putative close relatives of pentacodontids (i.e., pantolestids). This suggests that the heavy dental wear described in some *A. orieli* specimens was not related to aquatic malacophagy.

Grant Information
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Technical Session X (Friday, October 16, 2015, 10:30 AM)

AN ARTICULATED CAENAGNATHID SKELETON FROM THE HORSESHOE CANYON FORMATION OF ALBERTA, CANADA, AND ITS PHYLOGENETIC AND PALEOBIOLOGICAL IMPLICATIONS

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Our understanding of caenagnathids has benefitted recently from new material, including nearly complete skeletons from the Hell Creek Formation of Montana. Despite these advances, the biology and systematics of Caenagnathidae remain unclear. A new specimen from the Horseshoe Canyon Formation of Alberta has implications for phylogeny and paleobiology of these creatures. Initially recovered in 1993 and believed to be an ornithomimid, the skeleton remained unprepared until 2008. The partial skeleton is articulated and includes a mandible, a full cervical and dorsal series of vertebrae, a right pectoral girdle and arm, a sternum, gastralia, a partial ilium, and a partial hindlimb. It represents the first articulated caenagnathid skeleton, and one of the most complete oviraptorosaurs known from North America to date. The morphology of the mandible is unique and the cervical vertebrae are distinct from *Epichirostenotes*. In addition, the manual proportions are autapomorphic, indicating that it represents a new taxon. The mandible is edentulous and the articular ridge is intermediate in size and form between *Caenagnathus collinsi* and *Chirostenotes pergracilis*. The neck is long and composed of twelve well-pneumatized cervical vertebrae with fused cervical ribs. The dorsal ribs have finger-like uncinate processes dissimilar in shape to those of other oviraptorosaurs, and closer in morphology to *Velociraptor*. The pectoral girdle is large and typically maniraptoran, except that the glenoid of the scapulocoracoid faces laterally instead of posteroventrally. The arm is elongate and culminates in gracile digits tipped with strongly curved, sharp-tipped claws. Close analysis of the ulna suggests the presence of feather scars. In addition to the anatomical adaptations of the taxon, ichnology and comparisons to modern-day herons provide support for previous proposals of wading habits in this group. The adaptations of the mandible and manus are congruent with omnivory, as proposed by previous authors. Phylogenetic analysis produces the most well-resolved cladogram of Caenagnathidae to date. The resulting tree splits Caenagnathidae into the deep-beaked Elmisaurinae and the shallow-beaked Caenagnathinae, and elucidates relationships within each subfamily.

Grant Information
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Technical Session VIII (Thursday, October 15, 2015, 1:45 PM)

SOMETHING OLD, SOMETHING NEW, SOMETHING SWIMMING IN THE BLUE: AN ANALYSIS OF THE MIOCENE PINNIPED *ALLODEMUS*, ITS PHYLOGENETIC POSITION AND SWIMMING MODE

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Pinnipeds (seals, sea lions and walruses) are a small but diverse clade of marine mammals that reentered the water in the late Oligocene (27–25 Ma). *Allodesmus* is a genus of extinct pinniped in the family Desmatophocidae, whose phylogenetic position has long been debated as being either more closely related to phocids (seals) or more closely related to otariids (sea lions). Previous research has allied desmatophocids with otariids and odobenids (walruses) in the clade Otarioidea or desmatophocids with phocids and odobenids in the clade Phocoidea.

The first objective of this study was to resolve interfamilial relationships within Pinnipedia and determine the placement of desmatophocids. Both molecular and morphological data were used. Molecular data were collected for all extant species in the analysis and included three nuclear (IRBP, RAG1, SRY) and two mitochondrial (CTYB, ND2) genes totaling 5196 base pairs, and partitioned by codon position. Morphological data were collected for all species included in the study and consisted of 75 characters (49 cranial, 26 postcranial). Both parsimony and Bayesian analyses were conducted, first individually on the separate molecular and morphological datasets, then on the combined dataset. Both analyses supported the validity of Otarioidea, containing otariids, odobenids (walruses), and desmatophocids with high support (BS = 71, PP = 0.72), and with otariids and odobenids as sister taxa.

The second objective of this study was to evaluate the evolutionary pattern of aquatic locomotion in pinnipeds. Phocids and otariids use very distinct aquatic locomotor styles, leading to debate concerning the swimming method employed by extinct pinnipeds. Ancestral state reconstruction was performed for all postcranial characters showing a correlation with either hind or forelimb swimming, using a maximum likelihood analysis in Mesquite. Percentage association with forelimb swimming was calculated for fossil pinnipeds with postcranial material and hypothesized for the ancestral pinniped and otarioid ancestor. Based on the results, it is likely that pinnipeds entered the water as hind limb dominated swimmers, with phocids and otarioids each specializing in a different kind of locomotion (hind or forelimb). While the transition was almost completely polarized in phocids and otariids, odobenids maintained the ancestral condition, a combination of hind and forelimb swimming with hind limb dominating, while desmatophocids developed a combination style with forelimb dominating.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

AN ENDOCRANIAL COMPARISON OF PLEISTOCENE *SMILODON FATALIS* OF DORCHESTER COUNTY, SOUTH CAROLINA TO PREHISTORIC AND MODERN FELIDS

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Felid brain evolution can be traced in the fossil record dating back 35 million years. Due to the sequential changes in structure that occurred in the felid brain over time, pinpointing the systematic position of a species and interpreting the functional anatomy of the brain is possible. Six late Pleistocene (Irvingtonian Mammal Age; ~450 ka) *Smilodon fatalis* were collected at the Giant Cement Quarry in Harleyville, South Carolina. These are part of a high diversity megafauna within a paleochannel known as the Camelot Site. The skulls are significant due to their relatively small size compared to other *S. fatalis* and their unique paleobiogeography. By evaluating the brain morphology of these felids, it is possible to (1) confirm these skulls are representative of *S. fatalis* and are small in scale due to sexual dimorphism or belonging to immature individuals; (2) determine their systematic position among other modern and prehistoric felids; and (3) evaluate their sensory specializations. Latex endocasts of the Camelot *S. fatalis* skulls are compared to the endocasts of prehistoric and modern felids including *Panthera leo, Acinonyx jubatus, Barbourofelis fricki*, and *S. fatalis* from Rancho La Brea. Endocasts preserve exterior brain morphology in great detail along with other such features as the intracranial blood vessels and nerves. These imprints are species specific. The brains of prehistoric felids were relatively simple compared to the complex brains of modern felids. In comparison to modern felids, early felid brains had: a smaller cerebral cortex; a smaller temporal lobe; no sylvian sulcus; a frontal lobe that is noticeably underdeveloped; and olfactory bulbs that appear to have a smaller area receiving incoming olfactory nerve fibers.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

A LATE OLIGOCENE CHELONIID TURTLE FROM SOUTHERN NEW ZEALAND

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A single cheloniid plate from a *Puppigerus*-like turtle has been recovered from mudstone of the upper Oligocene Pomahaka Formation of west Otago, New Zealand. This bone provides only the second report of a turtle from the NZ Oligocene, and one of few fossil cheloniids from the southwest Pacific. The fossil is a well-preserved thin single element, an apparent xiphiplastron, 121 mm long. The element is triangular, and elongated anterolaterally. The lateral margin is gently curved. The slightly serrated medial margin presumably sutured with the contralateral element. There is minor surface ornamentation and fine foramina on an otherwise rather smooth bone. Previous records of NZ marine Cenozoic turtles include indeterminate bones from the Paleocene, *Psephophorus* and Cheloniidae from the Eocene, a possible large cheloniid from the lower Oligocene Ototara Limestone, and fragments from the Miocene. As yet, cheloniids have not been recognized amongst the diverse late Oligocene marine tetrapods from the Kokoamu Greensand and Otekaike Limestone of the Waitaki region.

The setting for the Pomahaka turtle is inferred to be estuarine, as revealed by freshwater and brackish molluscs and benthic foraminifera, and a sequence including muds, silts, clays, and occasionally sands interbedded with lignite seams. The late Oligocene age is based on pollen and molluscs. The Pomahaka Formation is at least 23 m thick, and lies unconformably on Permian basement rocks; it represents a paleoshoreline on the archipelago of Zealandia. The overlying glaucony-rich Chatton Formation represents a fully marine setting. The Pomahaka Formation has produced other vertebrate fossils including chondrichthyan teeth and teleost remains, such as bone fragments and otoliths. These fossils and the *Puppigerus*-like turtle are noteworthy because of their paleo-estuarine provenance.

Grant Information
Marsden Grant, The University of Otago Benson Fund

Technical Session XV (Saturday, October 17, 2015, 8:15 AM)

ADVANCED SHAPE-FITTING ALGORITHMS APPLIED TO ESTIMATES OF MAMMOTH AND SLOTH BODY MASS

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Body mass is arguably the most fundamental physical property of an individual, and has a large bearing upon organismal ecology and physiology. Generating reliable estimates for fossil species' mass is therefore an important precursory step in many paleontological studies. Typically, fossil mass estimates are based upon one to two individual skeletal measurements (such as molar height or femoral circumference), due in part to the fragmentary nature of the fossil record. Such estimates can be problematic, however, if based upon unusually robust or gracile features.

Increasingly, volumetric techniques have been applied to fossil material (when completeness permits) in order to avoid this issue. Previous studies have applied 'convex hulling' to estimate the volume of articulated fossil skeletons, in which tight-fitting polytopes are wrapped around 3D computer models of the specimen. Yet this process requires manual segmentation, and sometimes arbitrary subdivision, of the skeleton. Additionally, the dimensions of fitted convex hulls depend solely upon the extremities of each body segment; ensuring most of the 3D model does not contribute to the resulting mass estimate.

Here we apply a new shape-fitting algorithm known as 'alpha-shapes' to fossil body mass estimation. Alpha-shapes do not require segmentation of the skeleton and are based on more than just the outermost points. We fitted alpha-shapes to 14 extant quadrupedal mammals to generate skeletal volumes, which were subsequently regressed against body mass to generate predictive equations. Predictive equations were then applied to a 3D model of the composite skeleton of a small woolly mammoth *Mammuthus primigenius* (USNM 23792) from the Smithsonian Museum's 'X 3D' website and an articulated

composite cast of a giant ground sloth *Megatherium americanum* (NHMUK 26540) on public display in the Natural History Museum, London.

Our 'alpha-shapes' predictive equation is characterised by a high correlation coefficient and low percentage prediction error (r^2 = 0.973, %PE = 12.3%). The mass of *M. primagenius* and *M. americanu* were estimated to be 3635 kg and the 3706 kg respectively, which match well with previous volumetric estimates of body mass. The application of alpha-shapes matches the predictive capacity of the convex hulling method but reduces the potential bias that segmentation of the skeletons may introduce. Future work should attempt to combine aspects of both convex hulls and alpha-shapes methods to provide a reliable mass estimation technique for complete fossil skeletons.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

BIOMECHANICAL ADAPTATIONS TO INCREASED BODY SIZE IN THE NEURAL SPINES OF THEROPOD DINOSAURS

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Theropod dinosaurs exhibit diversity in diet, lifestyle, cranial and body ornamentation, and body size, among other traits. However, the majority of theropods are characterized by a bipedal posture and locomotion. Unlike quadrupedal posture, which distributes weight across both fore- and hind limbs, bipedal posture distributes weight only on the hind limbs. This posture therefore generates bending moments in the vertebral column about the hips. Rugosities on the anterior and posterior aspects of neural spines are common in theropods. Histologic analysis of these spinal projections indicates that they are composed of metaplastic bone associated with the intervertebral ligaments. We hypothesize that these rugosities were a physiological adaptation to stresses incurred by bipedal posture in large-bodied species. This predicts the presence of rugosities in large-bodied theropods and the relative absence in small bodied theropods. We tested this hypothesis with a phylogenetic t-test to determine whether average body size differs between species with and without neural spine rugosities. We find strong support for this correlation ($p < 1.0e\text{-}^{10}$). Projecting rugosities also appear to vary between juveniles and adults of the same species, with juveniles either lacking them or exhibiting smaller rugosities. This limited ontogenetic evidence also supports our hypothesis. Metaplastic ossification of the interspinal ligament would likely affect the flexibility of the spinal column, increasing passive support for body weight. A stiff spinal column would also provide support for the primary hip flexors and therefor influence locomotor performance in large-bodied theropod dinosaurs.

Colbert Prize (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

EARLY MIOCENE PALEOENVIRONMENTS OF RUSINGA ISLAND, KENYA: NEW DATA FROM FOSSIL MAMMALIAN TOOTH ENAMEL STABLE ISOTOPE COMPOSITIONS

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The fossil-bearing Early Miocene formations on Rusinga and Mfangano Islands, Kenya (ca. 17–20.5 Ma) preserve diverse mammalian faunas, including numerous catarrhine primates. These assemblages are key references for understanding the evolution and diversification of crown catarrhines, so placing the Rusinga vertebrate communities in a clear ecological context is crucial to resolving the ecology and behavior of early apes and Old World monkeys. Prior paleoenvironmental reconstructions have yielded a range of conflicting results from closed-canopy tropical rainforests to open and semi-arid environments. Our recent work has integrated multiple paleoenvironmental methods at individual localities in the Hiwegi Fm, including leaf margin and leaf area analyses of fossil leaves, paleosol micromorphology and geochemistry, and vertebrate taphonomy and paleoecology. Our results suggest more open, drier woodland habitats low in the Hiwegi Fm that transition to a dense, closed canopy forest up section. Notably, the same species of catarrhines are found in both intervals, indicating they habitually occupied both open woodlands and closed forests.

We present carbon isotope compositions ($\delta^{13}C$) of tooth enamel of proboscideans, suids, rhinocerotids, chalicotheres, anthracotheres, tragulids, hyracoids, and carnivores from a series of formations (Kiahera, Hiwegi, and Kulu) on Rusinga Island. While paleosols record environmental information averaged over hundreds to thousands of years at a single site, enamel $\delta^{13}C$ provides paleoenvironmental information over the short interval of tooth formation (months to years) and integrates the dietary signal over the foraging habitats of a consumer, which aids evaluation of temporal and spatial environmental variability. The sampled teeth (currently n=48) have $d^{13}C$ values that span the entire range of modern C_3 biomes. The majority of specimens fall within one standard deviation of modern mean C_3 vegetation, indicating most sampled animals foraged in C_3 environments with neither light/water stress nor closed canopies. Interestingly, numerous specimens have $\delta^{13}C$ values consistent with foraging in more open habitats in which plants experienced light/water stress. Only two specimens, both tragulids, have $\delta^{13}C$ values low enough to indicate foraging in a closed-canopy forest. Our results are broadly consistent with the reconstructions based on paleosols and fossil leaves for the Hiwegi Fm, but suggest high spatial variability in habitats throughout the Early Miocene succession on Rusinga Island.

Grant Information
Leakey Foundation; University of Minnesota; Baylor University; Evolving Earth Foundation; Geological Society of America; Society for Sedimentary Geology; Explorers Club

Technical Session VII (Thursday, October 15, 2015, 3:15 PM)

MACROEVOLUTIONARY TRENDS IN THE PREORBITAL SKULL REGION OF ORNITHOPOD (ORNITHISCHIA) DINOSAURS

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Hadrosauroid dinosaurs are some of the most derived megahebivorous tetrapods ever to evolve, typified by elongated preorbital skulls and large external naris that began as the opposite condition in more primitive ancestors such as *Lesothosaurus*, dating from the Early Jurassic. Though the evolution of the preorbital skull in ornithopod dinosaurs appears to be directional based on observation of primitive versus derived Late Cretaceous species, Late Jurassic and mid-Cretaceous ornithopods allow rigorous testing of this hypothesis by providing pivotal anatomical data throughout the ornithopod tree. The evolutionary modes and correlations of three features in the ornithopod skull-preorbital skull length, area of the antorbital fenestra, and area of the narial fenestra-were tested using a variety of phylogenetic comparative methods on 37 ornithopod taxa and 750 time-scaled trees to account for stratigraphic uncertainty in species occurrences. An evolutionary mode test in BayesTraits revealed no statistical difference between a random walk model and directional model in preorbital skull length evolution, either considering each of the traits singly or wholesale. Phylogenetic generalized least squares regression shows a strong degree of correlation between length of the preorbital skull and size of the naris (R^2 = 0.48), a weak correlation with preorbital skull length and size of the antorbital fenestra (R^2 = 0.18), and a moderate correlation between size of the naris and antorbital fenestra (R^2 = 0.33). These results do not support the hypothesis that ornithopod cranial evolution was on a directional path towards the hadrosaurid morphology. Much of the seeming randomness in skull evolutionary modes may be due to the inclusion of smaller bodied, mid- Late Cretaceous basal ornithopods/basal ornithischians such as *Orodromeus* and *Thescelosaurus*, yet excluding these taxa from analyses does not change the result that the preorbital region of ornithopod skulls generally evolved via Brownian processes. As such, there may be a larger array of cryptic dietary morphology among ornithopods than previously appreciated, a major consideration for future modeling of megaherbivorous dietary evolution across dinosaurs.

Technical Session IX (Thursday, October 15, 2015, 4:00 PM)

AN IN-DEPTH LOOK AT 'SHALLOW' DINOSAUR TRACKS

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An animal's foot can indirectly deform layers beneath the substrate's surface, leading to the creation of 'undertracks' that are frequently discovered in the fossil record. Despite the benefits of the undertrack model, its application to footprints formed by different mechanisms is not justified. For example, Mesozoic dinosaurs moving through soft, wet substrates sank to significant depths without transmitting deformation far below the foot. In taxa with relatively long toes, such as theropods and some ornithischians, the sediment collapsed and sealed shut behind each penetrating digit, leaving a V-shaped sulcus. Such slit-like tracks can be easily misinterpreted, particularly if only one surface is available for analysis.

We combine results from computer simulations with multi-slab specimens from the Hitchcock Ichnology Collection in the Beneski Museum of Natural History at Amherst College to illustrate four scenarios: 1) If sulci are fully prepared, tracks can be construed as shallow marks left by a thin-toed foot (often avian) or the product of swimming or scraping motions. 2) If sulci are incompletely prepared, remaining fill can give the illusion of a shallow track made by a wide-toed foot. 3) Sampling of incompletely exposed sulci at multiple levels yields a sequence (one of Hitchcock's "stony volumes") that appears to show a shallow track transmitting undertracks over long distances. 4) Finally, morphologically detailed undertracks are sometimes found below collapsed sulci, contrary to the popular conception that detail decreases with depth. Given that deep track surfaces are more likely to be encountered than very shallow track surfaces, we believe that these errors and similar mistakes may be quite common in studies of dinosaurs and other taxa. A more complete understanding of track formation dynamics is critical for correct interpretation of morphologies encountered in the field and collections.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

PALEOGENE XENARTHRA AND THE EVOLUTION OF SOUTH AMERICAN MAMMALS

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Recent studies show Xenarthra to be even more isolated systematically from other placental mammals than traditionally thought. The group not only represents one of four primary placental clades, but proposed links to other fossorial mammal taxa (e.g., Pholidota, Palaeanodonta) have been contradicted. No unambiguous Paleocene fossil xenarthran remains are known, and Eocene remains consist almost exclusively of isolated cingulate osteoderms and isolated postcrania of uncertain systematic provenance. Cingulate skulls are unknown until the late middle Eocene, and the oldest sloth and anteater skulls are early Oligocene and early Miocene age, respectively; there are no nearly complete xenarthran skeletons until the early Miocene. Ecological reconstructions of early xenarthrans based on extant species and the paleobiology of extinct Neogene taxa suggest the group's progenitors were myrmecophagous with digging and perhaps some climbing adaptations. The earliest cingulates were terrestrial diggers and likely myrmecophagous but soon diverged into numerous omnivorous lineages. Early sloths were herbivores with a preference for forested habitats, exhibiting both digging and climbing adaptations. We attribute the rarity of early xenarthran remains to low population densities associated with myrmecophagy, lack of durable, enamel-covered teeth, and general scarcity of fossil localities from tropical latitudes of South America. The derivation of numerous omnivorous and herbivorous lineages from a myrmecophagous ancestor is a curious and unique feature of xenarthran history and may be due to the peculiar ecology of the native South American mammal fauna. Further

progress in understanding early xenarthran evolution may depend on locating new Paleogene fossil sites in northern South America.

Grant Information
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Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

DID THE HUNT FOR EARLY MAMMALS IN ARIZONA CREATE A SIGNIFICANT SAMPLING BIAS?

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The completeness of the fossil record and biases in our collections of this record have been the subject of numerous previous studies. Most of these have focused on two main areas: the relative completeness of organisms or the overall body mass of the recovered organisms. This has resulted in a fairly good understanding of the completeness of the fossil record in what could be termed "normal" conditions; prospectors collecting specimens with no particular focus on clade collected or size of the organism. Overall, large-bodied organisms tend to be discovered and described soonest while smaller-bodied organisms are generally discovered later and tend to be less complete.

To test if this trend is robust, the Lower Jurassic (Sinemurian–Pliensbachian) Kayenta Formation of Northern Arizona was investigated. In the 1970s and early 1980s, intensive fieldwork was undertaken by crews from the Museum of Northern Arizona and Harvard's Museum of Comparative Zoology attempting to locate early mammals and stem-mammal synapsids. Based on this focus we hypothesized that a "rebound" would exist, with a greater number of small-bodied organisms being discovered before larger-bodied ones, reversing the "normal" trend. A review of the published literature suggested this hypothesis was supported.

A specimen-level analysis of the Kayenta Formation collections of the Museum of Northern Arizona was conducted to test these results from the literature review. Data collected included date of collection, least-inclusive clade, estimated body length, and a completeness index score. Analyses of these data did not support the rebound hypothesis. Declining trendlines for size over time have an R-squared value between 0.95 and 0.97, indicating a good fit to a standard "big first" model. This suggests a publishing bias may exist and literature-based studies of collection biases may be missing an underlying signal in collections themselves.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

THE IMPORTANCE OF SENSITIVITY ANALYSES FOR THE INFERENCE OF FUNCTION FROM STRUCTURE

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The inference of function from structure is a challenging aspect of vertebrate paleontology, yet provides fascinating paleobiological insights. For example, understanding the variability in temporal activity patterns is crucial for gaining insight into ecological interactions and resource partitioning in paleoecosystems. Recent studies have shown that the morphology of the scleral ring and orbit structures may prove to reliably distinguish between different activity patterns. Strong correlations between visual performance features and activity patterns among extant avians and squamates provide a basis for drawing inferences about the activity patterns of extinct saurians. However, several factors (e.g., taphonomic, allometric, polymorphic) may introduce potentially confounding noise in classifying extinct taxa.

In order to evaluate the robustness of such inferences, we performed a sensitivity analysis. We combined time-calibrated phylogenies with data from extant (n = 368, with known diel activity pattern) and extinct (n = 33) saurian species to devise a resampling and simulation approach.

First, we tested how sample size affects the estimation of optimal lambda, a tree transformation parameter that seeks to maximize the correlation between form and function. Optimal lambda is important for accurate functional classifications of fossil samples. Our resampling results demonstrated that optimal lambda estimates for datasets of less than 100 species are unreliable, with many false near zero estimates.

Second, we designed a simulation approach to explore the effects of measurement variability. On the basis of empirically derived proxies, we generated several measurement distributions that reflect variation in fossils, ranging from natural variation to geologic deformation. While functional classifications of many fossils (including, e.g., *Velociraptor*, *Confuciusornis*) remained robust across all traits when assuming natural variation, some were more labile for at least one trait (e.g., *Ornithomimus*, *Pterodasutro, Rhamphorhynchus*). When introducing a high degree of variation, representative of geologic deformation, all taxa were prone to be misclassified.

Our results have important implications for future comparative studies. In order to avoid inaccurate paleobiological inferences, datasets must be sufficiently large to avoid problems with statistical inference of model parameters, and effects of natural variation and geologic deformation should be explored.

Technical Session V (Wednesday, October 14, 2015, 3:15 PM)

NEW TECHNIQUES FOR REMOVING THE EFFECT OF MORPHOLOGICAL INTEGRATION ON PHYLOGENETIC ANALYSIS

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One of the assumptions of phylogenetic analysis is that all of the characters being assessed evolve independently of one another. However, morphological characters may be linked due to a shared developmental or epigenetic process, or because states are selected together because of shared functional or ecological pressures. The interdependence of characters is referred to as morphological integration and has been a major source of arguments against using morphology to construct phylogenetic hypotheses in favor of using molecular data instead. The most common method used to remove the effect of morphological integration has been for the investigator to identify a suite of correlated character changes, usually associated with a particular ecomorph, and then downweight or delete those characters to reduce their collective contribution to tree length. I have developed two techniques that remove potential investigator biases by allowing the covariance structure of the data to determine how each character ultimately contributes to the tree length or model of evolution. For the first time, the structure of the data is determined using a phylogenetically informed categorical factor analysis. This uses the tree structure and a mix of Pearson's, tetrachoric, polychoric, and polyserial correlations to integrate discrete and continuous data into the same covariance structure. It also allows the researcher to include data such as sex or environmental factors into the data structure without using them as characters in the phylogenetic analysis. For parsimony searches, my new technique uses the degree to which its state can be predicted by other characters' states to determine the appropriate reweighting scheme. Because the factor analysis is sensitive to the tree structure, I use an iterative process to gradually converge on the best re-weighting scheme and tree topology together. For maximum likelihood based searches, I use the factor structure to find the difference between the state of each character and the state predicted by the states of the other characters, similar to a phylogenetically informed size correction. For each tree in a search of tree-space, the model of evolution is estimated for each character that maximizes the likelihood of the observed residual. These new techniques allow researchers to use all available morphological data to construct phylogenetic hypotheses without the looming specter of morphological integration.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

A NEW DIVERSE SQUAMATE FAUNA FROM THE LATE MIOCENE OF NORTHERN GREECE

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Late Miocene microvertebrate faunas from Southeastern Europe are crucial for our understanding of the evolution, extinction events and biogeographic scenarios of Neogene squamates. However, the relative scarcity of such localities from this region and the overall interest of most researchers in micromammals have hindered the identification of squamate remains. Therefore, the majority of squamate specimens from these localities have not been properly identified and are, usually, only tentatively assigned up to the family level. New squamate material is here presented from the late Miocene locality of Ano Metochi. Located in the Serres Basin in Northern Greece, Ano Metochi is already well known for its rich micromammal fauna as also some important large mammal finds, which all have pointed with certainty a late Turolian age (MN 13). Squamates have only received minor attention, with only a few sporadic referrals of the existing finds. However, new undescribed material recovered from this locality indicates a highly diverse squamate fauna. Lizards are represented by numerous agamids, lacertids, scincids and anguids, as also some indeterminate forms. Much of the material consists of dentaries, maxillae, vertebrae, osteoderms and limb elements, permitting the identification of a multitaxic lizard fauna. Snakes are represented by a large number of isolated vertebrae, but also from cranial elements as well as fangs, allowing the identification of scolecophidians, natricine and non-natricine colubrids, and several indeterminate forms. The presence of a scolecophidian is rather important as it constitutes one of the few occurences in the Neogene fossil record of this group at a global level. Comparison with the adjacent and slightly coeval locality of Maramena, also from the Serres Basin, reveals the notable absence of varanids, viperids and elapids from the Ano Metochi fauna. This absence should be attributed to preservation or collection biases, as Maramena has been more extensively investigated for microvertebrates, although a genuine absence of these groups due to ecological factors should not be ruled out. Deciphering the alpha taxonomy of the Ano Metochi lizards and snakes adds significantly to the known diversity of squamates from the Neogene of Southeastern Europe, contributing also to the knowledge of their ecology, evolution and biogeography.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

TAPHONOMIC DESCRIPTION OF THREE RECENTLY DISCOVERED *TROODON* CLUTCHES FROM EGG MOUNTAIN

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Troodon eggs are known from the Upper Cretaceous (Campanian) Two Medicine and Judith River Formations. Egg clutches document the reproductive behavior of this dinosaur and provide insight into the evolutionary transitions from non-avian dinosaurs to birds. Here we describe the taphonomy of three recently discovered *Troodon* clutches excavated during 2012, 2013, and 2014 at the Two Medicine Egg Mountain locality. These partial clutches consist of between 3 and 8 eggs in varying condition with associated eggshell debris. The 2012 clutch is the most heavily disturbed since the eggs lack the near-vertical posture typical of better-preserved clutches. In contrast, the less disturbed 2013 and 2014 clutches retain upright eggs leaning toward the clutch center. Because the eggs were partially buried in sediment after being laid, these clutches indicate autochthonous nesting. Sediment samples from the clutches indicate grey siltstones that are very poorly to moderately sorted. Orientation of associated eggshell from the 2012 and 2013 clutches favor concave down, n = 73 of 122 and, n = 118 of 225, respectively, whereas those from the 2014 clutch favor concave up (n = 30 of 56). Eggshell orientation from modern avian nesting sites and transport experiments may provide insight into the interpretation of these clutches. Eggshell orientations from all three clutches are inconsistent with transported assemblages. Eggshell orientations near the 2012 and 2013 clutches compare most closely with fragmentation caused by trampling by chicks after hatching. Orientations near the 2014 clutch more closely compare to fragmentation due to either hatching or predation. The 2012 (n = 11) and 2013 (n = 17) clutches preserve high numbers of shed *Troodon* teeth and may record feeding near the clutch or the lengthy brooding period. *Orodromeus* and small skeletal remains near these two clutches could be consistent with the former.

Grant Information
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Technical Session VI (Thursday, October 15, 2015, 9:00 AM)

MULTIDENTICULATE TEETH IN TRIASSIC FISH *HEMICALYPTERUS WEIRI* (OSTEICHTHYES: ACTINOPTERYGII): EVIDENCE FOR A SPECIALIZED FEEDING NICHE IN THE MESOZOIC

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Fishes are one of the largest extant vertebrate groups, and occupy multiple ecological niches. Many living fishes have evolved specialized multidenticulate teeth that are often associated with a herbivorous or omnivorous lifestyle, and fishes with this specialized dentition occur in both marine (e.g., surgeonfishes, rabbitfishes) and freshwater (e.g., haplochromine cichlids, characiforms) systems. These fishes often exploit a benthic feeding behavior, using their multicuspid teeth to scrape algae or attached invertebrates from a hard substrate. The fossil record for this unique tooth morphology is limited, and fishes displaying multidenticulate dentition only extend into the Eocene. I report evidence of the oldest example of specialized multicuspid dentition in a ray-finned fish, *Hemicalypterus weiri*, from the Upper Triassic Chinle Formation (~210–205 Ma) of southeastern Utah. *Hemicalypterus* possessed a deep, disc-shaped body, ganoid scales covering only the anterior half of the body, and a scaleless posterior flank, which likely aided in flexibility. *Hemicalypterus* also possessed several multidenticulate teeth on the premaxilla and dentary; each tooth has a rounded base, a flattened, scoop-like crown, and terminates with four individual cusps. The morphology of these specialized teeth converges with many living teleost fishes, and these scoop-like edges likely allowed *Hemicalypterus* to effectively scrape algae off of a rock substrate. This discovery fundamentally alters perceptions of the ecological roles of fishes during the Mesozoic, which were previously hypothesized to be limited to generalist or durophagous feeding niches. This finding indicates that specialized dentition associated with herbivory is not restricted to teleosts and that fishes likely exploited a herbivorous or omnivorous scraping ecological niche long before previously thought.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

NEW SIVALADAPID PRIMATE FROM SUNETAR, A LOWER SIWALIK LOCALITY NEAR THE TOWN OF RAMNAGAR (JAMMU AND KASHMIR, INDIA)

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Lower Siwalik fossil localities near the town of Ramnagar, India are well known to vertebrate paleontologists. Over the past century, numerous specimens collected near Ramnagar have proven important to understanding the evolution and biogeography of many mammalian groups. Primates from Ramnagar, though rare, include a number of hominoid ape fossils attributable to *Sivapithecus* as well as a single published mandibular fragment preserving the p4–m1 of the Miocene adapoid *Sivaladapis palaeindicus*. Since 2010, we have renewed fossil prospecting in the Lower Siwalik deposits near Ramnagar in an attempt to better understand the evolution, biogeographic timing, and paleoclimatic context of mammalian radiations in Asia, with a particular focus on primates. To date, our explorations have resulted in the identification of new fossil localities in the Ramnagar area, including the site of Sunetar. In October 2014, a partial mandible of a sivaladapid was recovered at Sunetar, preserving the mandibular corpus with worn m1–m3 dentition. Although sivaladapids are known by numerous specimens of two genera (*Sivaladapis* and *Indraloris*) at Lower Siwalik sites on the Potwar Plateau and at the Middle Siwalik locality of Haritalyangar, this new specimen is just the second known sivaladapid primate from the Ramnagar region. We compared measurements of the Sunetar specimen with those taken from *Sivaladapis* and *Indraloris* specimens in museum collections as well as the literature. Our results suggest that *Sivaladapis* can be reliably distinguished from *Indraloris* by its significantly narrower molars and significantly more compressed molar trigonids. For m1–m3, the Sunetar specimen either falls close to or within the range of *Sivaladapis* for these two molar features and outside of the *Indraloris* range. Because the Sunetar specimen is most similar in overall molar shape to *Sivaladapis*, and yet 20% smaller than known *Sivaladapis* taxa, we suggest that it may represent a new species similar in absolute size to *I. kamlialensis* from the Potwar Plateau. The age of Sunetar and the Ramnagar region, in general, can be bracketed by the suid *Conohyus* and the rodents *Antemus chinjiensis* and *Kanysamys* cf. *potwarensis* to an approximate age of 14 Ma–12.7 Ma. However, future collection efforts and paleomagnetic studies are still necessary to confidently and more precisely resolve the age of the Ramnagar deposits.

Grant Information
This study was generously supported by the PSC-CUNY faculty research award program, Hunter College, AAPA Professional Development Program, and Wenner-Gren Foundation.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

NEW MICROVERTEBRATE MATERIAL FROM THE BELLY RIVER GROUP, DINOSAUR PARK FORMATION (CAMPANIAN) OF SOUTHWESTERN SASKATCHEWAN, CANADA

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The Belly River Group comprises an eastward-thinning paralic to non-marine Campanian clastic succession in the Western Canadian Sedimentary Basin. Three formations are formally recognized in the western Canadian Plains. In ascending order, these are the Foremost, Oldman, and Dinosaur Park formations. In Alberta, the Group is well known for its rich and diverse vertebrate fauna, and is one of the most productive dinosaur-bearing units in the world. Though exposed in Saskatchewan, outcropping is sparse, widely distributed, and often difficult to access. Despite this, recently, several microfossil sites have been identified throughout southwestern Saskatchewan, Canada. The Saskatchewan sites produce a rich vertebrate record, including chondrichthyans, osteichthyans, turtles, champsosaurs, crocodiles, squamates, amphibians, birds, mammals, and dinosaurs. Integration of geological and paleontological information to place these sites into a geological context, as well as a meaningful microfossil database, is ongoing. Due to the provinces' proximity to the transgressive Bearpaw Sea paleocoastline, these sites offer a unique opportunity to test paleoecological hypothesis regarding community response to sea level rise and inundation across the coastal and alluvial plain of Western Canada.

Technical Session IV (Wednesday, October 14, 2015, 2:15 PM)

NEW PARTIAL SKELETON, BODY SIZE, AND BRAIN SIZE IN THE LATE EOCENE WHALE *ZYGORHIZA KOCHII*, AND A COMPARISON OF ENCEPHALIZATION RESIDUALS IN ARCHAEOCETI (MAMMALIA, CETACEA)

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A new partial skeleton of the late Eocene archaeocete *Zygorhiza kochii* is described, based on a Field Museum specimen from the Pachuta Marl member of the Yazoo Formation near Melvin, Alabama. The body weight of *Z. kochii* is estimated to have been about 1077 kg, based on vertebral size. The new *Zygorhiza* skeleton includes a cranium with a well preserved braincase, which has yielded one of the best endocranial casts known for an archaeocete. The endocast has the large dorsal and rostral retia mirabilia characteristic of basilosaurids. The dorsolateral surface of the cerebrum, where exposed, is smoothly curved, with no suggestion of the cortical folding characteristic of modern cetacean brains.

Encephalization is necessarily quantified relative to a reference sample, and terrestrial mammals provide a logical baseline. The encephalization residual for living terrestrial mammals as a class (ER_{TC}) is the difference between observed $\log_2$ brain weight (E_i in g) and expected $\log_2$ brain weight (E_e in g), where the latter is estimated from $\log_2$ body weight (P_i in g) as $E_e = 0.740 \cdot P_i - 4.004$. A log base-2 ER scale is intuitive as it involves halvings and doublings on a uniform arithmetic scale, and it is appropriate for the observed range of encephalization differences. Encephalization quotients (EQ) are unsuitable for comparison because they are proportions on a non-uniform scale.

Endocranial volume of the skull of *Zygorhiza kochii* is 1189 cm^3, which, when retia mirabilia are subtracted, corresponds to a brain weight of about 960 g. This yields an encephalization residual, ER_{TC}, for *Z. kochii* of −0.92, and an encephalization quotient, $EQ_{TC} = 2 \text{ ^ } ER_{TC} = 0.53$. Middle Eocene archaeocetes have ER_{TC} values close to −2 (two halvings compared to expectation), while late Eocene archaeocetes have ER_{TC} values close to −1 (one halving compared to expectation). ER_{TC} is not known for fossil mysticetes, but living mysticetes have ER_{TC} values averaging about −2. Oligocene–Recent odontocetes appear to have ER_{TC} values averaging about +1 (one doubling compared to expectation) through their temporal range. Definitive interpretation of patterns of encephalization will require better documentation for all three groups, Archaeoceti, Mysticeti, and Odontoceti.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

ON THE NATURE OF ULTRASCULPTURE IN THE DERMAL SKELETON OF PSAMMOSTEIDS (AGNATHA: PTERASPIDIFORMES)

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The ultrasculpture present on the superficial layer of the dentin tubercles of psammosteids is represented by cell-sized polygons, separated by walls or grooves. This type of ultrasculpture can be formed by epithelial cells (10-30 μm length) or ameloblasts (approximately 3-6 μm in length). The finding of small-sized ultrasculpture in psammosteids have led some authors to assumption that its origin is connected with enameloid tissue. Research has been carried out in order to verify information about the absence of enameloid in psammosteids. The tubercles of three species of psammosteids with different stratigraphic ranges (*Ganosteus stellatus, Psammosteus livonicus, Psammosteus falcatus*) were fixed in epoxy resin and ground down horizontally. They were subsequently etched with 2N HCl for 2-15 seconds. The prepared tissues were examined under scanning electron microscope (SEM). It appeared that the superficial layer in horizontal sections of the three species is composed of orthodentin and doesn't differ from the inner layers. The study of ultrasculpture in psammosteids belonging to four different families (Pycnosteidae, Psammolepididae, Psammosteidae, Guerichosteidae) under the SEM has shown that its average size is 8-11 μm.

The distribution of ultrasculpture is generally limited to the lower half of the tubercles with vertically oriented crowns. In the case of tubercles with low crowns, or slanted tubercles, the ultrasculpture covers almost the whole surface. On those tubercles which underwent intravital abrasion and on secondery tubercles as well as "blisters", the ultrasculpture is preserved in uninvolved bottom regions.

Histological research and measurements of ultrasculptural polygons confirm the absence of enameloid in psemmosteid tubercles. One of the functions of ultrasculpture was attachment of epidermis to the surface of the dermal skeleton. It has been discovered that the upper limit of distribution of ultrasculptural imprints corresponds to the height of distribution of microtubercles on the radial ribs and crenulations. Therefore, the function of microtubercles could be reinforcement of fixation of epidermis.

Grant Information
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Colbert Prize (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

QUANTITATIVE FRAMEWORK FOR INFERRING DIETS FROM SKULL AND JAW MORPHOLOGY OF EXTANT AND FOSSIL ACTINOPTERYGIANS AND ELASMOBRANCHS

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There is much interest in the paleoecology of extinct fishes, especially in the structure of ancient food webs. Understanding these food webs requires knowing the diets of the fishes within the communities. In many cases direct evidence of diet (i.e., stomach contents) is not preserved, so jaw and skull morphology are instead used to estimate the diets. These functional inferences are usually qualitative, however, given the lack of quantitative framework based on the morphology of extant fishes. Here we demonstrate the relationship between known diet and the morphology of the jaw and skull in extant actinopterygians and elasmobranchs. We determined 8 broad diet groups for 267 extant species of actinopterygians and elasmobranchs by using cluster analysis to group species by the similarity of the proportions of different categories of food items in their diets. We measured 14 characteristics of the jaws and skulls of museum specimens of 33 species of bony fishes and sharks. We performed a linear discriminant analysis (LDA) to determine which combinations of jaw and skull measurements were best at distinguishing among the dietary groups. The resulting misclassification rate from self-reclassification using LDA was 12.5%, suggesting that these measurements are useful in discriminating among dietary groups. Bony fishes and sharks within the same dietary group occupy similar parts of the morphospace defined by LDA axes, while each diet group occupies a separate region. We estimated the diets of several species of extinct fishes by inputting jaw and skull measurements from museum specimens into the LDA trained by the extant species. The Early Triassic fishes *Australosomus merlei, Boreosomus gillioti, Haywardia jordani, Perleidus madagascariensis, Pteronisculus macropterus,* and *Watsonulus eugnathoides* are reconstructed as invertivores. In the absence of gut contents or behavioral evidence of feeding, morphology can be used to estimate the diets of fishes.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

THE POSTCRANIAL ANATOMY OF *PISSARRACHAMPSA SERA* (MESOEUCROCODYLIA, BAURUSUCHIDAE), FROM THE LATE CRETACEOUS OF BRAZIL

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Recent work has challenged the historical view that information from the crocodyliform postcranium is of secondary importance to cranial anatomy. However, detailed descriptions of postcranial elements are still scarce and phylogenetic analyses continue to include only a relatively small proportion of postcranial characters (less than 25%). Here, we present the first postcranial anatomical data for *Pissarrachampsa sera*, a baurusuchid from the Vale do Rio do Peixe Formation (Late Cretaceous) of southeastern Brazil, which was originally described based on two nearly complete skulls. Baurusuchidae is a group of Gondwanan notosuchians (Mesoeucrocodylia) with specialized skull anatomy, a high and laterally compressed rostrum and ziphodont dentition, that played the role of terrestrial, large-sized predators in South America during the Cretaceous. Analysis and preparation of additional material from the type locality of *P. sera* revealed postcranial elements associated with the holotype, as well as new referred specimens representing at least three individuals. Together, these specimens provide information on almost the entire postcranial skeleton of *P. sera*. After comparisons with other taxa belonging to the clade Notosuchia, the postcranial anatomy of *Pissarrachampsa sera* revealed features that are in agreement with the terrestrial lifestyle proposed for members of this group, including evidence for a semi-erect to erect posture and parasagittal limb movements. This is supported by the close association of the radius and ulna, the presence of a tubercle on the dorsal surface of the ischial blade for the attachment of M. pubioischiotibialis, a well-excavated fossa flexoria separating the proximal sloping facets of the tibia, a tuberosity for the insertion of M. flexor tibialis internus, and the oblique angle between long axes of the astragalus and calcaneum. Some of these characters are present in other terrestrial crocodyliforms, although autapomorphic features of *P. sera* were also recognized. The new postcranial information was incorporated into a previously published phylogenetic analysis focused on crocodyliform postcranial anatomy. The results provide additional postcranial support for the two major baurusuchid clades Pissarrachampsinae (*P. sera* + *Campinasuchus dinizi*) and Baurusuchinae (*Stratiotosuchus maxhechti* + *Baurusuchus*). This suggests underestimated postcranial variation within Baurusuchidae similarly to what was recently proposed for the cranial anatomy of this unique clade.

Romer Prize Session (Thursday, October 15, 2015, 9:45 AM)

EVOLUTION OF THE FLIGHT-READY BRAIN IN THEROPOD DINOSAURS THROUGH NOVEL HIGH RESOLUTION IMAGING SYSTEMS

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The evolution of flight-related features in theropod dinosaurs is an iconic and well-documented transition in the fossil record. Although much of the morphological infrastructure for flight precedes crown group birds, being also found in non-avian dinosaurs, the precise origin of powered flight has eluded paleontologists because of the difficulty in directly linking morphology to flight capacity. Recently, endocranial data have demonstrated that a highly encephalized brain evolved in non-avian theropods, but whether these neuroanatomical changes reflect behavioral transformations is untested. To explore the relationship between endocranial anatomy and locomotion I used positron emission tomography (PET) scanning to record brain activity in starlings performing a variety of locomotor behaviors. Results demonstrate specific locomotor behaviors and brain activity are highly correlated. Overlaying PET data onto iodine-enhanced CT scans of a starling head showed that these regions correspond to the entopallium and anterior Wulst, both of which are involved in visual processing. Therefore, it would be expected that the regions containing these areas would expand at the evolutionary origin of flight. Flight may have first appeared as an escape-mechanism through wing-assisted incline running up vertical surfaces in forested or otherwise cluttered environments. A sophisticated visual processing system would be necessary for navigating through complicated three-dimensional environments. Using geometric morphometric techniques on 78 theropod endocasts, I showed that the forebrain, along with the optic lobes, experienced expansion at the appearance of crown group Aves, corroborating the use of these areas for flight. Together, these data suggest that the shape changes observed in non-avian theropods reflect the selective enlargement of cerebral nuclei associated with functions like vision. These findings corroborate that these areas are associated with flight and suggest that the potential development of cerebral nuclei is responsible for the shape changes and pulses of expansion we see in theropod endocast evolution. Brain activation maps in starlings represent a first step in a new aspect of paleontology, and can eventually lead to inferring behaviors in fossil animals through correlating morphological features with behaviors in extant taxa.

Technical Session XVII (Saturday, October 17, 2015, 3:15 PM)

THE RE-EVALUATION OF THE SAUROPOD DINOSAURS FROM THE DINOSAUR BEDS OF MALAWI REVEAL A HIDDEN DIVERSITY FOR SUB-EQUATORIAL AFRICAN FAUNAS

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Malawisaurus dixeyi represents the most complete titanosaurian sauropod dinosaur yet recovered from continental Africa. Along with the co-occurring *Karongasaurus gittelmani*, known from only a partial dentary and teeth, the Aptian Dinosaur Beds of Malawi have been critical for our understanding of Cretaceous African faunas and early titanosaurian evolution. Yet, *Malawisaurus dixeyi* has a lengthy taxonomic history starting with the description of SAM 7405 in 1928, which includes the holotypic anterior caudal vertebra. During the late 1980s and early 1990s, additional sauropod materials were recovered from seven nearby localities with most referred to *Malawisaurus* on the basis of being from the same inferred stratigraphic horizon as SAM 7405. Of these sites, locality CD-9 constitutes a rich, multi-individual and multi-taxon bonebed as evidenced by two left humeri and the distinct *Malawisaurus* and *Karongasaurus* dentaries. However, the holotypic anterior caudal vertebra for *Malawisaurus,* SAM 7405, lacks specific diagnostic features and does not compare favorably with most of the more recently recovered anterior caudal vertebrae.

Materials from the seven localities and SAM 7405 were compared based on firsthand observations. Localities CD-11, CD-12, and CD-13 do not preserve overlapping elements with SAM 7405 or CD-9, thereby questioning the referral of the previously assigned radii, metatarsal III, and a tibia to *Malawisaurus*. Further, select anterior and middle caudal vertebrae from localities CD-9, CD-10, and CD-15 differ notably from the SAM 7405 holotype. Though consistent with the presence of multiple taxa in the Dinosaur Beds, confident assignment of these caudal vertebral morphs to either Malawian taxon is tenuous. Due to the lack of overlapping, diagnostic, and confident referral of elements, *Malawisaurus* and *Karongasaurus* may be best diagnosed by their respective dentary and tooth morphologies. Some of the aforementioned caudal morphotypes are also similar to the South American aeolosaurian titanosaurians based on an anteriorly inclined centrum, an elongate prezygapophysis, and a vertical-to-anteriorly oriented neural spine. The presence of African aeolosaurian-like titanosaurians is further supported by discoveries from the middle Cretaceous Galula Formation of Tanzania. Though not as complete as the South American fossil record, the middle Cretaceous African titanosaurian record suggests that several titanosaurian lineages were present at the time both continents were still at least partially connected.

Symposium 3 (Saturday, October 17, 2015, 9:45 AM)

SHAPING SHAPE: HOW PHENOTYPIC INTEGRATION AND MODULARITY INFLUENCE THE EVOLUTION OF ORGANISMAL FORM

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Phenotypic integration, the complex interactions among morphological traits, is a pervasive characteristic of organisms and can be identified through quantitative analysis of geometric morphometric data. These interactions, and their organization into semi-autonomous sets of highly-correlated traits, or modules, have been hypothesized to be a fundamental influence on morphological evolution. To test this hypothesis, we conducted simulations using covariance matrices derived from 3-D landmark data for 97 living and extinct mammalian taxa to confirm that trait integration can influence both the trajectory ($r = 0.86$, $p < 0.01$) and magnitude ($r - 0.85$, $p < 0.01$) of response to selection. We further demonstrate that phenotypic integration can produce both more and less disparate organisms than would be expected under random walk models by repartitioning variance in preferred directions, thereby increasing range of occupied morphospace range ($r = 0.87$, $p < 0.01$) but not variance. This effect can also be expected to favour homoplasy and convergent evolution.

In order to further assess how phenotypic integration may influence morphological evolution, we analysed evolutionary rates and disparity for a 3-D morphometric dataset of cranial landmarks representing 36 living and extinct carnivorans. Evolutionary rates were reconstructed along phylogenetic branches of a fully resolved tree using an adaptive peak-based approach. Disparity was estimated as landmark variance and compared with rates across the cranium and within previously-identified modules. Results indicate that evolutionary rates and disparity are not significantly correlated (Spearman's $r = 0.23$, $p = 0.09$) across the entire skull. Modules that display the greatest disparity in carnivorans (orbit and zygomatic regions) do not display significantly higher rates of evolution than other modules. The basicranial module shows strong integration and low disparity, but

one of the highest rates of evolution, suggesting that integration does not necessarily constrain rate of morphological evolution, although it may constrain morphological diversity. Discordance between evolutionary rates and morphological disparity suggest that carnivorans evolve rapidly but within a relatively limited area of morphospace, consistent with previous qualitative and quantitative assessment of repeated convergences in morphology across distantly-related carnivorans. Thus, phenotypic integration may shape the direction of evolutionary change, but not necessarily its speed.

Grant Information
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Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

NOVEL LATERAL LINE AND CAUDAL FIN MORPHOLOGY IN A PALEOGENE 'TARPON' (MEGALOPIDAE) FROM NEW ZEALAND

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A large (ca. 1.2 m total length), nearly complete, and three-dimensionally preserved megalopid teleost from the Paleogene Red Bluff Tuff of Pitt Island (Chatham Islands), New Zealand, reveals a unique configuration of the posterior lateral line scales and caudal fin. The specimen's elopomorph affinities are evidenced by its primitively retained median gular and lack of a separate retroarticular ossification on the lower jaw, and within elopomorphs it is assigned to Megalopidae (tarpons) based on its strongly superior mouth position and laterally compressed body covered in large overlapping cycloid scales.

The specimen has several distinctive features indicating that it is a new taxon within megalopids; here, we focus on the series of six progressively smaller lateral line scales that continue beyond the posterior border of the caudal peduncle and carry the lateral line over the proximal caudal fin rays onto the anteromedial portion of the fin. These scales have prolonged and pointed posterior borders, rather than the straight vertical posterior borders of the more typical and larger lateral line scales anterior to the caudal peduncle. It is clear that the scales in question are carrying the lateral line, as the lateral line canal can be seen in cross-section along a break in the specimen.

The configuration in this specimen is broadly, and clearly convergently, reminiscent of caudal morphology in certain tetrapodomorph and actinistian sarcopterygian fishes in which the lateral line extends out onto the caudal fin via an epicaudal lobe. The caudal fin of the New Zealand megalopid is in other respects conventionally homocercal, with an externally symmetrical and deeply forked equilobate shape very similar to that of a Recent tarpon, and there is no indication of a fleshy lobe supporting the 'extra' lateral line scales. This novel configuration has likely implications for the mechanosensory function of the lateral line in this new taxon given that such a large and presumably active predator would have generated substantial hydrodynamic stimulation to lateral line neuromasts located on the caudal fin during pursuit of its prey.

Grant Information
University of Otago and Michigan State University

Technical Session XIII (Friday, October 16, 2015, 2:30 PM)

A GEOMETRIC MORPHOMETRIC APPROACH TO UNDERSTANDING VARIATION IN DINOSAUR FOOTPRINT OUTLINES

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Two dimensional outlines of fossil footprints have been the primary way in which these data are presented and discussed in the literature. Outline shape, and its variations and metrics, has formed the basis of ichnotaxonomy, but has also been used to address matters of locomotion and paleobiology. While outlines may not be the ideal means of communicating the complex 3D morphology of a track, the wealth of outlines in literature spanning over 150 years demands a means of comparing and using the data.

An objective and quantitative approach to analyzing variation in dinosaur footprint outlines is needed to help distinguish differences due to foot shape, foot motion, sediment consistency, or degree of weathering. Geometric morphometrics provides a useful tool for examining underlying patterns of variation and co-variation in footprint outline morphology. In this study, we used a geometric morphometric outline analysis based on elliptical Fourier analysis to examine the variation in footprint outline morphology found in the published literature.

We put together a sample of published footprint outlines, and used elliptical Fourier analysis to ordinate them in principal component space. Our results indicate that high level taxonomic/morphological distinctions (e.g., between sauropod-type tracks and tridactyl tracks) explain a large portion of the variation seen in outlines. However variation between tridactyl feet assigned to theropods was greater along some dimensions than variation between tridactyl and sauropod-type feet: variation in tridactyl footprint morphology is considerable within taxonomic groups. We also analyzed multiple trackways derived from different depths within a single track. Form varied significantly between outlines produced only a small distance apart, indicating the necessity for a standardized means of recording track morphology.

Understanding patterns of variation in footprint outline is challenging. Geometric morphometrics provides a feasible, easy to use, assumption-free way of approaching this problem. This should enable objective discrimination of track data into categories useful for higher level ichnotaxonomic diversity studies.

Technical Session XIII (Friday, October 16, 2015, 4:00 PM)

DINOSAUR ENERGETICS AND THERMOREGULATION: THE EVIDENCE FROM GROWTH

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The nature of dinosaur thermoregulation has been hotly debated for decades. Early depictions of dinosaurs as sluggish, overgrown reptiles have been largely replaced by portraits of warm-blooded, feathered hunters, but there is, as of yet, still no consensus. Some of the strongest evidence that dinosaurs were not ectotherms comes from analyses of fossil bone tissue, but this work has lacked appropriate comparative data and direct linkages to energy use. To address this issue, we assembled an extensive data set on ontogenetic growth and metabolism in vertebrates and used a metabolic scaling approach to infer dinosaur physiology.

We found that maximum growth rates strongly predict resting metabolic rates in extant vertebrates (r^2 = 0.90) and correspond closely with theoretical predictions. Endotherms with high metabolic rates grew fastest, low-metabolizing ectotherms were slowest, and an eclectic group of thermally intermediate taxa, termed mesotherms, grew and metabolized at intermediate rates. Somewhat surprisingly, we found that dinosaur metabolic rates were most similar to extant mesotherms. While this result was not predicted at the outset of the study, it is actually consistent with much of the current anatomical and ecological data on dinosaurs. More broadly, the strength of the correlation between growth and metabolic rate lays a foundation for predicting metabolic rates in extinct taxa, including energetically ambiguous pterosaurs, therapsids, and sauropterygians. We suggest further approaches for testing the dinosaur mesothermy hypothesis, and consider the ecological implications of metabolic power across the Phanerozoic.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

STABLE ISOTOPE GEOCHEMISTRY OF DINOSAUR EGGSHELL FROM THE GOBI DESERT, MONGOLIA

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Thirty-nine fragments of dinosaur eggshell, paleosol carbonates from five localities, and calcite crystals from inside a sauropod femur were collected from the Campanian to Maastrichtian Barungoyot and Nemegt formations at Bugin Tsav, Altan Ula, Gurlin Tsav, Nugin Tsav, Narin Bulak, and Khermeen Tsav, Gobi Desert, Mongolia. The eggshell samples represented both herbivorous and carnivorous dinosaurs. The samples were examined for diagenesis using light microscopy, SEM, and cathodoluminescence, and each was analyzed for carbon and oxygen stable isotope values. Most samples indicate some degree of diagenesis. Isotope values plot between three end members: pristine eggshell with primary microstructure, non-luminescent eggshell with no preserved microstucture, and luminescent eggshell with no preserved microstructure. The two end members showing no preservation of microstructure indicate different phases of diagenesis. The two phases likely represent depth of burial relative to the vadose and phreatic zones. Permian-age detrital zircons in the fossiliferous sediment suggest that enriched carbon values may have been caused by phreatic zone diagenetic waters incorporating Permian marine host rock.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

PALEOTEACH: STEM INTEGRATION THROUGH PALEONTOLOGY AND 3D TECHNOLOGYB

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PaleoTeach is a collaboration involving the Florida Museum of Natural History, Duke University, and science educators. The goal is to create curricula using high quality 3D models for a K–12 audience. Fossils are oftentimes delicate or rare, and not universally suitable for classroom use. Therefore, 3D scanning and printing technology provides a unique opportunity to make these specimens available for K–12 education. In addition, paleontology is an interdisciplinary and engaging area of study that provides distinctive opportunities for STEM integration.

STEM integration is an instructional method that aims to emphasize the connections between science, technology, engineering, and math. This method helps introduce concepts in these subjects in a way that is more meaningful to students and also replicates the way science is practiced. Students can acquire 21st century skills and improve STEM literacy when they understand relationships between disciplines and can apply these relationships to real life experiences. Instruction through STEM integration and connection to real life issues is more relevant to students and therefore, increases motivation, self-efficacy, college readiness, and potentially promotes interest in science careers.

PaleoTeach advances our understanding of the potential efficacy of the recently developed 3D scanning technology in K–12 science learning. This approach to integrate 3D technology can improve the relevance of educational practices in our schools and broaden the impact of ongoing digitization efforts of paleontological research collections. Lessons that we have developed are rooted in the idea of STEM integration. For example, research on *Carcharocles megalodon* provides multiple opportunities for K–12 educators. Lessons have been designed to teach concepts of extinction and evolution (science) through the use of 3D printed teeth (technology). Students replicate scientific processes by measuring the teeth and calculating the size of the animal (math). Ultimately, they reconstruct the entire jaw by applying concepts of engineering. Like the study of *C. megalodon*, there are other examples from the fossil record (e.g., *Titanoboa cerrejonensis*

and equid evolution) that can increase educators' content knowledge and guide students through this integrated process. Furthermore, making specific fossils available for 3D reproduction can help educators introduce examples of important topics, such as climate change, fostering new learning opportunities in issues of current societal relevance.

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Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

INTEGRATION AND MODULARITY IN THE SLOTH SCAPULA

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There are currently two extant genera of sloths, the three toed *Bradypus*, and the two-toed *Choloepus*. Both of these genera exhibit a rather unusual suspensory lifestyle, and similar adaptations to their forelimbs and hindlimbs to facilitate this lifestyle. However, phylogenetic analyses generally recover *Bradypus* in its own monotypic family and basal to all other sloths, with *Choloepus* falling out as a member of the family Megalonychidae. This has led to conjecture that their shared suspensory lifestyle must be an example of extreme convergence. However, evidence from dental patterns and scapula shape also indicate that heterochrony may be involved between *Bradypus* and *Choloepus* as well. One of the most striking morphological differences between these two genera is that *Bradypus* does not possess a coracoacromial arch, where the acromion process and coracoid process fuse, a feature present in *Choloepus* and all other observed sloths. This unusual feature has only been observed in one other animal, a small bat from New Zealand, and the fusing of two otherwise separate growth centers may have an effect on growth patterns in the scapula, especially integration. The scapula is generally divided into the blade, the spine (including the acromion process), the glenoid fossa, and the coracoid process. Geometric morphometric landmark measurements, including sliding semi-landmarks, were taken on the scapulae of several sloth genera, and then divided between *Bradypus* and all other sloths, to determine if there were any differences in integration and modularity between scapulae that possess a coracoacromial arch, and those that do not. The scapulae of *Choloepus* and all other sloths were moderately integrated between the blade, spine, glenoid, and coracoid, with an RV of 0.6 and a p-value of 0.01, indicating that there is slightly more covariance between these four modules than within them. Pairwise partial least squares comparisons between them all showed significant correlation of 85–90%. The scapula of *Bradypus* also showed similar levels of correlation between each module. However, the RV value for the scapula as a whole was 0.8, but with a p-value of 0.33, showing that the defined modules do show a high covariance between them, and that there is less modularity in the *Bradypus* scapula than other sloths. This difference in growth patterns show that heterochrony, if present, is not the only source of morphological differences between the scapula of *Bradypus* and *Choloepus*, and supports the phylogenetic hypothesis that they are distantly related.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

AGAMID (REPTILIA: SQUAMATA) ASSEMBLAGES FROM SOUTH AUSTRALIA SUGGEST DIFFERENCES BETWEEN PLEISTOCENE AND MODERN DISTRIBUTIONS THAT REFLECT CLIMATE CHANGES

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Although extant species of lizard show different environmental preferences, their recent fossil record has rarely been used to infer environment. This is mainly because the extensive osteological variation of squamate reptiles (lizards and snakes) remains incompletely documented, obstructing accurate identification of fossils. South Australia is just one region from where lizard fossils are known but species-level identification is difficult.

I examined 17 agamid lizard maxillae from Kelly Hill Caves (Kangaroo Island) and Naracoorte Caves (mainland) of South Australia: specimens derived from multiple Pleistocene layers between 6500 and 47 000 BP dated using parallel methods. Where possible specimens were subjected to micro Computer Tomography and 3D computer models were constructed. The fossils were scored using a set of discrete morphological characters developed from examination of extant agamid taxa. The computer models were represented using 52 landmarks and compared using geometric morphometrics. Principal components analysis following Procrustes alignment helped to characterize the variation found amongst extant taxa and facilitated objective comparisons between fossils and particular taxa.

The discrete character set permitted identification of three species from Kelly Hill Caves and five from Naracoorte Caves. *Ctenophorus decresii*, the only agamid species living on Kangaroo Island today, was only present in the most shallow sediments of Kelly Hill Caves (<6800 BP). Several specimens of *Rankinia diemensis,* which today is restricted to cooler and wetter environments over 900 km south and east of the fossil sites, were found at both locations from sediments older than 6800 BP. Thus during the glacial maximum, this cold-adapted species apparently expanded its range as far west as Kangaroo Island. Conversely several specimens from Kelly Hill older than 20 000 BP are referred to *Tympanocryptis lineata*, suggesting this taxon, found today on the adjacent mainland, may have disappeared from the Kangaroo Island region when the climate was coldest around the glacial maximum. Our combination of methods enables species-level identification and allows us to make some of the first strong inferences regarding squamate range changes associated with climate change during the last glacial cycle. This can in future be integrated with similar results from other taxa.

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Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

ORTHODENTINE MICROWEAR IN *MEGATHERIUM AMERICANUM* (XENARTHRA: MEGATHERIIDAE): DO MICROWEAR PATTERNS IN SLOTHS REFLECT HABITAT MORE THAN DIET?

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Xenarthran teeth (unique among most mammals in their lack of an outer enamel layer and being composed instead of orthodentine, vasodentine, and sometimes cementum) have recently been subject to a number of microstructure and microwear analyses. In this context, we here present new data on microwear patterns in the giant ground sloth, *Megatherium americanum* (Megatheriidae). Orthodentine wear facets on seven molariforms of *M. americanum* were cleaned, molded, and cast for microwear analysis. Two non-overlapping digital images were captured at 500x (20 kV operating voltage) on each tooth via scanning electron microscopy. Four quantitative variables [mean scratch number (S); mean pit number (P); mean microwear feature width (FW); degree of parallel orientation of all features (R)] were measured on each image using the semi-automated program Microware 4.02 under blind conditions by JLG. Results from *M. americanum* were statistically compared to previously collected data from living (*Bradypus*, *Choloepus*) and fossil sloths (*Acratocnus*, *Megalonyx*, *Thinobadistes*), all sampled using the same methodology by the same user (JLG). *Megatherium americanum* teeth have higher S (43.46) and lower P (6.43), FW (1.67 µm), and R (0.58) relative to previously sampled sloths, with the exception of *Thinobadistes*. A hierarchical cluster analysis (using all 4 variables, nearest neighbor linkage, taxon as grouping variable) revealed that *Thinobadistes* and *M. americanum* are most similar to each other relative to other sampled sloths. Relatively high S and low FW in *Thinobadistes* (a North American sloth that lived in open, arid habitats) have been suggested to represent grazing and/or the inclusion of high amounts of grit during feeding. Independent evidence of paleodiet (tooth morphology, snout shape, jaw biomechanics, attributed fecal matter) suggests that *M. americanum*, a South American sloth that inhabited open, arid habitats, was most likely a selective herbivore but not a grazer. We suggest that the presence of relatively high S and low FW in *Thinobadistes* and *M. americanum* compared to other sloths reflects the consumption of higher amounts of grit (rather than grazing) during feeding in an open habitat, as opposed to feeding in a closed-canopy, humid forest with less available grit; the latter reflects the interpreted habitat of all other sampled sloths. Thus, we observe a trend that orthodentine microwear in extinct sloths may reflect habitat and the relative consumption of abrasive grit as much as, if not more than, diet.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

SOFT TISSUES IN AN EOCENE SEA TURTLE HATCHLING PROVIDES CLUES ABOUT PRESERVATION AND TAPHONOMY

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Micrometer-sized bodies found within exceptionally preserved fossils have recently been interpreted as remnant melanosomes – eukaryotic, pigment-bearing cellular organelles. However, studies reporting remnant melanosomes have been met with controversy, and an alternative hypothesis has been put forth favoring a more conservative interpretation of the fossil microstructures as microbes colonizing the degrading tissues. Indeed, microorganisms have an extensive fossil record, are intimately associated with decaying organics, overlap in both size and morphology with melanosomes, and can even synthesize melanin. Hence, caution needs to be exercised before any inferences on biology and ecology are made from putative pigment traces.

We examined MHM-K2 (housed in Mo-clay Museum, Denmark), the arguably best preserved fossil sea turtle hatchling on record, using a broad array of sensitive chemical and imaging techniques. MHM-K2 is the holotype of *Tasbacka danica* (Testudines, Chelonioidea) and the specimen was collected from the Early Eocene Fur Formation of Denmark. The fossil is skeletally complete and includes a partial body outline preserved as a dark corona around the bones. FEG-SEM and TEM imaging of the presumed soft tissue remains revealed masses of solid, sub-spherical to ovoid bodies measuring about 0.5–1 µm in length and 0.3–0.8 µm in width. The microstructures were partially embedded in a porous, sponge-like matrix of probably biotic origin. ToF-SIMS analysis detected negative ions characteristic of animal eumelanin pigments associated with the soft tissue residues, a result that was further corroborated by IR microspectroscopy. These data provide novel insights into the preservation and taphonomy of this extraordinary fossil turtle at the sub-cellular level.

Technical Session X (Friday, October 16, 2015, 8:00 AM)

DOES THE MAXIMUM BODY SIZE OF THEROPOD DINOSAURS INCREASE ACROSS THE TRIASSIC-JURASSIC BOUNDARY? INTEGRATING PHYLOGENY, GROWTH, AND BODY SIZE

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Dinosaurs originated in the Late Triassic as small (i.e., 2–3 m long) generalists, but by the Early Jurassic they had evolved a wider range of body sizes than previously seen in terrestrial vertebrates. A sharp increase in the maximum body size of theropod dinosaurs, from ~75% the size of *Dilophosaurus wetherilli* to *D. wetherilli*-sized, has been reported across the T-J boundary in central Pangaea based on footprint data, but quantifying the maximum body size of Triassic theropod body fossils is necessary to enable comparison with large-bodied theropods of the Early Jurassic (e.g., *D. wetherilli*, 6 m long). Several larger Triassic theropods are known; e.g., *Gojirasaurus* and *Liliensternus* (~79% and ~70% the size of *D. wetherilli*, respectively), and we incorporated analysis of skeletal maturity of available specimens to better understand body size evolution. Because the dinosaur fossil record is dominated by immature individuals, ignoring indicators of the ontogenetic stage of specimens (i.e., osteohistology and skeletal fusion events) when undertaking an analysis of body size can skew results in such a poorly-represented group as Triassic theropods.

We assessed the maturity of two large neotheropods from the Late Triassic of New Mexico. We histologically sampled a partial isolated fibula, ~68% the size of *D. wetherilli*, with three lines of arrested growth (LAGs) and highly vascularized primary woven bone throughout, suggesting that rapid growth had not ceased. The other individual, represented by a partial postcranial skeleton, was ~56% the size of *D. wetherilli*. The tarsal elements of this individual are partially fused, and the pelvic elements are unfused. We found no LAGs in the rib and long bone cortex histology, and the highly vascular primary woven bone throughout suggests that this individual was still undergoing rapid growth. *Gojirasaurus* and *Liliensternus* individuals also lack tarsal and pelvic fusion.

The presence of these unfused skeletal elements, an indicator of skeletal immaturity in the closely related *Coelophysis bauri*, suggests that these individuals had not yet reached skeletal maturity, although they are of sufficient size to form the largest Triassic tracks in central Pangaea. Moreover, osteohistology of the two partial neotheropods indicates that the examined specimens were still rapidly growing. These data suggest that the sharp increase in theropod track size in central Pangaea is a local, not worldwide, trend. The maximum body size of neotheropods does not expand much or at all across the Tr-Jr boundary.

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Poster Symposia (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

REALITY OR FANTASY? ASSESSING THE CONDITION OF FOSSIL SPECIMENS WITH CT DATA

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Fossil specimens collected decades, or even centuries ago, are still critically important to modern scientific study. Unfortunately, the preparatory history of these specimens is commonly unrecorded, leading to confusion over morphological features.

An excellent example is found in *Simocyon primigenius*, the type species of the genus *Simocyon*. This genus is closely related to the red panda (*Ailurus fulgens)* and lived during the middle Miocene to the early Pliocene in North America, Europe, and Asia. The holotype of *S. primigenius* is a skull with associated lower jaws from the Turolian (late Miocene) deposits of Pikermi, Greece, and is stored at the Bavarian State Collection of Palaeontology and Geology, Munich. In addition to lateral deformation during fossilization, this holotype has several parts superficially filled by artificial material that partially hide its original morphology. We obtained high resolution three-dimensional data of the holotype using a CT scanner. We were able to identify clear density differences between not only the bone and matrix, but also the reconstructed anatomy-which was impossible to differentiate externally from bone by macroscopy. Artificial fillings are found in the right parietal and temporal (4–5 cm in certain areas), the dorsal premaxilla, nasals, maxilla, most of the left zygomatic arch (temporal), and the left upper and lower canines. As these elements do not constitute original anatomy of this holotype, their potential impact on former systematic studies needs to be checked and future use of the specimen in fossil comparisons, identifications, or studies of the intraspecific variation of *Simocyon* requires selective evaluation.

An additional example for which CT data unravel the past history of fossils can be found in the holotype of *Sinopa lania* (Creodonta) AMNH 13142, from the middle Bridgerian North American Land Mammal Age (middle Eocene) of southwestern Wyoming. The anterior rostrum and palate of this specimen has been filled in with artificial material, sculpted and colored in various areas to closely resemble natural bone. CT scanning not only revealed the large extent of artificial material, but also revealed that the left upper incisors were buried within this material. As this is the only skull, this increases our morphological knowledge of this taxon.

Our study thus highlights the importance of CT data for assessing preservation status of specimens and investigating their history from the point of discovery in the field to their management in museum collections.

Grant Information
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Technical Session IX (Thursday, October 15, 2015, 2:15 PM)

JAW AND MOLAR MORPHOLOGIES IN EARLY MAMMALS EVOLVED IN CONCERT TO ALLOW INCREASED OCCLUSAL COMPLEXITY

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The lower jaws of Mesozoic Era mammals show disparate morphologies. It is expected that differences in jaw shape correlate with biomechanical functions, molar morphologies, and diets. To examine potential correlations, I analyzed shapes and positions of posterior jaw processes belonging to 105 genera of Mesozoic mammals and nonmammalian cynodonts. For both the angular process and coronoid process, shapes were quantified and compared using semilandmark outlines subjected to two-dimensional geometric morphometric techniques, and mean shapes of processes were calculated for major mammalian groups. Further, the elevation of the condylar process relative to the base of the molar row was measured. Results indicate convergent jaw changes within three long-lived groups: cimolodontan multituberculates, australosphenidans (i.e., stem monotremes), and cladotherians (i.e., eutherians, metatherians, and close kin). These groups evolve an elevated condyle, a posteriorly positioned angular process, and a more inclined coronoid process. The jaw changes appear to have arisen in concert with greater grinding capabilities in the molars, suggesting a trend toward increased omnivory or herbivory. For instance, in early cladotherians, increased medially-directed movement of the working-side jaw during occlusion allows for grinding, or extended shearing, between cusps of the upper molar and the novel talonid of the lower molars. In addition, the extension of the posterior angular process produces changes in force vectors of the jaw adductor muscles-decreasing the mechanical advantage of orthal jaw movements while simultaneously increasing the mechanical advantage of medial jaw movements. Thus, the concurrent changes in jaws and molars provide strong evidence that oral adaptations in early mammals evolved in concert to allow more complex occlusion, likely accompanying a more omnivorous diet.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

ANATOMY OF *MAIASAURA* NEONATES FROM THE UPPER CRETACEOUS OF MONTANA (USA) AND THE EARLY ONTOGENY OF HADROSAURID DINOSAURS

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Nestling specimens of hadrosaurids discovered in the late 1970s by field crews from Princeton University and Montana State University were significant in providing definitive evidence of North American dinosaur nests and neonates. These specimens from the Campanian (Upper Cretaceous Two Medicine Formation of Montana) include YPM-PU 22400, a collection consisting of 15 skeletons that has been referred to *Maiasaura peeblesorum*. The neonate specimens have been utilized in a range of research including histological studies and muscle reconstructions. The preservational quality of the specimens is such that significant morphological characteristics, including muscle scars, are retained. Here, we redescribe YPM-PU 22400 and provide a more complete understanding of the morphology of these specimens, further distinguishing taxonomically relevant characters from those that are ontogenetically variable. Characters that support referral of these skeletons to *Maiasaura* include the presence of plantar ridges on pedal unguals. Other characters, such as the presence of a tooth row flush with the caudal margin of the coronoid process, appear to change with ontogeny. This collection also offers an opportunity to examine variation within this early ontogenetic stage. The few complete femora in the collection measure approximately 130 mm. An analysis of postcranial elements found an average humeral length of 73.1 mm with a standard deviation of 3.9 mm and an average tibial length of 119.6 mm with a standard deviation of 4.1 mm.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

FIRST FOSSIL RECORDS OF MEXICAN RODENTS *PEROMYSCUS DIFFICILIS* AND *NEOTOMODON ALSTONI* IN THE MIXTECA ALTA OF OAXACA, SOUTHERN MEXICO

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Recent record of Rodentia is moderately well known in Mexico. However, its fossil record has not been extensively studied; most reports come from central and northern Mexico and almost nothing is known from southern Mexico. A rich fossiliferous area in southern Mexico is located at northwestern Oaxaca, in the Mixteca Alta. This zone has a great diversity of late Pleistocene outcrops. Studied specimens come from two localities near the villages of San Antonio Acutla and Tejupam de la Union, from fluvial sediments. The maximum age of fossiliferous beds is of 60 ka, given the record of *Bison antiquus* in both localities.

Peromyscus difficilis and *Neotomodon alstoni* were discovered in an assemblage composed by a diversity of invertebrate and vertebrate species, including algae, freshwater mollusks and ostracods, continental mollusks, other rodents, lagomorphs, salamanders, indeterminate squamates and indeterminate amphibians. The late Pleistocene observed association of rodent taxa from the Mixteca oaxaqueña has been reported at modern environments in localities from central Mexico, thus indicating an autochthonous microfaunal assemblage. With the discovery of these specimens, temporal and geographical ranges of *P. difficilis* and *N. alstoni*are extended from Recent to late Pleistocene. Their records in the Mixteca Alta Oaxaqueña are the most austral for North America during late Pleistocene.

Currently, *N. alstoni* is distributed in the central and eastern sectors of the Mexican Volcanic Belt, with no records in Oaxaca or other southern Mexican states. Recent distribution could be a relict of a more extended range during the late Pleistocene. The Recent geographic range of *P. difficilis* is located mainly at medium to high altitudes from northern to southern Mexico. The late Pleistocene Oaxacan localities are within this range, indicating that this rodent species has been present in this area since at least the Rancholabrean. Both Pleistocene records provide a reference to a better understanding of the dynamics through space and time of both species.

Grant Information
Research funded by PROMEP Project 'Consideraciones paleobiológicas de las microfaunas continentales del Distrito de Teposcolula, Oaxaca...' and UMAR Project 2IR1502.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

PLIOCENE BATS (CHIROPTERA) FROM THE KANAPOI FORMATION, NORTHERN KENYA

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The Kanapoi Formation can be found in the southwestern part of the Turkana Basin in northern Kenya. Fossiliferous horizons are bracketed between three tuffs, which range from 4.108 to 4.195 Ma indicating an early Pliocene (Zanclean) age. Kanapoi is best known for producing the holotype and other specimens of the fossil hominin *Australopithecus anamensis* but several localities, among them most notably the Bat Site, have produced an abundance of fossil bat jaws, teeth and isolated bones. The Bat Site is located below the Upper Pumiceous Tuff, so is greater than 4.12 but less than 4.195 million years old. The Bat Site assemblage may represent an attritional accumulation of skeletal elements underneath a roosting area or an owl accumulation. There are three

distinct bat taxa known from Kanapoi, one pteropodid and two microbat species representing the family Molossidae. The pteropodid is represented by a single small upper first molar that is similar in size to extant *Micropteropus pusillus* and *Nanonycteris veldkompi*. The tooth resembles *Micropteropus* more than *Nanonycteris* in having a more gently sloping anterior surface and the sides of the tooth remaining parallel through their length producing an elongate and rectangular tooth. This tooth can be assigned to *Micropteropus* sp. indet. In addition to the fruit bat, there are abundant remains of two molossids from Kanapoi, differentiated mostly based on tooth size. The larger molossid is very similar to extant *Tadarida aegyptiaca* in sharing upper molars with distinct hypocone shelves on M1-2, small, high hypocones, two distinct ectoflexi, one anterior and one posterior to a distinct, rounded, buccally extended mesostyle, and a deep and buccally extended protofossa. The large form differs from *T. aegyptiaca* in having upper molars with broadly open trigons posteriorly, p2 larger than p4, and more robust premolars. The smaller Kanapoi molossid is similar in size and morphology to extant *Tadarida bocagei*, differing mostly in being somewhat smaller, in having upper molars with a more distinct hypocone and posteriorly open trigon and in having more robust premolars. The paleoenvironment at Kanapoi has been reconstructed as having been open, dry savannah grassland with some shrub and woodland areas developed along water courses. The bats support this interpretation. Extant *Micropteropus pusillus* typically lives in dry, open woodlands and roosts in the leaves of shrubs near the ground. African *Tadarida* species live in a variety of habitats including open woodlands and typically roost in trees.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

USING A HIGH SCHOOL PALEONTOLOGY CLASS TO DOCUMENT THE TERMINAL TRIASSIC PERIOD IN SOUTHEASTERN UTAH

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Comb Ridge in southeastern Utah exposes parts of the inland continental geologic record from the Late Triassic and Early Jurassic epochs of North America. Mission Heights Preparatory High School, a public charter college-preparatory high school located in rural southern Arizona, has been actively investigating this area for the past several years. One particularly rich microsite, dubbed The Hills Have Teeth, has produced the majority of the specimens collected by MHP students. Biostratigraphic work by staff and students indicates that this site dates from the latest Carnian or earliest Norian Stages of the Triassic Period. We have previously reported on the first occurrence of *Crosbysaurus* from the Chinle Formation in Utah from this locality. Along with *Crosbysaurus* other taxa have been collected from Comb Ridge such as phytosaurs, metoposaurs, and dinosauromorphs. Most taxa are represented by dental remains only.

Students have been involved in all aspects of the Comb Ridge project since its inception. Primary data collection in the form of specimens, stratigraphic information, and measurements have been conducted by MHP students. Several manuscripts are in preparation with students as the lead authors. Additionally, a student was the coauthor on our publication describing the first occurrence of *Crosbysaurus* from Utah.

Among the future expectations for the paleontology program at Mission Heights is that it will serve as a model for other schools elsewhere. We hope to inspire other schools and paleontologists to give students a hands-on field science opportunity such as this program offers. We also aspire to expand beyond Mission Heights and collaborate with students across the globe to create a generation more interested in science. Science is not only important in our schools, but a scientifically literate population is key for our future. Going forward, the paleontology program at Mission Heights will continue to investigate Comb Ridge and educate students in a hands-on way. We will continue to make students an integral part of all aspects in our future research.

Grant Information
Fieldwork has been partially supported by a Discovery Pool grant (grant no. BLM-3-2015) from the Canyonlands Natural History Association.

Technical Session XVII (Saturday, October 17, 2015, 1:45 PM)

ELASTIC TITANS: FUNCTIONAL ANALYSIS OF SAUROPOD NECKS REVEALS POTENTIAL FOR ELASTIC DAMPENING AND A NOVEL BLOOD FLOW ASSISTANCE MECHANISM

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The hugely extended neck of giant sauropods, while possibly advantageous in feeding, could have carried important energetic costs. Inertial effects could result in significant surges of the neck during locomotion. Moving blood to the upper neck and head could also be costly in sauropods, particularly if the neck was habitually elevated, since the cost of blood transport would be proportional to the total vessel area and the change in gravitational potential.

A new titanosaur specimen from New Mexico (LACM 7948) preserves undistorted cervical vertebrae in articulation, along with exquisitely preserved cervical ribs. Comparable 'ribs' in other sauropods have been previously demonstrated to be ossified tendons. The cervical ribs recovered for LACM 7948 are up to 1.8 meters in length, and overlap three vertebrae. The taphonomy and internal structure of the cervical ribs in LACM 7948 suggest that these structures were comprised of bone with relatively low material stiffness. This would reduce the compressive load resistance of the cervical ribs compared to prior models (since they would deflect under load). However, the higher elasticity and crescent cross-sectional shape would allow the cervical ribs to act as flat springs.

We created a serial flat spring model of the cervical ribs in LACM 7948. Our results indicate that elastic deformation of cervical ribs could dampen inertial surges of the neck during locomotion, especially if the neck was elevated. Our results also indicate that spring loading of the cervical ribs would have redirected some muscle forces towards the carotid vasculature in a step-wise fashion, allowing a small fraction of the power from cervical musculature to accelerate arterial blood. Even conservative calculations applying 1-3% of cervical muscular power to spring storage reduce the required mass of the heart by over 25%. We note that this mechanism of blood flow assistance would be intrinsically scalable with neck length, thereby alleviating potential constraints on neck size and posture.

Applied across sauropods, our model makes testable predictions about how cervical rib diameter, length, and sectional shape should correlate with neck length, diameter, and posture. Our model appears to accurately predict patterns of cervical rib structure in mamenchisaurs, brachiosaurids, titanosaurs, and diplodocids. Complete cervical ribs are still relatively rare in collections. Future recovery of more complete cervical ribs will provide additional testing for our model.

Grant Information
Gretchen Augustyn and family

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

TAPHONOMY, AGE, AND GEOLOGICAL CONTEXT OF THE ORIGINAL *LOTOSAURUS ADENTUS* (ARCHOSAURIA, POPOSAUROIDEA) BONEBED IN THE MIDDLE TRIASSIC BADONG FORMATION, HUNAN, CHINA

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Lotosaurus adentus is a highly unusual, sail-backed, edentulous poposauroid pseudosuchian archosaur known primarily from a single site in Sangzhi County, Hunan Province, south China. This locality, the *Lotosaurus* Quarry, is traditionally dated to the Anisian and is distinctive in being a dense bonebed from which dozens if not hundreds of individual bones and occasional partial skeletons of *Lotosaurus* have been collected since it was discovered in 1970. In 2012, members of our team returned to the *Lotosaurus* Quarry and excavated an expansive new section of the bonebed in a search for other Middle Triassic vertebrates. Over 600 new *Lotosaurus* bones were exposed and left in situ, and a protective structure was subsequently built over the site by the local authorities to facilitate future research and geotourism. Early in 2015, our team mapped the distribution of the exposed fossils and investigated the taphonomy of this important locality, few details of which were recorded during the original excavations. Our results indicate that the bonebed is a monospecific assemblage (with the exception of several non-*Lotosaurus* skeletal and dental elements), characterized by pervasive disarticulation, a lack of apparent damage from predators and scavengers, and a preferential orientation of elements. We also conducted detailed sedimentological analyses of the locality and other exposures of the Middle Triassic Badong Formation. In addition, we utilized U-Pb detrital zircon geochronology to better constrain the age of the locality and formation, and to help reconstruct sedimentary provenance patterns and paleogeography. The site appears to have formed in a fluvial-floodplain depocenter with sediment derived from multiple sources, rather than in a tidal flat setting as previously suggested. The presence of a population of unexpectedly young detrital zircons from the bone bed unit indicates that *Lotosaurus* is likely to be Ladinian in age, rather than Anisian as previously reported. This result is more congruent with the phylogenetic position of *Lotosaurus*, which lies among or just outside a grouping of derived poposauroids known from the Upper Triassic of North and South America.

Grant Information
National Natural Science Foundation of China (grants 41472017 and 41120124002)

Technical Session II (Wednesday, October 14, 2015, 8:45 AM)

THE FUNCTIONAL SIGNIFICANCE OF PTILOPODY IN EXTANT AND EXTINCT BIRDS

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Crural and tarsal feathers in fossil paravians are often interpreted as aerodynamic structures. By contrasting this with a review of the non-paleontological literature and specimens in ornithological collections, I show that crural and tarsal feathering, known as ptilopody, is not that unusual for modern birds and that caution should be used when inferring function for these structures in fossils. Ptilopody occurs across a wide range of extant avian taxa including martins, pigeons, caracallas, eagles, hawks, owls, and chickens. Breeders have artificially selected species of chicken and pigeon for high degrees of ptilopody and have worked out some of the genetics behind ptilopody in chickens. In silkie chickens, elongate leg feathering is controlled by three genes, 2 dominant (*Pti-1* and *Pti-2*) and one recessive (*Pti-3*). These genes may act either individually, or in concert to produce feathers along the leg. A variant form of leg feathering known as 'vulture hock' occurs in these chickens as a mutation related to leg feathering, in spite of continuous efforts by breeders to remove this trait. When the gene for 'vulture hock' is active, elongate, stiff, asymmetric, pennaceous and overlapping feathers project posteriorly from the leg, showing that it may be relatively easy for large, pennaceous feathers to suddenly arise in clades with otherwise plumaceous ptilopody. While some extant taxa have large crural feathers and may utilize them functionally to increase stability during dives, or to assist in maneuvering in-flight, most instances of ptilopody are unlikely to be aerodynamically significant, or beneficial to extant or fossil birds. In light of this reevaluation of the extent of ptilopody in extant birds, I show that recent arguments that fossil birds, such as *Confuciusornis* and *Cathayornis*, possessed functionally significant 'hindwings' which were used in a four-winged gliding phase should be reevaluated. Plumaceous feathers along the leg and foot are unlikely to produce aerodynamically significant lift. Only taxa with very large hind limb feathers, such as *Microraptor* and other microraptorines are likely to have had aerodynamically significant 'hindwings'.

Romer Prize Session (Thursday, October 15, 2015, 10:15 AM)

PALEOCENE PLACENTALS AND THE POST-CRETACEOUS RADIATION OF MAMMALS

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The end-Cretaceous mass extinction heralded the beginning of the 'Age of Mammals', with the first uncontentious crown placental mammal fossils appearing in the early Paleogene. Despite striking differences between the faunal composition and ecological niches of Mesozoic and Cenozoic mammal communities, many studies find no change in evolutionary rate or morphological disparity for eutherian mammals across the Cretaceous-Paleogene (K-Pg) boundary. However, few studies have explicitly considered early Paleogene taxa, largely due to a lack of a resolved phylogeny.

I first coded 680 morphological characters for 177 mostly Cretaceous or Paleogene eutherians-those closest in time to the extinction event. I dated the resultant trees using maximum likelihood methods, reconstructing the origin of Placentalia in the latest Cretaceous, but the diversification of most internal crown nodes in the Cenozoic. I then reconstructed ancestral character states on the dated topologies, and binned branches into stage-level bins. I compared the rate of accumulation of character changes across the phylogeny and among time bins, identifying a significant increase in evolutionary rate associated with the K-Pg boundary, and with several internal branches of crown Placentalia.

Finally, I assessed the change in morphological disparity of eutherian taxa through time. Taking the reconstructed ancestral character distributions for all internal nodes and terminal tips, I calculated mean pairwise distance (MPD) among taxa, and sums of variances (SV) and ranges (SR) of morphospace occupation for each bin. MPD and SV were stable for most of the Mesozoic, with a decrease in disparity from the Campanian to the Maastrichtian. No significant change occurred over the K-Pg boundary, and both measures then increased to the middle Eocene. SR values remained low during the Cretaceous, increasing suddenly at the end-Cretaceous.

This pattern suggests a three phase model of eutherian evolution across the K-Pg boundary. (1) Extinction of most stem eutherians during the Campanian, and initial diversification of crown and near-crown eutherians, leading to reduced average morphological dissimilarity. (2) Extinction of most remaining stem eutherians at the K-Pg boundary, and rapid taxonomic diversification of Placentalia alongside high rates of evolution and exploration of morphospace in the early Paleocene. (3) Ecological specialisation and separation of placental groups in morphospace throughout the Paleogene, increasing morphological disparity to present day levels.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

MORPHOLOGICAL VARIATION IN *PTYCHODUS MORTONI* (ELASMOBRANCHII: PTYCHODONTIDAE)

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Diagnosis of Late Cretaceous shark *Ptychodus mortoni* is largely due to teeth possessing a high conical crown with ridges that radiate from a single point at the apex. Morphological variation in newly recovered articulated and associated tooth sets from the Boquillas Formation and the Penn Formation in the Big Bend region of Texas prompted a review of specimens referred to *P. mortoni.* This study has revealed nine different tooth morphologies, all ranging from the lower middle Turonian to Santonian age (~92.5 Ma-~84 Ma) of the Late Cretaceous. There appears to be some temporal segregation of morphotypes, but the influences of ontogeny, individual variation, regional variation, and anagenic change are poorly understood at this time due to sample size and prior lack of recognition of variation in the literature. Nonetheless, the diagnosis of *P. mortoni* at this point is too general and does not document the range of morphologies present in this taxon, and thus limits its potential biostratigraphic utility. This study provides new data on morphological variation within *P. mortoni* in a temporal framework that may improve the biostratigraphic utility of this taxon in the future.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

ANCESTRAL RECONSTRUCTION OF SKULL FORM IN OLD WORLD LEAF-NOSED BATS (HIPPOSIDERIDAE AND RHINONYCTERIDAE) USING GEOMETRIC MORPHOMETRICS

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Old World leaf-nosed bats (Hipposideridae and Rhinonycteridae; 65 extant spp.) have an Old World tropical to subtropical distribution, with a fossil record extending back to the middle Eocene of Europe. They emit pure-tone echolocation calls through the nostrils that allow detection of fluttering prey around vegetation, and have expanded nasal chambers that are associated with energy transmission. Call frequencies are species specific, facilitating resource partitioning. Generally there is an inverse relationship between body size and call frequency but, in species of similar body size, nasal chamber size can vary conspicuously.

Standard craniodental features and measurements traditionally used in mammalian phylogenetic and morphometric analyses do not fully capture differences between Old World leaf-nosed bat taxa. Current species diagnostic tools may be improved by the use of geometric morphometrics to quantify skull form, and particularly to extract novel characters describing nasal chamber shape.

We used (2D) geometric morphometrics (1) to examine skull shape in Old World leaf-nosed bats of the families Hipposideridae and Rhinonycteridae; (2) to refer unallocated Australian and European Eocene, Oligocene and Miocene species to each family within a phylogenetic framework (using molecular constraints); and (3) to reconstruct ancestral skull form for key clades in these Old World radiations. Our sample included the skulls of 24 extant species and 10 extinct species of hipposiderids and rhinonycterids, in which 30 landmarks and semi-landmarks were placed in lateral and ventral views.

Clades generally formed distinctive clusters in morphospace. Hipposiderids showed greater variability in skull shape than rhinonycterids, except when extinct taxa were included in the analyses. While hipposiderids appear to be at least as diverse today as in the past, several Oligo-Miocene rhinonycterid clades are absent from modern bat communities. These extinct clades represent distinctive ecomorphs that appear to have been mostly replaced by related bat lineages. Other ecomorphs have been completely lost, possibly as Old World subtropical palaeoenvironments shifted in the later Cenozoic from rainforest habitats to the open forests and grasslands in which the few surviving rhinonycterids now live. By tracing the evolution of skull shape across a new phylogenetic framework, we reconstructed the probable skull form for the common ancestor of Hipposideridae and Rhinonycteridae and make predictions about its early Eocene hunting grounds.

Grant Information
This research is supported by Australian Research Council grant DP130100197.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

A JUVENILE SAUROPOD FROM THE MORRISON FORMATION OF NORTH AMERICA

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An articulated sequence of five partial dorsal vertebrae (Carnegie Museum [CM] 79038) from an exposure of the Upper Jurassic (upper Kimmeridgian) Morrison Formation at the Carnegie Quarry at Dinosaur National Monument is described. The small size (centrum length approximately 9 cm) and unfused sutures between the neural arches and centra suggest that the specimen belongs to a skeletally immature individual. The deep lateral pneumatic fossae ('pleurocoels') and pronounced lamination of the neural spines and arches, inclusive of spinodiapophyseal, prezygoparapophyseal, and centroparapophyseal laminae, indicate eusauropod affinities; given the spatiotemporal provenance of the specimen, it is most likely that of a neosauropod. The simplicity of the lamination points to a basal neosauropod, potentially *Haplocanthosaurus* or the basal macronarian *Camarasaurus*, although the ontogenetic immaturity and generally plesiomorphic nature of the specimen make it difficult to determine potential affinities within that group. Here we suggest that, based upon the presence of conjoined prezygodiapophyseal and paradiapophyseal laminae in the mid-dorsal vertebrae and the significantly dorsolateral orientation of the transverse processes, CM 79038 likely represents a juvenile *Haplocanthosaurus.* If it does indeed represent *Haplocanthosaurus*, CM 79038 would represent both the presumably youngest specimen and the highest stratigraphic occurrence of the genus yet known.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

AN EARLY ARIKAREEAN (MIDDLE OLIGOCENE) MAMMAL ASSEMBLAGE FROM WEST CENTRAL MONTANA

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A mammalian faunal assemblage from the Six Mile Creek Formation in west central Montana is termed the White Earth local fauna. This fauna, collected from two neighboring localities, is characterized by abundant specimens of the large oreodont *Megoreodon grandis,* with an additional 21 mammalian taxa presently identified. Three species of didelphid marsupials- *Herpetotherium youngi, Copedelphys stevensoni*, and a larger, possibly new, species of *Copedelphys* are recorded. A bat (Chiroptera, species unknown) and the leptomerycid *Pronodens silberlingi* are represented by single specimens. Rodents include *Prosciurus* sp., *Palaeocastor* cf. *P. peninsulatus, Leidymus* sp., *Paradjidaumo trilophus,* and two others yet unidentified. Four additional taxa of oreodonts are known- *Mesoreodon chelonyx, Merycoides pariogonus, ?Merycoides longiceps,* and *Cyclopidius* sp. Other mammalian taxa include *Pogonodon platycopis, Cynodesmus thooides, Daeodon hollandi, Diceratherium annectens, Miohippus* sp., and a large camelid. Non-mammalian fossils include a single gastropod and two chelonian carapace/plastron specimens. The presence of fragmentary fish fossils suggests an aquatic depositional environment. Large bird tracks (Gruiformes?) have recently been discovered. Several mammal specimens have apparent scavenger damage and others show obvious weathering effects.

This fauna contains a number of taxa in common with the early Arikareean Cabbage Patch and Deep River/Fort Logan faunas of Montana, and correlates with the Gering and Monroe Creek Formations of the northern Great Plains and with the Turtle Cove member of the John Day Formation in Oregon. The paucity of key species from the White Earth local fauna does not presently allow a precise correlation to the other Montana localities, but it shares the greatest number of taxa with the Cabbage Patch fauna, located approximately 100 km to the west. Most of the taxa in the White Earth local fauna are components of the Arikareean NALMA, but two taxa (*Copedelphys, Prosciurus*) have published ranges ending prior to the start of the Arikareean. *Leidymus, Daeodon,* and *Pronodens* have their first appearance at or just above the Whitneyan/Arikareean boundary. Based on the first appearances and the two taxa previously known only from earlier occurrences, the data best support an early Arikareean (Ar1) assignment.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

TESTING THE VALIDITY OF PUBLISHED MORPHOLOGICAL CHARACTER DESCRIPTIONS OF NORTH AMERICAN PLEISTOCENE LIZARDS REFERRED TO THE GENUS *SCELOPORUS*

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Sceloporus is a diverse group of iguanian lizards distributed across much of North America and Central America. At least 97 species are currently recognized in the extant biota, and *Sceloporus* is well represented in the Pleistocene fossil record of North America. We surveyed 145 publications that document primary descriptions of fossils referred to *Sceloporus* from the North American Pleistocene. Less than 3% of those publications (n = 4) relied on apomorphies to facilitate identification of specimens. The primary literature is, thus, dominated by specimen identifications that were made under different philosophical and methodological approaches than those that center on apomorphies. Taxonomic identifications in the literature were based on general resemblance criteria, limited comparative statements restricted to (purported) differentiation of only two taxa, and a strong reliance on geographic distribution of modern species to limit the pool of species with which comparisons of fossils were made. Although many morphological characters used in the literature are difficult to render in an apomorphy-based framework, they may still be useful for taxonomic discrimination (they were, after all, deemed by previous authors to have some merit for taxonomic discrimination). In an effort to understand the potential efficacy of published characters for discriminating *Sceloporus* from the related iguanian lizards *Uta* and *Urosaurus*, and for discriminating among species of *Sceloporus*, we evaluated all characters across a comparative sample of 14 extant North American species of those three groups. For 11 of those species we had more than ten individual skeletal specimens, and for four of them sample sizes exceeded 50 specimens. Our total comparative sample allowed us to assess published characters across both sexes, across ontogenetic ages, and across broad geographic space. Patterns of intraspecific variation for most of the purportedly diagnostic features equal or exceed the differences observed between species. Almost all characters published in the literature to identify fossil specimens have no power to discriminate reliably between *Uta*, *Urosaurus*, and *Sceloporus*, nor between species of *Sceloporus* we examined. If we are to obtain meaningful data from the fossil record for these groups, we must develop a more thorough understanding of patterns of morphological variation within extant lizards, and utilize those data in a search for morphological features that may help to identify fossil specimens with greater reliability.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

NEW TAENIODONT REMAINS FROM THE EARLY EOCENE WILLWOOD FORMATION, BIGHORN BASIN, WYOMING

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Taeniodonts are a Cretaceous and Paleogene clade of relatively large-bodied eutherians that have left a sparse fossil record mainly in regions associated with Laramide uplift in the Western Interior of North America. Obvious morphological trends in this group's history include increasingly hypsodont and simplified cheek teeth, enlarged and eventually evergrowing canines, and progressively more powerful forelimb leverage, especially in the family Stylinodontidae.

Recently collected skeletal material from Wasachian-7 ('Lostcabinian') strata of the Willwood Formation, Bighorn Basin, Wyoming presents new details of the hind limb morphology of a derived taeniodont (cf. *Ectoganus*). Elements recovered include vertebrae, fragmentary pelves, proximal femur, tibia and astragalus. Comparative evidence is provided to exclude relationships with other large Paleogene taxa endemic to the intermountain basins of the American Rockies, and to affirm reference of these fossils to Taeniodonta. The material presented here includes the most completely preserved tibia and only preserved astragalus of Stylinodontidae from the Wasatchian.

Preliminary review of astragalar characteristics shows that cf. *Ectoganus* had a morphology typical of coeval plantigrade eutherians, with a hemispherical navicular facet and a generally quadrate outline. One notable derived character of the astragalus is the reduction or loss of the astragalar foramen, which allowed for greater dorso-ventral excursion at the tibial articulation. Compared to the astragalus known in later *Stylinodon mirus,* this specimen is of similar size, but has a lower more cylindrical tibial articular surface, and more rounded features generally.

Initial interpretations of this astragalar morphology suggest that locomotion in these taeniodonts was generally slow and inefficient over long distances. Additionally, the lack of capabilities for extreme abduction at the hip joint or extreme eversion of the pes, suggest that these animals were mostly adapted for digging superficial, as opposed to extensive, burrows. However, this morphology is consistent with the use of gravity to brace the hind limbs against reaction forces generated while digging with the forelimb, similar to modern large diggers.

Grant Information

Field work resulting in discovery of the new specimen was supported by a grant from the National Geographic Society to A.E. Chew.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

RESOLVING DEEP DIVERGENCES: A FOSSIL-CALIBRATED PHYLOGENY OF THE AELUROIDEA

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The carnivoran clade Aeluroidea includes the living families Nandiniidae, Felidae, Hyaenidae, Viverridae, Herpestidae, Eupleridae and possibly Prionodontidae. This group underwent several rapid radiations early in their evolutionary history and there has been ongoing debate regarding the precise timing and order of diversification for the constituent families. In addition to this, evidence has been accumulating that suggests that the viverrid genus, *Prionodon*, should be elevated to its own family, Prionodontidae, and that Prionodontidae is more closely related to Felidae than to Viverridae. Resolving these issues is of high importance since most workers who study patterns of morphological and ecological change depend on the context that a high-quality, well-supported phylogeny can provide.

Here, we present two phylogenies for the aeluroid Carnivora. The first is a fossil-calibrated molecular phylogeny that includes over forty extant aeluroids evenly sampled from across the clade. In addition to clearly establishing the order and timing of the family-level divergences, this molecular phylogeny also helps clarify the phylogenetic position of Prionodontidae. The second phylogeny incorporates morphological data from both living and fossil species into the data matrix and helps establish the phylogenetic position of fifteen fossil species. We use this second phylogeny to trace patterns of phenotypic change relating to diet and to assess the influence of correlated environmental pressures on diet, phenotype, and biogeographic patterns.

Grant Information

NSF DDIG # 050-8848 to Jill A. Holliday, NSF DEB # 0108450 to Scott Steppan

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

USING ECOLOGICAL MODELLING TO QUANTIFY THERMAL CONSTRAINTS ON TWO LATE TRIASSIC DINOSAURS

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Recent geochronology has shown the End Triassic Extinction coincides with the initial rifting of the Atlantic basin and the emplacement of the Central Atlantic Magmatic Provinces. A carbon isotope excursion suggests a massive (12k-38k gigatons) input of CO_2 in less than 1 Ma, which lead to global warming events of 6-8 degrees Celsius. Other authors have suggested that warming caused the terrestrial extinctions, however, the connection between climate change and the proximate causes of extinction (e.g., heat stress) and extinction selectivity can be difficult to disentangle.

We used the physiological modelling program Niche Mapper to estimate the thermal constraints of tetrapods living in a hothouse world during the End Triassic Extinction. For the first stage of the project we evaluated two taxa, *Coelophysis* and *Plateosaurus*. The selection of two saurischian dinosaurs emphasizes the role of mass and shape in mediating heat exchange between an organism and the environment and thereby minimizes confounding phylogenetic differences in life history, locomotion, and energy demands. We examined heat stress for the two taxa under a broad range of physiological and environmental interpretations, and an estimated ontogenetic series. We also ran simulated "metabolic chamber" analyses to estimate thermal equilibrium in *Coelophysis* and *Plateosaurus*.

Our results support the plausibility of elevated metabolic rates in Triassic saurischian dinosaurs during global warming events, and suggest that the elongate bauplans may have increased heat radiation while minimizing the absorption of solar radiation during diurnal activity. We also find that young individuals were at significant risk of thermal stress, indicating that rapid growth may have been a key survival strategy for species too large to easily avoid peaks in daytime temperatures.

Technical Session VIII (Thursday, October 15, 2015, 2:15 PM)

THE DIVERSE DIETS OF THE MIO-PLIOCENE CARNIVORANS OF LANGEBAANWEG, SOUTH AFRICA

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The Mio-Pliocene guild of carnivorans found in Langebaanweg (LBW), South Africa, is both phylogenetically and ecologically diverse. Unlike the modern African fauna, this fossil sample contains a large ursid (*Agriotherium*). Although there are mustelids, herpestids and viverrids in Africa today, some of the LBW members of those families were much larger than any of the modern forms. There were also numerous felids including forms that approach a more saber-toothed morphology. The LBW hyaenids were also substantially different than modern forms although these were smaller than extant confamilials. This diverse guild contained both small and large species substantially different than any modern carnivore guild, and thus questions remain about the dietary morphospace that individual families within the guild occupied. Which taxa were the durophages and which were the most hypercarnivorous and did the level of durophagy and hypercarnivory in the LBW taxa reach the level of specialization found in modern carnivores? In the current study, we evaluate the dietary specializations through analysis of the radii-of-curvature (ROC) and intercuspid notches (ICN) of all of the large carnivorans found at Langebaanweg. We found that, although not as specialized as modern hyenas, the LBW hyenas were the most durophagous members of the guild. The LBW mustelids were also fairly durophagous as were, rather surprisingly so, the LBW viverrids. The giant *Agriotherium* exhibited a suite of morphology unlike any other large carnivoran-exhibiting some pieces of morphology that appear rather durophagous while others that place it among the most hypercarnivorous of modern carnivorans. In this respect, *Agriotherium* apparently used its teeth differently than any modern carnivoran and was capable of consuming high levels of both flesh and bone.

Grant Information

This project was funded by numerous grants from the University of South Carolina.

Technical Session XVI (Saturday, October 17, 2015, 11:30 AM)

RARE IN SITU PRESERVATION OF ADULT CROCODYLIAN WITH EGGS FROM THE MIDDLE EOCENE GEISELTAL FOSSILLAGERSTÄTTE, GERMANY

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Parental care is found in all extant archosaurs (crocodylians and birds) and parsimony suggests this behavior is homologous. This concept is supported by known 'parent atop eggs' fossils of non-avian theropod dinosaurs (ancestors to birds), but no equivalent fossils for crocodylians have been reported yet within this context. Here we present a remarkable fossil of an adult crocodylian, *Diplocynodon darwini*, preserved *in*

situ with eggs from the Middle Eocene of Geiseltal, Germany, providing rare evidence for the antiquity of parental care in the crocodylian lineage.

Size relationships between the fossil adult and eggs are consistent with known relationships between mother snout-vent length and egg length in extant relatives (*Alligator* and *Caiman*). The fossil was collected from a large site with hundreds of vertebrate fossils preserved within a single stratigraphic horizon. Thorough documentation of the site demonstrates that no other crocodylian fossil was found within 12 m of the eggs. Compass orientations of 204 vertebrate skeletons, primarily fish, found within 1 m of the crocodylian fossil do not indicate that past water current influenced the unusual curled posture of the adult. The presence of the eggs with the adult strongly indicates sexual maturity, yet the adult did not exhibit full fusion of the neurocentral sutures, a common indicator of morphological immaturity in non-avian archosaurs. This fossil highlights the potentially important difference between sexual and morphological maturity.

The degree of articulation, the atypical posture of the adult, the position of the eggs, and the surrounding sediment indicate the adult may have died atop its nest after oviposition. The Geiseltal region was subtropical during the Middle Eocene, with a Coldest Month Mean Temperature (CMMT) estimated at 16.9–23.0°C based on fossil plants. Even in the subtropics, temperatures can drop below cold-tolerance for warm-adapted crocodylians for a short time, as seen in the Florida Everglades in 2010 (CMMT = ca. 20°C), resulting in the death of 70 American Crocodiles (*Crocodylus acutus*) and thousands of fish. The scenario of short-term, cold-induced event mortality at Geiseltal remains at least a possible explanation for the death of the adult and the young inside the unhatched eggs. Although still indicating egg attendance, the fossil may alternatively indicate the mother died from dystocia ('egg-binding') during oviposition, which would be to our knowledge the first record of this rare phenomenon in a fossil archosaur.

Grant Information
Kulturstiftung des Bundes (Federal Cultural Foundation, Germany): International Museum Fellowship program

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

QUANTITATIVE ANALYSIS OF FOSSIL CROCODYLIAN TEETH TO IDENTIFY A POTENTIAL JUVENILE REFUGE OR NESTING GROUND IN THE MIOCENE OF PANAMA

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Nesting behavior in modern crocodylians has been well studied, but its presence in the fossil record is difficult to establish and quantify. The abundance of small crocodylian teeth at the Panamanian Miocene fossil locality 'Hodge's Hill' suggests that the area served as a hatchery/refuge for juvenile crocodylians. Variation in tooth morphology is substantial enough to distinguish between adults of small species with blunter dentition (durophagy), and juveniles of larger species with more conical dentition (piscivory). Moreover, tooth size may be used to approximate body size. If we find that the teeth from Hodge's Hill are significantly smaller than teeth from coeval nearby sites and are indistinguishable in size from modern yearling crocodylians, then this would support our interpretation of Hodge's Hill as a nesting ground or juvenile refuge in the Miocene.

Our study included teeth from sites Centenario #2 (C2), #6 (C6), and Hodge's Hill (HH) of the Cucaracha Formation (n =444) and Las Cascadas (LC) and Lirio Norte (LN) of the Cascadas Formation (n = 33). All teeth were measured on three axes: crown height (CH), basal width (BW), and fore-aft basal breadth (FABB). Each tooth was assigned to a shape category: blunt, button, conical, recurved, spade, or broken. For a modern comparison, we measured total body length and CH of all teeth for 49 yearling American alligators (*Alligator mississippiensis*). Statistical analyses of the data showed that conical teeth were the most common category in all five localities (29–67%), suggesting low durophagy at all sites. Hodge's Hill was consistently composed of smaller teeth than other sites (non-parametric Kruskal-Wallis test). Teeth from HH had a smaller BW (mean = 2.46 mm) than C6 (3.2 mm, $p<0.001$) and LN (5.4 mm, $p<0.001$); smaller CH (mean = 4.82 mm) than C2 (6.73 mm, $p=0.038$), C6 (6.59 mm, $p<0.001$), and LN (7.7 mm, $p<0.001$); and smaller FABB (mean = 4.39 mm) than C6 (4.19 mm, $p<0.001$) and LN (5.4 mm, $p = 0.005$). When compared to yearling alligators, CH from HH was significantly larger (1.27 mm, $p<0.001$). These results indicate that HH likely represents a community of young individuals, possibly a refuge for sub-adult crocodylians. Recovery and identification of even smaller teeth from screen-washed sediment may indicate that the area also served as a nesting ground. Our results demonstrate that the high abundance of crocodylian teeth in the fossil record can provide a quantitative method for interpreting demography and can clarify the timing and development of specific reproductive behavioral strategies in this group.

Grant Information
Panama Canal Project - Partnerships for International Research and Education (PCP-PIRE), U.S. NSF grant 0966884 (OISE, EAR, DRL)

Symposium 3 (Saturday, October 17, 2015, 8:30 AM)

SNAKING THROUGH A GRADIENT: COMBINING GEOMETRIC MORPHOMETRICS AND MAXIMUM LIKELIHOOD TO MODEL AN ANATOMICAL CONTINUUM

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Geometric morphometrics (GM) is the standard analytical tool for quantifying biological shape. Shape variables derived from GM are used in exploratory methods such as principal components analysis and cluster analysis and in statistical methods such as regression, analysis of variance, and comparative phylogenetic tests. However, many problems in paleontology are better expressed in terms of model selection. Geometric morphometrics can be embedded in model selection frameworks like maximum likelihood (ML) and Bayesian analysis whose goal is to select the best hypothesis or model given an empirical set of data. We show how GM and ML can be combined to address problems as basic as specimen identification or as sophisticated as testing competing scenarios about the origin and diversification of a clade.

We focus on the vertebral column of extant and fossil amniotes, especially snakes, in which the shape of successive vertebrae form an anatomical continuum that can confound ordinary exploratory and statistical morphometric analyses. Using a baseline of GM characterizations of the shape of successive vertebrae from multiple taxa, maximum likelihood can be used to find the best placement of an isolated vertebra by finding the position that maximizes its fit given the variation among taxa. The likelihood framework not only identifies the best hypothesis for the position of the isolated bone, but the relative likelihood of other positions can be assessed.

GM and ML can also be used to evaluate competing scenarios about the evolution of axial regionalization. Developmental studies suggest that the origin of the elongate snake-like body form involved modification of standard Hox expression to "de-regionalize" the axial skeleton. We combined GM and ML to objectively assess the amount of regionalization in the vertebral column of snakes, other elongate squamates, limbed squamates, mammals, and archosaurs by applying segmented linear regression to shape variables that describe intracolumnar variation. The likelihood framework finds the best model of regionalization for each taxon, and can be used to evaluate competing hypotheses whether morphological boundaries match Hox express boundaries and whether regionalization decreased in origin of snakes and other long-bodied squamates. We found that there were no differences in regionalization between snake-like and limbed amniotes, and that morphometric boundaries correspond to Hox expression patterns in taxa where the latter are known.

Grant Information
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Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

A MARINE REPTILE IN THE STEELE SHALE: A NEW LOOK AT THE WESTERN INTERIOR SEAWAY IN THE HANNA BASIN, WYOMING

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Exposures of the Late Cretaceous (Campanian) Steele Shale are found in the northern part of the Hanna Basin in south-central Wyoming. The fauna from the Steele Shale is only poorly known from a limited number of localities and consists predominantly of invertebrates and isolated shark teeth. Marine reptiles are especially scarce and have never been formally reported from this area.

Recent field work uncovered a new locality yielding at least two genera of sharks (*Squalicorax* and *Scapanorhyncus*), at least one genus of ammonite, and an assortment of highly selenitized mollusk fossils, presumably pelecypods. A number of bone fragments were also discovered but were too fragmentary and weathered for identification based on morphology alone. Thin-section analysis of the bone histology found with reasonable certainty that these bone fragments belong to a marine reptile. The orientation of primary and secondary osteons and the thickness of the cortical bone strongly suggest that the reptile belongs to the family Mosasauridae, which has been reported from localities further to the north in Wyoming. There is also the possibility that these remains are plesiosaurian, which has never been reported for this unit.

At this new locality, the Steele Shale coarsens upward from a muddy shale into a fine grained sandstone interbedded by a very thin lens of shale. Ammonites are most prominent in the shale and mud layers and are infilled by the same material. The pelecypod shells and marine reptile were found mostly in the coarse-grained strata toward the top of the local section. This progression suggests a shallower environment than the 200 m previously asserted, possibly a prodelta to inner shore (~60-100 m), that was experiencing shallowing at this time.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

BONE GROWTH IN THE NINE-BANDED ARMADILLO (*DASYPUS NOVEMCINCTUS*): IMPLICATIONS FOR EXTINCT TAXA

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Increasing importance has been placed on bone microstructure studies of extant organisms to better interpret the fossil record. For instance, studies examining extant crocodylians, aves, and mammals help describe and interpret extinct tetrapod growth. Nine-banded armadillos (*Dasypus novemcinctus*) are common taxa throughout the southern United States. Although armadillo biology has been studied extensively, work on growth rates is limited. Here we describe long bone microstructure in an ontogenetic series of nine-banded armadillos to elucidate patterns of bone growth. Primary woven bone of fibrolamellar organization is present in the smallest specimen. The smallest individual displays signs of erosion on both the periosteal and endosteal surfaces. The primary tissue becomes remodeled extensively into compacted coarse cancellous bone throughout the cortex of the larger specimens. Primary tissue near the trochanteric side of the femora is the last area of the cortex to undergo remodeling. In the larger specimens, multiple layers of avascular lamellar bone are deposited along the eroded endosteal surface, leaving behind faint tide lines. Avascular lamellar bone is also deposited along the periosteal surface, but this deposition is completed later in femoral bone growth. Circumferential growth lines are evident in the large specimen on the trochanteric side, but merge onto the periosteal surface away from the trochanter. Bone development and growth in nine-banded armadillos appears to be a unique process that requires further investigation. Understanding the full developmental process can provide a framework for use on extinct cingulates and other extinct taxa.

Grant Information
Montana State University Undergraduate Scholars Program

Technical Session XVI (Saturday, October 17, 2015, 8:30 AM)

VARIATION IN THE ORNAMENTATION PATTERN OF AETOSAUR (ARCHOSAURIA: SUCHIA) OSTEODERMS: TAXONOMIC AND PALEOBIOLOGICAL IMPLICATIONS

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The Aetosauria are a clade of crocodile-line archosaurs known from Upper Triassic strata across much of the world that possess paired columns of paramedian and lateral osteoderms that parallel the vertebral column to form a carapace. These osteoderms constitute the most abundant aetosaur fossils and vary in size, shape, and ornamentation, so workers have striven to determine the extent to which osteoderm morphology is diagnostic of taxa, especially as multiple aetosaur taxa are known entirely from their armor. Due to a paucity of reasonably complete specimens, addressing intraspecific variation (e.g., positional, ontogenetic, or dimorphic) in osteoderms has been especially difficult. Aetosaur osteoderms exhibit a pattern of ornamentation that consists of pits, grooves, and ridges, often emanating from a keel or boss sometimes termed the 'center of ossification' (CO). Historically this pattern was usually described as either 'radial' or 'random'. More recently the 'radial' pattern was subdivided into three sub-patterns: 'radial', 'intermediate', and 'anastomosing', with the key difference between the radial and anastomosing end-members being the length and shape of the ridges bounding pits and grooves. Concurrently, histological studies recently demonstrated that relatively primitive aetosaurs such as *Aetosauroides* often preserve LAGs (lines of arrested growth) in the basal cortex of paramedian osteoderms, providing a means of estimating age, and therefore growth rate, that is independent of raw size or suture closure, and confirming that the CO is appropriately named.

Because multiple articulated carapaces of *Aetosauroides* preserve a LAG record, variation in osteoderm pattern within a carapace can be described relative to the specimen's ontogenetic age. In individual specimens, the narrower osteoderms exhibit a more anastomosing pattern and the broader ones a more radial one. Furthermore, in two individuals of similar size but different ontogenetic ages, the older specimen exhibits more of an anastomosing pattern and the younger a more radial one in homologous osteoderms (e.g., those from the same row). Thus, even in specimens where LAG archives are not known, ornamentation patterns may reflect growth rates. This impacts interpretation of several characters used in phylogenetic analyses, as the placement of the CO should be considered more taxonomically informative than ornamentation pattern alone, and renders the identification of isolated osteoderms even more problematic than previously thought.

Grant Information
Off-campus scholarly assignment from the Department of Geology and a Board of Trustees International Research Grant at Appalachian State University

Technical Session VII (Thursday, October 15, 2015, 3:30 PM)

QUANTIFYING THE IMPACT OF DIAGENETIC DEFORMATION OF DINOSAUR FOSSILS ON GEOMETRIC MORPHOMETRICS STUDIES

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Geometric morphometrics has emerged as a powerful method to statistically analyze shape in fossil specimens to better understand biologic shape change. However, all vertebrate fossils have undergone some level of diagenetic deformation and the degree to which diagenetic deformation impacts shape studies has not yet been quantified. To test whether shape studies of fossils are strongly impacted by diagenetic deformation, I examined an intraspecific sample of the basal ceratopsian dinosaur *Psittacosaurus* using three-dimensional geometric morphometrics. The specimens were all found in the same locality and the same beds of the Yixian Formation, thus eliminating geographic and temporal variation. This study demonstrated that diagenetic deformation has the potential to drive location in morphospace, obscuring biologic shape and making the assessment of intraspecific and ontogenetic variability using geometric morphometrics on fossils challenging. However, this analysis alone did not directly quantify the magnitude of diagenetic deformation. Fluctuating asymmetry is a method for analyzing the random right-left asymmetry that occurs during development in modern organisms. In order to determine the magnitude of diagenetic deformation in a fossil sample, I compared the fluctuating asymmetry of *Psittacosaurus* and Red-tailed Hawk (*Buteo jamaicensis*) girdle and long bones (scapula, humerus, ilium, femur) using multi-factor ANOVAs. Effect size metrics were used to determine the percent of total variation in fluctuating asymmetry for each bone of each animal. The left-right asymmetry in the Red-tailed Hawk is entirely biologic in nature; it has not undergone diagenetic deformation and provides a proxy for biologic asymmetry. The magnitude of diagenetic deformation was quantified by subtracting the fluctuating asymmetry of the Red-tailed Hawk (biologic asymmetry) from that of *Psittacosaurus* (both diagenetic-based and biologic asymmetry). The levels of diagenetic deformation in *Psittacosaurus* were up to 30% of the total variation, explaining why diagenetic-based shape information swamped biologic shape information in principal components analyses of *Psittacosaurus* crania and postcrania. Given that diagenetic deformation has a strong impact on geometric morphometric studies in fossils, it is necessary to evaluate morphometric results in the context of diagenetic deformation and to recognize that not all shape information is biologically meaningful.

Technical Session II (Wednesday, October 14, 2015, 8:30 AM)

BUILDING A BIRD: ONTOGENETIC AND EVOLUTIONARY CONSTRUCTION OF THE AVIAN BODY PLAN

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In the process of invading aerial environments, birds and theropod dinosaurs have undertaken some of the most dramatic morphological and functional transformations in vertebrate history. Flight is the most physically demanding form of locomotion (in terms of power output), and flight-capable adult birds possess many anatomical features that are presumably adaptations or exaptations to meet these demands. However, juvenile birds, like early winged dinosaurs, lack many hallmarks of advanced flight capacity. Instead of large wings they have small 'protowings', and instead of the robust, interlocking forelimb skeleton associated with powerful and highly canalized flight strokes, their limbs are more gracile and their joints less constrained. Such features have long been assumed to preclude early theropods from powered flight, yet immature birds with dinosaur-like anatomies engage their incipient wings to flap-run up slopes and even briefly fly. How do juvenile birds accomplish such behaviors in the apparent absence of flight adaptations? To address this question and assess how changes in anatomy effect improvements in wing-based locomotor performance during posthatching development, we constructed three-dimensional musculoskeletal models of a precocial ground bird (*Alectoris chukar*) (SIMM; Software for Interactive Musculoskeletal Modeling) and simulated flapping behaviors at different ontogenetic stages (static optimization; OpenSim). Aerodynamic measurements, *in vivo* kinematics and model simulations collectively suggest that changes in feather morphology, rather than musculoskeletal anatomy or flapping kinematics, contribute most to ontogenetic increases in wing performance. Immature birds therefore have excess muscle capacity and seem to be limited most by feather morphology, which they compensate for by supplementing their rudimentary wings with their legs (e.g., wing-assisted incline running) until the wings can fully support body weight during flight. In conjunction with work on live animals, these results thus disentangle a complex biomechanical interplay between different components of the avian flight apparatus, and help elucidate the ontogeny and evolution of avian locomotion by (i) establishing how muscular and aerodynamic forces interface with the skeletal system to generate movement in morphing juvenile birds, and (ii) providing a benchmark to inform biomechanical modeling and simulation of extinct theropods with similar anatomies.

Grant Information
NSF PRFB

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

VARIATION IN FORE- AND HIND LIMB INTEGRATION PATTERNS OF AVIAN THEROPODS

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The origin of flight is one of the major locomotion transitions in evolutionary history. When flight evolved in the theropod lineage, fore- and hind limb function was fundamentally changed. As the primary source of locomotion shifted from the hind limbs in non-avian theropods to the forelimbs in avian theropods, the biomechanical requirements of flight likely placed substantially different selective regimes on the skeletal elements of the limbs.

Previous research, using disparity of limb proportions, has suggested that non-avian theropods had relaxed biomechanical constraints on forelimb elements and tighter constraints on the hind limb elements resulting in the potential for greater and lesser variation of fore- and hind limb integration patterns respectively. In contrast, avian theropods have been hypothesized to have tight biomechanical constraints on the forelimb elements and more relaxed constraints on the hind limb, resulting in greater variation in hind limb integration patterns and less variation in forelimb integration patterns.

In this study, we tested whether the patterns of limb integration in birds were less variable in the forelimbs and more variable in the hind limbs. Unlike previous studies that used only element length, we used multiple limb element measurements in cluster analyses to generate limb integration patterns of 15 avian theropod species. We found that the forelimb integration pattern is relatively constant among species; the only taxa that wavered from this pattern were the Cedar Waxwing, Chimney Swift, and guineafowl. Conversely, we found that the pattern of hind limb integration was highly variable among species.

This study supports the hypothesis that avian theropods have a variable hind limb integration pattern and a less variable forelimb integration pattern. This may be the result of biomechanical constraints on the forelimb. Avian theropods have many different flight styles, but any variation in forelimb design is likely constrained by the biomechanics of flight. The hind limbs of avian theropods, freed from acting as the primary source of locomotion, are able to adopt greater variation in function (e.g., swimming, climbing, catching prey, etc.) and in patterns of integration.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

PALEOENVIRONMENT AND PALEOCLIMATE OF EARLY ASIAN HOMININS NEAR THEIR NORTHEASTERN RANGE LIMIT IN CHINA

HENSLEY-MARSCHAND, Blaire, Indiana University, Bloomington, IN, United States of America, 47405

The first hominins in East Asia faced environments and climates that were potentially very different from their ancestral lands in Africa, and the Nihewan Basin of China records the earliest evidence of their presence this new area. This down-faulted intermontane basin, located approximately 120 kilometers west of Beijing, contains multiple archaeological sites that record the presence of hominins and other fauna dating from 1.7–0.4 million years ago. Previous researchers have hypothesized that the paleoclimate of the area was variable and inhospitable for hominins during the early Quaternary and that their occupations of the area were seasonal or infrequent. Here I evaluate this hypothesis by investigating the composition, body mass estimates, and hypsodonty indices of fauna belonging to collections from the Nihewan Basin sites of Donggutuo and Feiliang. The presence of *Equus sanmeniensis*, *E. teilhardi*, *Coelodonta nihowanensis*, *Elasmotherium* cf. *caucasicum*, and *Mammuthus* cf. *trogontherii* indicates an open, grassland environment and arid climate. Additionally, a cenogram of log body mass values of the herbivorous species identified from these sites indicates a gap in medium-sized mammals, also supporting a hypothesis of an open environment. Hypsodonty indices for herbivorous species identified from these two sites provide a paleoprecipitation estimate of 200.9mm/year with a range of 0–589mm/year. This range of precipitation is found today in western North America, northern Africa, and western

and Northern Asia, indicating a relatively arid climate. The presence of a crodocilian tooth, the first known from the Quaternary of the Nihewan Basin, places a lower limit for the average temperature of the coldest winter month at 5.5°C. This evidence suggests an arid, temperate climate in an open, grassland environment, which is incongruent with the hypothesis that the region was too challenging for early hominins. The faunal remains from Donggutuo and Feiliang indicate that this was a location in which hominins may have been able to establish year-round occupation.

Preparators' Session (Thursday, October 15, 2015, 10:15 AM)

BRINGING A CONCRETE DINOSAUR SKELETON BACK TO LIFE

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The Carnegie *Diplodocus* skeleton, collected in the late 1800s and later described by John Bell Hatcher, became known as 'Dippy' after ten casts of the skeleton were distributed to museums around the world. In the 1950s, the Italian-made molds were donated to the Vernal Field House (now Utah Field House of Natural History) as plans for an outdoor cast of the beast was desired. After much experimentation, a concrete and aragonite mixture was used to cast the large dinosaur. In 1956, this *Diplodocus* cast was unveiled on the Field House's grounds where it stood for decades until plans to have a new museum building with an indoor fiberglass skeleton was approved. Prior to construction of the new building and after 45 years of exposure to seasonal weather conditions, the skeleton was disassembled and stored. In 2013, the old cast, with a wide variety of external and internal damage, was donated to the Utah State University (USU) Eastern Prehistoric Museum. Grant monies from the Utah Arts & Museums in 2014–15 provided financial support to clean, repair, reconstruct, stabilize, and seal the concrete material. Planned fundraising to construct new steel armature and mounting the repaired skeleton on the USU Eastern campus in Price, UT, will begin Fall of 2015.

Substantial amounts of epoxy paint and sealant coated every concrete bone thus requiring removal using industrial sandblasting methods. After analyzing and testing several brands of concrete repair and resurfacing materials, Permacrete was selected as the product of choice due to its strength in all weather conditions, its history of successful airport tarmac repair, as well as its use in coating several concrete sculptures in the United States. Once sandblasted, each concrete bone was repaired and reconstructed using the concrete repair products along with steel rods and fiber cloth. The next step required each bone to be resurfaced and sealed using other Permacrete products following manufacturer's specifications. Tests performed on the concrete bones indicate that these applications increased durability and greatly lessened breakage from significant impacts as compared to previous products used for repair on the skeleton. Heat and cold does not damage or warp the material; therefore, the repaired skeleton will be able to withstand exposure to varying weather conditions-an important consideration as this skeleton will be remounted outside in eastern Utah, a land of extremes. The condition of this historic dinosaur cast is now better than ever and ready to see the sun again after 15 years in storage.

Grant Information
2014–15 Museum Projects grant monies from the Utah Arts & Museums, Salt Lake City, UT.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

NEW RECORDS OF SOLEMYDID TURTLES IN NORTH AMERICA: SPECIMENS FROM THE UPPER CRETACEOUS MUSSENTUCHIT MEMBER OF THE CEDAR MOUNTAIN FORMATION

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Solemydidae is a phylogenetically contentious clade of turtles that inhabited the Late Jurassic through Late Cretaceous of Europe and Cretaceous North America. Members of the clade are united by a histologically diagnostic and easily recognizable shell surface texture characterized by a series of raised, diminutive tubercles. Solemydid remains have been collected in Europe since the mid-19th century, and their presence in North America was recognized in 1908 when the western taxon *Naomichelys speciosa* was assigned to this group by Oliver P. Hay. In the century since, only one specimen containing diagnostic skull and postcranial skeletal elements (FMNH PR273) has been recovered. The remaining known material is fragmentary and largely unidentifiable, with the exception of the distinctive tubercle-patterned shell. Current research suggests this pattern permits assignment only to Solemydidae gen. et sp. indet., and we follow that assignment here.

Solemydids are widespread in the western part of North America and have been reported from a chronostratigraphic and geographic interval comparable to that encompassed by multiple species on the European continent. Solemydid remains are currently restricted to Cretaceous strata in North America. To date, the clade is known the Aptian (~120 Ma) to the Campanian (~70 Ma) and from a large portion of the North American continent including Canada (i.e., Alberta, British Columbia) and the United States (i.e., Montana, New Mexico, Texas, Utah, Missouri, Wyoming, Nevada, Oklahoma, and Maryland).

Here, we report on the discovery of two new specimens from the Upper Cretaceous (Cenomanian) Mussentuchit Member of the Cedar Mountain Formation, which crops out in central Utah. One specimen of a large-bodied solemydid (>70 cm in length) preserves portions of the carapace, plastron, and appendicular elements. Clusters of conical osteoderms 1-2 cm in size are also preserved, supporting previous paleoecological interpretations of terrestriality for the clade. Solemydid remains are commonly encountered in the Mussentuchit; however, to our knowledge, significant skeletal material is rare. A second, more recently collected specimen (FMNH UT130904-2), although partially disarticulated, is more complete and includes elements of the carapace, plastron and osteoderms. These new specimens help elucidate the biodiversity of solemydids inhabiting North America during the Late Cretaceous and their paleoecological significance.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

BRAINCASE ANATOMY OF *MAIASAURA PEEBLESORUM*

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Braincase anatomy is an important source of information relevant to understanding diverse aspects including organismal anatomy, phylogenetic relationships, and even behavior through the study of endocranial spaces. Dinosaurian braincase anatomy is often poorly documented relative to other aspects of their anatomy, even in groups where cranial material is well known, such as Hadrosauridae. The hadrosaurine hadrosaurid *Maiasaura peeblesorum* from the Late Cretaceous (Campanian) Two Medicine Formation of Montana is known from an extensive fossil record that includes huge bonebeds that indicate gregariousness, a nesting site that suggest post-hatching parental investment in offspring, and excellent ontogenetic representation of skeletal elements. Despite this, the braincase anatomy of *M. peeblesorum* has remained poorly documented, particularly in light of abundant fossil data.

Here we describe the braincase and endocranial anatomy of *M. peeblesorum* for the first time, based on an ontogenetic series of well-preserved braincases derived from a single bonebed. The largest specimen, ROM 66180, represents a partial skull with a nearly complete braincase pertaining to an adult individual. In general, the braincase anatomy of ROM 66180 was found to be consistent with other hadrosaurine taxa, including *Edmontosaurus* and *Gryposaurus*. Computed tomographic scan data was used to generate a virtual endocast of the brain cavity of ROM 66180. The anterior portion of the braincase is absent, precluding formation of the forebrain region of the brain cavity endocast; however, preserved mid- and hindbrain regions of the brain cavity show no noticeable differences from those of other hadrosaurine taxa. Comparison of the cranial nerve (CN) foramina in ROM 66180 to other hadrosaurid taxa led to clarification in the identification of the cranial nerve foramina for CN IX – XII and the metotic (vagus) foramen, which are inconsistently reported in the literature. A close relationship between CN IX and the oval window is unlikely, based on comparisons with extant reptiles, and CN IX more likely emerged from the brain cavity along with CN X and XI through the vagus foramen. CN XII appears to have emerged through a single foramen on the lateral wall of the exoccipital. The presence of a pit-like fossa dorsal to the basal tubera appears to be a characteristic unique to *M. peeblesorum*; however, its presence may be ontogeny-dependent.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

INFERRING DIET FROM MOLAR RELIEF: INDEX VALUES FOR EXTANT BATS AND OPOSSUMS WITH APPLICATION TO CRETACEOUS *ALPHADON*

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The ecology of many fossil taxa can only be reconstructed on the basis of dentition or isolated teeth. In this study, the size-independent relief index, which is the ratio of the 3D surface area of a molar crown to the 2D base area, is used to test the hypothesis that the complexity of tooth crown shape reflects dietary preferences. Bats developed a variety of different feeding strategies and diverse dentitions, ranging from a primitive insectivorous feeding strategy with slightly modified tribosphenic molars, to frugivory in pteropodids with buccal and lingual longitudinal ridges and a median depression at the molars. Extant opossums are known to be generally omnivorous and insectivorous / carnivorous and have more uniform tribosphenic molars.

Three-dimensional models of lower molars with minor wear of more than 20 extant bat species with primarily frugivorous, insectivorous, carnivorous, omnivorous or sanguivorous diets were used in this study. Three opossums, primarily frugivorous *Caluromys*, omnivorous *Didelphis* and insectivorous / carnivorous *Monodelphis* were used for comparison. There is a clear separation of frugivorous, insectivorous / carnivorous / omnivorous and sanguivorous bats, with frugivores having the lowest relief index values and sanguivores the highest. *Caluromys* overall has lower values than *Didelphis*, while the relief index of *Monodelphis* is considerably higher. The values of opossums are generally higher in every diet group than the equivalent values of bats. This may be related to the opportunistic lifestyle of opossums; whereas bats are more specialized in their diet preferences. Overlap especially exists between *Didelphis* and the highest values of frugivorous bats and lowest values of insectivorous, carnivorous and omnivorous bats.

In order to test the applicability of the relief index to fossil taxa, two species of the Cretaceous *Alphadon* were studied. *A. halleyi* has relief index values which are lower than those of *A. wilsoni* and similar to omnivorous values of both bats and opossums. The values of *A. wilsoni* are higher and indicate a more insectivorous diet.

Grant Information
Travel grant by Evangelisches Studienwerk Villigst

Colbert Prize (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

SYNTHESIZING TAPHONOMIC, SEDIMENTOLOGIC, AND GEOCHRONOLOGIC ANALYSES OF THE UPPER OLIGOCENE NSUNGWE FORMATION (RUKWE RIFT BASIN, TANZANIA) TO UNRAVEL EVOLUTIONARY PATTERNS AND ECOLOGICAL CHANGE AMID AN EVOLVING LANDSCAPE

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A decade of exploration in the upper Oligocene Nsungwe Formation in the Rukwa Rift Basin, Tanzania has resulted in the recovery of a diverse fauna, including fossil evidence for the earliest divergence of Old World monkeys and apes, the oldest venomous elapid snake from mainland Africa, the earliest evidence of the endemic frog family Ptychadenidae, and an array of other invertebrate and vertebrate groups. The

Nsungwe Fm is significant in that it captures the Paleogene–Neogene transition, when major tectonic and environmental changes drastically affected the landscape, climate, and biotas. We combine faunal information with new data from sedimentologic, geochronologic, and thermochronologic studies to understand this ancient ecosystem and obtain a rare glimpse into an undersampled region and time period in Africa's history. One of the key, unanswered questions of East African landscape evolution is whether significant uplift accompanied late Oligocene basin development (i.e., do these fossil localities represent high- or low-elevation communities?). We are testing this question using (U-Th)/He and fission track dating of fossiliferous sediments to determine if a rapid cooling event (uplift) is recorded in rocks eroded from the rift flanks.

The Nsungwe Fm records a transition from alluvial fan to low-energy lake and wetland environments. Carbonatite tuffs intercalated with the fossiliferous strata indicate that the landscape was also heavily influenced by volcanism. The most significant fossil locality in the Nsungwe Fm is characterized by a bimodal grain size distribution, volcanic heavy mineral sand, bentonitic clay, elevated fossil preservation, and carnivore coprolites with bacilliform and coccoid bacteria. This deposit and other key localities are interpreted to have formed as hyperconcentrated flows or lahars that rapidly buried vertebrates in a mosaic of small channels and lakes. The Nsungwe Fm ecosystem records a semi-arid wetland setting with perennial availability of surface water and wet/dry seasonality, similar to Plio–Pleistocene depositional environments at Laetoli, which are also significantly influenced by carbonatite volcanism. Our preliminary results indicate that local uplift accompanied Oligocene rifting and likely influenced deposition and paleoenvironments. As one of the best-dated continental, fossiliferous sequences in Africa, the Nsungwe Fm records the dramatic effects of the initiation of the modern East African Rift System and provides the paleoenvironmental context for resident faunas.

Grant Information
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James Cook University

Technical Session V (Wednesday, October 14, 2015, 2:45 PM)

EVOLUTION OF THE LOWER JAW OF GNATHOSTOMES

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The origin of the lower jaw is a key innovation that underpins the adaptive radiation of gnathostomes. The jaw has undergone fundamental changes to its composition and has endured major ecological changes including the transitions from water to land, from land to the air, and from land back to water. Changes in jaw shape and structure may have facilitated the emergence of different feeding behaviors. Here we present an analysis to deduce the timing (geological time) and tempo (evolutionary rates) of lower jaw shape change through gnathostome evolutionary history. We achieve this via an exploration of lower jaw morphospace and an evaluation of the functional and ecological consequences of lower jaw shape variation.

Outline analysis and extended eigenshape analysis were used to mathematically quantify variation in lower jaw morphology for five hundred lower jaw specimens spanning three major evolutionary transitions: the origin of Osteichthyes, Amniota, and Mammalia. Jaw shape data were subjected to Principal Component Analysis (PCA). 28.1% of lower jaw shape variation is attributable to overall length of the dentary bone and/or the configuration of the bones located posteriorly (i.e., angular, articular, retroarticular process, and surangular). 15.5% of the variation is attributable to the robustness of the lower jaw, while the relative thickness of the dentary bone and the angle of the bones located posteriorly account for 11.4% of variation. Initial taxonomic group patterns illustrate that fish (including chondrichthyans and osteichthyans) are the most disparate group; birds show little variance in comparison to mammals except for the overall curvature of the mandible and thickness of the (fused) dentary bone. Squamates have less morphological diversity than mammals, but comparable disparity to birds whereas snakes have restricted morphospace occupation. From these results, it is most likely that both ecological and functional consequences affect lower jaw shape variation and that transformation in lower jaw shape allowed different feeding behaviors to emerge.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

BRAINCASE ANATOMY AND ONTOGENY IN JUVENILE *PINACOSAURUS GRANGERI* (ORNITHISCHIA: ANKYLOSAURIA)

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Juvenile dinosaur skulls are rare but important for understanding basic cranial anatomy as well as anatomical change through ontogeny. This is especially true for ankylosaurs, in which a trend toward hyperossification causes the fusion of individual skull bones, obscuring sutural relationships. We report on a juvenile specimen of *Pinacosaurus grangeri* that preserves a largely unfused and taphonomically disarticulated braincase. The specimen includes isolated laterosphenoid-orbitosphenoid elements, the right prootic, basioccipital-parabasisphenoid complex, and paired exoccipital-opisthotic (=otoccipital) elements. The isolated nature of the individual braincase bones, extremely rare for an ankylosaur, permits direct observation of both the external and internal surfaces, and facilitates comparisons with other dinosaur skulls and endocasts.

Unlike many adult ankylosaur braincases, this juvenile specimen exhibits some plesiomorphies found in basal archosauriforms. The shared opening for cranial nerves III and IV is a dorsoventrally elongate slit, in contrast to the separate foramina known in many adult ankylosaurs. The foramen for the trigeminal nerve is primarily bounded by the prootic, with a small contribution from the laterosphenoid rostrally. The foramen for cranial nerve VII is small and located caudoventral to the trigeminal foramen. The optic foramen is completely enclosed, and additional vascular foramina are observed. New digital endocasts of *Pinacosaurus* and *Edmontonia* broaden the basis for comparisons within Ankylosauria. Digital reconstructions of the disarticulated *Pinacosaurus* braincase suggest a narrower divergence of olfactory bulbs than reported for other ankylosaurids, a character that may reflect the young age or basal phylogenetic position of this species.

The specimen also helps to illuminate the ontogenetic sequence of skull fusion in *P. grangeri*. Whereas the interparietal, basioccipital-basisphenoid, and laterosphenoid-orbitosphenoid sutures are already fused, the contacts of the prootics and otoccipitals remain open. The cranial nerve foramina are large relative to skull size, when contrasted with adult ankylosaurs. This feature reflects the relatively early development of central nervous system structures and may be useful as an independent estimate of ontogenetic status in specimens that lack traditional indicators of age.

Colbert Prize (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

THE OLDEST DELPHINID FROM THE SERRAVALLIAN OF JAPAN REVEALS THE ORIGIN AND DIVERGENCE OF OCEANIC DOLPHINS (DELPHINIDAE: ODONTOCETI: CETARTIODACTYLA)

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Oceanic dolphins (Delphinidae) are the most speciose group of cetaceans inhabiting the modern oceans. Despite their current diversity, the fossil record of delphinids is limited. It remains unclear where and when they evolved. Molecular clock analyses suggest the divergence of delphinids from other delphinoids in the Early or Middle Miocene (about 23–14 Ma). By contrast, the so far 'oldest' extinct taxon confidently referred to the group is no older than the Late Miocene (about 9 Ma). Thus, there was a considerable gap between the estimated time of origin of the delphinids inferred from molecular data and their fossil records.

Although the extinct dolphin *Sinanodelphis izumidaensis* Makiyama, 1936, from the Middle Miocene Bessho Formation (approximately 13.6–11.8 Ma), Nagano Prefecture, central Japan, was initially described as a delphinid based on a partial skeleton, later studies classified this species as Delphinoidea incertae sedis because of a lack of diagnostic characters and the incomplete preparation of the holotype. Our recent studies revealed, however, that the two additional undescribed specimens (previously reported as Delphinoidea fam., gen. et sp. indet.) that were recovered from nearly the same locality and horizon are almost identical to the holotype of *S. izumidaensis* in terms of general skull proportions, in having numerous, small teeth, and in having markedly asymmetrical external bony nares, indicating that they likely belong to the same species. Accordingly, we performed phylogenetic analysis for *S. izumidaensis* based on 85 species (all odontocetes) and 278 morphological characters, with the archaeocetes *Georgiacetus* and *Zygorhiza* used as out-group.

Our results identified *S. izumidaensis* within the stem group of the Delphinidae. This placement extends the fossil record of delphinids to ca. 14–12 Ma, only slightly younger than the youngest molecular divergence dates. Based on both records of the oldest fossil delphinid described here and its sister taxa as well as the molecular divergence times of the delphinids, the origin and early divergence of the delphinids might have occurred in the Middle Miocene of the North Pacific.

Interestingly, the fossil records of the stem delphinoids (i.e., 'kentriodontids') are generally known from shallow marine deposits, whereas Miocene fossil delphinids including *Sinanodelphis izumidaensis* are from bathyal deposits. This indicates that the earliest delphinids possibly diverged in the off-shore environment.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

TERRESTRIAL VERTEBRATES FROM THE LATE CRETACEOUS (SANTONIAN) OF IWATE PREFECTURE, EASTERN JAPAN

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The Tamagawa Formation in Kuji Group of Kuji City, Iwate Prefecture of northeastern Japan is the richest geological unit bearing Late Cretaceous terrestrial vertebrates as well as amber in this country. More than eight hundred vertebrate fossils have been found from the bone bed (about 20 cm thick coaly mudstone) of the Tamagawa Formation since 2005. This bone bed is overlain by a one meter thick sandstone layer bearing shark teeth. Fission track dating carried out on the volcanic tuff layer inter-bedded between the bone bed and marine sandstone indicates an early Santonian age (Late Cretaceous).

Turtles (Order Testudines) are the most abundant vertebrates (390 specimens in total), identified as the genus *Adocus* (Adocidae), Trionychidae, Nanhsiungchelyidae, and Lindholmemydidae. Most of turtle remains are isolated shell elements; little cranial and appendicular material was collected. *Adocus* from the Tamagawa Formation seems to be the most derived species of this genus in the possession of wide marginal scales and with the loss of the cervical scale of the carapace. The largest specimen of *Adocus* from this locality suggests an individual with a 70 cm-long shell.

Crocodiles (Order Crocodylomorpha) are the next-most abundant group (92 specimens in total). Their amphicoelous vertebrae, osteoderms and dental morphology suggest they were members of the neosuchian grade, possibly close to the genus *Bernissartia*. Twenty-two isolated almost-cylindrical teeth of sauropods (Order Saurischia) have been collected, whereas other dinosaurs (Theropoda and Ornithischia) are known from a few limb bones. A wing digital bone of a medium size pterosaur (Order Pterosauria) was found in 2010.

All terrestrial vertebrate fossils are from bone beds inter-bedded with marine sandstone layers, except two partially articulated shells of *Adocus*, which are isolated and fragmentary. This occurrence suggests that they were transported by streams near the river mouth. The abundance of sauropod teeth and conifers are unique to this Late Cretaceous biota.

The fauna and flora of the Kuji Group are some of the best examples of Late Cretaceous terrestrial vertebrates and plants from Japan. Our excavation will continue over the coming years, yielding plentiful new results.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

A COMPREHENSIVE STUDY OF KEY PALEOENVIRONMENTAL CHANGES USING MAJOR FAUNAL TURNOVERS FOCUSING ON THE TURKANA BASIN, KENYA

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Lake Turkana in Kenya, Africa has been home to many discoveries that are critical for understanding human evolution. These include a *Paranthropus bosei* cranium; *Homo ergaster* type specimen, cranium, and full skeleton; *Homo rudolfensis* cranium; *Homo habilis* cranium; *Paranthropus aethiopicus* cranium; *Australopithecus anamensis* mandible; *Kenyanthropus platyops* cranium; and hominin footprints. However, we have limited understanding of the factors that drove adaptations observed in hominins. To date, efforts to understand the environmental underpinning of these adaptations have been based mainly on isotopic analysis of paleosols, using carbon and strontium isotopes from paleosols, and comparing carbon dioxide ratios taken from paleosols to modern day carbon dioxide ratios taken from soil. The environmental information that is extracted from these isotopic analyses is limited. The purpose of this study was to diagnose significant environmental transitions based directly on faunal turnover of aquatic/amphibious and fully terrestrial biotas in the middle-late Miocene to the Recent. By compiling and creating a comprehensive synthesis of previous research in the Turkana Basin, I was able to document faunal turnover and then determine environmental changes. Based on analysis of crocodilians, fish, turtles/tortoises, hippopotamids, bovids, equids, and primates, I was able to diagnose significant environmental changes at the late Miocene, middle Pliocene and early Pleistocene. At these stages of time, respectively, there was a change from woodlands/forests to open grassy woodlands to wooded/bushed grasslands and riparian forests associated with the proto-Omo River. There was also evidence of a cyclical transition from lacustrine to fluvial conditions in the Late Pleistocene. The synthesis of diagnoses of significant environmental changes and cyclical patterns provide a more complete understanding of the paleoenvironmental history of the Turkana Basin and can be used for further analysis of hominin adaptations.

Colbert Prize (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

A NEAR COMPLETE CTENACANTHIFORM SHARK FROM THE MIDDLE PENNSYLVANIAN (MISSOURIAN) TINAJAS MEMBER OF THE ATRASADO FORMATION, CENTRAL NEW MEXICO

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The group of chondrichthyans referred to as 'ctenacanths' remains an enigmatic clade of Paleozoic sharks, as its fossil record is dominated by isolated spines, teeth, and occasional endoskeletal elements. Controversy continues as to whether ctenacanths represent a monophyletic or paraphyletic taxon, and even if ctenacanths are stem elasmobranchs or stem chondrichthyans. Partial endoskeletons and teeth of proposed ctenacanths such as *Ctenacanthus*, *Tamiobatis*, *Goodrichthyes*, *Cladodus*, and *Heslerodus* have been used previously in attempts to give insight into what traits could be used to define 'ctenacanth'. However, none of the above taxa are complete enough to establish a solid monophyletic clade. Here we present a new nearly complete ctenacanth taxon from the Tinajas Member of the Atrasado Formation of central New Mexico that may help define the Ctenacanthiformes. This specimen, herein referred to as the 'Manzano ctenacanth', is approximately two meters long and is the first taxon to bear *Ctenacanthus*-like dorsal spines, a *Tamiobatis*-like neurocranium, and a *Heslerodus*-like dentition.

The 'Manzano ctenacanth' is a new genus with 'classic' ctenacanth features. The dorsal spine length is proportionately a quarter of the body length, the greatest spine- to-body- length proportion yet described in a ctenacanthiform. Both dorsal spines possess a single smooth anterior costa, a trait similar to the spine taxon of *'Ctenacanthus' amblyxiphias*. The dentition is *Heslerodus*-like, with two orolingual and basolabial buttons, but differs from *Heslerodus* in the lack of a deep basolabial depression and possession of short, mesiodistally broad cusps ornamented with coarse vertical cristae. The pectoral propterygium is longer than the mesopterygium and the fin was probably aplesodic. The ventral lobe of the caudal fin is oriented almost at right angles to the dorsal lobe, which is unlike the state seen in other ctenacanths but is characteristic of some benthic sharks (e.g., the angel shark *Squatina*). The 'Manzano ctenacanth' may have possessed paired hypohyals, but also had a tribasal pectoral fin. The 'Manzano ctenacanth' thus provides new morphological data about these enigmatic chondrichthyans, which will help define what a 'ctenacanth' is, and help clarify their role in the evolutionary story of Chondrichthyes.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

DIFFERENCES IN PHYTOSAUR (DIAPSIDA:ARCHOSAURIFORMES) TOOTH ENAMEL MICROSTRUCTURE BETWEEN BASINS AND POSSIBLE ECOLOGICAL IMPLICATIONS

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The phytosaur fossil record contains a large proportion of isolated teeth, which are not considered to be taxonomically useful as all possess essentially the same ziphodont tooth morphology, although some phytosaurs are known to be heterodont. Other workers have demonstrated that tooth enamel microstructure (EM, or schmelzmuster) may hold a phylogenetic signal in some reptiles, which would provide an alternative to gross morphology. Past studies of phytosaur EM (n = 4 teeth) were inconclusive, other than documenting great variation of enamel thickness (20-150 µm). We examined the EM of teeth from different tooth positions of heterodont taxa from several stratigraphically superposed localities in the Chinle Group of the western USA (n = 14) and the Newark Supergroup of North Carolina (n = 5) of various ages. From stratigraphically lowest to highest, the Chinle taxa are: *Angistorhinus*, *Smilosuchus*, *Machaeroprosopus*, and *Redondasaurus*; the Newark phytosaur is considered '*Rutiodon*'. We found enamel thickness to vary from 18-156 µm, although typical enamel thickness is between 40-80 µm with type B (maxillary teeth, low and blade-like with serrations) having the thickest enamel when controlled for size. This partly reflects the observation that type B teeth generally have more denticles, which tend to have thicker than average enamel, but may have other functional implications. Interspecific differences within a basin appear minimal, as all Chinle teeth exhibit well-defined columnar enamel of similar average thickness. We were unable to replicate previous reports of phytosaur teeth with thin (20 µm) enamel composed entirely of parallel crystallites. Column width (5-37 µm) did not exhibit any trends between taxa or tooth position. However, differences between basins are easily recognizable. All of the sampled Newark Supergroup teeth exhibit numerous strongly developed lines of incremental growth (LIGs), whereas only a single Chinle tooth (of *Smilosuchus*) exhibited weakly developed LIGs. Our results indicate that there is no clear taxonomic signal in phytosaur schmelzmuster in the Chinle. The developmental differences indicated by the LIGs may reflect differing ecologies of Chinle and Newark phytosaurs, possibly related to metabolism, climate, or other environmental factors. The different EM of the North Carolina phytosaurs does support the hypothesis that they are generically distinct from the Chinle taxa.

Technical Session I (Wednesday, October 14, 2015, 10:30 AM)

GRAIN SIZE DISTRIBUTION OF INGESTED SILICA BY EXTANT UNGULATES: IMPLICATIONS FOR MASTICATORY PROCESSING AND MICROWEAR

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Experimentalin vitro and in vivo studies have illustrated the abrasive properties of exogenous silica (e.g., soil, ash) and the potential for grit-induced microscopic tooth wear, or microwear, in mammals. A corollary of this work is the observed correlation between the size of silica particles and microwear: medium-grained particles (250–425 µm) are more easily fractured to produce angular, finer grains (<125 µm) capable of abrading tooth enamel to create microwear features. Feature shape is then defined by jaw mechanics (i.e., shearing or compression to produce scratches or pits, respectively). While numerous studies have evaluated the fecal silica content of natural populations of modern ungulates, little work has been done to assess the grain size distribution of consumed silica. To test the hypothesis that exogenous silica undergoes size-dependent fracturing during mastication, we compared the grain size distributions of the naturally ingested silica for wild populations of modern bison (*Bison bison*) and deer (*Odocoileus hemionus* and *Odocoileus virginianus*) from Kansas and California. We collected fecal, plant, and soil samples and used sequential loss-on-ignition analysis to remove water, organics, and carbonates. The remaining silica in the fecal and soil ash was then sieved and sorted into five size classes: ≥850 µm, 250 to 850 µm, 125 to 250 µm, 75 to 125 µm, and <75 µm. For both locations, we found the ash of the grazers (bison), browsers (deer), and soil to all fall within the size classification of silty sand with fine to very fine skewed grain size distributions. We calculated the ratio of the medium-coarse sand class (250–850 µm) to the fine sand-silt class (<125 µm) and found that the ungulate taxa at both sites have lower medium:fine ratios than the corresponding soils. Additionally, the bison have lower medium:fine ratios than the corresponding deer and the browse and grass silica contents (i.e., phytoliths <53 µm) overlap considerably at both sites. This overlap in plant silica content suggests that the higher proportion of fine silica grains in bison feces, relative to deer feces and soil, reflects the contribution of not only biogenic silica but also medium-grained abiotic silica that is consumed while grazing close to the ground and fractured during mastication into finer grains capable of microwear formation.

Grant Information
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Technical Session IX (Thursday, October 15, 2015, 2:00 PM)

INNER EAR MORPHOLOGY OF A NEW LATE CRETACEOUS MALAGASY MAMMAL INDICATES CONVERGENCE IN COCHLEAR EVOLUTION

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Studies of inner ear morphology, in particular those based on high-resolution µCT imaging, remain rare among Mesozoic mammaliaforms. Here we present a digital reconstruction of the cochlear canal in a previously undescribed mammal from the Upper Cretaceous (Maastrichtian) Maevarano Formation of Madagascar. The specimen represents a new genus and species possibly related to the gondwanatherian *Vintana sertichi*. The new malagasy taxon has a cochlear canal that is short and slightly curved at the apex. It exhibits a derived innervation of the cochlea, including primary and secondary osseous laminae, a tractus foraminosus, and a cochlear ganglion canal. Among extant mammals, osseous laminae are considered to be derived features, being present in therians (but absent in monotremes). The earliest unambiguous evidence of primary and secondary osseous laminae is provided, albeit fragmentarily, by *Vintana*. The new Malagasy taxon preserves a nearly complete primary osseous lamina, allowing for a more detailed comparison of cochlear innervation in extinct and extant mammals. Strikingly, as in *Vintana*, the new taxon shows a secondary canal that is parallel to the ganglion canal. Both canals are connected to the internal acoustic meatus by several small canals.

Even more intriguing, but in stark contrast to *Vintana*, a separate canal that extends to the apex of the cochlea is present in the new Malagasy mammal. In conjunction with an apical expansion of the cochlear canal, this morphology suggests that the new taxon

retained a lagena. A lagena is a common feature in many extant vertebrates and is thus assumed to have been primitively present in basal mammaliaforms. However, fossil evidence supporting this hypothesis is often ambiguous. In fossil mammaliaforms an apical expansion of the cochlear canal and a separate canal to the apex indicate the presence of a lagena. However, a separate lagenar nerve canal is difficult to detect without μCT imaging and its presence is thus uncertain in the majority of Mesozoic mammaliaforms. Based on these two features, a lagena was previously only documented in the docodont *Haldanodon*; it is presumed to have been absent in *Vintana* and the dryolestoids *Henkelotherium* and *Dryolestes*.

The Malagasy taxon is unique in preserving a lagena and osseous laminae, a combination that has not been described in any mammaliaform, extinct or extant. If future analyses support a close relationship to Gondwanatheria within Allotheria then a lagena was probably lost independently in at least *Vintana* and cladotherians.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

THE PHYLOGENY OF PERISSODACTYLA (MAMMALIA): EXAMINING THE EFFECT OF OUTGROUP CHOICE

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Despite a rich fossil record and a long history of study, perissodactyl phylogeny is not well understood. While there is general agreement on the membership of the major lineages, there is considerable uncertainty regarding relationships among those major lineages, as well as the relationships of various early taxa to each other and to the major lineages. Contributing to this uncertainty was ambiguity regarding the sister-taxon to perissodactyls, which raised the question of how different sister-taxon scenarios affect interpretation of perissodactyl phylogeny and the timing and geography of perissodactyl origins. The discovery that cambaytheres from the Eocene of India are sister-taxon to Perissodactyla provided an important insight into perissodactyl origins, but this did not resolve what role, if any, might be played by previously hypothesized perissodactyl sister-taxa in understanding perissodactyl phylogeny.

To test the effect of different sister-taxon scenarios on perissodactyl phylogeny, a series of parsimony analyses were run on a matrix of perissodactyls, cambaytheres, and anthracobunids, plus one of the following outgroups: the artiodactyl *Diacodexis*; the Asian archaic ungulate *Radinskya*; the phenacodontid *Tetraclaenodon*; the phenacodontid *Ectocion*; the phenacodontid *Phenacodus*; the three phenacodontids *Tetraclaenodon*, *Ectocion*, and *Phenacodus* together; and all five outgroup taxa included. Two additional analyses removed these outgroups and used cambaytheres as the outgroup; one of these two analyses included anthracobunids in the ingroup, and the other excluded anthracobunids. The results of these various analyses exhibit important differences, including the placement of brontotheriids and Ancylopoda, the position of anthracobunids, and the placement of various North American early equoids relative to European palaeotheriids. There is no clear criterion for choosing among these results, but they illustrate the importance of considering the impact of outgroup choice. In the case of perissodactyls, these results suggest that multiple outgroups should be included, and analyses should be run with different outgroup sets to evaluate different sister-taxon scenarios.

Grant Information
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Technical Session XVI (Saturday, October 17, 2015, 12:00 PM)

PMJS AND TMJS: CONVERGENCE IN THE CRANIOMANDIBULAR JOINTS OF CROCODYLIFORMS AND MAMMALS

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Few evolutionary transformations are as iconic as the flattening of the crocodyliform skull or the transformation of the mammalian middle ear. Although the characteristic pterygoid buttress of crocodyliforms has long been recognized to contact the mandible, the anatomical components, biomechanical significance, and evolution of the articulation are poorly understood. Similarly, despite substantial understanding of the evolutionary and developmental origins of the middle-ear ossicles of mammals, the concomitant changes in the temporomandibular joint (TMJ), articular disc, and jaw musculature remain to be thoroughly explored. Here we present evidence from the anatomy, biomechanics, and fossil record of crocodylomorphs that reveals that they evolved a second craniomandibular joint, the pterygomandibular joint (PMJ). The joint is an enthesis organ where a cartilaginous sesamoid glides between the trochlear surface of the pterygoid and coronoid region of the mandible. The PMJ receives significant moments from jaw musculature and is a second fulcrum of the mandible, stabilizing it from long axis rotation and medial bending. Acquisition of the PMJ preceded the evolution of akinesis and laterally-wrapping pterygoideus muscles. The characteristic feeding behaviors and high bite forces evolved later in the clade, suggesting that this new joint was a key innovation in suchian cranial evolution. Reciprocally, these findings inspired new interpretation of the mammalian jaw joint and ear. As with the suchian cartilago transiliens, the TMJ articular disc is actually a sesamoid within the mammalian lateral ptergyoideus musculature, spanning the connection between the dentary and the malleus via the discomallear ligament, a vestige of the primitive attachment to the articular bone. The TMJ articular disc likely formed when the pterygoideus musculature was compressed by the trochlea-like condyle of the incipient dentary-squamosal joint, resulting in the formation of a sesamoid during mammaliaform evolution. Thus, suchians and synapsids convergently evolved dual craniomandibular joint systems using enthesis organs.

Grant Information
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Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

THE EFFECTS OF CRANIAL SUTURES ON STRAIN DISTRIBUTION PATTERNS IN THE AMERICAN ALLIGATOR CRANIUM

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The cranium and lower jaw comprise several skeletal elements that articulate with one another at sutures consisting of fibrocollagenous soft-tissue. Still, biomechanical analyses of the skull in a variety of extant and extinct forms typically treat the entire model as a homogeneous material, overlooking the differences between material properties of sutures and surrounding bone. Those studies that have attempted to model the effects of cranial sutures in biomechanical analyses have largely focused on mammalian taxa, such as pigs and primates, though a small number have investigated sauropsids such as *Sphenodon*. Cranial sutures of these taxa vary considerably in their morphology, patency throughout ontogeny, and percentage of overall cranial volume that they represent. The effects of cranial sutures on strain distribution patterns have been shown to be likewise variable in these taxa. Crocodylian cranial sutures often exhibit a relatively complex morphology and represent a relatively small percentage of overall cranial volume, unlike some other sauropsids. Extant crocodylians are often used as anatomical or functional models for a variety of extinct taxa, yet the effects of sutures on strain distribution patterns in their crania have not yet been investigated. This study used Finite Element Analysis to model the biomechanical effects of sutures on the global distribution of strain throughout the cranium of *Alligator mississippiensis* during simulated bite loading. Models including and excluding sutures were compared. The inclusion of cranial sutures in the model lowered strain in the immediate vicinity of a given suture and increased it elsewhere in the skull, usually coinciding with the location of another suture. Sutures were thus included in the model individually and iteratively, being first added to the region of greatest strain in the fused-suture model, then to the region that exhibited an increase in strain as a result of the previous suture addition, and so on. The result was that whereas strain in the fused-suture model was confined to one particular region of the skull, strain in the model that included all sutures was more evenly distributed throughout the skull. However, the degree to which sutures were effective at redistributing strain in the model was highly sensitive to input parameters of the suture material properties. This study highlights both the importance of an often overlooked aspect of cranial anatomy in biomechanical analyses and a need to further investigate the mechanical properties of cranial suture soft-tissues.

Technical Session XII (Friday, October 16, 2015, 9:00 AM)

NETWORK ANALYSIS DEMONSTRATES SOUTHERN PROVINCIALITY IN CAMPANIAN NORTH AMERICAN TURTLES

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Turtles are among the most diverse aquatic vertebrate groups in the Late Cretaceous and are common in the fossil record of western North America. As such, they provide a unique and complementary study system for assessing hypotheses of biogeographic provinciality and climatically-controlled latitudinal variation based on co-occurring terrestrial biota. Here we test previous hypotheses of provinciality using both traditional methods and a suite of emerging methods of bipartite network analysis. We draw upon a greatly expanded Campanian data set of new and recently published occurrences that range from northern Mexico into southern Canada. Seven distinct formations and/or members are represented. Both presence/absence data and abundance data (where available) are used to examine differences among these faunas.

Bipartite network analyses on presence/absence data demonstrate that the Campanian faunas are significantly nested, and identify the faunas of Utah, New Mexico, Texas and northern Mexico as the strongest cluster due to the joint co-occurrence of the trionychid *Helopanoplia*, *Compsemys*, kinosternoids, and the baenid *Denazinemys*. The more northerly faunas of Wyoming, Montana and Alberta are not united by any exclusively shared taxa, although they uniquely share the presence of chelydrids with assemblages from the Kaiparowits Formation of Utah. These patterns are generally consistent with some provinciality hypotheses and possible climatic controls on selected taxa. However, tabulating occurrences on a locality-by-locality basis to assess richness and abundance reveals subtle differences that are not readily apparent in formation- or member-level summaries of taxonomic presence or absence. Some taxa are restricted to certain localities and show clear habitat preferences (e.g., large channels or distance from salt water). Therefore, additional variation among formations or areas is also likely due to the variety and types of local environments being collected. Ideally, these sampling differences across the paleo-landscape should be considered and analyzed as an additional facet of the observed geographic variation among Late Cretaceous faunas.

Grant Information
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Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

PLEISTOCENE *CERVUS ELAPHUS* IN CALIFORNIA INHABITED XERIC SHRUBLAND MUCH LIKE EXTANT TULE ELK

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Understanding the evolutionary, paleoecological and paleobiogeographic history of Tule Elk is important, as this subspecies declined from an estimated historic population of 500,000 to a maximum of only 12 individuals in the span of just a century and today only survives in protected areas that represent a fraction of its historic range.

Cervus remains are relatively rare in the Pleistocene fossil record of California, but three elk subspecies occur in the state today: Rocky Mountain elk (*Cervus elaphus nelsonii* Bailey 1935) which are restricted to a small portion of the northeastern Sierras; Roosevelt elk (*Cervus elaphus roosevelti* Merriam 1897) which prefer the northwestern Coastal ranges and redwoods; and the endemic Tule elk (*Cervus elaphus nannodes* Merriam 1905) which utilize open country such as the perennial grasslands, marshlands, scrublands and oak scrublands of the Central Valley. To understand how current and historic distributions of these subspecies compare with prehistoric distributions, I examined published records and museum collections of *Cervus* from the Pleistocene of California, along with associated faunal assemblages and environmental indicators including pollen and sedimentological records. I found that Pleistocene localities with remains of *C. elaphus* in California are distributed along the length of the Central Valley and are associated with an environment that would have ranged from temperate oak scrubland to semi-arid open scrubland, often with indicators of nearby (< 50km distant) closed woodlands. This environment is similar to that utilized by extant Tule Elk, which suggests that by the late Pleistocene the *C. elaphus* population in California may have already differentiated into the *nannodes* subspecies.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

FIRST RECORD OF PROCYONIDS FROM THE THOMAS FARM FOSSIL SITE, GILCHRIST COUNTY, FLORIDA

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The first occurrence of procyonids in North America is stem-procyonid *Amphictis* sp. from the early Miocene Anderson Ranch Formation, Nebraska. By the early Hemingfordian, fossil New World procyonids were widespread from Panama (~9°N) to the northern Gulf Coast (~30°N) and Nevada (~39°N). Procyonids colonized South America during the late Miocene via island hopping before the final closure of the Panama Isthmus during the Pliocene. The Thomas Farm Fossil Site (TF) is one of most fossiliferous early Hemingfordian (~18.5 Ma) localities in the world. Excavations at TF have been ongoing since the early 1930s, but new species are still being described. The increase of screenwashing in the last few years has uncovered a wealth of small-sized fossil specimens, including isolated carnivoran teeth. Some of these teeth were originally referred to *Phlaocyon*, a borophagine canid that has dental characters thought to be convergent with procyonids due to their very similar hypocarnivorous dentition. The TF specimens are identified as procyonid based on the presence of an upper P4 with a more developed parastyle, a metacone blade that is shorter, and a protocone that is more posterior than in the stem-procyonid *Broiliana*. In comparison to *Phlaocyon*, the upper P4 of the TF procyonid has a more labially oriented paraconule but lacks the distinctive prominent external cingulum of *Phlaocyon*. The upper M1 has a reduced metaconule and lacks the paraconule. It has an enlarged protocone subequal in height to the metacone and paracone. A robust postprotocrista connects the highly reduced hypocone with the metacone. The parastylar shelf is labially expanded in relation to *Phlaocyon* but not as in the extant *Bassariscus astutus*. The lower m1 has a highly reduced anteriolabial cingulum, a prominent hypoconid, and a slightly posterointernal hypoconulid. In comparison to *Phlaocyon*, the relatively shorter trigonid basin opens lingually with a paraconid being the shortest cuspid while the metaconid and protoconid are relatively subequal in height. The mesoconid of TF specimens is in contact with the hypoconid and both are located on the lingual side and more distinct than in *B. astutus.* The talonid basin is wider and the trigonid basin is less expanded posteriorly than in *B. astutus*. Because the specimens from TF are remarkably different from those of the *Phlaocyon* holotype and are more similar to *B. astutus*, we tentatively refer the TF specimens to *Bassariscus*.

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Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

A NEW SPECIMEN OF *ANZU* (CAENAGNATHIDAE, OVIRAPTOROSAURIA): IMPLICATIONS FOR THE PROPOSED CAENAGNATHINAE/ELMISAURINAE DIVISION AND FOR CURSORIALITY IN CAENAGNATHIDS

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A new medium-sized theropod dinosaur was discovered by field crews of the Burpee Museum in mudstones of the lower Hell Creek Formation (latest Maastrichtian) of Carter County, Montana, in June 2013. Additional material was recovered during the field season of Summer 2014. This individual has provisionally been referred to the oviraptorosaurian species *Anzu wylei*, previously known from partial skeletons from coeval beds in North and South Dakota and tentatively from Saskatchewan. This specimen includes elements (including both nearly complete metatarsi) previously unrecovered in *Anzu*, which allow for a more complete understanding of the taxon, its position within oviraptorosaur phylogeny, and its paleobiology.

Recent work based on new specimens from Asia and North America has suggested a split within the Campano-Maastrichtian species of the oviraptorosaur clade Caenagnathidae into Caenangathinae and Elmisaurinae. The latter have been characterized by fusion of the distal tarsals and proximal metatarsals and by a pair of pronounced cruciate ridges on the plantar surface of metatarsal III. The new *Anzu* specimen possesses character states for both these traits intermediate in morphology between typical "caenagnathines" and Elmisaurinae. Whereas the distal tarsals and proximal metatarsals II-IV are fused together in Elmisaurinae, in *Anzu* only distal tarsal IV is fused to its metatarsal, and the proximal metatarsals are separate. The new *Anzu* specimen demonstrates two clear pronounced cruciate ridges as in specimens of Elmisaurinae but not as in other caenagnathoids, creating a trapezoidal cross-section; however, these do not extend to the proximal end of the plantar surface of metatarsal III as they do in elmisaurines.

The metatarsus in this specimen confirms the presence of an arctometatarsus in this taxon as in other caenagnathids. The relative completeness of the individual allows its measurements to be incorporated in a larger allometric study of theropod hind limb proportions. Unlike other theropods with an arctometatarsalian pes, the length of metatarsal III does not fall among the trend of elongate-footed taxa such as tyrannosaurids, ornithomimids, derived troodontids, and oviraptorosaurs such as *Avimimus*, *Gigantoraptor*, and other caenagnathids. Instead, it falls along the plesiomorphic trend present in the majority of non-avian theropods. Given the phylogenetic position of this taxon, this appears to be a reversal in terms of metatarsal elongation: the first such identified in a taxon with an arctometatarsus.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

ONTOGENETIC DIFFERENCES IN TOOTH REPLACEMENT RATES IN ADULT AND JUVENILE DIPLODOCIDS

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An important factor in sauropod evolutionary success was their specialized feeding apparatus, which enabled efficient food intake. High feeding efficiency results in extensive tooth use and fast wear, which was accounted for in sauropods by high tooth replacement rates. Sauropod dentition varies morphologically among clades; diplodocoids, for instance, have markedly elongate teeth, and even more elevated tooth replacement rates than other lineages. However, whereas tooth replacement is well understood in adults, the effects of ontogeny on this adaptation have not been studied thus far.

Because of varying skull morphologies between young juveniles and adults (e.g., shorter muzzle, larger orbits), it is possible that there was less accommodation space for replacement teeth in juvenile tooth-bearing bones. In non-sauropod dinosaurs, tooth count increases during ontogeny, thus implying a change in feeding behavior and diet. Although this has not been clearly observed yet in sauropods, evidence from microwear studies also points to dietary niche changes through ontogeny in neosauropods.

Four well-preserved tooth-bearing bones (one premaxilla, two maxillae, one dentary) from diplodocid specimens in early ontogenetic stages from the Upper Jurassic Morrison Formation at Howe Ranch, northern Bighorn Basin, Wyoming, USA, are compared with an exceptionally preserved adult diplodocid skull from the same locality, and with other known diplodocid skull material from various ontogenetic stages from similar strata from the USA. To calculate tooth replacement rates, micro-computed tomography data is used, which has been post-processed in Avizo to produce digital three-dimensional models.

The juvenile teeth show a size range intermediate between that of diplodocids and camarasaurids, indicating a difference in tooth size and shape through ontogeny in diplodocids. The tooth replacement rates of juveniles and adults vary as well, showing three generations of teeth in the juvenile tooth-bearing bones, and up to five generations in adult elements. Calculated tooth replacement rates based on the computed tomography data are higher in adults than in juveniles. This implies a difference in use and wear of teeth between juveniles and adults, and a possible gradual change in dietary niche from an early ontogenetic stage to later stages.

Technical Session VIII (Thursday, October 15, 2015, 2:00 PM)

CARNASSIAL TOOTH MORPHOLOGY IS STRUCTURED BOTH BY ECOLOGY AND PHYLOGENY AMONG MAMMALIAN CARNIVORES (MAMMALIA: CARNIVORA)

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The morphology of the carnassials in Carnivora have been widely used to reconstruct diets of extinct carnivorous mammals. The diversity of diets among living carnivores allows the robust examination of the correlations between dental morphology and diets that range from large vertebrate prey to insects, fruit, and even bamboo. The modified upper fourth premolar and lower first molar (carnassial teeth) in most Carnivorans are generally the teeth most important to food processing, as well as the ones most easily identified in the fossil record, although the posterior molars can also be an important line of evidence for diet. Vertebrate flesh-dominated diets are associated with well-developed shearing blades on P4 and m1. The crushing function of the talonid basin is retained in some species but not in others and bears have completely re-evolved a broad, flat-crowned carnassial molar in association with their relatively omnivorous diets. While these correlations are strong in extant species, we examine the role of phylogeny in constraining the relationship between diet and dental morphology in living Carnivora. We infer the evolutionary history of the carnassial morphology across living carnivorans and separately within each sub-order (cats: Feliformia and dogs: Caniformia), which have been evolving independently for approximately 55 million years. We estimated carnassial morphology across 114 terrestrial species of living Carnivora, using three linear morphometric proxies from the lower carnassial and four geometric morphometrics landmarks on the occlusal view of the upper and lower carnassial. The upper and lower carnassials show very different relationships among phylogeny, diet and morphology. It is clear that a great deal of the relationship between dental morphology and diet is a reflection of phylogenetic structure to both diet and dental morphology. Ecological and evolutionary patterns are particularly evident in the lower tooth. Across Carnivora, the main axis of variation in the lower carnassial is elongation, with more elongated teeth associated with a greater proportion of vertebrates in the diet. However, cats and dogs primarily achieve this shape change through different means. Carnassial morphology is more labile within caniforms, with stronger phylogenetic signal within feliforms. According to their lower carnassial morphology cats and their relatives appear to have evolved through a series of ecomorphological radiations, primarily partitioning the ecomorphospace early in their evolutionary history.

Technical Session III (Wednesday, October 14, 2015, 11:15 AM)

A JUVENILE SPECIMEN OF THE TRIRACHODONTID CYNODONT *CRICODON METABOLUS* FROM THE LUANGWA BASIN OF ZAMBIA: IMPLICATIONS FOR TOOTH REPLACEMENT IN GOMPHODONT CYNODONTS AND FOR TRIRACHODONTID SYSTEMATICS

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The trirachodontid cynodont *Cricodon metabolus* was initially recognized from the Middle Triassic Manda Beds (Anisian) of the Ruhuhu Basin, Tanzania. Here we report on a recently collected juvenile specimen, identified as *C. metabolus* on the basis of postcanine apomorphies, from the coeval Ntawere Formation of the Luangwa Basin of northeastern Zambia. The skeleton is remarkably complete, including most pro- and epipodials, some girdle material, and a disarticulated skull with a well-preserved dentition. The dentary of the new specimen is about half the length of the holotype dentary, indicating that the individual was about half-grown. This juvenile specimen demonstrates the pattern of postcanine tooth succession more completely than does any other gomphodont cynodont.

The upper postcanine dentition is divisible into four replacement sequences, each with a distinct morphology. From front to back they are: (1) one very small sectorial tooth; (2) five transversely-expanded teeth of increasing size, the last is unerupted; (3) three transversely-expanded teeth of decreasing size, the first, about to be shed, in the same tooth position as the larger unerupted tooth of sequence two and the third tooth partially erupted; and (4) two small sectorial teeth, the first a partially resorbed remnant lying labial to the last tooth of sequence three and the second erupting behind the first. The dentition thus consists of 10 functional tooth positions with 12 individual teeth. It appears that the earliest wave of tooth eruption consisted of narrow sectorial teeth now preserved only at the rear of the tooth row. The second wave consists of transversely-expanded teeth that presumably increased in size posteriorly but then decreased in size toward the rear of the tooth row. The third wave consists of progressively larger transversely-expanded teeth replacing the second wave of smaller teeth. Finally, at the front of the tooth row very small sectorial teeth appear to be replacing small transverse teeth.

We recognize four valid species of trirachodontids: *Langbergia modisei* of Early Triassic age; *Trirachodon berryi* and *T. kannemeyeri* mainly of basal Middle Triassic age and *C. metabolus* of later Middle Triassic age. The Early Triassic *Beishanodon youngi* and Middle Triassic *Sinognathus gracilis* from China are generally considered to be trirachodontids. Contrary to recent studies, our cladistic results place the stratigraphically oldest, *Langbergia,* at the base of Trirachodontidae and exclude the Chinese taxa from this family, allying them with Probainognathia.

Grant Information
This research supported by National Science Foundation EAR-1337569.

Technical Session IV (Wednesday, October 14, 2015, 2:30 PM)

FROM LAND TO SEA-ARCHAEOCETE BONE MICROANATOMICAL INVESTIGATION

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Many amniote groups made the evolutionary transition from a fully terrestrial to a semi- or fully aquatic life. Cetacea, which are now totally independent of the terrestrial environment, underwent their land-to-sea transition during the Eocene. For lineages with transitional fossil forms, it remains difficult to determine both their degree of physiological adaptation to life in water and their locomotor ability in water. This study investigates the lifestyles of primitive cetaceans, archaeocetes, which are essential for understanding the process of secondary adaptation to life in water. We document the internal structure of long bones, ribs, and vertebrae in fifteen specimens belonging to the three more derived archaeocete families–Remingtonocetidae, Protocetidae, and Basilosauridae–using conventional and synchrotron microtomography for virtual thin-sectioning. This reveals osseous specializations observed in these taxa and enables us to comment on their possible swimming behavior. Bone mass increase is observed in the ribs and femora of all taxa, whereas the vertebrae are essentially spongious. Humeri change from very compact to spongious in the progressive independence of cetaceans from a terrestrial environment. This is consistent with progressive loss of a propulsive role for forelimbs used instead for steering and stabilization. The opposite trend is observed in femora, with basilosaurid hind limbs being strongly reduced with no involvement in locomotion. Our results confirm that Remingtonocetidae and Protocetidae were almost exclusively aquatic in locomotion for the taxa sampled, which probably were shallow-water suspended swimmers. Conversely, basilosaurids display osseous specializations similar to those of modern cetaceans and were more active open-sea swimmers. It is important that homologous sections be used in comparative microanatomical studies, and also that information from several bones of the same taxon be combined for reliable functional interpretation.

Colbert Prize (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

FAUNAL ANALYSIS OF EARLIEST TORREJONIAN (TO1) MAMMALS FROM NORTHEASTERN MONTANA, USA

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The Tullock Formation in northeastern Montana documents the recovery from the Cretaceous-Paleogene mass extinction and the early radiation of placental mammals. It preserves fossils from the early Puercan (Pu1) to the earliest Torrejonian (To1) North American Land Mammal 'age'. More than 7,000 mammalian specimens have been recovered from Pu1 and Pu3 localities in this area, but until now, only 78 had been described from the To1 localities (Farrand Channel and Horsethief Canyon localities), which are bracketed by radiometric ages of 65.12 Ma and 65.04 Ma. Previous research on these assemblages suggests that by the To1 the early radiation of placentals and the decline of multituberculates had begun, but whether this is an artifact of sampling or a meaningful evolutionary trend has not been fully tested.

Here, we describe 209 newly recovered mammalian specimens from the To1 Horsethief Canyon localities and analyze the taxonomic diversity and composition of this local fauna relative to the Pu3 Garbani local fauna from our study area. We record 46 species in our assemblage, of which eight represent new occurrences and two likely represent new archaic ungulate species. Relative to the Pu3 local fauna (at least 40 spp.), the Horsethief Canyon local fauna might record a slight increase in raw species richness, despite far less sampling of this To1 local fauna; it results from slightly fewer multituberculate species but twice as many archaic ungulate species. Relative abundances of major taxa show substantial changes from Pu3 to To1: multituberculates fall from 58% to 15%, whereas archaic ungulates increase from 12% to 23% and plesiadapiform primates from 25% to 57% of all specimens; 'insectivorans' and triisodontids include 5% of all specimens. Our results corroborate previous results that by To1 metatherians were locally extinct, multituberculates were numerically in decline, and plesiadapiform primates and archaic ungulates were increasing in richness and relative abundances to different degrees. Future work will illuminate how these new ecologically important groups were partitioning resources relative to other components of the mammalian fauna.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

A NEW ENANTIORNITHINE SPECIMEN FROM THE LOWER CRETACEOUS OF NORTHERN HEBEI, CHINA

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In the last two decades, numerous enantiornithine fossils have been recovered from the Early Cretaceous Jehol Biota of north-eastern China, and these discoveries have greatly improved our understanding of the early evolution of the group. Here we report on a new enantiornithine specimen, Chaoyang Shanyang Fossil Museum (CSFM)-B00002a, b. The specimen is a nearly complete, mostly articulated skeleton from the Lower Cretaceous Dabeigou Formation (about 131 Ma) of Fengning County, northern Hebei province, China. The Dabeigou formation is slightly older than the Lower Cretaceous Yixian and Jiufotang formations; extremely abundant fossil birds have found from the latter, whereas only two avian taxa have been reported from the former, including *Eoconfuciusornis zhengi* and *Protopteryx fengningensis*. The new specimen is a younger individual, as indicated by the incomplete fusion of the synsacrum and incomplete ossification of the sternum. It is smaller in body size than *Liaoningornis longidigitrus*, but is similar to the latter in limb segment proportions and sternum. This bird differs from other known enantiornithines by a unique combination of following features: rostrum occupying half the length of the skull, teeth on upper jaw more numerous than on mandible, lateral margin of coracoid straight, caudal end of xiphoid process forked laterally as a goblet-like shape, forelimb longer than hind limb (about 115% length of hind limb), alular digit not extending as far distally as major metacarpal, metatarsals III and IV subequal in length, pedal digit III longer than metatarsal III, and a pair of strap-like tail feathers tapered distally. This type of tail feather has not been reported in Mesozoic birds. Further discoveries are needed to confirm whether the tail feathers are also present in adult birds.

Grant Information
National Natural Science Foundation of China (41172026) and Education Bureau Foundation (LR2012038) of Liaoning Province

A NEW SPECIES OF PENGORNITHIDAE (AVES: ENANTIORNITHES) FROM THE LOWER CRETACEOUS OF CHINA SUGGESTS A SPECIALIZED SCANSORIAL HABITAT PREVIOUSLY UNKNOWN IN EARLY BIRDS

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We describe a new enantiornithine bird from the Lower Cretaceous Jiufotang Formation of Liaoning, China. Although morphologically similar to previously described pengornithids *Pengornis houi*, *Pengornis* IVPP V18632, and *Eopengornis martini*, morphological differences indicate it represents a new taxon of the Pengornithidae. Based on new information from this specimen we reassign IVPP V18632 to *Parapengornis* sp. The well preserved pygostyle of the new specimen elucidates the morphology of this element for the clade, which is unique in pengornithids among Mesozoic birds. Similarities with modern scansores such as woodpeckers may indicate a specialized vertical climbing and clinging behavior that has not previously been inferred for early birds. The new specimen preserves a pair of fully pennaceous rachis-dominated feathers like those in the holotype of *Eopengornis martini*; together with the unique morphology of the pygostyle, this discovery lends evidence to early hypotheses that rachis-dominated feathers may have had a functional significance. This discovery adds to the diversity of ecological niches occupied by enantiornithines and if correct reveals are remarkable amount of locomotive differentiation among Enantiornithes.

Grant Information
The Chinese Academy of Sciences and the National Basic Research Program of China (973 Program, 2012CB821906); The National Natural Science Foundation of China (41172020).

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

A VIRTUAL GEOMETRIC MORPHOMETRIC APPROACH TO THE QUANTIFICATION OF LONG BONE BILATERAL ASYMMETRY AND CROSS-SECTIONAL SHAPE

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The widespread use of 3D digitization means that models of whole bone geometry are routinely captured for many applications in virtual palaeontology. Current methods to extract and analyze long bone cross sections either typically rely on traditional linear measurements and casting methods, or do not fully utilize geometric data available in virtual models. Here we introduce a quantitative approach to orient virtual long bone models, extract cross sections, and analyze the shape of those sections using a geometric morphometrics protocol. An example study set of 20 paired humeri (N = 40) from Andaman Islanders were sampled at 35%, 50%, and 65% of measured length from the distal end of the bone. We retain anatomical orientation of the shape data by capturing landmarks using polar radii. Our results show that the directionality of shape change (distribution of bone from centroid) can be evaluated in the context of whole outline shape and in relation to the axis of maximum bending rigidity, thereby providing a sensitive means to quantifying amount and extent of diaphyseal plasticity. We recover differences in shape between left and right cross sections that are not detected by traditional measurements and introduce a new scale-independent metric that allows for differences in circularity along the humeral shaft to be evaluated using outline shape. We show that the main axes of outline shape change (PC1, PC2) relate to measures of Imax/Imin (planes of maximum/minimum bending rigidity) and Ix/Iy (anterior-posterior and medial–lateral planes), biomechanical indices used to quantify resistance to bending. This relationship varies with sampling location, suggesting that neither all, nor potentially the same, aspects of shape variation between left and right cross sectional outlines is captured by the study of Imax/Imin or Ix/Iy. This approach can be used on surface scan and computed tomography (CT) data, and we provide examples of how the method can be extended for integration with variables collected in bone histology studies.

Grant Information
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Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

TRAILING DINOSAUR TRACKS IN THE EARLY CRETACEOUS: THE DOCUMENTATION AND PUBLIC INTERPRETATION OF THE MILL CANYON DINOSAUR TRACKSITE, UTAH

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A new tracksite within the Cedar Mountain Formation was discovered north of Moab, Utah in 2009. This site not only represents a unique assemblage of tracks for the Early Cretaceous, but it also provides an excellent opportunity for public visitation and interpretation. The Mill Canyon Dinosaur Tracksite (MCDT) is administered by the Bureau of Land Management's Moab Field Office.

An international team of scientists has collaborated to study the site. Originally exposed in a dry wash, an enhanced picture of the tracksite was gained by exposing the surface through excavation. A diverse vertebrate ichnofauna with a minimum of 10 named ichnotaxa was discovered, including dinosaurian, crocodilian and bird tracks. High-resolution photogrammetric documentation was conducted throughout the project, which has resulted in a 3D digital record of the site containing the location and condition of the tracks and traces. The documentation and photogrammetric mapping are used to highlight the recreational and educational values of these unique paleontological resources.

To both encourage visitation to the site and minimize impact to the surface, an interpretive trail was constructed, composed of a combination of land based and raised boardwalks, which navigate the site. To help with protection and interpretation, a Site Stewardship project has been established with the Utah Friends of Paleontology. Training sessions have also been given to local guides and outfitters to help convey proper site stewardship and scientific interpretations of the site.

Year-round activities and field trips, along with teacher/educational packages have been developed. Integrating new technology, such as podcasts, that work in conjunction with traditional interpretive efforts to convey information about the site helps to reach a variety of audiences and ability levels. Visitors are encouraged to observe and learn about this exceptionally preserved tracksite, as well as the methods of science, research and photogrammetric documentation. The scientific research and visitation developments at the MCDT are in line with current Federal legislation to manage paleontological resources using scientific principles and expertise for the benefit of the public, as well as U.S. Secretary of the Interior Sally Jewell's efforts to engage the next generation – "For the health of our economy and our public lands, it's critical that we work now to establish meaningful and deep connections between young people – from every background and every community – and the great outdoors."

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

FIRST OCCURRENCE OF AN OVIRAPTOROSAUR (THEROPODA: MANIRAPTORA) FROM THE MESAVERDE GROUP (WILLIAMS FORK FORMATION) OF NORTHWESTERN COLORADO

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We report on the discovery of an oviraptorosaur dinosaur element from the Douglas Creek Arch area of northwestern Colorado on lands administered by the Bureau of Land Management. The specimen was recovered from the William Fork Formation (Mesaverde Group), which is dated to the late Campanian – earliest Maastrichtian based on ammonite biostratigraphy. This discovery is based on a single, fairly well preserved, left humerus and represents the first oviraptorosaur dinosaur reported from the William Fork Formation. Previous finds of North American oviraptorosaurs have been restricted to Texas, New Mexico and southern Utah to the south, and South Dakota, Montana, and Alberta in the north. Oviraptorosaurs are unknown from Wyoming, eastern Utah and, up until now, Colorado, within the enigmatic break between the southern and northern biogeographic provinces of Laramidia. New specimens from this region are of interest in that they provide additional insights into the development, extent, and possible transitional areas that exist in these upper Campanian – lower Maastrichtian biogeographic zones. Laramidia in general is known for its endemic southern and northern macrovertebrate faunas, highlighted by studies in the Kaiparowits and Dinosaur Park Formations. Taxa of similar age constraints include *Hagryphus giganteus* from southern Utah, *Leptorhynchos gaddisi* and ? *Chirostenotes* from west Texas, along with *Leptorhynchos elegans*, *Chirostenotes pergracilis*, *Epichirostenotes curriei* and *Caenagnathus collinsi* from Alberta. The fragmentary and non-overlapping nature of the existing specimens in the late Campanian and earliest Maastrichtian complicates the attempt at finding resolution between the southern and northern faunas of Laramidia. No humerus exists for any of the temporally equivalent specimens. The Williams Fork specimen is currently more similar in form to that of the Aptian-Albian age primitive oviraptorosaur *Microvenator celer* from the Cloverly Formation of Montana, than it is to the later, North American Maastrichtian specimen *Anzu wyliei*. Closely related forms from Asia include *Ingenia yanshini* and the undescribed Zamyn Khondt "*Citipati*" GI 100/42 specimen. The Williams Fork specimen was found in a lag deposit near the base of a multi-story channel sandstone complex, unlike other North American oviraptorosaur sites, which indicate this group may have favored floodplain settings over channel margins.

Technical Session III (Wednesday, October 14, 2015, 9:15 AM)

VASCULAR CORRELATES OF RED BLOOD CELL SIZE AND THE EVOLUTION OF SYNAPSID BONE MICROSTRUCTURE

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Red blood cells (RBCs) display a range of sizes among tetrapod species and higher clades, with some groups differing by orders of magnitude in volume. In vertebrate muscle, capillary caliber has been shown to vary with RBC diameter, the largest being found in amphibians and non-avian reptiles and the smallest in mammals (which also have enucleated RBCs). In recent and fossil limb bone cortices, vascular channels show a variety of motifs, sizes, and densities that have been considered in light of bone growth and biomechanics, but the influence of RBC size on channel caliber within a single bone and physiological constraints on their minima have rarely been considered. Here, we evaluate the relationship between RBC size and vascular channel histometrics in several tetrapod species. Blood smears were taken when available and femora were dissected, sectioned at the midshaft, and digitally imaged for analysis. Non-phylogenetic and PGLS regressions support that minimum and harmonic mean channel caliber covary with RBC width and area (i.e., with those species having smaller channels accommodating smaller RBCs). Moreover, vascular density is strongly negatively correlated with RBC size independent of body size. Osteocyte densities are also negatively correlated with channel sizes and positively correlated with vascular density. The smallest channels and highest vascular densities were found in sampled mammals and birds, which have the smallest RBCs. We hypothesize that smaller channel sizes permit greater vascular densities and shorter diffusion distances to the lacunocanalicular network. We use these results to infer patterns of RBC size evolution along the mammalian stem, and suggest the acquisition of mammal-like physiology early in the evolution of Permo-Triassic therapsids. Specifically, we show that reduced channel caliber, coupled with high vascular and osteocyte densities, predates the origin of mammals by at least 30 million years.

Grant Information
NSF-BIO 1309040

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

A NEW ANACORACID SHARK FROM THE LATE CRETACEOUS MIFUNE GROUP, KUMAMOTO PREFECTURE, JAPAN

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Many remains of terrestrial vertebrates have been found in non-marine deposits in the upper part of the Mifune Group. Abundant fossils of shallow marine and brackish water molluscs have been found in the lower part of the Mifune Group, but remains of vertebrates are rare in this sediment. A new anacoracid tooth was recently discovered in the 'Lower' Formation of the Mifune Group, and this object is described in this study. The tooth was found in fine sandstone at a fossil site in the Asanoyabu area, which is an outcrop of a section of the 'Lower' Formation of the Mifune Group containing fossils of crocodyliforms, carettochelyid turtles, and diverse shallow marine and brackish water molluscs. This section has been interpreted as containing intertidal and coastal marsh deposits. *Actinoceramus tamurai*, an index fossil, has been discovered in this horizon, indicating that the deposit formed during the middle or late Cenomanian. The tooth crown, which is comparatively large in anacoracids, is well preserved, but the root is partly eroded. The shape, from the labiolingual aspect, is distally obliquely triangular, and mesiodistally broader than high. The crown is very thin and possesses a narrow apex and serrated cutting edges, the mesial edge being long, clearly convex, and strongly sinuous and the distal edge being nearly straight and connected at an acute angle to a short distal convex heel. The serrations are simple and of varying sizes. The tilted crown indicates that the tooth had a lateral or posterior position in the jaw. The completely serrated cutting edge shows that this specimen belongs to *Squalicorax* or *Scindocorax* rather than to another small anacoracid genus (e.g., *Nanocorax*, *Palaeoanacorax*, or *Pseudocorax*). Although the convex and sinuous mesial margin is similar to that found in *Scindocorax*, the crown described here is somewhat larger than crowns of other *Scindocorax* species. The combination of a tilted acute cusp, a basal convex and sinuous mesial cutting edge, and a short distal convex heel is unique to *Squalicorax*. Several *Squalicorax* fossils from the Upper Cretaceous have been found in Japan, but records of this genus in Cenomanian deposits have been limited to two specimens from the Middle Yezo Group. This is the first record of an anacoracid shark found in the Mifune Group, and it is probably one of the oldest records in Japan of a species from the genus

Squalicorax. Therefore, this specimen might provide new information on the diversity and paleobiogeography of anacoracid sharks off the east coast of Asia.

Technical Session XVI (Saturday, October 17, 2015, 9:15 AM)

LATITUDINAL GRADIENTS IN LATE TRIASSIC NON-MARINE ECOSYSTEMS: NEW INSIGHTS FROM THE UPPER CHINLE FORMATION OF NORTHEASTERN UTAH, USA

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Detailed paleoenvironmental and paleontological studies over the past 10 years revealed distinct latitudinal climate zonation in Late Triassic Pangaea, with hot and humid equatorial tropics, hot and arid low latitudes, and more temperate and humid mid-latitudes. These climatic belts biogeographically sorted organisms, such as early dinosaurs and other amniotes. In contrast, less attention has been paid to latitudinal differences in ecosystems within these major climatic zones. The Upper Triassic Chinle Formation of the Colorado Plateau, southwestern North America, is an ideal study system to answer this question. Outcrops of this formation not only span 6° of present-day latitude, but they also were deposited over a span of 20 million years, during which time Pangaea moved northward by ~10°. To test whether climatic differences within the low latitude arid zone affected ecosystem composition, we examined late Norian-Rhaetian upper Chinle Formation exposures in the southern Uinta Mountains, northeastern Utah, in and around Dinosaur National Monument. These outcrops are the northernmost exposures of the formation, far from well-known fossil localities further south in Arizona and New Mexico. Based on sedimentological and invertebrate ichnological data (e.g., notostracan traces), we interpret these strata as ephemeral stream and sheet flow deposits, indicating a generally drier climate than more southern Chinle outcrops. Our work indicates that body fossils are relatively rare and fragmentary, though they do include specimens of actinopterygians and phytosaurs. In contrast, trace fossils are abundant and well-preserved, but low in diversity. Vertebrate traces include those of actinopterygians (*Undichnia*), small ?archosauromorph reptiles (*Rhynchosauroides*, *Gwyneddichnium*), pseudosuchians (*Brachychirotherium*), and small theropod dinosaurs (*Grallator*). This tetrapod ichnological assemblage is one-third less diverse than those from southern Utah, and under half the diversity of those from lower latitude eastern North America. This indicates that although similar vertebrate clades were present across the Chinle depositional basin, the vertebrate assemblage at this northern margin was depauperate compared to further south. Our new data from northern Utah suggest that within this low-latitude arid zone, the further away from the equator an area was, the drier conditions became. As a result, vertebrate diversity decreased, which may have stressed ecosystems, putting them at risk during the end-Triassic extinction.

Grant Information
Great Basin Cooperative Ecosystem Study Unit

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

FIRST DISCOVERY OF DIDACTYL THEROPOD FOOTPRINTS FROM THE UPPER CRETACEOUS OF MONGOLIA

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One trackway consisting of two footprints of a didactyl theropod was discovered from the Upper Cretaceous of Shar Tsav, Eastern Gobi Desert, Mongolia. This is the first evidence of didactyl theropod footprints from Mongolia. Two consecutive imprints in the trackway are both right footprints, and the left footprint between them is not clearly imprinted. Footprint length is 19 cm, footprint width is 10 cm, stride length is 119 cm and the pace angulation is 157°. The digit III impression does not jut out and the terminating point of the digit IV impression is slightly behind of the terminating point of the digit III impression. Both digital impressions have tapered termination. Average divarication angle between III and IV is 14°. It appears that both digits are semi-parallel. There is no proximal phalangeal pad impression of digit II. These characteristics suggest that the trackmaker was a dromaeosaurid dinosaur, and the footprints are attributable to the ichnogenus *Dromaeosauripus*. Dromaeosaurid body fossils have been discovered from all of the Upper Cretaceous deposits in Mongolia: the Nemegt Formation (*Adasaurus mongoliensis*), the Barun Goyot Formation (*Hulsanpes perlei*), the Djadokhta Formation (*Velociraptor mongoliensis*) and the Bayn Shire Formation (*Achillobator giganticus*). Stratigraphically, the stratum of Shar Tsav is attributed to the Upper Cretaceous Nemegt Formation based on the fossil remains, but attribution of the tracks to body fossil genera cannot be confirmed. However, it is certain that didactyl trackmakers existed in every age of the Upper Cretaceous in Mongolia. From the Shar Tsav area, almost 20 000 footprints have been discovered, and most of them are tridactyl theropod footprints ranging from 6 cm to 70 cm in length. In spite of the abundance of theropod footprints of various size, didactyl footprints are extremely rare. In contrast, body fossils of dromaeosaurid dinosaurs are not as rare as didactyl footprints in the Nemegt Formation and Djadokhta Formation. This suggests that the dromaeosaurid trackmakers in Shar Tsav rarely entered the wet footprint-preserving floodplain.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

MICROWEAR OBSERVED ON TEETH OF *EDESTUS MINOR*: EVIDENCE FOR AN UNUSUAL FEEDING STRATEGY

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The symphyseal tooth whorls of the Carboniferous chondrichthyan *Edestus* consist of files of teeth having sharply-pointed, serrated crowns, joined at their bases. A single tooth whorl was present in each jaw. How these tooth whorls functioned is not obvious, since the convex curvature of the whorls allows only a few of the most lingual crowns of opposite tooth whorls to occlude. Rather than working in opposition, like scissors, the teeth might have been used to cut and disable prey with a vertical motion of the anterior part of the body, with jaws fixed. Microwear of *Edestus* teeth, in particular the orientation of feeding-related scratches, might be used to distinguish between these two functional modes. Diagenetic alteration and often unknown preparation history makes problematic the analysis of microwear of *Edestus* teeth found in carbonaceous shales associated with coal deposits. *Edestus minor* teeth from an unusual locality not associated with coal deposits and with unusually good preservation of crown surfaces were examined for microwear. These teeth are from the Strawn Group (Desmoinesian, Middle Pennsylvanian) of San Saba County, Texas. They are reposited at the Vertebrate Paleontology Laboratory of the University of Texas at Austin. The best-preserved crown surfaces display numerous scratches 50 to 500 micrometers long. The scratches are oriented predominantly transverse to the basal-apical axis. This observation favors the jaws-fixed, vertical slashing hypothesis. In some cases, two or three parallel scratches are observed, separated by 30 to 50 micrometers. These complex scratches might have been caused by contact with chondrichthyan dermal denticles having multiple cusps or ridges. A few scratches caused by manual preparation are easily recognized by their fresh appearance and sometimes form a crisscrossed pattern.

Grant Information
Karl Hirsch Memorial Grant (Western Interior Paleontological Society)

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

EARLY PLEISTOCENE REDUNCINI (BOVIDAE) FROM THE KONSO FORMATION, SOUTHERN ETHIOPIA

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The Early Pleistocene Konso Formation is exposed at the southwestern part of the Main Ethiopian Rift. The Konso Formation has yielded over 8000 identifiable fossil specimens including 66 taxa in six orders of mammals and other vertebrates. Bovid specimens account for approximately 70% of the whole mammal collection from the Konso Formation. The tribe Reduncini dominates the Konso bovid specimens. We identified two taxa, *Kobus sigmoidalis* and *Redunca* sp., from 207 horncores and seven skulls of the Konso reduncine specimens. The horncores of *K. sigmoidalis* have long and relatively slender bases and unclear transverse ridges, high basal divergence, teardrop shaped cross sections with a flattened lateral surface and upright insertions. The horncores of genus *Redunca* were identifiable by their size and short tapered shape. These characteristics and size of the *K. sigmoidalis* horncores from the Konso Formation were relatively constant during the Konso Formation range from interval 1 (~1.9 Ma) to interval 5 (~1.3 Ma); the Konso *K. sigmoidalis* horncores were smaller in size than those from the Koobi Fora Formation, and larger than those from the Shungura Formation. Furthermore, the open dry grassland index (ODG) based on bovid tribe proportions (Alcelaphini + Antilopini against Reduncini + Bovini + Tragelaphini + Aepycerotini) suggests an overall drier condition at Konso compared with the Shungura and Koobi Fora Formations, and an overall more humid condition at Konso compared with the Olduvai area.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

NEW EARLY-MIDDLE PERMIAN CHONDRICHTHYAN FAUNAS FROM GUADALUPE MOUNTAINS NATIONAL PARK, TEXAS, USA

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Vertebrate microfossils, obtained by bulk-sampling of matrix by Gordon Bell between 2002 and 2004 in Guadalupe Mountains National Park, include diverse marine chondrichthyan teeth, scales, denticles, a cephalic spine, and a fin spine. A new genus, similar to the euselachian *Gissarodus*, occurs in the Shumard and El Centro members of Cutoff Formation (Kungurian). A new ctenacanthiform, *Ctenacanthus* sp.nov., occurs in the Pipeline Shale of Brushy Canyon Formation (lower Roadian) and Getaway Member of the Cherry Canyon Formation (upper Roadian-lower Wordian). New chondrichthyans from the Lamar and Reef Trail members of the Bell Canyon Formation (Capitanian) are represented by teeth of a new genus of anachronistid neoselachian and a new petalodontiform resembling *Tanaodus* and *Netsepoye*.

The chondrichthyan fauna from the Pipeline Shale and Getaway Member is dominated by the teeth of symmoriiforms *Stethacanthulus meccaensis* and *S. decorus*, and the ctenacanthiforms *Glikmanius myachkovensis* and *G. occidentalis*. Less common are teeth of the xenacanthimorph *Bransonella lingulata*, a symmoriiform *Stethacanthus* sp., ctenacanthiforms *Heslerodus divergens*, cf. *Tamiobatis* sp., and cf. *Cladodus* sp., hybodontoids *'Acrodus' sweetlacruzensis*, *'Lissodus'* sp. and an unidentified fin spine; tooth fragments of Agassizodontidae; and a cochliodontid tooth-plate. The chondrichthyans from the Lamar and Reef Trail members are represented by teeth of the ctenacanthiform *G. myachkovensis*, the jalodontid *Texasodus* sp., and a psephodontid tooth-plate. Teeth that occur in the Shumard and El Centro members include the symmoriiforms *Stethacanthulus meccaensis* and a taxon related to *Denaea* and *Cobelodus,* ctenacanthiforms *G. occidentalis*, *H. divergens*, *Tamiobatis* sp., *Cladodus* sp., and a taxon related to *Saivodus* and *Tamiobatis,* and the hybodontoid *'Lissodus'* sp. Also present throughout the sampled section are palaeoniscoid teeth, tooth plates, bones, and scales.

Grant Information
Paleontological Society Sepkoski PalSIRP grant to AI, RFBR research project No. 14-04-01507 a

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

NEOGENE HERPETOFAUNAS FROM THE CENTRAL GREAT PLAINS: DIVERSITY, MODERNIZATION, AND RELATIONSHIPS TO CLIMATE CHANGE

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Fossil Cenozoic herpetofaunas are potentially useful proxies for environmental reconstruction because extant faunal properties are strongly correlated to habitat. The fossil records of reptiles and amphibians are more poorly sampled than coeval mammalian records, however, due to perceived taphonomic biases and taxonomic ambiguity of preserved elements. Long, well-preserved herpetofaunal records do occur in numerous stratigraphic sequences throughout the Neogene, and documenting these records is a necessary first step in understanding environmental change.

To reconstruct histories of richness, turnover, and modernization of herpetofaunas through the climatic transitions of the Central Great Plains, we calculated generic richness and documented patterns of first and last occurrences based on ~1000 records of reptiles and amphibians from 133 localities spanning the Hemingfordian through Blancan NALMAs of Nebraska. Total generic richness tracked record quality, represented by number of localities for each NALMA substage, with increasing richness through the early Miocene to a maximum during the late Barstovian, followed by a general pattern of decreasing richness through the late Miocene and Pliocene. Snakes and turtles possessed the highest richness, but with disjunct histories of change. Richness in snakes tracks the total generic pattern, whereas turtles demonstrate patterns of increasing richness during substages with comparatively few localities. Differences in histories of richness between clades indicate that record quality is not sufficient to explain changes in diversity through time.

Patterns of first and last occurrence indicate that herpetofaunal modernization did not result from distinct episodes of faunal turnover. Instead, assembly of modern Central Great Plains reptile and amphibian communities resulted from the accumulation of extant clades throughout the Neogene, with diffuse, continuous extinction of archaic taxa or extirpation of fully aquatic and subtropical taxa throughout the record. Last occurrences of subtropical taxa that suggest cooling climates include the elapid snake *Micrurus* and the amphisbaenian *Rhineura* during the late Barstovian, whereas the last occurrences of cryptobranchid salamanders and *Siren* during the late Barstovian and *Alligator* during the late Clarendonian indicate increasing aridity in the North American interior.

Grant Information
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Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

LATE CRETACEOUS DROMAEOSAURID THEROPOD DINOSAURS (DINOSAURIA: DROMAEOSAURIDAE) FROM SOUTHERN LARAMIDIA AND IMPLICATIONS FOR DINOSAUR FAUNAL PROVINCIALITY IN NORTH AMERICA

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While numerous dromaeosaurid (Dromaeosauridae) taxa are known from the Late Cretaceous of northern Laramidia, those of southern Laramidia have been far more enigmatic. This is even more apparent after a taxon named from the late Campanian of New Mexico was recently found to represent a troodontid (Troodontidae) rather than a dromaeosaurid as was originally described. Otherwise the fossil record of dromaeosaurids from the Late Cretaceous of southern Laramidia is made up almost exclusively of teeth. Fossil dromaeosaurid (or presumed dromaeosaurid) teeth have been collected in Late Cretaceous strata in Utah, Texas, New Mexico, and Mexico. Based on tooth morphotypes, previous studies have estimated there were at least two dromaeosaurid taxa during the Late Cretaceous in New Mexico, Utah, and Mexico, and potentially three in Texas. In addition to the dromaeosaurid tooth fossils recovered, some skeletal remains have also been reported from Texas and Utah. Those from Texas include an isolated metacarpal and phalanx. Those from Utah include mostly isolated pedal phalanges and unguals. A recently named species of dromaeosaurid, known as *Saurornitholestes sullivani*, has been recovered from late Campanian strata in New Mexico. Additionally a specimen with both cranial and postcranial material is known from the Maastrichtian of New Mexico, probably representing a distinct taxon, and is by far the most complete dromaeosaurid material recovered from Late Cretaceous strata in southern Laramidia. While the Campanian dromaeosaurid from New Mexico seems closely related to the northern Laramidian dromaeosaurid *Saurornitholestes langstoni*, the Maastrichtian dromaeosaurid from New Mexico is distinct from *Saurornitholestes* and appears distinct from other described dromaeosaurid taxa. Although the New Mexican taxa show some similarities between the dinosaurian faunas of northern and southern Laramidia during the late Campanian, they show greater distinctiveness during the Maastrichtian. Indeed, it appears that dinosaurian faunal provinciality and dynamics among small theropod taxa were complex during the Campanian and Maastrichtian of the Late Cretaceous of western North America.

Technical Session XIX (Saturday, October 17, 2015, 3:00 PM)

A NEW SALAMANDER FROM THE UPPER JURASSIC TIAOJISHAN FORMATION OF HEBEI PROVINCE, CHINA, AND EARLY EVOLUTION OF SALAMANDROIDS

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Salamandroidea is a major salamander clade, comprising more than 600 extant species. Such a species-diverse clade overwhelmingly outnumbers its sister clade, the Cryptobranchoidea, consisting of some 70 extant species. The fossil record of salamandroids, however, is mainly known from the Cenozoic worldwide, with rare fossils found from the Mesozoic beds in Europe and Asia. Among the few Mesozoic taxa known, *Beiyanerpeton* represents the basalmost salamandroid from the Upper Jurassic of Liaoning, China. This study reports a second salamandroid from the Upper Jurassic Tiaojishan Formation ($^{40}Ar/^{39}Ar$ dates of 161.8±0.4 Ma – 159.5±0.6 Ma), cropping out in Hebei Province, China. A total of 47 specimens used in this study, including both juvenile and adult individuals, were collected from the Nanshimenzi locality near the provincial border with Liaoning. All these specimens are deposited at Peking University Paleontological Collections.

Cladistic analysis places the new salamander as the sister taxon *of Beiyanerpeton*, which in turn forms the sister clade to the remaining salamandroids. Like *Beiyanerpeton*, the new salamander is a neotenic form, as evidenced by its retention of internal and external gill structures in the adult stage. Interestingly, adult specimens of the new salamander have the toothed palatine ossified as a discrete element, and have a toothed coronoid ossified in the lower jaw. The pterygoid has a slender anterior process curved medially, and the process bears a single tooth row. In extant salamanders, the palatine and coronoid only occur in early larval stages, but are all absent by fusion or resorption at the adult stage, with the exception of sirenids that retain the toothed palatine, and proteids and sirenids that retain a toothed coronoid. The new discovery indicates that these elements were indeed present at the adult stage in the early evolution of salamandroids. Previous studies have shown that the hyobranchium is by far the most variable region of the skull in salamanders. In this respect, the new fossil taxon displays a distinct configuration of the basibranchial II, with its trident anterior portion fused with an elongated posterior process, and a pair of short processes projecting posterolaterally. Such a peculiar configuration is previously unknown from any fossil or extant salamander. Along with *Beiyanerpeton*, the new discovery indicates that morphological disparity was already underway for the salamandroid clade by the early Late Jurassic (Oxfordian).

Grant Information
National Natural Science Foundation of China (grant 41072007/41272016).

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

A NEW ANISIAN (MIDDLE TRIASSIC) EOSAUROPTERYGIAN FROM PANXIAN, GUIZHOU PROVINCE, SOUTHWESTERN CHINA

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The Triassic stem eosauropterygians first emerged in the late Early Triassic, but rapidly diversified in the Anisian (Middle Triassic) when pachypleurosaurs and nothosaurs invaded both the western and eastern Tethys. This is the same time period as the first radiation of Triassic ichthyopterygians, and also corresponds to the period by which the invertebrates had completely recovered from the end-Permian mass extinction. From the small Panxian and Luoping intra-basins on the carbonate platform in southwestern China, the Pelsonian (Anisian) deposits alone yielded seven or more eosauropterygians, including pachypleurosaur-like forms such as *Wumengosaurus delicatomandibularis*, *Dianopachysaurus dingi* and *Diandongosaurus acutidentatus*, nothosaurs such as *Nothosaurus yangjuanensis*, *N. zhangi*, the lariosaur *Lariosaurus hongguoensis*, and the strange *Atopodentatus unicus*, indicating that eosauropterygians exhibited diversified ecological niches, from top predators to filter-feeders.

Here, we report a new specimen, GMPKU-P-1059, excavated from the fossil Bed 87 in the Upper Member of the Guanling Formation at Yangjuan in Xinmin of Panxian in 2006. The specimen was initially referred to *Keichousaurus* sp., but can now be described as a new eosauropterygian taxon after the detailed preparation and comparisons were completed. It is an almost complete and small pachypleurosaur-like specimen, with a preserved skeleton of 36 cm total length. The upper temporal fenestra is smaller than the orbit, the parietal table is broad and flat, the cervical ribs bear two proximal heads, the proximal ends of the dorsal ribs are typically pachyostotic, and the sacral ribs are not distally expanded. These features indicate the specimen is a pachypleurosaur eosauropterygian. However, this specimen also shows some differences from all other eosauropterygians, such as its rounded and shortened snout, its 24 cervical and 20 dorsal vertebrae, the straight ulna with the concave posterior margin, and four distal carpals. The preliminary cladistic analysis shows this new taxon nests within pachypleurosaurs, with close affinity to the Ladinian species *Keichousaurus hui*.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

THE OLDEST POCKET GOPHERS (RODENTIA: GEOMYIDAE) IN NORTH AMERICA

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Currently, the species of the family Geomyidae are distributed mainly in North and Central America with fewer species in northern South America; they are known as pocket gophers, tuzas, or taltuzas in Mexico and Central America. The family is represented by the Late Oligocene (Ar1)–Middle Miocene (Cl1) Entoptychinae and the Middle Miocene (Ba2)–Recent Geomyinae.

Current paleontological research carried out in the Late Eocene sediments that crop out in the surroundings of Santiago Yolomécatl town, in northwestern Oaxaca, southern Mexico, has allowed us to collect diverse cranial and postcranial specimens of the entoptychine *Gregorymys*. The fossiliferous strata are constituted by mudstones and some paleosol horizons. Associated fauna include turtles, *Rhineura*, caniforms, jimomyid rodents, *Leptochoerus, Perchoerus probus, Merycoidodon*, protoceratids, *Poebrotherium, Nanotragulus*, *Miohippus assinoboiensis,* cf. *Amynodontopsis,* a chalicothere and *Trigonias,* all of which constitute the Iniyoo Local Fauna. The equid index fossil *M. assinoboiensis* as well as the radiometric dates of the volcanic rocks that conformably overlie the fossiliferous beds indicate a Chadronian (Ch2-Ch4) NALMA for the faunal association.

There are two *Gregorymys* morphs in our collection, whose character states suggest that at least one is a previously unknown species; various specimens have been collected in direct association with their burrows and their skeletons show some fossorial adaptations. The records of these two morphs in northwestern Oaxaca, southern Mexico pushes back the biochronological range of the family Geomyidae by around 4-5 Ma, from

the Ar1 to Ch2-4. This indicates a much older origin of fossoriality in geomyids, and indicates that Geomyidae probably originated in southern Mexico or Central America prior to the Chadronian (Late Eocene), given their absence in the fossil localities from central and northern Mexico.

Grant Information
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Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

NEW DATA ON A POTENTIAL NEW SPECIES OF THE YOUNGEST KNOWN TYLOSAURINE MOSASAUR FROM THE UPPER CAMPANIAN BEARPAW FORMATION OF SASKATCHEWAN, CANADA.

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The fossil record of tylosaurinae mosasaurs in North America has previously been known from the Turonian to the middle Campanian. New data obtained by preparation of the right side of the skull of a large tylosaurine mosasaur from the upper Campanian of Saskatchewan further supports recognition of this specimen as a new species. The specimen was collected in 1995 from the Bearpaw Formation, Southern Saskatchewan, Canada, and it presents features and combinations of features never seen before in tylosaurines. Some of the characters that support recognition of this animal as a new species include: exclusion of the prefrontal from the dorsal rim of the orbit by the anterior process of the postorbitofrontal, frontal extends anteriorly well into the narial openings, dorsal medial midline of the frontal appears as a well developed keel, parietal table straight in shape, thick tympanic ala of the quadrate, and 55 (+8) vertebrae anterior to chevron bearing caudals. This potential new species shares the edentulous rostrum, relatively long suprastapedial process of the quadrate that never reaches the infrastapedial process, and twelve to thirteen maxillary and dentary teeth with other tylosaurine species. This species extends the stratigraphic distribution of the genus *Tylosaurus* in North America, occupying the northern Western Interior Seaway during the late Campanian.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

FOSSIL FISHES FROM THE PFEIFER SHALE MEMBER OF THE UPPER CRETACEOUS GREENHORN LIMESTONE IN NORTH-CENTRAL KANSAS, U.S.A.

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The Pfeifer Shale Member of the Greenhorn Limestone is a Late Cretaceous rock unit deposited under the Western Interior Seaway in North America and represents deposition during the maximum transgressive phase of the Greenhorn Cyclothem. Various fossil invertebrates are known from the Pfeifer Shale, but the taxonomic composition of its vertebrate fauna is poorly known. Recently, through surface collecting in the field and acid treatment of sediment samples in the laboratory, approximately 50 isolated skeletal and dental elements of fossil fishes were recovered from the lower part of the Pfeifer Shale (approximately 1 m above from its base) at a locality in south-central Republic County, Kansas, U.S.A. They include a minimum of three chondrichthyan taxa and six osteichthyan taxa, comprising *Ptychodus* cf. *P. whipplei*, *Cretoxyrhina mantelli*, *Squalicorax* cf. *S. falcatus*, Caturidae indet., Actinopterygii (non-teleostean) indet., *Pachyrhizodus minimus*, *Enchodus shumardi*, and at least two additional teleost species. Whereas the most common vertebrate fossils collected in our study are teeth of *Pachyrhizodus minimus*, represented by slightly over 20 teeth, other fossil remains include several isolated placoid scales of Elasmobranchii indet. and some isolated vertebrae of teleosts. In addition, the collection also includes small phosphatic pebbles interpreted to be coprolites of uncertain origins, some of which contain fragmentary bones of small teleosts as inclusions. The present study is important because it represents the first collective study of fossil vertebrates from a specific stratigraphic horizon within the Pfeifer Shale, giving a snapshot of the types of fishes that lived in the Western Interior Seaway during the early Turonian. Even though the sample size is still small, the fossil record indicates that the fossil fish fauna encompassed a wide range of trophic regimes, including small bony fishes with small sharp teeth suited for catching smaller fishes and soft-bodied invertebrates (e.g., caturids, *Pachyrhizodus*, and *Enchodus*) as well as durophagous (*Ptychodus*), predatory (*Cretoxyrhina*), and scavenging (*Squalicorax*) sharks.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

THE CRANIAL BIOMECHANICS OF *EFFIGIA OKEEFFEAE* AND ITS CONVERGENCE WITH ORNITHOMIMOSAURIDAE

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Convergences in food processing morphology provide an opportunity to test hypotheses of repeated evolution into palaeobiological niches. This study assesses the previously speculated functional similarity between the edentate archosaur *Effigia okeeffeae* AMNH FR 30587 (Archosauria: Pseudosuchia) and ornithomimosaurid dinosaurs (Archosauria: Avemetatarsalia), specifically *Struthiomimus altus, Ornithomimus edmontonicus and Garudimimus brevipes*. The crushed skull of *Effigia* was CT scanned, digitally separated from the attached matrix and retrodeformed, producing a 3D model. Using this 3D model, adductor and temporal musculature was reconstructed using attachment scars, extant phylogenetic bracketing and osteological constraints. Adductor muscular force was subsequently calculated from cross sectional areas. The cranial model was converted into a finite element (FE) mesh using Hypermesh before being run in Abaqus to test hypothetical bite forces at three positions. The retrodeformed skull allowed further insight into the anatomy of *Effigia* which differed from previous anatomical hypotheses by possessing a dorsoventrally concave ventral edge of the cranium alongside more subtle changes. Our analysis showed *Effigia* to possess a rostral bite force comparable to ornithomimosaurs, but the resulting FE model showed that this pseudosuchian cranium suffers from higher and more widely distributed absolute stresses, in response to such a bite, than do the ornithomimosaurs. Conversely, the distribution of extreme stresses induced from a posterior bite were reduced in comparison to an anterior bite, despite the greater mechanical advantage afforded by a more posterior position. The previously suggested ornithomimosaur feeding mechanism of a rostral bite preceding a 'catch and throw' swallow is not supported in *Effigia* based on its comparatively poor stress allocation in rostral biting. This deficit may be due to differential positions and sizes of the nares between *Effigia* and ornithomimosaurs. The large nares of *Effigia* open posterior to the rostral bite point, leaving only a thin narial bridge to accommodate dorsal stresses. Ornithomimosaur nares are comparatively small and open dorsal to the bite point, posterior to this the rostrum is a hollow bony tube, continuous until the antorbital fenestrae and more resistant to stress. We suggest that *Effigia* was not ecologically homologous to ornithomimosaurs and if they occupied equivalent niches these may have been exploited in functionally different ways.

Colbert Prize (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

DIETARY ECOLOGY OF HERBIVOROUS MEGAFAUNA FROM THE LA BREA TAR PITS IN SOUTHERN CALIFORNIA: EVIDENCE OF CHANGING DIETARY BEHAVIOR COINCIDENT WITH CLIMATE CHANGE

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The La Brea tar pits is a highly fossiliferous late Pleistocene locality with over 230 vertebrate species found, to date. While the fossil pits contain approximately nine times as many carnivores as herbivores, the abundance of herbivorous mammals found in the tar pits can help clarify the ecology of Pleistocene megafauna. Further, the La Brea tar pits contain fossil accumulations that were deposited during the past ~40,000 years and subsequently can provide important insights regarding how mammals may have changed their diet with interglacial warming. Here, we use dental microwear texture analysis and dental mesowear analysis to assess the dietary behavior of the three largest and most abundant ungulates at La Brea. We examined *Bison*, *Camelops*, and *Equus* teeth from pits spanning ~35,000 to ~11,000 years before present (YBP), with a focus on pit 77 (mean calibrated age of 35,370 YBP) and pits 61/67 (mean calibrated age of 11,581 YBP). Specifically, we tested the following hypotheses: i) the textural properties of food consumed by each herbivorous taxon remained constant throughout the late Pleistocene at La Brea, despite changing climatic conditions; and, ii) both proxy methods suggest that *Bison* and *Equus* were predominantly grazing, in contrast to *Camelops* which was primarily browsing at La Brea.

Dental mesowear scores from eight individuals were averaged to determine mesowear values for each tooth. Average shape (sharp, round, and blunt), relief (low and high), and mesowear numerical-scale (MNS, 0–6) values distinguish *Equus* from *Bison* and *Camelops*, with *Equus* having significantly blunter shapes, lower relief, and higher MNS values. However, *Bison* are not statistically distinct from *Camelops*, suggesting that grass may not have been a major component of their diet at La Brea. Mesowear attributes of *Bison* and *Equus* were typically not significantly different between pit 77 and pits 61/67. In contrast, dental microwear textures (*Asfc*) in both *Bison* and *Equus* are significant greater at pit 77 as compared to pits 61/67 and modern populations. Further, *Camelops* consumed food with more brittle textures (greater *Asfc*) than both *Bison* and *Equus* during both glacial (pit 77) and interglacial (pits 61/67) periods. Collectively, these data suggest that *Bison* and *Equus* consumed vegetation with a broader range of textural properties during the last glacial period than they did ~11,000 years ago or today and in contrast to *Camelops* which consumed a diet of primarily browse during both glacial and interglacial periods at La Brea.

Grant Information
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Technical Session III (Wednesday, October 14, 2015, 12:00 PM)

THE EVOLUTION OF AXIAL REGIONALIZATION IN MAMMALS: INSIGHTS FROM THE SYNAPSID FOSSIL RECORD

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Regionalization of the presacral vertebral column is patterned by the expression of *Hox* genes during embryonic development. Division into neck (cervical vertebrae) and trunk (dorsal vertebrae) regions is traditionally perceived as plesiomorphic for amniotes, whereas strong regionalization of dorsal vertebrae into thoracic and lumbar identities is thought to be a derived feature of mammals and archosaurs. Recently, however, subtle but persistent dorsal regionalization has also been found in lepidosaurs, suggesting that the evolution of regionalization within amniotes is more complicated than previously inferred.

To understand the origin of the strongly differentiated presacral vertebral column in mammals, we examined presacral regionalization in their closest relatives, the non-mammalian synapsids, and a range of extant mammals and sauropsids. Axial regionalization was measured using a likelihood-based method that requires no a priori knowledge of region boundaries. Vertebral shape was quantified using linear measures and principal co-ordinates analysis, a data reduction technique which permits inclusion of fossils with missing data. Multivariate segmented regressions were used to simulate all possible vertebral regions, using zero to three breakpoints. Finally, the regionalization model best describing the data was selected using the Akaike Information Criterion based on regression residuals.

Among extant species we find support for four presacral regions in mammals, archosaurs and lepidosaurs, reflecting cervical, cervicothoracic, anterior dorsal and posterior dorsal modules, irrespective of the presence of a ribless lumbar region.

However, preliminary data suggest that non-mammalian synapsids have less regionalized columns than extant taxa. Specifically, the best models for both the dicynodont *Dinodontosaurus,* and the cynodont *Kayentatherium*, included only two to three presacral regions. Despite the ubiquity of regionalization amongst extant amniotes, our data suggest increasing regionalization through synapsid evolution and raises questions about axial patterning in stem sauropsids and the ancestral amniote condition.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

USING MULTI-IMAGE PHOTOGRAMMETRY TO MODEL FAUNAL REMAINS

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Multi-Image Photogrammetry is a method that can create digital 3D models for archiving and analysis purposes. This method can minimize physical manipulation of objects during research and display and help evaluate damage and decay over time. Once the models have been created, digital measurements can be made, creating the possibility of further analysis in absence of the physical object. Other methods used to scan in 3D, such as laser scanning and microscribe, require expensive equipment. Multi-Image Photogrammetry is an affordable alternative.

The objective was to test the accuracy of digital measurements taken from Photogrammetry created 3D models. Agisoft photoscan was used for generating the 3D models and MeshLab (an open source software) for taking digital measurements. A *Canis latrans* skull and a *Bison bison* scapula, sacrum, and metacarpal were selected for this study. Each specimen had unique features and shapes that would need to be photographed differently to produce enough overlap to create the model. Adhesive targets were added as landmarks to help photoscan when building the model. The targets also worked as a 2 cm scale to calibrate MeshLab for the measurements once the model was complete.

Preliminary results show that the software can be calibrated with the 2 cm targets and measurements can be made. The shape of the bone did not affect the margin of error, and short distance measurements (between 2 and 5 cm) were within 2–3 mm of accuracy. Measurements made of longer distances (10–15 cm) did have more effect on the margin of error, with a difference of 1–3 cm from the physical measurements made. Overall, the models can be built and measured with a 1–3 cm margin of error. For research purposes, that margin is too large. But, the results reveal that the error could have been introduced in the measuring process, and that changes in the methodology could lead to more accurate measurements.

Initial experiences with the technique have required many photographs and much operator time. More experience should produce improved technique and more efficient production. Outcomes to date indicate specific issues that need to be addressed to produce better results. They also provide a clear path of what needs to be done to develop a fully functional and accurate digital archive.

Symposium 3 (Saturday, October 17, 2015, 10:15 AM)

GEOMETRIC MORPHOMETRIC ANALYSIS OF HOLOCENE DENTARIES FROM NEW ZEALAND REFERRED TO *SPHENODON* SP., AND DENTARY SHAPE VARIATION AMONGST RHYNCHOCEPHALIA (REPTILIA: LEPIDOSAURIA)

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The New Zealand tuatara (*Sphenodon punctatus*) represents the only living member of Rhynchocephalia, which was a successful group during much of the Mesozoic. Although the tuatara has been extensively studied with respect to anatomy, behavior, physiology, and ecology, the history of its lineage on New Zealand is poorly known. Only a few specimens referable to Rhynchocephalia have been recovered from Miocene and Pleistocene sites, but numerous of Holocene fossils indicate that this genus once inhabited a greater geographic range than it does today. Nevertheless, this material remains largely undescribed and unexamined for any potential variation related to differences in habitat, latitude, or the effective separation of the North and South Islands in the Late Pleistocene. We examined over 400 dentaries previously referred to *Sphenodon* sp. from more than 20 Holocene sites. Being relatively robust, this bone is often the most common element within assemblages and it exhibits obvious variation in its general dimensions, chin shape, and size of the coronoid process. To assess the shape differences more objectively and permit quantitative comparisons we used a Geometric Morphometric approach. Specimens were photographed in lateral view and digitized with 42 landmarks (including 28 sliding semi-landmarks). Following Procrustes alignment a Principal Components Analysis shows that the greatest axes of variation includes differences in chin shape, dentary depth, and the relative length of the tooth row. Size accounts for the greatest portion of variation, with larger jaws being relatively deeper. No significant difference is found between dentaries when they are grouped according to North and South Island and the shape variation is not well explained by latitude or longitude. Differences are found between particular localities but to what extent this variation reflects differences in habit, lineage divergence, or both, requires further analysis. Nonetheless, Geometric Morphometrics has enormous potential for evaluating apparent variation in extensive samples of Holocene fossils. A comparison of the Holocene sample to Mesozoic Rhynchocephalia (e.g., *Gephyrosaurus*, *Clevosaurus*) shows that the disparity found amongst the latter is substantially greater, reflecting a wide range of dentary shapes associated with differences in dentition and likely feeding habits. This result highlights the morphological diversity of Mesozoic Rhynchocephalia, which remains frequently unappreciated.

Grant Information

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Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

NEOICHNOLOGY OF AN ECOLOGICALLY AND MORPHOLOGICALLY DIVERSE FAMILY OF BATS (CHIROPTERA: PHYLLOSTOMIDAE) AND IMPLICATIONS FOR IDENTIFYING BAT TRACES IN THE FOSSIL RECORD

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Modern bats comprise ~20% of all mammal taxa and have evolved to occupy a wide range of niches, including such varied feeding habits as nectarivory — exhibited by some bats of the Old and New World tropics and subtropics — and sanguinivory — observed in the parasitic vampire bats of the western hemisphere. The oldest known fossil bats date to the early Eocene (Ypresian), and bat fossils appear in deposits shortly thereafter on every continent except Antarctica. Postcranial material of fossil bats is usually sparse, and no presumed transitional forms are known, leaving gaps in our understanding of bat evolution and paleobiogeography. Trace fossils have been used in other taxa to supplement the body fossil record, and to extend both temporal and geographical ranges in areas where no body fossils are known. Although trace fossils are documented from other vertebrate groups capable of powered flight — birds and pterosaurs — no bat traces are known despite the natural histories of some extant bats that are very capable of terrestrial locomotion. This research establishes criteria to be used to identify potential bat traces in the fossil record. We observed the terrestrial behaviors and track morphology of the ecologically diverse Phyllostomidae, which include two of the three pelvic and hindlimb morphotypes (Types 1, 3) hypothesized to constrain the terrestrial abilities of extant bats. Nine phyllostomid species, including insectivores, frugivores, nectarivores, and sanguinivores, were observed and digitally video recorded in a custom-built PVC and Plexiglas® enclosure as they moved across calcium carbonate sand. Resulting tracks and trackways were then cast with Labstone® dental plaster. Only the common vampire bat, *Desmodus rotundus*, performed typical quadrupedal gaits, whereas all other species were restricted to a breaststroke-like crawl and nonambulatory searching behavior. All bats produced distinct manus and pes tracks, with pes tracks often being preserved as clusters of multiple individual tracks that correspond to the searching behavior. Manus tracks were either long and arcuate or relatively short and were always formed by (1) digit I, (2) the wrist and distal forearm, or (3) both. Terrestrial behavior was well aligned to pelvic and hindlimb morphotypes, as >*Desmodus*— the lone bat studied belonging to the robust-pelvis morphotype (Type 3) — was the only bat to perform a typical tetrapod gait. Ecological role appeared to have no bearing on terrestrial ability within this family.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

LATE PLEISTOCENE *SAIGA* (ARTIODACTYLA, BOVIDAE) FROM THE HOLARCTIC

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Saiga antelope (Artiodactyla, Bovidae) are steppe obligates with a variable distribution during the Late Pleistocene. Currently, *Saiga* are restricted to select habitats in Central Asia, yet their Late Pleistocene distribution is known to be from Great Britain to Alaska and the Yukon, Canada. Unfortunately, little information is available on the nature of this range retraction. Consequently, chronology of its distribution and local extirpation are the subjects here. Specifically, radiocarbon dates associated with *Saiga* are assessed, while imprecise allocations of the antelope to a generalized date range or land mammal age were excluded from this analysis. Radiocarbon dates associated with *Saiga* show biases towards Western and Eastern Europe (southern France/Crimea, Ukraine), Alaska, and Canada. Oldest radiocarbon dates on *Saiga* are 37,000–37,700 BP in Alaska and Crimea. Extirpation from North America appears to occur by 12,000 BP; with the latest (extralimital) date from Europe roughly 10,000 BP from Crimea. Explanations for the reduction of *Saiga*'s Late Pleistocene range are unresolved but human impact and/or climate change could be critical factors. Additional isotopic and radiometric data are needed to fully resolve why the range of *Saiga* reduced from Great Britain through to Canada to that of today in Central Asia.

Technical Session II (Wednesday, October 14, 2015, 9:45 AM)

CERVICAL INTER-VERTEBRAL KINEMATICS IN WILD TURKEYS: IMPLICATIONS FOR THE EVOLUTION OF THE AVIAN NECK

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From a mallard preening its wing with its head upside-down and backwards to a flamingo sleeping with its head tucked over its back, birds routinely use their flexible necks to reach a variety of elaborate poses. The evolution of the flexible avian neck from the necks of non-avian theropod dinosaurs is not well-understood – particularly the acquired capacity to achieve complicated neck configurations. Simple movements, such as dorsoventral and lateral flexion, have been examined, but few studies have measured joint motion in more intricate postures, such as those used in preening or sleeping. Historically, measuring inter-vertebral joint motion in the neck has been challenging, due to the loose overlying skin and the abundance of soft tissue structures.

Here we present results from a new project that investigates three-dimensional inter-vertebral joint mobility in the necks of wild turkeys (*Meleagris gallopavo*). We use X-ray Reconstruction of Moving Morphology (XROMM) to accurately measure joint kinematics during simple (e.g. dorsoventral/lateral bending) and complex (e.g. multiple-axis twisting, looking over shoulder) neck maneuvers in cadaveric material with all soft tissues intact (e.g. skin, muscle, ligament). Preliminary results reveal that during simple movements, cranial (e.g. C3-C4) and caudal joints (e.g. C10-C11) appear highly mobile, although they tend to bend in opposing directions; in contrast, the central zone (e.g. C6-C7) is very stiff, contributing little to overall neck mobility. When performing complex movements, inter-vertebral motions appear to be more evenly distributed along the neck,

indicating that joint motions measured during simple movements might not be predictive of those used to achieve more complex neck postures.

Our use of XROMM to peer through the soft tissues of the avian neck has provided unprecedented access to visualize three-dimensional joint function across a broad range of neck poses. These kinematic data reveal a hidden complexity that has not been fully appreciated using previous methods. We aim to further our investigations of the evolution of the avian neck by integrating experimental and modeling approaches, including in vivo measurements of cervical joint function in living birds and musculoskeletal simulations of cervical joint motion in extinct non-avian theropod dinosaurs.

Technical Session III (Wednesday, October 14, 2015, 11:30 AM)

A GIGANTIC CYNOGNATHID FROM THE TRIASSIC OF NAMIBIA AND THE EVOLUTION OF BODY SIZE IN CYNODONTS

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The Triassic record of African cynodonts is dominated by material from South Africa; the record of adjacent basins remains poorly known by comparison. Here I present a previously unrecognized cynodont from the Upper Omingonde Formation (Anisian–Ladinian) of Namibia represented by massive mandibular material. This specimen can be identified as a cynognathid, rather than the co-occurring large-bodied gomphognathid cynodont *Titanogomphodon crassus*, by its laterally compressed postcanine morphology and absence of a diastema between the canines and postcanine tooth row. This taxon has a mandibular symphyseal height of 10 cm, assuming similar proportions, as the only other known cynognathid taxon (*Cynognathus crateronotus*), the Namibian cynognathid, would exceed 60 cm in basal skull length, making it one of the largest known non-therian cynodonts. Both the new cynognathid and *Titanogomphodon* are significantly larger than their closest relatives (the stratigraphically earlier, also co-occuring *Cynognathus crateronotus* and *Diademodon tetragonus*, respectively), suggesting coevolution between these clades. Small size in therapsid predators in the Triassic has often been linked with archosaurian occupancy of that niche. However, adaptive release is not a possibility in the present case, given the presence of a large carnivorous archosauriform (erythrosuchid or 'rauisuchian') in the same deposits as the new cynognathid. Patterns of Triassic archosaur and cynodont body size distribution are complex and still poorly-understood, and the importance of large cynodonts in Triassic ecosystems has generally been underappreciated. The traditional narrative of global cynodont size decrease through the Triassic obscures high regional abundance of large cynodonts even in the Late Triassic (e.g., *Exaeretodon* in the Ischigualasto Formation) and significant variability among cynodont subclades. Bayesian analysis of basal skull length (a necessary size proxy given the craniocentric record of Triassic cynodonts) across cynodont phylogeny reveals that a negative size trend (miniaturization) only occurs in the immediate sister groups to mammals; most of cynodont evolution is size-neutral and many individual clades follow Cope's rule.

Grant Information
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Preparators' Session (Thursday, October 15, 2015, 11:15 AM)

DIGITAL TO PHYSICAL: CONSIDERATIONS FOR FABRICATION OF PALEONTOLOGICAL REPLICAS FROM DIGITAL FILES

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CT digitization of paleontological specimens has impacted preparation, research, archiving, data sharing, and exhibition. Likewise, machining and printing digitized files based on fossil specimens has emerged as another frontier for research and exhibition. Yet, there exists no universal or recognized workflow for the process of digitizing one or more fossils and then generating a physical model. Complicating factors include different scanning techniques and software, and different rapid prototyping methods and materials. Important considerations outlined below are based on the fabrication from digital data of an adult *Spinosaurus* skull for exhibition.

After CT-scanning an adult snout of *Spinosaurus*, the Computer Numerical Control (CNC)-machined rostrum was inadvertently mirrored because the jpg stack did not contain metadata on orientation. An important consideration is thus to make sure that Digital Imaging and Communications in Medicine (DICOM) header information is preserved in CT data files. As the project progressed, we adopted another software package for CT data processing. Models generated using Amira software produced an unexpected ten-fold mismatch in the size of elements of the same specimen vs. those that were generated using Mimics software. Careful measurements of fossil specimens thus were necessary to accurately resize the bones. A digitally reconstructed skull file was transferred to a company specialized in model-making. They used CNC-machine software to divide the file into machinable sections but ended up carving accessory details, such as internal spaces that were later in-filled prior to traditional molding and casting. Clearly communicating the desired end-product with a 3D printing company thus is very important to avoid wasted time, labor, and materials. Consideration of the stock material for the prototype is also important. It must support the weight of molding rubber and a fiberglass mother-mold. Finally, assembly and touch-up of the prototypes ought to match the aim of the project, be it for display or research. For display all evidence of the manufacturing process might best be smoothed away, whereas the unmodified prototype might be more appropriate for a research collection.

Technical Session XI (Friday, October 16, 2015, 10:45 AM)

3D DENTAL SHAPE DESCRIPTORS PREDICT TROPHIC CATEGORIES ACROSS MULTIPLE ORDERS OF NORTH AMERICAN MAMMALS

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Paleontologists have long inferred diet and ecology of extinct species using qualitative and quantitative measures of teeth. Recently developed homology- and orientation-free methods provide tools that capture aspects of dental functional morphology (e.g., curvature, relief). To test new ecomorphological methods, we amassed a library of high-resolution µCT scans of crania and mandibles for >200 extant North American rodent species. After extracting enamel and dentin isosurfaces for each species, we created idealized, 3D models of lower right cheek tooth rows. We replicated previously published measures such as orientation patch count, relief index (RFI), Dirichlet normal energy (DNE), and hypsodonty indices, and we developed several novel methods such as volumetric enamel:dentin ratio (EDR). We extract >300 shape descriptors per specimen, including variables for individual cheek teeth and whole tooth rows. For a dataset of 98 extant North American rodent species, discriminant function analysis (DFA) with cross-validation can successfully assign specimens to one of six trophic categories (folivore, F; rootivore, R; omnivore, O; granivore, G; frugivore, Fr; invertivore, I) with >87% accuracy. This analysis correctly assigns closely related species to trophic categories despite superficially similar dentitions. For example, 12 species of *Peromyscus* are all correctly assigned to one of three categories (Fr,O,G). We are extending the dataset to include the same measures on extant North American representatives of Carnivora, Lagomorpha, Soricomorpha, and Didelphimorphia (currently n=30 species) to test whether combinations of our metrics can distinguish different trophic categories in a phylogenetically and morphologically broader sample of species. Inclusion of these clades requires four new trophic categories: hypercarnivore, durophage, piscivore, and carnivory-dominated omnivore. A one-way analysis of variance on a subset of variables for the non-rodent species is significant, indicating measures useful to identify trophic category for rodents can also be applied to species in other orders. The durophagous *Enhydra lutris (*sea otter), for example, can be distinguished from the piscivorous *Lontra canadensis (*river otter) using DNE and RFI. Ultimately, we will identify the most effective sets of variables for classifying diets of extant species across mammalian orders and use these to reconstruct diets of extinct species and as ecometric traits to predict attributes of ancient ecosystems from distributions of trophic categories.

Grant Information
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Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

BRINGING A TRIASSIC DEATH ASSEMBLAGE TO LIFE WITH PHOTOGRAMMETRY: DIGITIZING BERLIN-ICHTHYOSAUR STATE PARK

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Berlin-Ichthyosaur State Park (BISP) in central Nevada preserves an iconic death assemblage of at least nine large (~15 meter) ichthyosaurs (*Shonisaurus popularis*) on a single bedding plane within the Carnian/Norian (Late Triassic) aged Luning Formation, exposed in a 25 meter wide public display quarry. Despite decades of study at the site, beginning with Charles Camp in the 1950s, major questions remain concerning the origins and paleoenvironmental context of the thanatocoenosis and the paleobiology of *Shonisaurus*, one of the largest ichthyosaurs. We created 3D models of the BISP quarry using digital photogrammetry and other techniques. We relocated other quarries within the park that also produced high densities of *Shonisaurus* fossils including the type material. Finally, we studied the type series and additional material housed at the Nevada State Museum, Las Vegas, and created 3D models for comparison with in situ quarry fossils. Digitization of the quarry facilitated taphonomic analysis and allows for a reevaluation of hypotheses pertaining to their death and emplacement.

Specimens in the public quarry range from ~5-85% complete and are mostly aligned parallel to subparallel. Five partial, articulated skeletons are more than half complete including skull fragments, limb and girdle elements, vertebrae and ribs but missing distal limb elements and caudal vertebrae. Approximately four others are represented by strings of associated vertebrae and ribs. Varying degrees of decomposition and reworking suggest that skeletons accumulated over a relatively long interval. Sandblasting during excavation prevents assessment of primary bioencrustation, but low invertebrate diversity in equivalent horizons (*Macrolobatus* zone of the shaly limestone member) indicates stressed conditions preceding Carnian/Norian faunal turnover. The monotaxic nature of the BISP death assemblage is seemingly at odds with a broad-spectrum kill mechanism such as harmful algal bloom (HAB). However, given the paucity of other vertebrates throughout the formation, and abundant *Shonisaurus* remains in some horizons, *Shonisaurus* might have been the only common large vertebrate in the region. This is unlike most other Triassic and later marine tetrapod assemblages, which are typically multitaxic. The concentration of *Shonisaurus* fossils in other quarries indicates that the mass death horizon preserved at the BISP visitor's quarry may be more extensive than previously recognized or may include multiple horizons representing repeated mass-mortality events.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

A NEW BASAL AZHDARCHOID (PTEROSAURIA, PTERODACTYLOIDEA) FROM THE CRETACEOUS BAURU BASIN

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A new fossil locality containing the first pterosaur bone bed from Brazil has been recently reported in the outskirts of the town Cruzeiro do Oeste, Paraná State, southern Brazil. This deposit corresponds to the Goio-Erê Formation (Turonian-Campanian) of the Caiuá Group, Bauru Basin, and preserved hundreds of isolated or partially articulated

elements. Most belong to the tapejarine tapejarid *Caiuajara* but some larger elements recovered during the preparation revealed the presence of a second much larger azhdarchoid taxon in this region that is reported here. The skull is long, with the rostral part gently curving ventrally. The edentulous jaws have thickened lateral margins bordering a slightly concave palatal surface. The mandible shows a small dentary crest and a palatal ridge, the latter unique to this pterosaur. The cervical vertebrae are slightly elongated with the centrum pierced by a lateral pneumatic foramen which is absent in azhdarchids and chaoangopterids and is very reduced in tapejarids. The coracoid lacks a developed coracoidal flange but shows a developed tuberculum on the posteroventral margin. The articulation with the sternum is dorsoventrally flattened, fork-like and strongly asymmetrical, with the posterior half of the articulation more developed. The sternal plate is quadrangular, being slightly longer than wide. The cristospine is elongated and low and the coracoidal articulations are asymmetrical. The pubis is plate-like and has an obturator foramen that is open posteriorly. The ischium shows a small pneumatic foramen. The ilium had a strong developed postacetabular process with a constricted neck and a large iliac posterior process. The humerus (174 mm) has a long and proximally placed deltopectoral crest that curves ventrally. All recovered first phalanges of the wing finger (~370 mm) have the extension tendon process unfused and bear two pneumatic foramina on the ventral surface of the proximal articulation. Ulnae (170-225 mm) show unfused proximal epiphyses and all scapulae and coracoids are unfused, indicating that all recovered specimens so far represent young individuals. The particular combination of characters observed suggests that this new species occupies a basal position within azhdarchoids and indicates that basal members of this clade had a more pneumatic skeleton than later forms.

Grant Information
FAPERJE-26/102.737/2012, CNPQ 304780/2013-8

Romer Prize Session (Thursday, October 15, 2015, 10:30 AM)

CONSERVATION PALEOBIOLOGY AS THE LENS FOR VIEWING THE FUTURE: CARIBBEAN LIZARDS AS A CASE STUDY

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Determining the factors that shape diversity and the persistence of species is a major aim of ecology and evolutionary biology, with direct conservation implications. Empirical data from present-day ecosystems have proven critical in characterizing how species interact with one another and their environment, but many of these studies lack a crucial element that would make them more applicable to projecting future dynamics: temporal resolution. While present-day Caribbean lizards serve as a model system for studying evolution in novel environments, few studies have integrated historic and prehistoric data into their analyses. This has resulted in limited dialogue about how global change has impacted communities previously, and no insight into what future global change will do. And despite a consensus that the persistence of many Caribbean lizards is uncertain with ongoing global change phenomena, factors that may play a role in Caribbean lizard extinction have not been identified. I use Quaternary Caribbean lizards to investigate ecological theory about the repercussions of colonization and extinction on community structure. At a local scale, I find that the extinction of a large-bodied, predatory lizard, *Leiocephalus*, leads to ecological release in *Anolis*, a widespread Neotropical genus. This extinction is just one manifestation of a Caribbean-wide trend of size-biased and lineage-specific extinction, which results most dramatically in the extirpation of *Leiocephalus* from the Lesser Antilles, but also a loss of large-bodied lizards in other families. I then evaluate colonization events subsequent to extinction events in the Lesser Antilles. While I find that there are a few focal taxa that successfully colonize islands or are vulnerable to extirpation and extinction, the resulting communities are more heterogeneous than previous communities were. This contrasts with global trends of biotic homogenization and may reflect the realization of species richness-island area relationships in the Lesser Antilles. My results recapitulate empirical evidence from ongoing studies operating at ecological scales while also providing a glimpse into what the potential outcomes of continued colonization and extinctions will be during the Anthropocene.

Grant Information
Stanford University, National Science Foundation, National Geographic, Sigma Xi

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

THE JUNIOR PALEONTOLOGIST PROGRAM: CHALLENGES AND SOLUTIONS OF DESIGNING AND IMPLEMENTING AN EDUCATIONAL MUSEUM ACTIVITY BOOKLET FOR A BROAD DEMOGRAPHIC

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The University of Wyoming Geological Museum hosts a notable assemblage of local fossil vertebrates, fossil invertebrates, fossil plants, minerals, and rocks from across the Rocky Mountain region. The museum works under a limited budget, yet fills a valuable role in public education, outreach, tourism, and collaborative research to a wide global visitor demographic. Prior to the program presented here, the museum had no specific outreach program targeted at youths and early adolescents. To address these limitations and to offer a more interactive museum experience, we developed the Junior Paleontologist program, an innovative self-guided sixteen-page activity booklet filled with puzzles and challenges. The program is designed to engage and encourage elementary through early high school participants (ages 5–15) to explore the exhibits in greater detail and to promote the importance of paleontology in interpreting the geologic past. Topics in the 2014 pilot program discuss but are not limited to broad paleontological and geological themes, including fossil formation, paleoecology across different timescales, and the rock cycle. The activity booklet consists of fifteen challenges that provide participants with tools for thinking critically, developing scientific best practices, exploring museum resources effectively, and applying what they learned in discussion with museum docents. Upon completion, each new Junior Paleontologist is awarded a certificate, badge, and photograph during a formal swearing-in ceremony. A critique of the pilot program was conducted by asking volunteer families to rank activities and provide comments regarding difficulty of activities, age restrictions, interests, disinterests, and time intensiveness. In spite of positive and enthusiastic feedback, we identified several roadblocks associated with developing the program. These include designing a professional-looking booklet broadly applicable to both boys and girls of varied ages and educational backgrounds, striking a balance between accessibility and accuracy for complex scientific concepts, developing a series of activities that could be completed in a single visit, and properly pricing the material to maintain low costs while covering the total fees associated with production, prizes, and certificates. Here, we discuss our solutions to these challenges in hopes of providing a framework for other educational facilities wishing to form similar programs.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

ENHANCED FOSSIL CALIBRATION POINTS FOR MOLECULAR CLOCKS OF MUROID RODENTS

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Time-calibrated molecular phylogeny is fundamental to addressing various questions of evolutionary biological interests. In many studies of molecular phylogeny, paleontological data play an important role on providing a temporal scale for absolute time estimates. Although Bayesian inference of divergence times can take analytical uncertainties into consideration, simulation studies evidence that accurate paleontological interpretation of fossil evidence for fossil calibration points is significant in improving the quality of calibration.

This study aims to determine the phylogenetic placement of murine fossils from the Miocene of Siwalik Group, Pakistan in order to refine the 12-Ma *Mus-Rattus* calibration point, which has been known as one of the most precise fossil dates. In this study, we first examined new dental characters that demonstrate lineage separation in Siwalik murine fossils and reconstructed ancestral states of the characters in a molecular phylogenetic tree, using 70 modern genera of murines, to trace the origin of the lineage separation. Then, we tested a published dataset with the updated placement and age of the fossils with a Bayesian divergence-dating program.

Our specimen-based approach indicates that the lineage separation event of Siwalik murine fossils represents the *Mus-Arvicanthis* split, a more internal node than *Mus-Rattus* split. The test analysis shows that species divergence times estimated with the newly refined calibration point are more consistent with the fossil record of Murinae than any other previous applications. Following the results, we will define the new calibration point as well as two other fossil dates within the Murinae.

A recently released database, Fossil Calibration Database, provides an easy access to paleontologists-approved calibration dates for molecular phylogenists. The importance of well-defined calibration points will increase in the future.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

MORPHOMETRIC ANALYSIS OF SEMICIRCULAR CANALS IN THERIZINOSAURIA (THEROPODA: MANIRAPTORA) WITH IMPLICATIONS FOR ENDOCRANIAL MODIFICATION DURING A TROPHIC SHIFT

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Therizinosaurs were a group of dinosaurs that experienced a trophic shift during the Cretaceous Period, 100-145 million years ago. This study uses preexisting computed tomography (CT) scans of three members of Therizinosauria (*Falcarius utahensis*, *Nothronychus mckinleyi*, and *Erlikosaurus andrewsi*) to track the changes in size of the endosseous labyrinths (inner ears) throughout the lineage. The semicircular canals of an organism work in tandem with the floccular lobes of the brain to maintain balance, gaze stabilization, and help with coordinating head movement. Larger semicircular canals imply a larger floccular lobe volume as well as a more nimble, well-balanced animal. The relationship between canal size and lobe size is correlated with locomotion in theropods but has not been correlated with diet. This study examines the rostral semicircular canal (RSC), caudal semicircular canal (CSC), and lateral semicircular canal (LSC) of the endosseous labyrinths to observe changes in labyrinth anatomy during a shift from omnivory to herbivory. Preliminary research was conducted to measure the height and width of the rostral, caudal, and lateral semicircular canal. All canals were measured from their tallest and widest points. Measurements of *E. andrewsi*, *N. mckinleyi*, and a subadult *F. utahensis* were compared to an adult specimen of *F. utahensis*, the basalmost known therizinosaur, to understand how therizinosaurian labyrinth anatomy changed through time. Both derived taxa show dorsoventral shortening in all three semicircular canals by up to 39.2% as compared to the adult *F. utahensis* specimen. *E. andrewsi* shows major lateral narrowing along the LSC (30.8%) but only widens marginally in the RSC (12.5%) and CSC (16.7%). *N. mckinleyi* exhibits minor narrowing in the LSC (3.8%) and more pronounced narrowing in the CSC (26.2%). The subadult *F. utahensis* showed marginal dorsoventral shortening (3.8% - 16.7%) and lateral narrowing (7.5% - 10.0%) in all canals except for the CSC, which experienced a 2.4% widening. Overall, therizinosaurian semicircular canals were shrinking dorsoventrally and laterally as the lineage became more derived with respect to *F. utahensis*. The research presented here is preliminary research for future work that will be used to make correlations between changes in sensory anatomy and trophic shifts in this enigmatic clade of dinosaurs. This project is important as a model for endocranial anatomy changes within a poorly researched group of non-avian theropods.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

A PRELIMINARY ANALYSIS OF A POTENTIALLY NEW LATE CRETACEOUS VERTEBRATE MICROFOSSIL SITE IN THE LANCE (CREEK) FORMATION AT THE BOLAN RANCH, NIOBRARA COUNTY, WYOMING

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The Bolan Ranch vertebrate assemblage represents an upper Cretaceous biota of the uppermost Cretaceous Lance (Creek) Formation (dating to about 69-66 Ma) in eastern Wyoming. The area is dominated by nonmarine, coastal floodplain sandstones, mudstones, and marls, with marginal marine sandstones and shales in the lower part of the formation. The microvertebrate fossils and dinosaurs represent important components of the latest Mesozoic vertebrate assemblages. The dinosaurs are represented by some incomplete skeletal material, but the majority of the fossils are disarticulated to fragmentary limb bones, vertebrae, fish scales, osteoderms, jaws and cranial elements, and loose teeth belonging to crocodilians, turtles, lizards, gars, guitarfish, other fish, and mammals. The diversity o the microvertebrate assemblage varies through the succession and points to fluctuations in the paleoenvironmental conditions from terrestrial to restricted lacustrine. Importantly, the microvertebrate sites in this area are prolific and the fossils relatively diagnostic, recording a greater diversity of taxa (at higher taxonomic resolution) than do the more frequently collected large dinosaur elements. Many microfossil beds are multi-individual accumulations consisting of disarticulated and usually dissociated vertebrate had parts in the millimeter to centimeter size range.

Technical Session II (Wednesday, October 14, 2015, 9:30 AM)

3D GEOMETRIC MORPHOMETRICS IN MODERN AND EXTINCT FOOT-PROPELLED DIVING BIRDS: A REEVALUATION OF THE TARSOMETATARSUS FOR SPECIES IDENTIFICATION

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Historically in paleontology many extinct taxa have been identified using fragmentary or isolated specimens, particularly in the Hesperornithiformes (Aves: Ornithurae). Hesperornithiforms lived during the Late Cretaceous and have an excellent fossil record due to their dense bones, yet several species have been based solely on the tarsometatarsus, often focusing on size for identification. Little has been done to examine the amount of intraspecific variation in this bone, and traditional measurements of length and width are limited because they rely on absolute size, which has the potential to cause problems in the classification of future fossil finds and questions the validity of current taxonomy. To address the issue of inter- and intraspecific variation in the tarsometatarsus of foot-propelled diving birds, extant members of the families Gaviidae (loons) and Podicipedidae (grebes) were studied. These birds are morphologically similar to the extinct hesperornithiform taxa, which makes them appropriate analogues for the fossil birds. Only adult female specimens were chosen for analysis to eliminate the possibility of variation due to sexual dimorphism or ontogenetic differences. Landmark-based Geometric Morphometrics was performed on 3D scans of the extant families to test for intraspecific and interspecific variation, with three species per family totaling 34 modern specimens. Five species of *Hesperornis* were scanned and analyzed, totaling 11 individuals plus 13 specimens identified as *Hesperornis* sp. For each group of specimens (Gaviidae, Podicipedidae, and *Hesperornis*) separate analyses were performed on the shape of the full bone, the shape of the distal end, and the shape of the proximal end. In nearly every modern Principal Component (PC) morphospace, individuals were not shown to group by species, and any grouping that did occur was poorly defined. Similarly, the fossil PC morphospaces showed no species correlation based on current identifications. Results indicate that there is enough intraspecific variation and too little interspecific variation to confidently identify a species using the tarsometatarsus in foot-propelled divers. In light of these results, the use of the tarsometatarsus for species identification may not be valid and species identified using only this bone may require reevaluation.

Grant Information

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Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

A NEAR-CONTINUOUS, WELL-DATED SEQUENCE OF CRETACEOUS TERRESTRIAL FAUNAS: MID-CRETACEOUS FAUNAL CHANGE IN THE NORTHERN HEMISPHERE AS VIEWED FROM UTAH

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The lowest Cretaceous strata in the Cedar Mountain Fm (CM) of east-central Utah preserve a series of terrestrial faunas dominated by polacanthid ankylosaurians and styracosternan iguanodontians, with basal macronarian and brachiosaurid sauropods from the Barremian to middle Aptian (125-115 Ma). These faunas correlate to the European Wealden fauna and Asian Hekou and Jehol faunas. There is a marked faunal change within the Aptian may be tied to the isolation of North America with the flooding of much of Europe and/or global changes during Global Anoxic Event (OAE) 1C. The middle CM faunas of the late Aptian through Albian are characterized by nodosaurid ankylosaurians, basal iguanodontians (tenontosaurs), and exclusively slender-toothed, basal somphospondylan titanosauroids, suggesting isolation from Eurasia. In Asia, neoceratopsians along with polacanthid and basal ankylosaurid ankylosaurians, more derived hadrosauroid iguanodontians, and titanosaurid sauropods typify the Mazongshan fauna, while in Europe struthiosaurine nodosaurids replace polacanthids whereas styracosternan iguanodonts continue to dominate along with titanosaurids (Ariño fauna). A marked change occurs in the basal Cenomanian of Utah at the top of the CM at 100–98 Ma where hadrosauroids replace tenontosaurs among iguanodontians during a shift from Early to Late Cretaceous style faunas associated with an Asian immigration event and/or OAE 1D. In Utah, extensive microvertebrate faunas in the upper Cenomanian (95–93 Ma) Naturita Fm preserve a Jurassic-grade aquatic fauna dominated by lungfish, semionotids, and "glyptopsid" turtles. No major changes in terrestrial faunas are noted at the beginning of the Turonian, but the aquatic fauna changes markedly, to one dominated by gars and amioids coincident with the Cenomanian–Turonian extinctions in the marine realm (OAE 2). During the middle Turonian through late Santonian, the Straight Cliffs Fm of Utah documents the continued dominance of nodosaurid ankylosaurians and hadrosauroid iguanodonts and the introduction of more derived neoceratopsians. A similar pattern is documented by the Saniawjan and Iren Dabasu faunas in Asia with titanosaurs, ankylosaurids, hadrosauroids, and protoceratopsians. The more restricted Santonian record (Iharkút fauna) of central Europe is characterized by neoceratopsians, basal rhabdodontid iguanodonts, and struthiosaurine nodosaurids, suggesting a more endemic fauna.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

DEPOSITIONAL ENVIRONMENT AND TAPHONOMIC ANALYSIS OF A *PARAMYLODON HARLANI* (XENARTHRA: PILOSA) QUARRY AT VANDENBERG AIR FORCE BASE, SANTA BARBARA COUNTY, CALIFORNIA

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Paleontological fieldwork at the late Pleistocene Eiko's Elephant Graveyard (EEG) quarry at Vandenberg Air Force Base (VAFB) has resulted in the discovery of the most complete *Paramylodon harlani* ground sloth skeleton found in Santa Barbara County, CA. To date, approximately 30% of the skeleton has been recovered, including cervical, thoracic, and caudal vertebrae, ribs, manus and pes elements, femoral elements, a large portion of the pelvis, and a scapula. The size of elements present fall within the distribution of known specimens.

The EEG quarry is located south of Point Sal State Beach in the northern portion of VAFB. Rapid erosion of unconsolidated sand, silt, and clay has formed badland-style topography that differs from the surrounding fluvial and alluvial deposits of the 80 ka marine terrace. The bonebed is approximately three meters above the bedrock and is associated with a red, iron-rich caliche layer that is erosionally resistant and provides a good marker for the fossil horizon. Fossils were encapsulated in clay, with concentrations of manganese, wood fragments, and occasional rounded and polished pebbles. Above the fossil horizon is an unfossiliferous sand lens and an upper clay bed with occasional bone fragments that are unassociated with the main bonebed.

Sedimentary analysis of the EEG quarry suggests deposition in a periodic watering hole in an alluvial floodplain. Small, freshwater gastropods and pelecypods are found throughout the clay fossil horizon. The skeleton is disarticulated but associated. Most elements are complete and show excellent preservation. There is no evidence of predation or scavenging and small elements, such as osteoderms, are present. Other fossils found within this bonebed are two articulating *Camelops hesternus* thoracic vertebrae and associated ribs, and small, well preserved, isolated bird bones. Most other fossil localities in the region consist of isolated elements in fluvial environments. This quarry allows for more detailed analysis of the paleoecology of the Central Coast during the late Pleistocene. Excavation and study is ongoing and continues to produce a high number of fossil elements.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

A NEW LATE TRIASSIC MICROVERTEBRATE FAUNA FROM THE BLUE MESA MEMBER OF PETRIFIED FOREST NATIONAL PARK

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The record of small vertebrates from the Late Triassic is lacking owing to preservation and collection bias, and is poorly understood in comparison to larger vertebrates from the same time period. A new microvertebrate site in the Blue Mesa Member of the Chinle Formation in Petrified Forest National Park sheds light on the diversity of small vertebrates from the Late Triassic.

The Blue Mesa Member preserves fluvial and lacustrine siltstones, sandstones, and mudstones. The fossiliferous horizon examined here is located in the uppermost portion of the member, and is preserved as a shallow lacustrine siltstone deposit dominated by coprolites, fish elements, and tetrapod elements. Vertebrate elements are typically disarticulated, and often show signs of pre-depositional abrasion, including predation and digestion. Taphonomic and sedimentological evidence indicates that this horizon was deposited as a shallow pond with abundant wildlife whose large bodied vertebrate assemblage consists largely of temnospondyl amphibians and phytosaurian archosauriforms.

This site has produced a highly diverse vertebrate fauna. Non-tetrapod vertebrates include chondrichthyans, redfieldiids, semionotiformes, and basal sarcopterygians. Tetrapods include temnospondyl amphibians, lepidosauromorphs, procolophonids, and a diversity of archosauromorphs. Lepidosauromorphs are represented by abundant jaw fragments with pleurodont or acrodont dentitions. Archosauromorphs include *Trilophosaurus, Vancleavea*, aetosaurs, phytosaurs, rausuchians, *Acaenasuchus, Revueltosaurus,* and many unidentified tooth morphotypes. There are also many specimens that cannot yet be assigned to any taxa and that might represent new morphotypes.

The diversity of this site gives a more complete view of the entire fauna of the Blue Mesa Member, providing insight into the tetrapod fauna prior to the Adamanian-Revueltian faunal turnover in the Late Triassic of North America. The presence of jaw elements consistent with non-rhynchocephalian lepidosauromorphs and sphenodontians has significant biogeographic implications, and shows the presence of a diverse lepidosauromorph fauna in the Norian.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

TRACHEAL AND ESOPHAGEAL DISPLACEMENT IN THE REMARKABLY PRESERVED COMPSOGNATHID *SCIPIONYX SAMNITICUS*

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Tracheal and esophageal displacement refers to an asymmetrical arrangement of the trachea and/or esophagus along the length of the neck. This differs from what would be referred to as a 'normal' condition (i.e., a medioventral positioning of both organs). Displacement has been reported in many birds and some crocodylians. Scapular and infrahyoid muscles limit mobility of both the trachea and esophagus, but such constraints can be overcome (as is seen in crocodiles). As the trait is reasonably well bracketed phylogenetically, this work explores whether or not dinosaurs also possessed some type of displacement. Dissections of lizards, crocodylians, and birds were performed to provide a broad comparative anatomical basis for understanding tracheal and esophageal positions. *Scipionyx samniticus* represents an ideal opportunity to study this in the fossil record as it has remarkable preservation, and the trachea and esophagus are preserved in situ with minimal distortion. Homologous cervical, strap, and infrahyoid muscles were reconstructed to demonstrate potential constraints on the mobility of the organs. The trachea and esophagus were reconstructed and a most efficient pathway (i.e., lateral or normal) was reconstructed for both. Tracheal rotation as well as an oblique (i.e., the trachea crosses between the lateral and medial planes) and strongly angled trachea in a caudal position, with a more dorsal situation at the base of the neck was observed; this supports the presence of a laterally displaced trachea. These data suggest that *Scipionyx*, and perhaps other non-avian theropods, likely possessed tracheal and esophageal displacement.

Technical Session III (Wednesday, October 14, 2015, 9:45 AM)

THE EVOLUTION OF MAXIMUM METABOLIC RATE IN *DIMETRODON* (SPHENACODONTIDAE)

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Today, endothermic animals show at least a five-fold increase in maximum aerobic activity over ectothermic amniotes. Traditionally, pelycosaurs, non-therapsid synapsids, have been considered to be clearly ectothermic, forming the very beginning of the trend towards endothermy and high maximum metabolic rates (MMR). Yet growth trajectories of the derived sphenacodontid *Dimetrodon* obtained through bone histological analysis suggest that the size of different species of the genus increased evolutionarily through an increase in growth rate. Here we discuss the impact of a rise in MMR on the evolution of size increase in *Dimetrodon*. Using µCT, we measured cross-sectional area of the femoral nutrient canal. Scaled to femur length, it serves as a proxy for blood flow rate into the bone that indicates MMR of large and small species. Preliminary analysis of smaller species reveals small nutrient canal radii relative to femur length similar to modern reptiles indicating low MMR. Larger species show larger nutrient canal cross sections after correcting for size. This indicates that the evolutionary size increase was likely accompanied by a rise in MMR in the sister group of the Therapsida. In combination with morphological and bone histological data, bone micro-anatomical analysis of nutrient canal cross-sectional area relative to femoral size facilitates the distinction between sympatric species of *Dimetrodon* even from isolated femora. Future research will include analysis of the evolution of MMR in Therapsida.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

FROM GRASSLANDS TO WELL PAD: A MITIGATION PALEONTOLOGICAL DISCOVERY, LANCE FORMATION (MAASTRICHTIAN), WYOMING PROVES THE VALUE OF IMPLEMENTING BEST PRACTICES

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Since the 1970s, mitigation paleontology in the United States has achieved growing success in fossil resource management. Here we report on a new upper Cretaceous (Maastrichtian) locality from the Lance Formation of eastern Wyoming discovered as a result of the implementation of paleontological mitigation best practices. In the spring of 2014, paleontologists from SWCA Environmental Consultants conducted initial surveys for a proposed well pad development. The survey area was of moderate to low relief and nearly entirely vegetated, and it presented few bedrock exposures. Though sparse, observed fossils consisted of heavily weathered bone fragments. Pad construction was initiated in late March 2015, and, as part of the Bureau of Land Management's surface-use conditions of approval for the project, a paleontologist was on site to monitor ground-disturbing activities full time. Initial discoveries included isolated skeletal elements from hadrosaur and ceratopsian dinosaurs separated by 18 to 24 meters. Smaller fossils, including turtle shell fragments, dinosaur and mammal teeth, gar scales, and crocodilian osteoderms, were found in association with the larger bones. As construction progressed, specimen salvage and site evaluations required the assistance of an additional paleontologist. This allowed construction to continue while the paleontologists properly mitigated each discovery. At 3.35 meters below the original surface elevation, three closely associated bones were exposed in a channel sandstone horizon. An exploratory excavation revealed that the elements belonged to a partially complete skull of cf. *Triceratops horridus*. Since the late 1880s, the Lance Formation has produced a number of *Triceratops* specimens, including the type skull of *T. horridus* in 1888. However, existing records of stratigraphic positions of historic *Triceratops* specimens are poor, rendering them useless in modern stratigraphic analyses of the genus. Because this project followed proper mitigation protocol, a new specimen of *Triceratops* and associated geographic and stratigraphic data will be available for study. The results of this mitigation project demonstrate the importance of construction monitoring based on best practices in geologic units with very high potential to produce important fossils regardless of survey results.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

A NEW WAY OF COMBINING BIOMECHANICAL DATA AND 3D GEOMETRIC MORPHOMETRICS WITH IMPLICATIONS FOR STUDYING FOSSIL PRIMATE MASTICATORY FUNCTION

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An inherent problem when studying extinct organisms is that often only certain aspects of anatomy are preserved and available to analyze, typically teeth and bone. Thus, researchers rely heavily on observational and experimental studies of extant taxa to infer relationships or processes in the past. Such work has been done to understand the form and function of the masticatory apparatus in primates. Multiple in vivo experimental studies of the primate masticatory apparatus have been performed on living taxa and have provided invaluable information for understanding mandibular form and function. As similar experimental studies cannot be performed on extinct taxa, the present study is a test case for correlating published electromyography (EMG) data from the jaw muscles (i.e., relative recruitment levels and firing patterns for the deep/superficial masseter and anterior/posterior temporalis muscles) and geometric morphometric shape data to infer functional information for fossil primate specimens. Here, mandibular shape is quantified using a series of landmarks and semilandmarks for a sample of nine anthropoid and strepsirrhine species for which published EMG data are available. Landmarks and semilandmarks are placed on 3D surface models of primate mandibles using Checkpoint software. The landmark configurations are superimposed using a generalized Procrustes analysis, and mean configurations for each taxon are computed. Mean configurations are used in the analysis since available EMG data are averaged for each species and shape data for the individuals used in the experiments are not available. A partial least squares analysis, with the biomechanical data and landmark/semilandmark data as separate blocks, identifies vectors of shape change that maximally covary with changes in the EMG activity exhibited by this sample of primate species means. Using the calculated shape vectors as proxies for changes in masticatory loading regimes, functional inferences are made for fossil primate specimens (e.g., *Epipliopithecus*) by projecting them into the shape space oriented using the biomechanical data and comparing them to extant taxa. *Epipliopithecus* falls within the range of living anthropoids, and closest to *Macaca*, suggesting it exhibited a similar loading regime. Different combinations of landmarks are used as a result of fossil preservation and to determine which aspects of mandibular morphology are relevant for making functional inferences (e.g., condylar height, corpus depth, and symphyseal robusticity and orientation).

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

COMPARATIVE PALEONEUROLOGY OF THE BASAL DICRAEOSAURID SAUROPOD *SUUWASSEA EMILIEAE*

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Dicraeosauridae is a small clade of diplodocoid sauropods with a spotty distribution but a significant time range (ca. 28 Ma) suggesting an incomplete fossil record. Dicraeosaurids are unusual among sauropods in being relatively short-necked, large-headed, and moderately sized. Although the phylogenetic position of *Suuwassea emilieae* (Tithonian, USA) with respect to Diplodocidae and Dicraeosauridae proved initially difficult to settle, it is now generally resolved as a basal member of the latter. This clade also includes *Dicraeosaurus hansemanni*, *Amargasaurus cazaui*, and *Brachytrachelopan mesai*. We CT scanned the holotype and only available braincase of *Suuwassea*, generated 3D renderings of the cranial endocast and inner-ear system, and compared the brain neuroanatomy and inner ear morphology with those of *Dicraeosaurus*, *Amargasaurus*, and other diplodocoids.

The endocast of *Dicraeosaurus* is remarkable for its voluminous dorsal excrescence. In *Amargasaurus*, the rostrodorsally inclined occipital plate contributes to a reduced, although still significant, and somewhat more rostrally situated, endocast dorsal expansion. In *Suuwassea*, the dural outgrowth is even less pronounced, especially because the parietal opening is far smaller in this taxon than in either *Dicraeosaurus* or *Amargasaurus*. The semicircular canals of *Dicraeosaurus* form roughly an equilateral triangle. Interestingly, the semicircular canals in *Amargasaurus* form a completely different circuit, in which the continuity between the rostral, caudal, and lateral semicircular canals is not interrupted by sharp angles, but instead describes a fairly rounded course in lateral view. In *Suuwassea*, the caudal semicircular canal appears straight in lateral view, recalling the situation in *Dicraeosaurus*, but the rostral canal is not as straight and as such more similar to that in *Diplodocus*. As a result, the semicircular canals in *Suuwassea* form a shape more like an acute isosceles triangle in lateral view. Further, the lateral semicircular canal of *Suuwassea* is strongly bowed in dorsal view, unlike that of *Dicraeosaurus*, which is only slightly bent in this aspect.

The endocranial morphology of *Suuwassea* does not shed much light on the phylogenetic affinities of this taxon within Flagellicaudata. The presence of a dural peak associated with the postparietal foramen has been proposed as a synapomorphy of Dicraeosauridae, which may indeed be legitimate, but the character is fairly widely distributed in sauropodomorphs.

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Technical Session X (Friday, October 16, 2015, 9:45 AM)

A NEW THERIZINOSAUR WITH FUNCTIONALLY DIDACTYL HANDS FROM THE BAYANSHIREE FORMATION (CENOMANIAN-TURONIAN), OMNOGOVI PROVINCE, SOUTHEASTERN MONGOLIA

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Mongolia is rich in therizinosaur dinosaurs, known from two Upper Cretaceous formations (*Enigmosaurus*, *Erlikosaurus,* and *Segnosaurus* from the Cenomanian-Turonian Bayanshiree Formation and *Therizinosaurus* from the Maastrichtian Nemegt Formation). The Bayanshiree therizinosaurs are important taxa to understand the evolution of this group because these are positioned as successive taxa between the Early Cretaceous to late Late Cretaceous forms; however, these taxa are represented by incomplete specimens.

In 2012, the Institute of Paleontology and Geology, Mongolian Academy of Sciences, discovered a new therizinosaur specimen from the Bayanshiree Formation at Urlibe Khudak in Omnogovi Province, southeastern Mongolia. The Urlibe Khudak locality has produced ornithopod (hadrosauroid), sauropod, and theropod (dromaeosaurid, ornithomimosaur, and therizinosaur) dinosaurs. The Urlibe Khudak therizinosaur includes an articulated ulna, radius, carpals and manus from both sides. This is the first record of a complete articulated manus from the Bayanshiree Formation and sheds light on the manual morphology of early Late Cretaceous therizinosaurs.

The manus of the Urlibe Khudak therizinosaur is, in general, similar to other therizinosaurs (e.g., *Alxasaurus*, *Erliansaurus*, and *Nothronychus*) except in the third digit. Metacarpal III, missing its distal end, shows bizarre features for therizinosaurs. Metacarpal III does not participate proximally in the articulation of the metacarpal complex and is positioned more distally overall. Strikingly, it is reduced in size (one-fourth the width of metacarpal II at the proximal end) almost to a splint, suggesting an absence or a great reduction of digit III. No element of digit III was preserved or discovered from the locality despite its excellent preservation. Although the absence of digit III cannot be confirmed at this point, the morphology of metacarpal III indicates the Urlibe Khudak therizinosaur had functionally didactyl hands, as seen in tyrannosaurs. Left phalanx I-2 preserves a keratinous sheath. The keratinous sheath of digit I is strongly curved and is longer by 54% than the supporting ungual along the dorsal margin. The Urlibe Khudak therizinosaur may have used the claws as grasping hooks during foraging because the morphology of unguals is similar to other therizinosaurs such as *Nothronychus*.

Symposium 2 (Friday, October 16, 2015, 4:15 PM)

ASSESSING THE VULNERABILITY OF ANTARCTIC SEALS TO ENVIRONMENTAL CHANGE: INSIGHTS FROM STUDIES OF SEAL MUMMIES

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Polar systems are shifting rapidly in response to human-induced environmental change. Records of response to past environmental shifts may reveal the vulnerability of species or ecosystems by demonstrating their sensitivity and adaptability to such changes. Our prior work has shown that for much of the Holocene (7000 to 500 years ago), and unlike the situation today, land-fast ice shelves were absent along the southwestern coast of the Ross Sea, Antarctica, allowing the region to be inhabited by a large population of southern elephant seals (*Mirounga leonina*). We are using data from mummified remains to explore the response of three currently common Antarctic seals (crabeater seals, *Lobodon carcinophagus*; Weddell seals, *Leptonychotes weddellii*; leopard seals, *Hydrurga leptonyx*) to changes in iciness and the abundance of a large potential competitor.

During field seasons in 2012–13 and 2013–14, we collected samples (bone, skin, fur, etc.) from mummified seals that occur in the Dry Valleys region of Antarctica (~76.75 °S to ~78.25 °S and up to 60 km from the coast). While species identification is still underway, we found >300 crabeater seals, nearly 100 Weddell seals, and ~20 leopard seals. We calibrated carcass weathering stage against approximately 130 ^{14}C dates. Carcass weathering varies with age to ~1000 years old, then plateaus, and most carcasses are under 1500 years of age. Stable carbon and nitrogen isotope ratio variations in seal bone, which reflect trophic level, foraging zone, and marine biogeochemistry, match expectations among these species. In addition, there are no strong temporal patterns in any species (though data from leopard seals are sparse). Our isotopic data suggest that the ecology of these land-fast ice or pack-ice dependent seals was not affected by the change in iciness or elephant seal abundance that began ~1000 years ago. This contrasts with isotopic data from fossil penguins and elephant seals, which point to drops in ^{15}N-concentration over the last 1000 to 100 years, perhaps due to changes in the productivity of the Ross Sea. The constancy of ecological patterns among crabeater, Weddell and leopard seals and the failure of these seals to respond to shifts in Ross Sea productivity suggest a low adaptability in foraging patterns, which may affect their vulnerability to environmental change. Beyond its ongoing use in species identification, we will use ancient DNA data to explore historical population dynamics and signals for selection in the context of the ecological constancy we observed in the face of environmental shifts.

Grant Information
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Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

DESMOSTYLIAN REMAINS FROM UNALASKA (USA)

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Derived members of the enigmatic extinct mammalian order Desmostylia have molars comprised of appressed columns whose morphology does not render their function in feeding simple to discern. Here we describe specimens of a new desmostylid desmostylian from the Arriaga Quarry, Dutch Harbor Member of the Unalaska Formation, Unalaska Island, Aleutian Chain. The quarry was originally used to obtain road metal but a school has since been built over it. The age is limited between 24.1 and 13 Ma, but most likely falls near the Oligocene-Miocene boundary (23.03 Ma). The descriptions are augmented by three dimensional scans. Specimens from Unalaska vary in ontogenetic stages but all appear to belong to a single species because they share unique morphological features. We conducted phylogenetic analysis based on 37 characters from the previous study with two newly added characters (number of major cusps on M_2 and M_3). The strict consensus tree derived from 12 most parsimonious trees (tree length = 61, consistency index = 0.70, retention index = 0.76, rescaled consistency index = 0.53) shows the Unalaska taxon is more derived than *Cornwallius* and the sister taxon to the clade that includes *Desmostylus and Vanderhoofius*. The Unalaska taxon has more cusps and higher crown on M_2 and M_3 than *Cornwallius* but lower crown than *Desmostylus*. The morphology of the teeth and the vaulted palate seen in derived desmostylids, including the new Unalaska taxon, indicate that derived desmostylids may have clenched their teeth strongly while employing suction during feeding, most likely on marine and coastal plants as previously suggested.

Technical Session XIV (Friday, October 16, 2015, 4:00 PM)

A MOSASAUR (SQUAMATA: MOSASAURIDAE) SNEEZE: A HYPOTHESIS CONCERNING SALT EXCRETION IN THE TOP PREDATORS OF THE CRETACEOUS SEAS

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Due to the inability of reptilian kidneys to handle a large salt influx, marine reptiles have evolved salt glands through modification of a wide variety of cephalic organs. This physiological modification was so critical that in the earliest-known sea turtle, *Santanochelys*, the foramen interorbitale was already enlarged to house large lachrymal glands, which would have served as salt glands as in extant taxa, while the paddles were still largely underdeveloped. Following this sequence of events in adaptation to life in marine environs, hydropedal mosasaurs are expected to have had well-developed salt glands, yet no osteological structures have so far been postulated to have been associated with such a structure. Using a new high-fidelity 3D skull reconstruction of a halisaurine mosasaur, I here propose that paired palatines, which in mosasaurs extend well anterior to the antorbital wall, may have supported enlarged nasal glands that functioned as salt glands in these marine reptiles. First, it is the posterior end of the palatine body where the antorbital wall of the prefrontal articulates from above, as opposed to the anterior margin of the palatine body near the choanal emargination as in extant squamates. From the level of the antorbital wall of the prefrontal, the main palatine body extends anteriorly, approximately to the level of the posterior terminus of the external naris above. The posterior terminus of the choana thus becomes vertically aligned with that of the external naris. The dorsal surface of this palatine body forms a shallow, well vascularized basin, and when articulated with the prefrontal, forms the floor of what is here referred to as the preorbital dermal enclosure, longitudinally occupying the space between the choana and the orbit, and is wide open medially and anteriorly, and connected to the orbit posteriorly via a notch that is open medially at the dorsomedial corner of the antorbital wall. It is unlikely that this enclosure was occupied by the nasal chamber, which does not extend posteriorly beyond the level of the choana. Salt glands are highly vascularized organs and can occupy a significant cranial space in reptiles. The large enclosure, along with a well vascularized inner wall and its close proximity to the nasal chamber, may have housed such a gland and allowed mosasaurs to excrete excessive salt when breathing.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

FIRST RECORD OF POSTCRANIAL BONES IN THE EXTINCT SUBFAMILY DEVINOPHOCINAE (CARNIVORA, PHOCIDAE)

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Despite a long history of phocid studies, no fossil postcranial bones have ever been described for the extinct subfamily Devinophocinae. The recent description of new cranial material (skull, mandibles and teeth) classified a new species, *Devinophoca emryi*, as the sister taxon of the previously described *D. claytoni*. The cranial and postcranial bones were discovered at the same locality during several excavations at the base of the Malé Karpaty Mountains (Slovakia), specifically at the Bonanza site near the junction of the Morava and Danube rivers. The new *Devinophoca* postcranial material from the early Badenian, early Middle Miocene (16.26–14.89 Ma) presents mixed characters with the three extant phocid subfamilies (Cystophorinae, Monachinae and Phocinae) as well as unique postcranial characters not seen in any representatives of the other three subfamilies. These distinguishing characters (i.e., well-outlined, large oval facet on greater tubercle of humerus; broader width between the head and lesser tubercle of humerus; femoral proximal epiphysis larger than distal; thin innominate ilium that is excavated on ventral surface) demonstrate that this material belongs to a new species not previously known. During ecomorphotype analyses, fossil humerus and femur bones were directly associated with their corresponding mandible to reveal associations based on Recent morphological analogues. Also, strong correlation between ecomorphotypes

and cranial/postcranial morphology supports placement of this postcranial material to the newly described *D. emryi* and not its sister taxon, *D. claytoni*. As the first record of postcranial bones for the extinct subfamily Devinophocinae, this material allows for emended diagnoses of the species based on cranial and postcranial morphology, updated assessments of geographical distribution and provides further material for clarification of controversial phylogenetic relationships in the Family Phocidae.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

ANATOMY OF THE ENDOSSEOUS LABYRINTH IN THE MULTITUBERCULATE MAMMAL *NEOPLAGIAULAX*

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Multituberculate mammals are represented by an abundant fossil record ranging from the Jurassic to the Paleogene. Because most species are known only from dental remains, and because multituberculates have no close extant relatives, the cranial anatomy and corresponding functional morphology of many taxa are relatively unknown. Here, we document the endocast from the endosseous labyrinth in a nearly complete skull of *Neoplagiaulax* sp., RAM 9048 (Raymond M. Alf Museum of Paleontology, Claremont, California), from the Paleocene-aged (Tiffanian) Goler Formation of southern California. Study of the labyrinth can provide information about optimal hearing frequency, mode of life, and phylogenetically relevant traits. The inner ear has been described previously for *Nemegtbaatar*, *Chulsanbaatar*, *Catopsalis*, *Meniscoessus*, and *Lambdopsalis*, but not for a ptilodontoid. RAM 9048 was imaged using high resolution computed tomography, with isometric voxels of 26.61 microns over 1,818 slices. The labyrinth region was then isolated and reconstructed digitally for both left and right sides. Portions of all semicircular canals were visible, but only the lateral semicircular canal of the left ear was complete. As preserved, a secondary crus commune is not visible, supporting the variability of this structure within multituberculates. The cochlea, although incomplete, are only slightly curved and appear comparatively short. Vestibular volumes average 8.9 mm^3. Relative to a skull length of 37 mm, the vestibule in RAM 9048 is comparatively large, approaching the level of expansion seen in *Lambdopsalis*. Distinctly, the shape of the vestibule in RAM 9048 is quite bulbous, with a prominent dorsoventral expansion, a strongly curved lateral surface, and a flattened medial surface. Overall, the features of RAM 9048 are consistent with optimal hearing at relatively low frequencies, as suggested for many other multituberculate mammals.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

ENGAGING THE RATCHET: CARNIVORY IN *HESPEROCYON* ACROSS THE EOCENE-OLIGOCENE BOUNDARY

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A macroevolutionary ratchet occurs when selective pressures lead to the evolution of traits that heighten the effect of that selective pressure. In some cases, a ratchet may lead to extreme specialization and increased vulnerability to extinction. In carnivorans, this can be expressed as a trend towards large body size and hypercarnivory. While these specializations are likely driven by interactions with other organisms, it is unclear whether changes in the biotic or abiotic environment initially engage the evolutionary ratchet for predatory taxa. Hesperocyonine canids are a classic example of a carnivoran taxon affected by a macroevolutionary ratchet, increasing notably in both body size and carnivory through time. As the genus that likely gave rise to all later hesperocyonines, *Hesperocyon* provides an excellent model taxon for studying the beginnings of the macroevolutionary ratchet. While climate cools sharply across the Eocene-Oligocene Boundary, the extinction of hyaenodonts, with which hesperocyonines were likely competitive, occurred gradually during this interval. Sudden changes in body size and diet across the boundary could indicate a strong abiotic influence, whereas gradual change in these variables would indicate some biotic influence. We examined body size and carnivory rates in hesperocyonine specimens from the Eocene-Oligocene White River Group. Data collection consisted of measuring craniodental features strongly correlated to body size and carnivory, primarily the length of the first lower molar and the length of its trigonid. The total sample consisted of 102 specimens from the Field Museum and the University of Nebraska State Museum, all representing species of *Hesperocyon*. The data indicate a significant increase in relative blade length, but not in m1 length, across the Eocene-Oligocene Boundary. This suggests that changes in hesperocyonine diet during this interval were more significant than changes in body size. This mosaic, gradual acquisition of traits associated with hypercarnivory may suggest that biotic interactions played a particularly important role in driving hesperocyonine evolution early in the group's history.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

ESTIMATING BITE FORCE IN NEW PLESIADAPID MATERIAL FROM BERRU, FRANCE (THANETIAN, ELMA) AND CONSIDERATIONS FOR RECONSTRUCTING PLESIADAPIFORM JAW ADDUCTORS FROM EXTANT ANALOGUES

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Diversity in jaw morphology amongst plesiadapiforms is likely related to food processing. The importance of the muscles of mastication to tracking this dietary diversity is explored here. We employed tupaiid (tree shrew) and strepsirrhine primate specimens as extant analogues to estimate bite force along the tooth row in three plesiadapid specimens.

Muscle insertion area has previously been confirmed as a proxy for muscle physiological cross-sectional area (PCSA) in strepsirrhine primates. To confirm this in tree shrews, the jaw adductor muscle groups (temporalis, masseter, medial pterygoid) were dissected from several cadaveric *Tupaia* specimens. We plotted PCSA and insertion area for each muscle group against jaw length in log-log space, returning strong positive correlations (all $R^2 > 0.73$). PCSA data for estimating bite force was obtained by regressing PCSA on insertion area. Physiological cross-sectional area was predicted for the fossils from two statistically different ($p<0.05$) regression lines: one for tree shrews and one for strepsirrhines. Extreme differences in jaw size between the tree shrews and plesiadapiforms included in this study prevented confident predictions of plesiadapiform PCSA using the tree shrew model. An overlap in size between the plesiadapiform and strepsirrhine specimens supports the use of the strepsirrhine model.

Bite force at the anterior premolar, first molar, and third molar were estimated for all specimens. *Tupaia belangeri* has the smallest estimated bite force (0.14 kg) and *Platychoerops antiquus* the greatest (59.76 kg). In strepsirrhines, bite force scaled to jaw length isometrically (slope of 2 in log space) and increased posteriorly along the tooth row. In tree shrews, bite force scaled to jaw length with positive allometry (average slope of 12.56) and also increased posteriorly in tree shrews. However, this unrealistic slope for tupaiids is likely to change with the addition of more specimens. Given the much greater size of the plesiadapid specimens in this sample, tree shrews are presently not the best model for reconstructing bite force in the plesiadapid sample, but may be useful in future work that includes smaller plesiadapiforms. These results illustrate that choice of modern analogue is important and will have a profound influence on inferences about fossil primates.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

A NEW SPECIES OF *PACHYRHINOSAURUS* (CERATOPSIDAE, PACHYROSTRA) FROM THE WAPITI FORMATION (UPPER CAMPANIAN) OF ALBERTA, CANADA

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The Upper Cretaceous strata of the Grande Prairie region (Alberta, Canada) are exceptionally fossiliferous. *Pachyrhinosaurus* specimens from the Wapiti River Bonebed, a recently described multi-taxic ceratopsian-dominated site, represent a new species. The bonebed has an estimated age of 71.89 ± 0.14 Ma, equivalent to the Drumheller Member of the lower Horseshoe Canyon Formation and is located 150 meters stratigraphically higher than the well-known Pipestone Creek Bonebed that produces *Pachyrhinosaurus lakustai*. The Wapiti River Bonebed contains at least eight individuals of *Pachyrhinosaurus* and represents one of the most inland occurrences of centrosaurines in North America. Apomorphies of *Pachyrhinosaurus* sp. nov. include laterally curved Process 3 horns and a thick longitudinal ridge separating the supraorbital bosses. A phylogenetic analysis of seventeen ceratopsian taxa produced a weakly supported monophyletic *Pachyrhinosaurus* with a polotomy consisting of *P. canadensis*, *P. perotorum*, and *P.* sp. nov. The diversity of ceratopsians, especially centrosaurines, exploded in the Late Cretaceous during which time there was rapid species turn over. The Pachyrostra (*Achelousaurus* + *Pachyrhinosaurus*) are the youngest centrosaurine clade to appear in the fossil record.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

A DIVERSE THEROPOD TOOTH ASSEMBLAGE FROM THE MID-CRETACEOUS (ALBIAN-CENOMANIAN) WAYAN FORMATION OF IDAHO

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The middle-Cretaceous (latest Albian to Cenomanian) Wayan Formation of eastern Idaho contains an unusual vertebrate assemblage dominated by the small orodromine ornithopod *Oryctodromeus cubicularis*. Excluding eggshell, vertebrate remains are extremely rare, with skeletal remains of theropods being almost entirely unknown. The recent discovery of two multi-taxic localities, which have produced numerous partial to complete theropod teeth, provides the vast majority of evidence for theropods in the Wayan Formation, and shows an appreciable diversity of previously unknown forms.

The first locality, the Highway 34 Dinosaur Site, occurs high in the Wayan Formation, 1036 meters above the base. Theropod teeth from this locality group into three morphotypes, each of them representing small animals. The first morphotype consists of unusual teeth characterized by their large crown height ratio (CHR), with crowns being approximately twice the height of their fore-aft basal length (FABL), and with a maximum estimated crown height of 1.5 cm. The second morphotype has a lower CHR and a high degree of lateral compression. These tooth crowns have a maximum crown height of 0.7 cm and are assigned to a dromaeosaurid. The third tooth form consists of a small (crown height of 0.7 cm) premaxillary tooth with a D-shaped cross section and is referable to a tyrannosauroid.

The second locality, the Robison Bonebed, occurs at an undetermined height within the lower portion of the Wayan Formation. Theropod teeth from this locality are common and group into five morphotypes. Partial to complete teeth of a larger (maximum crown height 3.6 cm) theropod are characterized by crowns roughly three times as tall as their FABL, these teeth may belong to a larger tyrannosauroid. A second tooth form (crown height of 0.8 cm) is assigned to a dromaeosaurid. Two small incomplete and unserrated tooth morphotypes occur, with one form being similar to *Paronychodon*. Small (maximum crown height of 0.9 cm) serrated teeth belong to a small undetermined theropod distinct from the other Robison Bonebed forms.

While the sample size is small and some teeth are incomplete, enough specimens have been recovered to show that a surprising diversity of theropods occur in the Wayan Formation. The presence of a small tyrannosauroid, a possible larger tyrannosauroid, dromaeosaurids, and three distinct unidentified small forms makes the Wayan assemblage one of the most diverse theropod assemblages reported for the late Albian to Cenomanian of North America.

Technical Session II (Wednesday, October 14, 2015, 10:15 AM)

A NEW SPECIES OF EARLY PALEOCENE LANDBIRD AND THE POST-CRETACEOUS DIVERSIFICATION OF BIRDS IN NORTH AMERICA

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Although molecular divergence dating analyses suggest that the neoavian radiation was well under way by the early Paleocene, bird specimens and localities remain poorly represented for this time period. This paucity of data obscures our understanding of the initial phases of the neoavian diversification, particularly in terms of morphological and ecological specialization. Here, we report a partial skeleton of a new species of 'higher land bird' (Telluraves) from the Nacimiento Formation of New Mexico. At ~62 million years in age (latest Torrejonian), this species represents the oldest well-supported crown bird from the Northern Hemisphere and pushes the minimum implied stratigraphic ranges of at least nine additional neoavian clades backwards in time, compressing the duration of the proposed explosive post K-Pg radiation of modern birds into a short temporal window (~4 Ma), similar to that hypothesized for the placental mammal radiation in several recent studies.

The specimen includes portions of the mandible, vertebrae, coracoids, scapula, humeri, radius, femora, and tarsometatarsus. The arcuate arrangement of pedal trochleae in the new species bears a striking resemblance to owls, and implies that a semi-zygodactyl arrangement of the pedal digits represents the primitive condition for the clade Coraciimorphae, and perhaps even Telluraves as a whole. Additional fragmentary remains from the early Torrejonian of New Mexico reveal the presence of a larger raptorial bird of uncertain affinities, providing further evidence for ecological diversification of early Paleocene birds.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

TOOTH FRACTURE: A METHOD FOR DETERMING BITE FORCES IN MOLARIFORM TEETH

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Bite force is a physiological parameter that provides insight into the performance and paleoecology of organisms. However, bite force can only be robustly reconstructed in extant and fossil taxa known from well-preserved crania. Even then, such estimations are based upon a number of assumptions about adductor muscle attachment, mass, pennation, and physiology. On the other hand, teeth are ubiquitous in the fossil record. In addition, tooth fracture provides a direct proxy for inferring in vivo loads. Here, I present a model for calculating bite force based upon the load required to propagate an enamel margin failure. A three-dimensional half dome finite element model is constructed to resemble the geometry of a molariform tooth. Loads are applied based on stress distributions of a reversed Hertzian contact where tensile hoop stresses along the dentine-enamel junction (DEJ) are calculated. Using theoretical relationships, the bite force can then be estimated. In order to verify this model, I used an extant taxon for which bite forces throughout ontogeny are well known: the American alligator (*Alligator mississippiensis*). To simulate a bite, I modeled the system contact with bone. Next, the model was used to compute values for enamel fracture toughness (K_{IC}) values. Two disparately sized animals were used: a large animal with bite force of 4840 N and smaller animal with bite force of 2300 N. Using these forces, computed K_{IC} values were 1.73 $MPa/m^{1/2}$ and 1.08 $MPa/m^{1/2}$ for the smaller and larger animal, respectively. These values are within the range of toughness reported for tetrapod enamel, supporting the utility of this model. I suggest that extant crocodilians present an ideal test for this model, since the bite forces for all species are known and that the model can be used to estimate the bite forces of almost any extinct vertebrate taxon possessing molariform teeth.

Technical Session XVII (Saturday, October 17, 2015, 3:30 PM)

***IN OVO* 3D PRESERVATION OF A TITANOSAURIAN (DINOSAURIA: SAUROPODA) EMBRYONIC SKULL**

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We present a well-preserved skull of a titanosaurian embryo discovered inside an egg from Patagonia, Argentina. The egg, which had been illegally exported, was eventually brought to the attention of T.W.M. who realized its scientific importance after preparation exposed embryonic remains. T.W.M. secured the specimen (MCF-PVPH-874) and donated it to the Museo Municipal "Carmen Funes" in Plaza Huincul, Neuquén Province. The embryo has been imaged with propagation phase contrast synchrotron microtomography (PPC-SRμCT) at the European Synchrotron Radiation Facility.

The skull was found inside a megaloolithid egg. The eggshell thickness is approximately 1.8 mm, thicker than eggs with embryos from the Late Cretaceous Auca Mahuevo nesting site (Neuquén Province, Argentina). The basal globular cores show a pattern of partial resorption, which compares with a later, but not terminal, embryonic stage in living ostriches. Like most specimens from Auca Mahuevo, MCF-PVPH-874 contains only the embryonic skull, although preserved in three dimensions with most bones virtually intact and articulated.

The skull is exposed on its left side, but the 3D morphology and internal structure of all the preserved bones are accessible through virtual replicas produced by PPC-SRμCT; this makes MCF-PVPH-874 the most informative sauropod embryonic skull thus far. While the craniofacial bones are well ossified, the dermal skull roofing and the endochondral bones of the mandible and braincase are largely incomplete. This mirrors the condition of Nile crocodile embryos after two-thirds of incubation, potentially refining estimates of the prenatal stage.

The specimen differs in several characters from previously described titanosaurian embryos from Auca Mahuevo. These include: 1) a rostrally longer maxilla; 2) a small preantorbital fenestra that opens ventral to the rostral rim of the antorbital fenestra and is separated from the postdental emargination; 3) rostrodorsal rim of the postdental emargination slightly angled rather than notched; and 4) deeply incised caudal jugal. Furthermore, we have found that the eggshell/sediment sample of the new specimen is very different in its major elements (XRF data) and mineral content (XRD data) to the samples taken from specimens collected at Auca Mahuevo. Based on the anatomy, eggshell thickness, and mineralogical composition, we hypothesize that MCF-PVPH-874 represents the embryo of a titanosaurian different from those in Auca Mahuevo and from an unknown locality in northern Patagonia, Argentina.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

BIOSTRATIGRAPHIC ANALYSIS OF MAMMALIAN TAXA REVISES THE AGE OF RICH PLEISTOCENE SITES FROM THE LA HABRA FORMATION (ORANGE COUNTY, CALIFORNIA) FROM RANCHOLABREAN TO IRVINGTONIAN

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This study provides a new age assessment for the La Habra Formation at the Emery Borrow Pit, Ralph B. Clark Regional Park, Orange County, California, which contains one of the richest non-asphalt Pleistocene sites in California. Over 35 species of mammal, 19 species of birds, and 16 species of amphibians and reptiles have been identified from this site, although it remains poorly represented in the literature. Although Pleistocene terrestrial fossils from the Emery Borrow Pit have been mentioned occasionally, to date only a single fossil, a tapir tooth (*Tapirus merriami*), has been described and figured from the La Habra Formation. The La Habra Formation has been assigned to the Rancholabrean North American Land Mammal Age largely due to its proximity to another site, La Mirada. However, unlike La Mirada and other Rancholabrean sites, no *Bison* (a hallmark taxon for the Rancholabrean) have been found at the Emery Borrow Pit. This is despite the fact that an abundance of grazers such as *Camelops* and *Equus* have been found. Furthermore, the *Microtus* from the La Habra Formation most closely resemble *Microtus meadensis* (an Irvingtonian taxon). Combined with the presence of *Megalonyx jeffersoni* (known from the Late Irvingtonian to Rancholabrean), the *Microtus* and the lack of *Bison* suggest a late Irvingtonian age for the La Habra Formation. Faunas from the Irvingtonian are relatively rare compared to those from the Rancholabrean, increasing this site's importance for interpreting other Pleistocene faunas in the region. The high diversity and antiquity of the fauna from La Habra Formation present an excellent opportunity to characterize the fauna of the Los Angeles Basin just prior to the well-known asphalt site of Rancho La Brea, less than 40 km away.

Colbert Prize (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

NEW QUANTITATIVE METHODS FOR DISCRIMINATING POSTURE OF VERTEBRATES BASED ON LONG BONES

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The posture of an animal is an intrinsic character of its biology. The posture of extant animals is clear through observation, but posture and gait in the fossil record are harder to determine. There are a number of proposed methods for determining the posture of an extinct animal, none of which is without fault. These range from skeletal reconstruction aiming to determine the range of motion between elements, to looking at footprints, to generating digital models. These methods tend to be qualitative, with occasional quantitative metrics being developed ad hoc for use in a related analysis without the postural reconstruction being rigorously tested. We took a number of measurements from the humeri and femora of extant mammalian taxa (approximately 200 specimens from widely varied taxa ranging from elephants to pocket gophers) to quantitatively distinguish between different postural groupings in a number of different ways. These metrics include: bone length ratios, bone circumference ratios, the ratio of total cross-sectional area of nutrient foramena, and geometric morphometric analyses. These metrics were analyzed with discriminant function analyses to discriminate between two postural groups (bipeds and quadrupeds) and with MANOVAs to distinguish between multiple postural groups (obligate bipeds, facultative quadrupeds, facultative bipeds, and obligate quadrupeds). We also used phylogenetic generalized least squares to assess the phylogenetic signal in the data. Some metrics, particularly bone circumference and bone length ratios, achieved higher than 90% discrimination, while nutrient foramen area showed no useful signal in discriminating postural groupings. These discriminatory methods can be applied to fossil taxa to understand the evolution of posture in amniotes. This is particularly important in the evolution of mammals and of archosaurs. While this analysis has so far only included data from mammalian taxa, with proper validation these methods may be ideal for studying the evolution of posture in archosaurs throughout the Mesozoic.

Technical Session IV (Wednesday, October 14, 2015, 4:00 PM)

PHYSETEROIDS FROM THE MIOCENE OF PERU: NEW DATA ON *ACROPHYSETER* AND *LIVYATAN* SUPPORTS MACRORAPTORIAL FEEDING IN SEVERAL EXTINCT SPERM WHALES

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With only three extant species, modern sperm whales (Odontoceti, Physeteroidea) are generally considered as relicts of a previously more diversified clade, originating during the late Oligocene and reaching its maximum diversity in the Miocene. Displaying a spectacular size disparity, modern *Kogia* spp. (pygmy and dwarf sperm whales) and *Physeter* (giant sperm whale) share several morphological features (dental reduction, slender mandibles, and small temporal fossa) correlated to a specialized suction feeding technique on disphotic to mesopelagic prey.

Although remaining scarce, the fossil record of sperm whales suggests a broader past ecological diversity; based on cranial and dental characters, several middle to late Miocene taxa (the medium size *Acrophyseter*, the large *Brygmophyseter* and *Zygophyseter*, and the giant *Livyatan*) were tentatively interpreted as macroraptorial feeders, using massive teeth deeply embedded in robust upper and lower jaws to catch proportionally large prey.

Together with the study of two new *Acrophyseter* skulls, a detailed description of the type material of *A. deinodon* and *L. melvillei* (both originating from Miocene levels of the Pisco Formation, Peru) provides new clues about their hypothetical feeding strategies.

The analysis of the specimens followed different lines: (1) basic craniomandibular anatomy and comparison; (2) reconstruction of the musculature for adduction/abduction of the mandibles; (3) bone pathology including the description of buccal maxillary exostoses in *A. deinodon;* and (4) tooth wear. Observations and resulting interpretations point to a feeding technique involving intense use of teeth via powerful bites, contrasting markedly with the capture technique in both *Kogia* and *Physeter*. Placed in a phylogenetic context, the morphology of the oral apparatus in these macroraptorial sperm whales is thought to represent a combination of plesiomorphic and derived characters.

Finally, a detailed sedimentological and paleontological analysis of the fossil-rich localities of Cerro Colorado and Cerro los Quesos yielded a vast amount of data about the faunas associated to *Acrophyseter* and *Livyatan*; the mapping of several hundreds of marine vertebrate specimens, as well as their positioning along stratigraphic sections, provides valuable indications about potential prey of these extinct sperm whales.

Grant Information
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Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

A CLASSROOM METHODOLOGY FOR INVESTIGATING THE POSSIBLE FUTURE EFFECTS OF GLOBAL CLIMATE CHANGE THROUGH STUDENT PALEOCLIMATIC ANALYSIS OF VERTEBRATE AND INVERTEBRATE PALEOFAUNAS

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A common question posed to environmental scientists by non-scientists, particularly policy makers, is the following: How will specific local regions of the world change in response to global change? This question has been and continues to be addressed by computer modeling. However, an alternate approach is to look at geologically recent periods of the Earth's history when levels of carbon dioxide were as high or higher than today, use geological/paleontological evidence to recreate the climate at that time, and then extrapolate possible future climates based on that evidence.

Using the above methodology, students have the ability to realistically reconstruct paleoclimates with the goal of projecting future climates, in effect engaging in meaningful scientific research. The basis for this methodology lies in the connection between the modern geographic ranges of extant taxa and their climatic tolerance. By examining the extant taxa in a paleofauna, and tabulating their modern geographical ranges (which can be translated into climatic tolerances), students can deduce a plausible paleoclimate for a given fossil site, and then interpret the significance of this paleoclimate in the context of future global climate change.

The last Pleistocene interglacial period (LPIP), which occurred approximately 120,000 years ago, is an ideal time period for studies of this kind for a number of reasons. (1) The LPIP is geologically relatively recent, with the result that many species in faunas of this age are still extant. (2) Both terrestrial and marine fossil faunas of this age are relatively abundant, and well documented in the literature, serving as a potential source of metadata to include in the studies. Finally, (3) this period was characterized by high sea levels (roughly 6 m above the current level) and carbon dioxide levels similar to or somewhat higher than those of today, making it a plausible model for a hypothetical future high carbon dioxide world.

Results are presented from a project in which a class studied a LPIP invertebrate fauna from South Florida and the Ladds Mountain Quarry mammal fauna in north Georgia. Student analysis of the data indicated that during the LPIP South Florida had a nearly tropical climate much like that found in the area today, while north Georgia experienced modestly warmer (but still temperate) winters. Based on these findings, the students concluded that global warming might not necessarily produce dramatic climate change at relatively low latitudes.

Colbert Prize (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

A NEW MIDDLE PALEOCENE MAMMALIAN FAUNA FROM THE FORT UNION FORMATION, GREAT DIVIDE BASIN, WYOMING

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Over the last three decades, mammalian faunas that span the Torrejonian–Tiffanian boundary have been reported by others from the Hanna and Bighorn Basins, and are important for assessing mammalian diversity and evolution during middle Paleocene time. Here, we report a Torrejonian-Tiffanian transitional fauna from the Overland Member of the Fort Union Formation in the Great Divide Basin, south-central Wyoming. The fauna, which is primarily comprised of isolated teeth from anthills, includes 20 species in five mammalian orders. The taxa identified from the Overland Member include the pantodont *Pantolambda cavirictis*; 'condylarths' *Mimotricentes* sp., *Haplaletes disceptatrix, Haplaletes pelicatus*, *Litomylus dissentaneus, Litaletes disjunctus, Promioclaenus acolytus, Promioclaenus* sp., *Phenacodus* and *Ectocion*; cimolestids *Acmeodon hyoni, Acmeodon secans, Gelastops parcus* and *Gelastops joni*; pantolestids *Paleotomus junior* and *Paleotomus senior* as well as *Bessoecetor;* leptictids *Prodiacodon concordiarcensis and Prodiacodon puercensis;* and the primate *Nannodectes intermedius*.

The Overland fauna is similar to latest Torrejonian faunal assemblages elsewhere in containing *Acmeodon hyoni, Pantolambda cavirictis* and *Litaletes disjunctus*. However, it also contains the plesiadapid *Nannodectes intermedius,* an index taxon for the earliest Tiffanian (Ti1) lineage zone, and *Ectocion*, which first appears in Ti1 as well. Surprisingly, *Plesiadapis praecursor,* the index species on which Ti1 is defined, has not yet been recovered in the Overland fauna. Nevertheless, based upon presence of *N. intermedius* and *Ectocion*, as well as similarities to earliest Tiffanian fauna in the Hanna Basin, we suggest the Overland fauna is earliest Tiffanian (Ti1) in age.

With regard to geographic range extensions, the largest occurs for *Paleotomus junior,* previously documented only from localities in Alberta, Canada. We also report temporal range extensions for *Haplaletes pelicatus*, whose range is extended from Ti2-3 into Ti1, and *Acmeodon hyoni* is extended from To3 to Ti1. While the Overland fauna is not as diverse as the earliest Tiffanian fauna in the Hanna Basin, it is comparable to other earliest Tiffanian faunas comprised of anthill collections.

Colbert Prize (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

NEW EVIDENCE AND ANALYSES INDICATE THAT *TURSIOPS OSENNAE* IS A GLOBICEPHALINE (ODONTOCETI, DELPHINIDAE) FROM THE PLIOCENE OF SIENA BASIN (TUSCANY, ITALY)

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Tursiops osennae is a species of Delphinidae first described by Simonelli in 1911. It was found in Pliocene sediments (5.3–3.35 Ma) from the sedimentary basin of Siena-Radicofani in Tuscany, Italy. The holotype consists of an incomplete skull including the ear bones (right periotic and right and left tympanic bulla), a small portion of the left mandible, the atlas articulated with the axis, and the third and fourth cervical vertebrae. The objective of this study was to redescribe this fossil specimen and evaluate its phylogenetic position using both molecular and morphological data.

The morphology of *Tursiops oseannae* significantly differs from extant *Tursiops* spp. and from all other extant and fossil delphinids, indicating that it belongs to a new genus. Key diagnostic characters that identify this new taxon are: (1) broad rostrum; (2) very wide anterior angle between nasals; (3) very short orbit compared to skull length; (4) deep and narrow antorbital notches; (5) tilted posterior process of periodic; (6) tall atlas, with a long neural spine; and (7) little sloping neural spine of atlas.

The phylogenetic position of *Tursiops oseannae* was evaluated using a supermatrix of 19630 characters coded for 45 taxa. The molecular partition is previously published, whereas the morphological partition was developed for the present study. It includes 63 morphological characters, of which 13 are new. The entire supermatrix was analyzed with implied weighting, with the constant k = 3. The single tree from the combined dataset shows *T. osennae* as nested in the Globicephalinae rather than in Delphininae, where *Tursiops* is situated. *Tursiops osennae* is the sister-taxon of *Peponocephala electra* and its closest fossil relative is *Hemisyntrachelus cortesii*, which is the sister-group of the clade of Globicephalinae + *Steno bredanensis*. Thus *T. ossenae* represents the oldest fossil genus of Globicephalinae, confirming the great diversification of Delphinidae in the Pliocene.

Technical Session XII (Friday, October 16, 2015, 11:45 AM)

ECOMORPHOLOGICAL RELATIONSHIPS BETWEEN DIET AND MORPHOLOGY IN EXTANT *VARANUS* LIZARDS

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Ziphodont teeth, which are labio-lingually flattened, carinate, and often denticulate, have evolved convergently in numerous lineages of reptiles, as well as basal synapsids. Historically, in extinct amniotes, teeth with this morphology have been suggested to indicate a carnivorous diet. However, in the only group of extant ziphodont reptiles, *Varanus* lizards, diet is highly variable and often species-specific, from vertebrate hypercarnivory to frugivory, though the ecomorphological relationships between diet and tooth morphology have not yet been rigorously tested. We predict that variation in dietary preferences should be reflected in the tooth morphology of *Varanus*, as the dentition plays an important role in prey capture and manipulation, often serving as the first point of contact between an individual and its prey. Here, we use quantitative multivariate analyses to test the relationship between tooth and jaw morphology and known dietary preference in *Varanus*. We collected linear and geometric morphometric variables from over 150 specimens in 41 species of extant monitor lizards, representing over half of currently recognized biodiversity and including members from every subgenus and species complex. Dietary preference data, as indicated by gut contents, were collected from the literature. These two datasets were analyzed using a redundancy analysis to find which morphological variables best explained the observed dietary data. Results indicate that a substantial portion of morphological variation relates to dietary preference. The chief axes of variation in *Varanus* diet relate to the relative proportions of invertebrates to vertebrates in the diet and whether species eat predominantly aquatic or terrestrial taxa. Morphological variables relating to the invertebrate-vertebrate axis include general size and degree of crown height homodonty. The chief morphological feature explaining the aquatic-terrestrial prey axis is relative tooth denticle size. Using these data, a number of *Varanus* dietary ecomorphotypes can be characterized, including those that eat predominantly terrestrial invertebrates, terrestrial vertebrates, crustaceans, molluscs, fish, and a generalist category whose members consume prey from most or all of those categories. These results can be applied to the fossil record to infer the feeding ecology of extinct varanids and other ziphodont vertebrates. An assessment of the fossil varanoid taxa *Necrosaurus* and *Saniwa*, for example, suggest they may have been aquatic prey specialists.

Technical Session XVI (Saturday, October 17, 2015, 10:45 AM)

NEW GIANT LATE CRETACEOUS CROCODYLIFORM WITH FEEDING ADAPTATIONS CONVERGENT ON SPINOSAURIDS

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A new giant crocodyliform was discovered in two localities in the Sahara of Cenomanian age, the Kem Kem beds in Morocco and the Echkar Formation in Niger. The new taxon represents a late-surviving relative of the longirostrine crocodyliform *Stolokrosuchus* from mid-Cretaceous rocks in Niger. Features shared by these presumed sebecids include unique modifications to the narial region and anterior tooth occlusion. The incisive foramen is greatly expanded and the chamber dorsal to the foramen opens anteriorly through a midline foramen between the anterior premaxillary midline suture. This morphology presumably housed a vomeronasal organ, a sensory organ absent in extant crocodylians. A hypertrophied tusk-like first dentary tooth occludes into a deep recess on the premaxilla. The remaining premaxillary and anterior dentary teeth interlock to create a unique tight fitting anterior tooth rosette.

The new taxon converges with the contemporary theropod *Spinosaurus* in size and in several features of the snout. Convergences include the presence of a terminal rosette of teeth, elongate, laterally compressed, and gently down-sloping snout, recurved concical teeth, and gigantic skull size. Total skull length approached two meters and makes this crocodyliform one of the largest to have existed. Skull length is comparable to or even exceeds that of the giant piscivorous *Spinosaurus*. The presence of two gigantic, presumably piscovorous taxa is explained by the diverse fish fauna of these formations.

Technical Session IX (Thursday, October 15, 2015, 2:30 PM)

MORPHOLOGICAL EVOLUTION OF THE MAMMALIAN JAW ADDUCTOR COMPLEX

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The evolution of the mammalian jaw is characterised by the gradual reduction of its individual bones into a single element and the concomitant transformation of the jaw joint and incorporation of the post-dentary bones into the middle ear complex. This osteological transformation is accompanied by a rearrangement and modification of the jaw adductor musculature, which is thought to have allowed the evolution of a more efficient masticatory system in comparison to the plesiomorphic reptilian condition. While the functional aspects of the osteological and myological transition have been studied in detail for several decades, surprisingly little is known about the exact arrangement of the individual adductor muscles and reconstructions have often been vague or conjectural.

Here, we use digital techniques to reconstruct the jaw adductor musculature of different non- mammalian cynodonts and mammaliaforms (including *Thrinaxodon*, *Probainognathus*, *Diademodon*, and *Morganucodon*). Three-dimensional digital models of the adductor muscles were created on the basis of osteological correlates, homological criteria, and spatial constraints. Different hypothesized arrangements were tested taking into account maximum muscle stretch factors and differences in muscle architecture and comparative data derived from contrast-enhanced CT scans of an extant taxon (*Monodelphis*).

The resulting models show a trend in the arrangement of the neomorphic masseter muscle, shifting from an originally more vertical position in basal taxa such as *Thrinaxodon* to an anteroposteriorly diagonal position in *Morganucodon*, thus avoiding interference with the post-canine teeth. At the same time, the temporalis muscle increased in absolute and relative size in more derived mammaliaforms. The pseudotemporalis muscle group contributed only marginally to overall muscle mass and was likely retained in *Thrinaxodon*, but lost in more derived taxa. These digital models confirm existing assumptions, but also provide new data and quantitative assessments on the musculoskeletal evolution of the mammalian masticatory system and middle ear with relevance for functional and developmental studies of the mammalian skull.

Grant Information
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Technical Session XIV (Friday, October 16, 2015, 2:00 PM)

MARY ANNING'S MARINE REPTILES: TAXONOMY, SYSTEMATICS, MORPHOMETRICS AND EVOLUTION OF THE ICONIC *ICHTHYOSAURUS*

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Ichthyosaurus is by far the most famous of all fossil marine reptiles, yet its taxonomy, composition and evolution has remained little studied and poorly understood for more than 100 years. Hundreds of *Ichthyosaurus* specimens are known, and at least five species are recognized by recent authors; however, the autapomorphies and diagnoses of both *Ichthyosaurus* as a whole and its constituent species are poorly understood. Furthermore several specimens, many undescribed, variously reveal a complex range of intermediate conditions between currently recognized species. These are anatomically novel, or indicate profound polymorphism within some *Ichthyosaurus* species.

I report the most comprehensive analysis of *Ichthyosaurus* ever undertaken, based on a large sample of specimens (>200) referred to this taxon from across the Lias stratigraphy, including the classic Lyme Regis section. Precise data on the stratigraphic placement of specimens is scant; one aim of this study is to use palynomorphs to establish the age and provenance of specimens. Combined, this work has resulted in: (1) Anatomical clarification of the status of *Ichthyosaurus*; (2) Understanding of the likely species composition within *Ichthyosaurus*; (3) Large-scale morphometric, systematic and phylogenetic analyses within the clade, and; (4) A clear understanding of evolutionary trends within *Ichthyosaurus* across the Liassic. This groundwork sets *Ichthyosaurus* in an improved anatomical and phylogenetic context and will provide the state-of-the-art for future work on this and other Liassic ichthyosaurs.

Conclusions indicate that while the validity of *Ichthyosaurus* is supported by autapomorphies, specimen clusters recovered by principal-component (PC) and size-constrained PC morphometric analyses do not correspond to currently recognized species. *Ichthyosaurus* spans a range of body sizes and individuals cluster into several size classes. Some represent ontogenetic stages within species but more surprising is data showing the presence of lineages that reveal trends in body size evolution throughout the Lias. This work will help clarify both the true diversity and evolutionary history of this iconic Liassic animal, first brought to scientific attention by Mary Anning over a century ago.

Grant Information
Graduate School of the National Oceanography Centre, Institute for Life Sciences, the Jurassic Coast Trust, and The Primary Science Teaching Trust

Technical Session XII (Friday, October 16, 2015, 8:15 AM)

SKELETAL VARIATION IN *NAOMICHELYS* (TESTUDINATA: SOLEMYDIDAE): INSIGHTS FROM A NEW SPECIMEN FROM THE LOWER CRETACEOUS OF MONTANA

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Solemydidae is an enigmatic clade of stem turtles, primarily represented by fragmentary shell material found in Upper Jurassic and Cretaceous deposits of Europe and North America. Specimens are typically identified by a distinct surface ornamentation comprised of tall, narrow tubercles, which are often incompletely preserved due to taphonomic processes. The only currently recognized North American species of Solemydidae, *Naomichelys speciosa,* was erected in 1908 on the basis of a nearly complete entoplastron from the Lower Cretaceous Cloverly Formation of Montana; however, a far more complete specimen from the Lower Cretaceous Antler Formation of Texas was recently referred to this species and has shed light on the morphology of *Naomichelys.* Here, I describe a partial skeleton that was discovered in 1995 near the type locality in Montana, thus allowing for the first look at variation in many of the skeletal elements of the genus.

The new specimen is referable to Solemydidae based on a large, diamond shaped entoplastron, which exhibits the distinctive solemydid surface ornamentation and an entoplastral scute, and is referable to *Naomichelys* because of its near-identical morphology to that of the holotype. Preserved carapacial elements include the right costals and peripherals in articulation, albeit somewhat crushed, disarticulated left costals, and a single neural. The plastron is well preserved with only portions of the left bridge and xiphiplastra missing. Additional preserved elements include four cervical vertebrae (C5 - 8), both shoulder girdles, and the right femur. This material differs from previously described specimens in its exhibiting a smaller overall size, a complete lack of a central plastral fontanel, shallow and often difficult to identify sulci, a nuchal notch that is reduced or lacking completely, scapulocoracoids that are completely loose (not sutured), and equally developed distal condyles of the femur.

The morphological differences between the new material and the Texas specimen suggest two plausible conclusions. (1) They demonstrate two different ontogenetic stages of development, with MOR 941 representing a skeletally more mature, albeit smaller individual; or (2) there are two distinct species of *Naomichelys* from the Lower Cretaceous of North America.

Technical Session XVIII (Saturday, October 17, 2015, 4:00 PM)

A PHYLOGENETICALLY CONTROLLED APPROACH TO EXAMINE THE TEMPO AND MODE OF EVOLUTION IN AFRICAN UNGULATE CRANIODENTAL TRAITS AND DIET

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The evolutionary history of ungulates in Africa is marked by the appearance and diversification of a suite of craniodental adaptations presumably related to diet. These morphological traits, in addition to stable carbon isotope ($\delta^{13}C$) data, have been widely used to infer the diet of extinct species, although the relationship between these proxies remains poorly understood. Here, we test for correspondence between these proxies using phylogenetic comparative methods, in addition to analyzing the tempo and mode of evolution for craniodental traits and isotopes in African ungulates. We calculated 10 metrics derived from 27 craniodental traits and examined how they were related to $\delta^{13}C$ values using phylogenetic generalized least-squares regression models. Additionally, we examined how three models of evolution, Brownian motion (BM), Ornstein-Uhlenbeck (OU) and Early Burst (EB), explained interspecific variation in diet-related traits. Our results show that the five morphometric traits that best predict $\delta^{13}C$ isotope values are those that relate to the height of the tooth crown, width of the muzzle, basicranial angle, mesiodistal length of the first and second lower incisors, and width of the masseter muscle. We found that an EB model of evolution best explained the tempo of evolution of these traits, suggesting that they diversified early in the clade's history and subsequently slowed through time. Thus, we conclude that the basic suit of diet-related craniodental adaptations evolved in the early radiations of African ungulate clades. Our study has important implications for interpreting the evolution of ungulate clades in Africa and the relationship between diet and craniodental morphology in ungulates overall.

Grant Information
Ignacio A Lazagabaster is supported by *La Caixa* Graduate Fellowship.

Technical Session VII (Thursday, October 15, 2015, 2:45 PM)

TIMING IS EVERYTHING: HETEROCHRONY AND THE EVOLUTION OF THE HADROSAURID DENTAL BATTERY

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The hadrosaurid dental battery consists of hundreds of interlocking teeth that form a single pavement, and faciliated grinding and shearing of ingested plant material. Recent histological studies of hadrosaurid teeth have concluded that their teeth were more complex than those of other reptiles and were comparable to mammalian teeth in their tissue-level complexity. To date, however, no study has documented the development and mode of attachment of hadrosaurid dentition to determine how the battery formed before the teeth erupted and how it was maintained. Given the complexity of the hadrosaurid dental battery and dynamic nature of continuous tooth replacement, its development is of particular interest to understanding reptile dental evolution. We therefore undertook a histological investigation of dental batteries and isolated teeth in hadrosaurids and compared them to other archosaurs, as well as mammals, to determine the innovations that characterized the evolution of the dental battery.

Results show that hadrosaurids had evolved an increased rate of dental tissue formation and an earlier onset of the formation of the tooth attachment tissues compared to other amniotes. By the time a tooth had erupted, the pulp cavity of the tooth was completely plugged by dentine. This process entombed some of the vasculature of the pulp and created the giant tubules, which have been previously considered a novel tissue type. Interestingly, the teeth also formed all of the attachment tissues well before tooth eruption. These tissues allowed developing teeth to maintain a connection to the alveolus even in the initial stages of tooth development. Individual teeth in the battery were not connected by hard tissue to any of the surrounding jawbone or teeth. Instead, a network of ligaments suspended each tooth from the alveolar trough and from neighboring teeth. The main function of cementum in hadrosaurs was to anchor the fibers of these ligaments. Cementum was clearly an attachment tissue in hadrosaurids, as it is in other amniotes, and was developmentally distinct from the coronal cementum in ungulate mammals.

Our new data provide a novel perspective on dental battery evolution; despite their structural complexity, dental development in hadrosaurs was constrained by the same developmental processes present in other amniotes. These new findings allow us to conclude that heterochrony, and not de novo tissue formation, was the evolutionary mechanism that allowed hadrosaurids to develop such an unusual, complex dentition.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

THE FIRST CRETACEOUS LIZARD TRACKWAYS

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Three well-preserved lizard trackways (a total of 24 imprints) and three isolated tracks were discovered in the Hasandong Formation (Aptian), South Korea. They occur on the surface of an isolated dark grey mudstone slab (70 x 30 cm). Most tracks are pes tracks that are very small, averaging 24.0 mm long and 14.5 mm wide. Digit impressions are deeper (1 mm in depth), slightly curved inward, and better defined than the sole pad impression which is slightly raised. The interdigital angle between digits I and V of the pes is about 86 degrees. The pes tracks show "typical" lizard morphology, in having curved digit imprints that progressively increase in length from digits I to IV (average 5.1 mm, 8.1 mm, 14.1 mm, 17.7 mm), a smaller digit V (average 8.6 mm) that is separated from the other digits by a large interdigital angle, and digit V oriented more laterally. Only three manus tracks are preserved in two trackways. One complete manus track is 19.2 mm long and 19.3 mm wide, which shows different morphology from the pes: similar sized digits II (12.1 mm) and IV (12.0mm) are slightly shorter than digit III (12.9 mm) in length and the interdigital angle between digits I (6.7 mm) and V (6.1 mm) is about 130 degrees. Manus tracks are closer to the midline than the pes, suggesting the forelimb is relatively shorter than the hind limb in these trackmakers. The low number of manus tracks could be due to substrate condition associated with their light body weight. Two trackways are slightly overlapped with opposite directions, indicating a short time interval between timing of formation. Each pes track in the trackways shows about 10 degrees outward rotation. The strides of pes in trackways A and B are 161.2 mm and 143.2 mm, respectively. The pes-gait width of trackway A is narrower than that of trackway B. The consistent digital depth and pace angulation with no dragging marks suggest that lizards were walking on partially dried, firm and flat substrate rather than running. Tail traces are not observed.

Preparators' Session (Thursday, October 15, 2015, 9:00 AM)

COMPARISON OF QUANTITATIVE ASSESSMENT METHODS FOR POLYMER CONSOLIDANT PENETRATION ON ROCK AND FOSSIL SUBSTRATES

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A key objective for fossil preparators is to select the best consolidant for a given specimen, usually from a handful of consolidants whose properties are qualitatively observed through practice, including solubility, aging, and penetration depth from the application surface. We compared quantitative evaluation methods for consolidant penetration: iodine staining (IS), hydrophobicity comparisons (droplet test), and direct observation in petrographic thin section. We tested these methods on samples of Gobi Desert sandstone, Chilean ignimbrite, and Amazonian mudstone, and the fossil bone these rock types contain, capturing a range of porosities and shear strengths.

Samples from each substrate type were consolidated with 2 solution-based consolidants, and penetration depth was measured with each of the methods. Sample blocks were cut after the consolidant had dried completely, and the flat surfaces assessed using the IS and droplet tests. Exposure to iodine vapor stains consolidant polymers, and polymer saturated substrate is more hydrophobic than unsaturated, producing water drop sphericity variation. Both of these test results were assessed visually with a binocular microscope; the depth of iodine staining and the diameters of water drops along the section were both measured in microns. A thin section was produced from each sample for the third test. The refractive index (RI) of different consolidant polymers is an optical property of their molecular structure, and a goal of this study was to test whether polymer RI is consistent enough to observe penetration with a petrographic microscope. The thin section method enabled us to observe and map fine scale variation in penetration, and quantify it relative to specimen porosity.

The droplet test is the simplest method and requires minimal special instrumentation, but is subject to imprecision and subjectivity. The IS test is more replicable, and depth measurements are quick to make, so for comparison between many different substrates and polymer types it is recommended. To map fine scale characteristics of consolidant migration through a specific substrate, thin sections are promising, but require differentiation between the RIs of consolidant and slidemaking epoxy, facilities for thin section production, and ability to destructively sample the specimen.

Colbert Prize (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

RECONSTRUCTION OF CRANIAL KINEMATICS IN *TIKTAALIK ROSEAE* WITH INSIGHT INTO THE EVOLUTION OF THE TERRESTRIAL VERTEBRATE FEEDING SYSTEM

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Discussions of cranial kinesis in sarcopterygians are dominated by analyses of the intracranial hinge and what role it played in stem-tetrapod feeding dynamics. However, in many aquatic vertebrates, palatal arch mobility (or splanchnokinesis) is far more common, and plays an important role in feeding and respiration. Although the elpistostegid *Tiktaalik roseae* possessed a fused intracranial hinge, reduced hyomandibula, and lacked a bony operculum, there is evidence for cranial kinesis in the joints connecting the palate to the rest of the skull. In this study we use a 3D kinematic model based on computed tomography data to estimate range of motion and timing of joint rotation during inferred feeding behavior of *Tiktaalik*. Inferences of cranial kinesis are also bound by estimates of plesiomorphic jaw opening and closing muscles and comparisons with the generalized osteichthyan feeding systems maintained by basal actinopterygians. High speed videography of extant gars, *Lepisosteus* and *Atractosteus*, provides a baseline for comparison with *Tiktaalik* due to the high level of convergence in feeding morphology shared between gars and elpistostegalids, and helps demonstrate how an intermediate terrestrial-style feeding system can evolve in an aquatic environment before the water-to-land transition.

Colbert Prize (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

REVISED AGE CONSTRAINTS FOR LATE CRETACEOUS TO EARLY PALEOCENE STRATA FROM THE DAWSON CREEK SECTION, BIG BEND NATIONAL PARK, WEST TEXAS, USA

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Upper Cretaceous to Lower Paleocene alluvial deposits of the Dawson Creek section in Big Bend National Park are an ideal setting to assess the interplay between terrestrial ecosystems and cyclostratigraphy. Previous research on the dinosaur and mammalian faunas from the Upper Cretaceous Aguja and Javelina Formations and the Lower Paleocene Black Peaks Formation have been used to constrain the approximate position of the Cretaceous-Paleogene (K-Pg) boundary and to develop a biostratigraphic framework for the formations. Sedimentological, stratigraphic, and geochemical analyses done by previous workers were used to produce a paleoclimatic and sequence stratigraphic framework for the Dawson Creek section. Through a combination of biostratigraphy, estimates of sedimentation rates based on paleosol maturity, and correlations of local isotope stratigraphy to marine isotope curves an age model was developed for the Dawson Creek Cretaceous-Paleocene section.

A reevaluation of the mammalian fauna from the Black Peaks Formation indicates that the taxa originally identified to be diagnostic of the earliest Paleocene Puercan North American land mammal age (NALMA) were misidentified, and instead are indicative of the younger Torrejonian NALMA. These updated identifications indicate that the original biostratigraphic constraints for the Paleocene portion of the Dawson Creek section are incorrect and suggest that the age model for the entire section should be reexamined using independent methods. We revised the age model for the Cretaceous and Paleocene Dawson Creek section using magnetostratigraphy through the entire succession combined with the new biostratigraphic constraints for the Dawson Creek mammalian faunas and select detrital dates from large sandstone bodies throughout the section. Our analyses indicate that the Aguja Formation correlates to the C31r, the Javelina Formation correlates to C31n, C30r, and C29r, and the Black Peaks Formation correlates to C29r and C27r. Several long unconformities at previously identified sequence boundaries are present in the Javelina and Black Peaks Formations. The development of a revised geochronologic framework for the Dawson Creek section allows the Cretaceous and Paleocene faunas to be correlated to age equivalent strata within the San Juan Basin, as well as for direct comparisons of climates, depositional environments, cyclostratigraphy, and faunas of correlative strata across the Western Interior of North America.

Grant Information

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Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

A NEW TAXON OF RAUISUCHID (ARCHOSAURIA, PSEUDOSUCHIA) FROM THE UPPER TRIASSIC OF NEW MEXICO INCREASES THE DIVERSITY AND TEMPORAL RANGE OF THE CLADE

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Rauisuchids are large (2–6 m), carnivorous, and quadrupedal archosaurs closely related to crocodylomorphs. Specimens of these apex predators are relatively rare in Late Triassic assemblages. The middle Norian (~212 Ma) Hayden Quarry of New Mexico, from the Petrified Forest Member of the Chinle Formation, has yielded isolated postcranial elements and loosely associated skull elements of a new species of rauisuchid that increase the known diversity of Rauisuchidae. A nearly complete maxilla of the new taxon shares with the rauisuchids *Teratosaurus suevicus*, *Postosuchus kirkpatricki*, and *Polonosuchus silesiacus* the presence of fused interdental plates and a dorsoventrally tall ascending process at its posterior extent. The Hayden Quarry maxilla, *T. suevicus*, and *P. kirkpatricki* all have a less sinuous ventral margin than other members of Rauisuchidae, including *P. silesiacus*. Furthermore, the maxilla of the new taxon bears a ridge forming the antorbital fossa that is non-bulbous, rather than bulbous as in *P. kirkpatricki* or *P. silesiacus*, and an interdental groove connecting the alveoli that is sinuous, rather than straight as in *T. suevicus*. Other Hayden Quarry material includes a left premaxilla, right ectopterygoid, a partial jugal, quadrate, and two ilia. Although the material is disarticulated, all the cranial elements were associated and are independently assignable to clades within Loricata or Rauisuchidae. Thus, we hypothesize they belong to the same taxon as the maxilla. The premaxilla has five alveoli, in contrast to the typical four alveoli in nearly all other rauisuchids. However, the premaxilla shares with *Rauisuchus tiradentes* and *P. kirkpatricki* a protuberance at the base of the posterior process. The double-headed ectopterygoid, dorsoventrally oriented crest on the posterior side of the quadrate, and bulbous longitudinal ridge on the lateral surface of the jugal are all features shared with *P. kirkpatricki* and *P. silesiacus*. Unexpectedly, the new taxon shares many more maxillary apomorphies (e.g., a ventral margin that is convex anteriorly and straight posteriorly, a non-bulbous ridge forming the antorbital fossa, and a sharp dental groove connecting the alveoli) with *T. suevicus* from the mid-Norian of Germany than it does with the geographically closer *P. kirkpatricki*, from the early Norian of Texas, New Mexico, and Arizona. The recovery of the new taxon reveals an increased range of morphological diversity for the low-paleolatitude Chinle Formation and a clear biogeographic connection with high-latitude Pangaea.

Grant Information
National Science Foundation EAR-1349667

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

LEVERAGING PALEONTOLOGY RESEARCH, COLLECTIONS AND 3D TECHNOLOGIES TO PROMOTE CRITICAL THINKING

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Educators are required by state learning standards to teach students to think critically. A key question is how specific instructional activities can be designed to get students to think critically and keep them engaged. A related challenge is how to measure students' critical thinking. We created *Research Quests* for 6th grade students with the goals of prompting students to think critically while exploring real paleontological research questions and developing ways to measure this critical thinking. Dinosaurs and the story behind Cleveland Lloyd Dinosaur Quarry were used as a stimulus to generate student excitement and keep students engaged in the lesson. We 3D scanned 6 dentaries, 6 claws, and 4 femora of various Jurassic dinosaurs from the Cleveland Lloyd Dinosaur Quarry housed in our Paleontology Collections at the Natural History Museum of Utah. We 3D printed these bones and uploaded interactive, digital scans of the bones to iPads. To accompany the physical materials, we developed a series of videos of a paleontologist who provided guidance, background information and essential modeling of critical thinking that was tailored to support students as they progressed through their quest to answer two key questions; "What kind of dinosaur is this?" and "What happened where it died?" *Research Quests* were studied by museum educators and researchers in eight 6th grade classrooms. Facilitators showed the videos, distributed iPads and 3D scans with supplemental material and encouraged student thinking. To test the extent *Research Quests* affected students' critical thinking skills, written assessments and verbal analyses were used. Pre- and post-tests were issued. Classroom video and audio recordings were coded and analyzed for critical thinking verbiage. Results demonstrated *Research Quests* engaged students in critical thinking. Compared to matched controls, students who worked on *Research Quests* were more likely to agree with critical thinking statements and to accurately assess when evidence led to valid conclusions. Verbal analyses indicated that students who worked on *Research Quests* engaged in frequent critical thinking, particularly creating hypotheses, gathering evidence, and elaborating on evidence and ideas. Not only did we attain critical thinking outcomes as a result of *Research Quests*, the verbal analyses provide a rich and sensitive way to measure how much critical thinking was attained. Ultimately, *Research Quests* will be available online for teachers to access and implement.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

IMPLICATIONS OF AVIAN, REPTILE, AND MAMMALIAN DATA ON THE EVOLUTION OF VISION IN SAUROPOD DINOSAURS

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In this study we aim to estimate the visual capabilities of sauropods based on measurements of over 50 extinct and extant avian, reptile, and mammal intact heads and skulls. In all skulls, we measured orbit length, width, and depth and skull length; for the intact heads we additionally measured corneal and eyeball diameters. Our observations and measurements, as well as statistical data, indicate that birds have corneal diameters > 50% but < 80% of their respective orbits; in reptiles, corneal diameters are close to orbit diameters. Mammals have a range of values between those of birds and reptiles. For specific comparisons with herbivorous sauropods, we focused on herbivorous taxa, but included carnivorous taxa for reference. Some herbivorous birds, such as *Struthio camelus*, evolved relatively small eyeballs for utilizing the up-close food spectrum, the opposite of carnivorous birds, such as Strigiformes, whose members possess extraordinarily large eyeballs. The orbits of *Giraffa* and *Camelus* present laterally expanded caudal margins, highlighting laterally extensive views. We selected *Mamenchisaurus*, *Camarasaurus*, and *Diplodocus* as primitive models for sauropods. With dorsoventrally elongate skulls and caudally reduced nostrils, *Mamenchisaurus* and *Camarasaurus* have prominent, large orbits that are enlarged both dorsoventrally and laterally. These two sauropods may have been restricted to rostral, long-distance binocular fields of view with large lateral ranges. In contrast, *Diplodocus* bears a comparatively small orbit located farther caudally. Tentatively we draw conclusions for binocular fields of view and concentrations on horizontal view range in sauropods.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

A NEW SPECIES OF *XINPUSAURUS* (REPTILIA: THALATTOSAURIA) FROM THE MIDDLE TRIASSIC OF SOUTHWESTERN CHINA

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The Ladinian (late Middle Triassic) Xingyi Fauna and the Carnian (early Late Triassic) Guanling Fauna, both from Guizhou Province, China, are closely positioned to each other both spatially and temporally. The vertebrate component of the Upper Assemblage of the Xingyi Fauna is known to closely resemble that of the Guanling Fauna, with a notable exception: thalattosaurs are abundant in Guanling, with 4 genera, in contrast to only two species of the askeptosauroid *Anshunsaurus* in Xingyi. During the excavation in the Wusha District, Xingyi City, Guizhou Province from 2010 to 2013, a new thalattosaur specimen was excavated from fossil bed 53 of the Upper Assemblage of the Xingyi Fauna, where abundant marine reptiles, fishes and invertebrates are found. This new specimen represents a new species of the thalattosauroid *Xinpusaurus*. The skeleton is nearly complete and articulated, with only some caudal vertebrae missing. Its total length is about 2.1 m. The skull is preserved in ventral view, with a length of more than 40 cm. This specimen is ascribed to the genus *Xinpusaurus* based on the dorsally curved anterior end of maxilla, and a proximal end of the humerus that is wider than the distal end. It differs from the type species *Xinpusaurus suni* by several features. The posterior process of its jugal is undeveloped, while other thalattosaurs all possess triradiate jugals with an elongate posterior process. The coracoid is oval, different than the arch-shaped coracoid of *X. suni*. The radius is relatively short, only about half the length of the humerus, whereas in all specimens of *X. suni*, the length ratio of the radius to humerus is more than 0.63. The constriction of the femur at mid-shaft is unremarkable, which is quite unique in Thalattosauria. In addition, the posterior part of the iliac blade is rectangular without a pointed tip, an element that has not yet been described for *X. suni*. This is the first finding of the genus *Xinpusaurus* from the Middle Triassic; previously this genus was only known from the Carnian of Guanling. This new finding reconfirms the close relationship between the Upper Assemblage of the Xingyi Fauna and the Guanling Fauna, as suggested by previous research.

Colbert Prize (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

NEW INSIGHT INTO THE ANATOMY OF THE HYOLINGUAL APPARATUS OF *ALLIGATOR MISSISSIPPIENSIS* AND IMPLICATIONS FOR RECONSTRUCTING FEEDING IN EXTINCT ARCHOSAURS

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Anatomical studies of the cranium of crocodilians motivated by an interest in its function in feeding largely focused on bite force, the jaw apparatus, and associated muscles innervated by the trigeminal nerve. However, the ossified and cartilaginous elements of the hyoid and the associated hyolingual muscles, innervated by the facial, hypoglossal, and glossopharyngeal nerves, have received much less attention. Crocodilians are known to retain what are ancestrally the 'Rhythmic Hyobranchial Behaviors' such as buccal oscillation, but show diminished freedom and movement for the hyobranchial apparatus and the tongue in food transport and manipulation. Feeding among crocodilians, generally on larger prey items than other reptilian outgroups, involves passive transport of the food within the mouth. The tongue in extant crocodilians is firmly attached to the buccal floor and shows little movement during feeding. Here, we present a detailed anatomical description of the myology of the hyolingual apparatus of *Alligator mississippiensis*, utilizing contrast-enhanced Micro-computed tomography (CT) and dissection. We construct the first three-dimensional (3D) description of hyolingual myology in *Alligator mississippiensis* and discuss the detailed implications of these data for our understanding of hyolingual muscle homology across Reptilia. These anatomical data and an evaluation of the fossil record of hyoid structures also shed light on the evolution of feeding in Reptilia. Simplification of the hyoid occurs early in the evolution

of archosaurs. A hyoid with only one pair of ceratobranchials and a weakly ossified or cartilaginous midline basihyal is ancestral to Archosauriformes. The comparison with non-archosaurian reptilian outgroup demonstrates that loss of the second set of ceratobranchials as well as reduced ossification in the basihyal occurred prior to the origin of crown-clade archosaurs, crocodilians and birds. Early modification in feeding ecology appears to characterize the early evolution of the clade. Hyoid simplification has been linked to ingestion of large prey items and this shift in hyoid-related feeding ecology may occur in early archosauriform evolution. A second transformation in hyoid morphology occurs within the crocodilian stem lineage after the split from birds. In Crocodyliformes, deflections in the ceratobrachials become more pronounced. The morphology of the hyoid in Archosauriformes indicates that aspects of the hyolingual apparatus in extant crocodilians are derived.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

A SIMPLE METHOD OF INFERRING THE PALEOENVIRONMENTS OF EXTINCT TURTLES

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In recent years several methods have been proposed for inferring turtle paleoenvironments from fossil specimens. These have focused on the turtles of the Late Triassic, in particular *Proganochelys*. The results of these methods fall into two groups– those espousing a terrestrial paleoenvironment and those espousing a freshwater or swamp environment. A new method uses four measurements of the shell (two ratios) to infer the paleoenvironments of fossil turtles. These are the maximum width of the carapace, the width of the plastron at the abdominal-femoral sulcus, as well as the height and the length of the turtle's shell.

The new method indicates that *Proganochelys* was not a specialized terrestrial turtle but a freshwater, possibly swamp-dwelling turtle based on its narrow plastron and relatively low shell height. This conflicts with analysis based on forelimb proportions. However, note that as reconstructed the length-to-width ratio of the *Proganochelys* hand is the inverse of that of extant *Macrochelys temminckii,* suggesting that while the method may suggest different ecologies, the hands could push a similar amount of water. Conversely, this agrees with the principle of the enlarged intertrochnteric fossa indicating an aquatic paleoenvironmental preference, and the curve-fitting method that suggests a possible semi-aquatic paleoenvironmental preference in *Proganochelys*.

It has been argued that the 'tail club' and osteoderms of *Proganochelys* preclude its being aquatic. However, Gaffney used the term tail club but emphasized that this was not a suggestion of function. Furthermore, similar fused osteoderms at the tip of the tail in aetosaurs are not considered a weapon. We speculate that the tail club and osteoderms may be an adaptation against predation given that this long tail cannot be folded within the shell. Modern *Chelydra serpentina* possesses a similarly oriented set of spines that, while not ossified, would cause similar discomfort to a predator. Further, nipped tails are common in modern turtles, and the fused osteoderms of the tail may have been meant to prevent this.

Technical Session XI (Friday, October 16, 2015, 11:45 AM)

LEPORID RESPONSE TO INCREASED POST-GLACIAL C_4 GRASS ABUNDANCE

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Today, much of the northern Bighorn Basin consists of sagebrush steppe with a mix of C_3 and C_4 grasses. The proportion and relative abundance of these grass types in this area are highly sensitive to local environmental conditions, suggesting that climate fluctuations during the Pleistocene likely led to large fluctuations in C_4 grass abundance. Evidence of this comes from $\delta^{13}C$ values of sedimentary organic matter from Last Canyon Cave (LCC), a rockshelter near the Pryor Mountains at the northern limit of the Bighorn Basin. A significant increase in $d^{13}C$ values during the Last Glacial Maxium (LGM) suggests that C_4 grasses were present and abundant, peaking at ~15 ka. Pollen grains also identify a peak in grass abundance after the LGM, and climate-vegetation modeling suggests that this C_4 pulse was likely due to rising temperatures, despite rising pCO_2. Since C_4 grasses are often an important seasonal component of diets for small and medium-sized mammals, examination of their coprolites (fossilized fecal pellets), can be used to assess how these faunas responded to this environmental change during the late Pleistocene.

We examined faunal response of small and medium-sized mammals to changes in C_4 grass abundance in the late Pleistocene by analyzing the $\delta^{13}C$ values of organic matter preserved in coprolites. At LCC, rodent and leporid coprolites represent the majority of faunal remains. While rodent coprolites occur throughout the late Pleistocene and number in the 1000s, leporid coprolites only occur during a brief period between ~13.5–12 ka and are far less abundant (~300). As leporids are primarily grazers, their coprolites provide a good opportunity to test for temporal changes in C_4 consumption, and serve as a good contrast to the rodents, whose seasonal C_4 consumption is less clearly documented. Contribution of C_4 grass to rodent and leporid diets was estimated from coprolite $d^{13}C$ values using a mixing model for stable isotopic data (SIAR). We found that while coprolite $d^{13}C$ values for rodents were low and relatively invariant, leporid $d^{13}C$ values increased dramatically after the LGM, indicating that C_4 consumption increased during the C_4 grass pulse. Given sufficient preservation of body or trace fossils, our results highlight how leporids represent an ideal taxon for understanding changes in basin grassland dynamics.

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Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

POSTCRANIAL DIFFERENCES BETWEEN *NOTHOSAURUS* AND *LARIOSAURUS* (SAUROPTERYGIA: NOTHOSAURIDAE) REVEALED BY THE NEW SPECIMENS FROM THE MIDDLE TRIASSIC OF SOUTHWESTERN CHINA

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Nothosauridae is a monophyletic taxon that contains *Nothosaurus* and *Lariosaurus*. The family is mainly from the Middle Triassic, but a few species existed in the early Late Triassic of both the western and eastern Tethys. The anatomical differences between *Nothosaurus* and *Lariosaurus*, originally established on the basis of the study of European specimens, appeared diagnostic. The European *Nothosaurus* typically has a larger upper temporal fenestra that is two or more times the length of the orbit, while the same ratio in European *Lariosaurus* is less than 2, and the humerus and ulna are flattened in the latter taxon. These and other features easily distinguish between *Nothosaurus* and *Lariosaurus* from Europe, as well as from the Anisian Panxian fauna in Guizhou, southwestern China. However, the Chinese Ladinian specimens from the Xingyi fauna appeared to blur the boundary between *Nothosaurs* and *Lariosaurus*. We therefore tested the validity of these two genera through scrutinizing their whole-skeleton morphology.

Detailed observations and comparisons of the type specimens of Anisian *Nothosaurus yangjuanensis* and *Lariosaurus hongguoensis*, and the referred specimens of the Ladinian *Nothosaurus youngi* and *Lariosaurus xingyiensis*, revealed some distinctive anatomical differences between *Nothosaurus* and *Lariosaurus*, for both Anisian and Ladinian specimens. The skull of Chinese *Lariosaurus*, as its European counterpart, does have an upper temporal fenestra /orbit ratio of less than 2, but around 1.5-1.8. The upper temporal fenestra is thus relatively smaller than that of *Nothosaurus* with a ratio at least 1.95, whereas the holotype of *Lariosaurus xingyiensis* has almost the same ratio in *Nothosaurus youngi*, probably the result of taphonomic deformation. Furthermore, *Lariosaurus* can be easily distinguished from *Nothosaurus* on the basis of the postcranial skeleton other than differences in body size, such as the pachyostotic zygapophyses and dorsal ribs, the much narrower inter-costal space, five sacral ribs without expanded distal ends, the smoothly curved humerus without an angulated anterior margin and much shorter than the femur, the broad and flattened ulna with a straight or slightly convex postaxial margin, the dorsal blade of the ilium reduced to a simple dorsal process, and the absence of a praeacetabular process on the ilium. Therefore the two genera are most likely valid.

Technical Session XV (Saturday, October 17, 2015, 10:45 AM)

THE DISAPPEARANCE OF PLEISTOCENE MEGAFAUNA FROM THE SOUTH AMERICAN PAMPAS AND THE EFFECTS OF DIFFERENT ANALYTICAL METHODS ON INTERPRETING EXTINCTION DYNAMICS

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The pampas grasslands of southeastern South America supported a diverse assemblage of large mammals during the late Pleistocene, all but three species of which are now extinct. The relative influence of humans and climatic changes on the disappearance of these megafauna continues to be debated, as does the impact of the megafaunal extinction on local biotic communities. To quantitatively investigate extinction dynamics in this region, we compiled a database of >80 published and new direct dates on extinct megamammals, ranked these for robustness based on material dated, dating technique, and reported diagenetic concerns, and calculated confidence intervals to estimate the latest probable time of disappearance of each taxon. We compared the estimated time of extinction for different taxa with data on human presence, climatic and vegetational changes, and species ecology, including diet and life history characteristics. We also investigated the effects of using confidence intervals vs. last appearance dates, and of including vs. excluding low-ranked dates, on interpretations of extinction dynamics.

Our data indicate that humans arrived in the pampas around 12,500 years ago, shortly before end-Pleistocene climate changes precipitated heterogenous vegetational transitions across the region. Equids, *Paleolama*, and native South American ungulates appear to go extinct during or shortly after this transition, while Xenarthrans-ground sloths and glyptodonts-evidently survive well into the new vegetational regime. Proboscidean disappearance from the region may be coincident with the onset of vegetation transitions, which could suggest that the loss of a key ecosystem engineer contributed to some of the observed changes, such as increasing forest cover in the north, but the chronological data are currently too sparse to say anything definitive.

Our study suggests that: (1) different megafauna taxa were impacted individualistically by both vegetation changes and human actions; (2) human impacts on megafauna were protracted, and may have been synergistic with vegetation changes in driving extinction; (3) inclusion of low-ranked dates did not substantially change interpretations of data when confidence intervals were used; (4) and taking confidence intervals into account can alter interpretations of extinction dynamics, even for taxa for which many dates are available.

Grant Information
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Technical Session VI (Thursday, October 15, 2015, 9:30 AM)

GROWTH RATES DURING ONTOGENY OF EARLY EOCENE CATOSTOMIDS FROM BRITISH COLUMBIA, CANADA

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All extant catostomid fish have tetraploid karyotype because of a genome duplication event in their early evolutionary history. The faster growth of modern catostomids compared to other cypriniforms has been attributed to their tetraploid karyotype. However, little is known about the rate and mode by which fossil catostomids grew, despite the critical importance of the fossil record for providing early evidence of rapid growth indicative of a genome duplication event in the evolutionary history of this clade. We herein collect and compare age and growth data from annuli preserved on fish opercles and scales of two Eocene catostomid species, *Amyzon brevipinne* (Blakeburn Mine, BC, Canada) and *Amyzon aggregatum* (Horsefly, BC, Canada). Both localities are in the Eocene Okanagan Highland, which extends ~1000 km north-south across modern-day British Columbia, Canada and Washington, USA. Seven opercles and nine scales of *A. brevipinne*, and two opercles and 24 scales of *A. aggregatum* were used for annulus counting and measurement. Specimens are first selected during microscope examination, and then photographed with a camera-mounted microscope. TPS dig2 was used to mark annuli and make measurements. Results from size, age, and cumulative and non-cumulative growth data show that: 1) the growth curves of opercles and scales of *A. aggregatum* are steeper than those of *A. brevipinne*, indicating faster growth in the former; 2) at a given age, opercle size (directly related to the body size of a fish, and measured from opercular fossa to annulus marker along a diagonal line that parallels the opercular arm and crosses the opercular fossa) of *A. aggregatum* is about three times of that of *A. brevipinne*; 3) the size, cumulative, and non-cumulative growth of scales are less distinct than those of opercles for these two species, partly because of large variation in scale size and shape. Furthermore, comparison with data from extant species shows similar size and growth rate between *A. aggregatum* and modern *Catostomus*. In summary, the growth rate of *A. aggregatum* is significantly faster than that of *A. brevipinne*, the latter being a small-sized catostomid compared to its Eocene and modern relatives. Data from *A. aggregatum* indicate that accelerated growth in catostomids occurred as early as the early Eocene. Lastly, landscape heterogeneity across the Eocene Okanagan Highland suggests possible micro-climatic differences among localities at different altitudes, which probably influenced the ontogenetic development of catostomids living in different habitats.

Grant Information
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Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

HIGH-PRECISION TEMPORAL CALIBRATION OF MIDDLE TRIASSIC VERTEBRATE BIOSTRATIGRAPHY: U-PB ZIRCON CONSTRAINTS FOR THE *SINOKANNEMEYERIA* FAUNA OF NORTHERN CHINA

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The precise geological ages of terrestrial fossil faunas are often difficult to determine, but can be constrained effectively by radioisotopic dating provided ash layers or other datable geological features with an appropriate stratigraphic relationship to the beds containing a given fauna are available. However, few radioisotopic constraints on the ages of terrestrial Triassic tetrapod faunas have so far been established, so that efforts to understand the history of life on land during the Triassic are plagued by a severe lack of chronological precision. The terrestrial Middle Triassic strata of northern China, although highly fossiliferous, have historically exemplified the problem of uncertain dating. Age estimates for the various faunal horizons have been based mainly on long-range biostratigraphic correlations, often to assemblages on other continents that are themselves imprecisely dated, rather than on radioisotopic evidence.

As a step toward producing an improved chronological framework for the Triassic tetrapods of northern China, we collected some volcanic ash samples from the Ermaying and Tongchuan Formations of the Erdos Basin, which contain the *Sinokannemeyeria* Fauna and the younger gracilisuchid archosaur *Yonghesuchus*. U-Pb single-zircon dates were obtained using the chemical abrasion thermal ionization mass spectrometry (CA-TIMS) method. One ash bed from the Ermaying Formation is dated as 243.5 Ma, and the temporal range of *Sinokannemeyeria* fauna is estimated as 242-244 Ma (confined to the late Anisian). The age of *Yonghesuchus* is estimated as 241.4 Ma (early Ladinian). These dates also provide a valuable reference point for estimating the ages of other faunas, such as the Russian *Eryosuchus* Fauna and fauna of the *Cynognathus* C subzone of South Africa, that are thought to correlate at least roughly with the *Sinokannemeyeria* Fauna.

Grant Information
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Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

A NEW SPECIMEN OF *DIANDONGOSAURUS ACUTIDENTATUS* (SAUROPTERYGIA) FROM THE MIDDLE TRIASSIC OF YUNNAN, CHINA

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The eosauropterygian *Diandongosaurus acutidentatus*, first reported from the Upper Member of the Guanling Formation (Anisian, Middle Triassic) at Luoping, Yunnan Province, southwestern China, is a small pachypleurosaur-like form characterized by the following features: enlarged and procumbent teeth in the premaxilla and anterior portion of the dentary, fang-like maxillary teeth, clavicle with a distinct anterolateral process, 19 cervical and 19 dorsal vertebrae, and ungual phalanges of the pes extremely expanded. Except for the distinct anterolateral process of the clavicle, this taxon is very similar to *Dinopachysaurus dingi*, which is from the same locality and the same stratigraphic level, and of similar body size. Herein we describe a new, nearly complete skeleton of *Diandongosaurus*, which provides new information on the ventral side of the skull, the pectoral girdle and hind limbs. The posterior process of the interclavicle is absent, and the coracoid foramen is present in the new specimen, features that cannot be seen in the holotype. The anterolateral process of the clavicle is more slender than that of the holotype. Furthermore, the phalangeal formula of the pes of the new specimen is 2-3-4-5-3, whereas the preserved phalangeal formula of the holotype is 2-3-4-6-4, and thus has a higher count for the fourth and fifth digits. The new specimen also shows that there are no vomerine teeth, the 'anterior interpterygoid vacuity' is absent, but a natural oval-shaped 'posterior interpterygoid vacuity' is present, different from the referred specimen, NMNS-000933-F03498. The results of our phylogenetic analysis also suggest *Diandongosaurus* is an eosauropterygian, closely related to the Eusauropterygia, and grouped together with *Majiashanosaurus* to form the sister-group of the Eusauropterygia.

Technical Session XII (Friday, October 16, 2015, 9:30 AM)

IMPLICATIONS OF THE MORPHOLOGY OF THE BONY LABYRINTH FOR PALEOECOLOGY AND SYSTEMATICS OF TURTLES

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I compare the anatomy of the bony labyrinth of extant turtles in an attempt to link inner ear morphology to locomotion/ecology. The morphology of the inner ear often correlates with the locomotor ability of tetrapods, especially within Mammalia. The radius and orientations of the semicircular canals (SSCs) provide information about the sensitivity of the animal to angular accelerations. Understanding the correlation between inner ear anatomy and locomotion in extant tetrapods can then be used to help infer the paleoecology of extinct taxa. Little is known about the evolution of the bony labyrinth in turtles, a clade that includes fully terrestrial, semi-aquatic, and fully marine clades. The paleoecology of fossil turtles typically is inferred from appendicular and shell morphology, as well as from the depositional setting in which the fossils are discovered. I hypothesized that, as in other tetrapod clades, the anatomy of the inner ear may be just as informative about the paleoecology of turtles as those other features. However, few workers have explored the interspecific variation of the inner ear within extant turtles, making inferences about the paleoecology, physiology, auditory capabilities of extinct species difficult.

I used computed tomography to examine the morphology of the bony labyrinth in examples of most major clades of extant turtles. Overall, SSCs were found to be more-or-less oval in cross-sectional shape. Trionychids show a pattern of dorsoventrally depressed anterior and posterior SSCs with a well-developed lateral SSC. *Kinosternon bauri* possesses dorsoventrally taller anterior and posterior SSCs, with a similar overall labyrinth morphology to that of *Chelydra serpentina* documented by previous authors. Significant differences were observed between inner ear morphology of the testudinids *Gopherus polyphemus* and *Agrionemys horsfieldii*. *Gopherus polyphemus* possesses low, narrow SSCs, with a cavernous cochlear region, whereas *Agrionemys horsfieldii* possesses wider, more dorsoventrally pronounced SSCs and a narrower cochlea. Considering the similar ecology and locomotor styles of those taxa, it is possible that the morphology of the bony labyrinth is more informative about phylogenetic relationships within clades of turtles than it is for ecology. With an increased taxonomic sample, inner ear anatomy may yield useful data on the phylogenetic affinities of extinct taxa with ambiguous relationships in clades whose morphologic and genetic trees are not congruent, such as Testudinoidea.

Technical Session XIII (Friday, October 16, 2015, 3:15 PM)

DETECTING PHYLOGENETIC SIGNALS OF ENDEMISM AND DISPERSAL: THE EFFECTS OF PANGAEAN BREAKUP AND AVIAN FLIGHT ON MESOZOIC DINOSAURS

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An organism's ability to disperse can be restricted by major barriers such as oceans, or enhanced by an enabling trait such as powered flight, and this can have downstream effects on survival and diversification. Most currently adopted palaeobiogeographical methods require a priori designation of discrete areas to infer patterns of vicariance. Although this has the advantage of simplifying the associated methods and data input, it bears a cost in terms of assumptions regarding dispersal barriers. Here, in contrast, we use the raw continuous data of palaeocoordinates of latitude and longitude as input, and combine this with phylogenetic data as a means of inferring the existence or breakdown of barriers to dispersal.

As a case study, we use Mesozoic dinosaurs, a group that spans the breakup of Pangaea and the origin of a major dispersal-enhancing trait (powered flight). Palaeocoordinate data was sourced from the Paleobiology Database (paleobiodb.org) and phylogenetic data comes from a probabilistically time-scaled 1000-taxon supertree. Initial results based on a simple correlation approach and 16 time bins suggest: (1) that there is little or no evidence for barriers to dispersal when Pangaea was intact; (2) the first evidence for barriers to dispersal appears in the Middle Jurassic; (3) Early Cretaceous birds were just as constrained by dispersal barriers as contemporary non-avian dinosaurs; (4) dispersal barriers are most pronounced in Late Cretaceous non-avian dinosaurs; and (5) birds show a complete breakdown of dispersal barriers in the Late Cretaceous.

We discuss how this approach can be extended to be model-based by treating dispersal as simple random walks on a sphere with and without barriers. In this context, barriers can be created (as continents break apart) or destroyed (as continents join, or key dispersal-enabling traits are acquired). An R implementation

(github.com/laurasoul/dispeRse) for applying these models will allow investigation of other clades that span similar continental breakups or coalescences, as well as studying the effects of other dispersal-enhancing traits such as aquatic locomotion.

Grant Information
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Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

FOSSIL GIRAFFIDAE (MAMMALIA, ARTIODACTYLA) FROM 2.8 MA SEDIMENTS AT LEE ADOYTA, LEDI-GERARU: IMPLICATIONS FOR THE PALEOBIOLOGY OF *SIVATHERIUM MAURUSIUM*

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The Lee Adoyta region of the Ledi-Geraru Research Project Area, Mille District, Afar Regional State, Ethiopia, has 2.8 Ma sediments that fill a significant temporal gap in our understanding of Pliocene mammalian evolution in eastern Africa. Giraffid fossils from Lee Adoyta are identified as *Sivatherium maurusium* and *Giraffa gracilis*, the latter of which we consider to be distinct from *Giraffa stillei*. *Sivatherium* is found in greater abundance than *Giraffa* at Lee Adoyta, with two-thirds of the giraffid fossils attributed to *Sivatherium*. This contrasts with the nearby Hadar Formation at Hadar, where *Sivatherium* is rare and *Giraffa* is common throughout the 3.4 to 2.95 Ma sequence, which was variably characterized by bushland, open woodland, and shrubland.

In light of recent evidence for comparably open and arid habitats at 2.8 Ma at Lee Adoyta, we interpret the relative abundance of these two taxa to be of paleoecological and paleobiological significance for giraffid evolution in East Africa. We argue that the relative abundance of fossil giraffids from Lee Adoyta provides evidence of a shift in the habitat preference and, possibly, the dietary ecology of *Sivatherium maurusium*. Our hypothesis is corroborated by stable isotope evidence from elsewhere in East Africa indicating a change in this taxon from a browsing to grazing diet ca. 2 Ma. The increase in the abundance of *Sivatherium* relative to *Giraffa* at Lee Adoyta compared to the Hadar may signal an earlier evolution of open-habitat adaptations in *Sivatherium*, which facilitated its survival during the expansion of grassland ecosystems that took place across East Africa during the Plio-Pleistocene.

Grant Information
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Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

THE VALUE OF TETRAPOD TRACKS IN PALEOECOLOGICAL CENSUS STUDIES: EXAMPLES FROM THE CRETACEOUS OF CHINA

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Recent studies of Mesozoic tetrapod track assemblages from China reveal at least 100 well-documented sites, especially in the Lower Cretaceous of Gansu, Nei Mongol, Shandong and Sichuan provinces. In all these regions saurischian (avian and non-avian theropod and sauropod) ornithischian, pterosaur and turtle tracks occur in remarkable abundance, in most cases at sites with between >100 to >2000 footprints. Many of these sites are associated with formations, groups or basins from which body fossils, by comparison, are rare or absent. Thus, tracks provide important paleoecological census data that helps characterize extensive deposits previously considered barren or largely unproductive. Although some summary information has recently been noted in reviews of Chinese tetrapod ichnofaunas, until now no detailed attempts have been made to compare ichnofaunas formation-by-formation, group-by-group, basin-by-basin, or region-by region. This approach, demonstrated here, is a useful tool for characterizing local ichnofaunas, especially where few, if any, body fossils are present, and especially where multiple sites reveal ichnofaunas with similar compositions. Even in cases where body fossils are known, the ichnofaunas provide data to test bias and consistency between the body fossil and track records. In many cases, body fossil evidence is less abundant, less consistent, and less useful than the abundant footprint data.

These data, in turn, are useful for comparing local ichnofaunas with those found regionally or internationally. For example, abundant ichnofaunas of Lower Cretaceous age are also known from South Korea where they contain various apparently indigenous ichnotaxa only known in China. In both regions, bird tracks are abundant and skeletal fossils are often completely absent in some formations. Ichnofaunas from North America and Europe appear more generalized and lack representation of many of the groups found in Asian ichnofaunas. However, in all these regions ichnofaunas often indicate faunal lists quite different from those represent in the skeletal record, which in many units (formations) is very sparse.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

COPROLITES FROM PIPESTONE SPRINGS MAIN POCKET, MONTANA, AND THEIR PALEOECOLOGICAL AND TAPHONOMIC SIGNIFICANCE

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Pipestone Springs Main Pocket (Renova Formation, Jefferson County, Montana) has an unusually rich concentration of well-preserved small-bodied Chadronian mammals and an abundance of coprolites. Diameters of measurable coprolites varied from 4 mm to 29 mm. When plotted on a histogram, there is a very robust small diameter grouping of 269 specimens with a peak at 10–11 mm and range of 7–14 mm, as well as a broad diameter grouping of 47 specimens without a distinct peak that has a range of 15–29 mm. Dental elements representing Carnivora are relatively rare at Pipestone Springs, and of 45 specimens identified to taxon, the small canid *Hesperocyon* constituted 44% and the larger amphicyonid *Brachyrhynchocyon* 24% of the sample. If the percentage of dental remains per carnivore taxon reflects its activity at the depositional site, the smaller coprolites probably represent trace fossils of *Hesperocyon*. The diameter range of the larger coprolites appears to be too great to represent a single species, so they probably represent at least two larger carnivores, one likely to have been *Brachyrhynchocyon*. Bone is visible on the surface or cross section of 85% of the coprolites in both the large and small diameter size groups, with bone per coprolite much more abundant in the small diameter group. Although the great majority of bone is fragmentary and unidentifiable, in some cases osteoderms, bone ends, isolated teeth, or partial dentaries/maxillae could be identified to taxon. This indicated that marsupials, lizards, lagomorphs, and squirrel-sized rodents were prey of Pipestone Springs carnivores. Based on dental elements identified from the site, where *Paleolagus* and *Ischyromys* constitute 25% and 21% of the sample respectively, most elements identified as lagomorph and rodent probably represent these taxa. Thus, Pipestone Springs coprolites provide important insight into how many and which carnivores were active in the depositional area and what taxa they were ingesting. Also, a partial maxilla with M2–4 of a small marsupial was found within a prepared Pipestone Springs coprolite. This example suggests that undigested bone from disaggregated carnivore feces was a major source of the multitude of small well-preserved dentigerous elements found at Pipestone Springs.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

NEW SPECIES OF *ICHTHYOSAURUS* (REPTILIA: ICHTHYOSAURIA) FROM THE UPPER TRIASSIC-LOWER JURASSIC OF SOMERSET, U.K.

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During the 19th century, many well preserved specimens of the parvipelvian ichthyosaur genus *Ichthyosaurus* were collected from the uppermost Triassic-lowermost Jurassic (Rhaetian-Hettangian) strata in quarries around Street, Somerset. These quarries have since been filled in, making Somerset ichthyosaurs in historical collections all the more important. All of the *Ichthyosaurus* specimens have been assigned to *I. communis*, a common and extremely variable species found in Somerset as well as in the Lower Jurassic (Hettangian-Pliensbachian) strata from the Dorset coast and elsewhere in the U.K. A phylogenetic analysis of 15 well preserved, partial to nearly complete skeletons from Somerset suggests that at least three, and probably four, species are represented. Species can be distinguished by characters of the skull, forefin, pelvic girdle, and hindfin. Differences in tooth morphologies and forefin shapes suggest that these species differed in their prey preference and swimming capabilities as well. It appears that *I. communis* is not very common among Somerset specimens. With the recognition of these species, at least seven species of *Ichthyosaurus* are found in the Lower Jurassic strata of the U.K., making it the most diverse ichthyosaurian genus of that time interval.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

DISTINGUISHING SISTER SPECIES OF *PEROGNATHUS* (MAMMALIA, RODENTIA) USING LANDMARK GEOMETRIC MORPHOMETRICS OF MANDIBULAR SHAPE

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Perognathus flavus and *P. merriami* are sister species of pocket mice that are common today in arid central and southern North America. While morphologically similar, both comprise several geographically distinct populations that are genetically distinct based on both mitochondrial and nuclear sequences, which suggest divergences in each nominal species during the Pliocene. To explore inter- and intraspecific variation in these species, we µCT-scanned specimens at 5–17µm resolution, thresholded volume data to extract isosurfaces of right hemimandibles, and placed 3D landmarks on the models in Geomagic Design X using standardized reference planes, best-fit splines, and other software-aided tools. We gathered data from specimens identified genetically as *P. flavus*, *P. merriami,* or *Perognathus* sp. Discriminant functions computed between the species using various linear combinations of the landmark data range from adequate to excellent in their ability to discriminate. Jackknife cross-validations demonstrate that discriminant functions computed from the first several principal components perform well for reclassifying *P. flavus* but poorly for *P. merriami*. When specific components identified by stepwise discriminant analysis are used, cross-validation successfully reclassifies nearly 90% of specimens into species. Based on this function, two specimens that are genetically distinct from both species are morphologically more similar to *P. flavus*. We also separated specimens into groups at the population level. As with species differences, populations are not well sorted by principal component analysis, but discriminant functions optimized using stepwise discriminant analyses were very successful, with jackknife cross-validation rates at 100% for all populations. These data allow us to identify contrasts between inter- and intraspecific shape differences. Morphological variation between *P. flavus* and *P. merriami* is comprised primarily of differences among topographic regions of the mandible; landmarks that are anatomically close together are displaced in similar directions when the species are compared. Differences among populations of *P. flavus*, however, are characterized by anatomically proximate landmarks being displaced in different directions. These contrasts have implications for processes of morphological change during phyletic divergence. Using these methods, we can assign fossil specimens to species and even population to track biogeographic changes in relation to late Quaternary climate change.

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Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

THE OLDEST RECORD OF TURTLES IN MEXICO (LATE JURASSIC, SABINAL FORMATION, OAXACA)

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Until recently, the known Mesozoic record of Testudines in Mexico was restricted to the Cretaceous. However, recent discoveries pulled the Mesozoic record to the Late Jurassic (Kimmeridgian). Here we report the oldest turtle from Mexico that comes from Llano Yosobé area in Oaxaca State. The turtle remains were recovered from outcrops of the Sabinal Formation (Tlaxiaco Basin). This Formation is represented by intercalated marine and continental sediments deposited during the Late Jurassic under transgressive-regressive marine conditions. In previous studies these specimens were reported as representatives of the clade Plesiochelyidae. However, our study on the morphology of the specimens suggests instead that it belongs to a new species of the clade Platychelyidae. Members of the clade Platychelyidae have been recorded in Late Jurassic of Europe (*Platychelys oberndorferi*) and in the Late Jurassic-Early Cretaceous of South America and the Caribbean (*Notoemys* spp.). The new species from Mexico and Platychelyidae share some characters like the presence of a complete series of eight neurals and two suprapygals, mesoplastra wider than long and not meeting at the midline, and the presence of a hyoplastral-hypoplastral fontanelle. These Jurassic specimens from Mexico also share the following characteristics with *Notoemys*: smooth (absence of protuberances), relatively flat, cordiform shell, wide neurals and large suprapygal 1. The new taxon from Mexico is relatively larger than other members of the clade Platychelyidae. In addition, the new taxon shows the unique combination of the following characters: neurals 3 and 6 hexagonals, neural 4 pentagonal, suprapygal 1 contacts postero-laterally the corner of peripheral 11 and also laterally the costal 8, peripheral 10 contacts only costal 7, sulcus between pleurals 4 and 5 located on peripheral 11, and mesoplastron much wider than long. The discovery of new Jurassic turtles in Mexico expands the distribution of the Testudines along the Hispanic corridor. This Corridor acted as the main route for the major faunal exchange between the Tethys Sea and Proto-Pacific Ocean.

Grant Information
Proyecto UNAM-PAPPIT IN 207314

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

AT THE CROSSROADS BETWEEN ASIA AND AFRICA: PALEOBIOGEOGRAPHIC SIGNIFICANCE OF A NEW CTENODACTYLINE RODENT FROM THE MIOCENE OF LEBANON

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Ctenodactylinae (gundis) is a clade of rodents that experienced, in Miocene time, their greatest diversification and widest distribution. They expanded from the Far East, their area of origin, to Africa, which they entered from what would become the Arabian Peninsula. Questions concerning the origin of African Ctenodactylinae persist essentially because of a poor fossil record from the Miocene of Afro-Arabia. However, recent excavations in the Late Miocene of Lebanon have yielded a key taxon for our understanding of these issues.

The new species shares a mosaic of characters with both the most primitive and more derived members of the subfamily. As in the most plesiomorphic ctenodactylines, the dp4 of the Lebanese ctenodactyline has a distinct anteroconid and the metaconid lingually located (near the entoconid) and its lower molars show a well-developed posterolabial ledge. In addition, it shares with the most derived members of the subfamily the synapomorphic loss of metalophulid I on the dp4 and the obliteration of the metaflexus early in wear on the upper molars.

The Lebanese ctenodactyline is situated at a pivotal phylogenetic position between a paraphyletic group of *Sayimys*-like species and the more derived *Africanomys*. As such, it provides data so far unavailable on the dental morphology of the ancestor of most African ctenodactylines, including the crown group. Although not from Africa or even the African plate, the Lebanese taxon is the sister-species of the clade composed of almost all of the ctenodactylines that have originated in Africa and *Pellegrinia* (which represents a short-lived extra-African offshoot). In other words, it can be seen as virtually the most evolved of the non-African ctenodactylines. Its phylogenetic position between *Metasayimys curvidens* (Middle Miocene, Morocco) and *Africanomys* spp. suggests that these two taxa represent independent lineages that dispersed from Asia into Africa. This discovery demonstrates how the key to our understanding of mammalian phylogeographic history is continued fieldwork in the large but often neglected Arabian Peninsula and adjacent areas.

Grant Information
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Technical Session XI (Friday, October 16, 2015, 8:30 AM)

RE-ANALYSIS OF OMOMYOID MATERIAL FROM THE MIDDLE EOCENE OF SOUTHERN CALIFORNIA AND THE EXTINCTION OF NORTH AMERICAN PAROMOMYID PLESIADAPIFORMS

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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. Paromomyids have traditionally been thought to represent the longest-lived group of plesiadapiforms, initially appearing in the early Torrejonian (early Paleocene) and lasting until the Uintan (middle Eocene) of North America. Paromomyid diversity drops markedly after the end of the early Eocene, with the only records being *Elwynella oreas* in the early Bridgerian (earliest middle Eocene), and *Phenacolemur shifrae* and *Ignacius mcgrewi* in the Uintan.

We re-analyzed the primate material from the late Uintan of Southern California that was tentatively ascribed to cf. *Phenacolemur shifrae*. The Southern California material falls in the lowest end of the size range for the family. These specimens also document several dental features that separate them from most other paromomyids, such as a strong paraconid on the third lower molar. They further differ from other species of earlier *Phenacolemur* in not possessing a distally expanded distolingual basin on the upper molars. This combination of traits is never seen in early Eocene *Phenacolemur*, and is more typical of the earlier and more primitive paromomyids (e.g., *Paromomys*). As such, this pattern of traits is inconsistent with the late age of these specimens.

The Uintan paromomyids *P. shifrae* and *I. mcgrewi* share the characteristics found in the Southern California material that separate them from typical early Eocene paromomyids. These traits also shared with some trogolemurin omomyoids, a group of middle Eocene euprimates that overlaps in size with the Southern California material, and with previously identified Uintan paromomyids. Therefore, we propose that the Southern California material, *Phenacolemur shifrae*, and *Ignacius mcgrewi* should be transferred to Omomyoidea, and together with *Trogolemur leonardi* comprise a new genus of trogolemurin.

The implication of transferring all the North American Uintan paromomyid plesiadapiforms to Euprimates is that the extinction of North American paromomyids has been reset to an older age (by approximately 7 million years earlier than previously thought), making *Elwynella* from the early Bridgerian the latest occurrence of a true paromomyid.

Grant Information
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Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

PHYTOLITH ASSEMBLAGES OF THE BARSTOW FORMATION (MIDDLE MIOCENE), SOUTHEASTERN CALIFORNIA, THROUGH THE MIDDLE MIOCENE CLIMATIC OPTIMUM

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The Miocene Barstow Formation in the Mojave Desert of southern California is well known for its mammalian faunas, but little is known about the paleoenvironments inhabited by these faunas or how they changed through time. The type Barstow Formation (19.3 – 13.3 Ma) encompasses the Middle Miocene Climatic Optimum (MMCO), an interval of significant warming that occurred between 17.0 and 14.0 Ma and changing climate that may have significantly affected vegetation and paleoenvironments. Phytoliths (amorphous plant silica) offer the potential to directly sample paleovegetation from sediment and thereby reconstruct changes in paleoenvironments through the MMCO. Sediment samples were collected at approximately 20-m intervals from 12 stratigraphic sections measured through the Barstow Formation. Lithologies in the Barstow Formation are generally fine upsection, from coarse sandstones and conglomerates of the Owl Conglomerate Member, to thin-bedded siltstones and marls of the Middle Member, to mudstones and marls of the Upper Member. These facies transitions are interpreted as reflecting a transition from bedload-dominated fluvial environments to lacustrine and distal fluvial environments.

Phytoliths were rare overall but were extracted from all three members of the formation. Grass phytoliths are present in each member, and they occur with palm phytoliths in the uppermost Barstow Formation, deposited during the later part of the MMCO. Throughout the section, pedogenic horizons yielded the most abundant and most diverse phytolith assemblages, indicating where future sampling should be targeted. These phytolith data provide evidence that grasses were present throughout deposition of the Barstow Formation during the MMCO, and that they coexisted with palms in mixed-vegetation habitats for part of that time. Phytoliths can be used in the Barstow Formation to better understand Miocene ecosystems and mammalian habitats and how they may have changed through the Middle Miocene.

Grant Information
2014 Evolving Earth Student Grant; 2014 University of Michigan Rackham Spring/Summer Fellowship

Symposium 2 (Friday, October 16, 2015, 3:15 PM)

HOLOCENE EXTINCTION OF TIMOR'S ENDEMIC GIANT MURID COMMUNITY, AND IMPLICATION FOR MODERN MURID CONSERVATION ON ISLANDS

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The island of Timor, situated at the eastern end of the Indonesia archipelago, played host to an incredible diversity of giant murids spanning the late Quaternary. Four genera of giant murids have been identified, representing a minimum of eight species. To date only two of these have been formally described. Recent fieldwork at Laili, in the central-north of Timor-Leste, have provided the earliest dated records of giant rats on the island, with remains found in and immediately below archaeological deposits dated at 43.3–44.7 ka. A newly discovered fossil-bearing breccia in a limestone cave in the north-east has produced two of the recognised but undescribed genera. This site represents the first non-archaeological giant rat deposit on Timor. Endemic predators may have included a large raptor found associated with the large murids as well as an undescribed giant monitor

lizard found in Pleistocene fluvial deposits in central Timor. Other predators probably included smaller monitor lizards and large pythons. Evidence of butchery from the earliest archaeological deposits to the late Holocene indicates giant murids were regular prey items for humans for tens of thousands of years. Dogs and civets were introduced to Timor ca. 3000 years ago. Competitive exclusion may have come from a marsupial herbivore (cuscus) introduced at the same time, as well as two commensal rats, but given Timor's giant murids are associated with five smaller rat species throughout the Pleistocene this seems unlikely. Direct dating indicates that Timor's giant murids probably became extinct ca. 1000 years ago. Their persistence through the Last Glacial Maximum, moderate environmental disturbances, and disruption by introduced species echoes the ecological responses of smaller mammals found on continents and islands with long and complex histories. The giant murids' long and successful association with human predators on Timor over many millennia stands in marked contrast with the traditional view of human overkill on island ecosystems. Rather than hunting or climate change, the introduction of metal tools, coincident with massive forest clearances and the disappearance of all but two of Timor's other endemic mammals, precipitated the extinction of Timor's large murid community. These results suggest preservation of forests, even if moderately disturbed, on islands with equally long and complex histories, such as Flores or New Guinea, will be critical for the conservation of remaining giant murids.

Grant Information
ARC Laureate FL120100156

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

CORRELATION BETWEEN CHANGES IN PALEOENVIRONMENT AND MARINE REPTILE FAUNAL COMPOSITION IN THE MIDDLE TRIASSIC XINGYI FAUNA (GUIZHOU, SOUTHWESTERN CHINA)

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The Xingyi Fauna from the Zhuganpo Member of the Falang Formation in Xingyi, Guizhou, southwestern China contains a diversity of late Ladinian (Middle Triassic) marine reptiles from about 239 Ma. During our three year excavation at the Nimaigu section of Wusha, more than 300 skeletons of Triassic marine reptiles were collected from the 5.9 m thick fossil beds, providing detailed stratigraphic, paleobiologic, and paleoenvironmental information.

Xingyi Fauna contains at least 16 taxa of marine reptiles, about half of which are sauropterygians, including one placodont, two pachypleurosaurs, two nothosaurs, two pistosaurs, three thalattosaurs, three protorosaurs, one archosaur, and two ichthyosaurs. The fossil beds can be subdivided into two parts. The lower part mostly contains taxa including the pachypleurosaur *Keichousaurus*; the nothosaurians *Nothosaurus* and *Lariosaurus*; the protorosaurs *Macrocnemus*, *Fuyuansaurus,* and *Tanystropheus*; and the archosaur *Diandongosuchus*, representing a near-shore ecosystem on the carbonate platform with western Tethyan affinities. The upper part yields the large shastasaurid ichthyosaur *Guizhouichthyosaurus*, the medium sized euichthyosaur *Qianichthyosaurus* that is phylogenetically close to the North American *Toretocnemus*, and the pistosaurs *Yunguisaurus* and *Wangosaurus*. The faunal sequence displays a major transition from coastal to open ocean habitat.

The analyses of lithofacies and the $\delta^{13}C$ and $\delta^{18}O$ values document the paleoenvironmental background of the Xingyi Fauna. Five microfacies and three sedimentary facies including restricted sea, open sea, and interplatform basin were identified, indicating a transgression sequence. The $\delta^{13}C$ curve shows an obvious negative spike between the lower and upper parts of the fossil beds.

The combination of the microfacies, sedimentary facies, the $\delta^{13}C$ and $\delta^{18}O$ curves, and the transition of marine reptile faunas reveals that there is a distinct correspondence between changes in marine reptile composition and paleoenvironmental background.

Technical Session X (Friday, October 16, 2015, 10:45 AM)

A NEW OVIRAPTORID DINOSAUR (DINOSAURIA: OVIRAPTOROSAURIA) FROM THE LATE CRETACEOUS OF SOUTHERN CHINA

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Oviraptorosaurs, a special group of the coelurosaurian dinosaurs, are mainly distributed in three areas of China: northern China (including Inner Mongolia Autonomous Region and Liaoning Province), central China (Henan Province) and southern China (Guangdong and Jiangxi provinces). Except for northern China where both primitive and derived oviraptorosaurs were discovered, the other two areas have only produced derived oviraptorosaurs. At present, five genera of oviraptorid dinosaurs are reported from the late Late Cretaceous sediments in Ganzhou of Jiangxi Province, where has become the most productive place for oviraptorids in China. Herein reported is a new oviraptorid dinosaur from the Nanxiong Formation in Ganxian, Jiangxi Province. It is characterized by a dome-like skull roof, the anteroventral corner of the external narial opening above the line linking the articular end of the quadrate and the ventral margin of the premaxillae (shared with *Nemegtomaia barsboldi* and '*Oviraptor*' *mongoliensis*), and a mandibular symphysis that is not downturned as in other derived oviraptors (shared with *Nankangia jiangxiensis*). The skull morphology is similar to that of *Khaan mckennai*, but they differ from each other in the relative position of the external narial openings and the mandibular symphysis. A preliminary phylogenetic analysis shows that some taxa from Ganzhou and its surrounding areas are close to Mongolian taxa from the Djadokhta Formation, the Baruungoyot Formation, and the Nemegt Formation. At present, all Ganzhou oviraptors occur in the Nanxiong Formation. However, the thickness of the Nanxiong Formation changes remarkably in different basins of Jiangxi Province, from 600 to 7300 meters. Therefore we need to investigate the detailed stratigraphic occurrence for these Ganzhou oviraptors to clarify whether they co-occur stratigraphically.

Grant Information
National Natural Science Foundation of China (grant no.: 41272022) and the China Geological Survey (grant no.: 12120114026801) to J.C. Lü

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

EOCENE TURTLES FROM THE SAN JOSE FORMATION, SAN JUAN BASIN, NEW MEXICO

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E. D. Cope described the first Early Eocene turtles from the San Juan Basin during the 1870s. Hay subsequently (and last) reviewed these turtles, assigning them to 15 species in seven genera and five families. However, many of these species are based on nondiagnostic, fragmentary material and thus are nomina dubia. For example, we identify *'Kallistra costalata*' as a nomen dubium because its type material consists of fragments of two other species. Further, *Platypeltis seralis* is a nomen dubium because its type specimen has been missing since before the work of Hay. We have revised the alpha taxonomy of the San Jose Formation turtles to conclude that there are six genera and six valid species, all from the Regina Member 'Almagre local fauna'. These include *Baena arenosa* and *Hadrianus majuscules,* because we return the species *Geochelone* (*Manouria*) *majuscule* to the genus *Hadrianus* and to its former specific epithet. We do not believe there is sufficient reason to combine *Hadrianus* and *Geochelone (Manouria)* given the enormous ghost lineage this creates for the genus. Further, *Echmatemys cibolensis* is synonymized with *E. lativertebralis* on the basis of lacking sufficient differences to justify separation as two species. Many of the previously proposed differences appear to be the result of ontogenetic variation. All San Jose Formation trionychid specimens lack diagnostic types and are referred to Trionychidae indet. These species were defined largely on their shell ornamentation, which is not diagnostic, as it can vary greatly within a species. Collections that post-date the work of Hay include fragments attributable to *Baptemys garmani* and *Planetochelys ditheros*. The matching bosses of the carapace and plastron make *Planetochelys* distinct and easily recognized. We believe that some specimens in the New Mexico Museum of Natural History and Science Collection are *Planetochelys ditheros* because they do not appear to be from a large enough turtle to represent another known species of *Planetochelys*. Comparison to broadly coeval turtle assemblages in Wyoming indicates that the San Jose turtle assemblage coincides to approximately the Lysitean sub-land-mammal 'age', (middle Wasatachian), in agreement with the previously assessed age based on mammalian fossils.

Technical Session I (Wednesday, October 14, 2015, 9:45 AM)

POSTNATAL PETROSAL ONTOGENY WITHIN DOMESTIC SHEEP

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The mammalian petrosal is one of the more commonly preserved elements of the mammalian fossil record and its commonality has provided it a wealth of focused studies among fossil mammals. This state of study is not as abundant within modern mammals, as three-dimensionally observing the petrosal requires actual or digital dissection of the skull. Therefore, basic questions about ontogenetic growth of the petrosal and the soft tissues within (the inner ear) and around (various neurovascular structures) it are comparatively well-studied in some modern mammals but unstudied in many. The skulls of two postnatal juvenile domestic sheep of different ages were partially digitized by a microCT X-ray machine, segmented into separate osseous tissues, and compared to published observations on adult domestic sheep petrosal morphology. Generally the petrosal morphology of the juveniles resembles the adult morphology: by six months of age at least, the petrosal is equivalent in shape to the adult condition. The two main areas of quantitative difference between the two juveniles are in the development of the basicapsular groove and the amounts of ossification around openings for nerves. The former is probably driven by the petrosal continuing its ossification near the inferior petrosal sinus, while the latter is driven by continued ossification around these neural tissues. This incomplete ossification does conceal the distinctness of some foramina in the younger juvenile. The internal ear volume does not significantly differ between the two juvenile specimens, supporting previous work suggesting that the inner ear's growth in mammals is completed before birth. Between the ages of the older juvenile and the adult, the mastoid region increases in size and some minor characters appear to differ in presence or absence. However, the low sample sizes of this study make it difficult to determine whether observed differences in morphology were caused by intraspecific or ontogenetic variation. The adult internal petrosal morphology is definitely obtained by the domestic sheep fairly early in its postnatal life, and possibly in its prenatal life although this was untested in the current study. The external juvenile petrosal morphology is similar, but not identical, to the adult petrosal morphology, suggesting that fossil studies of petrosals can use juvenile petrosals, when possible, in conjunction with adult petrosals, for comparative and phylogenetic studies.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

FORM AND EVOLUTION OF THE NARIAL REGION IN CERATOPSIAN DINOSAURS: INSIGHTS FROM GEOMETRIC MORPHOMETRICS

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Ceratopsian (horned) dinosaurs were an iconic clade of Late Jurassic to terminal Cretaceous taxa that radiated into an array of phenotypic types. Historically, ceratopsid taxonomy and phylogenetics has been based almost exclusively on characters of the skull roof, with most of these related to horn and frill morphology. By contrast, the preorbital facial skeleton, formed primarily of the premaxilla, nasal, and lacrimal, is a region with a fundamental role in cranial function (e.g., food processing) that has been relatively understudied in comprehensive assessments of the clade. Two-dimensional geometric morphometrics were used to characterize craniofacial variation in 33 (n = 12

nonceratopsid ceratopsians, n = 21 ceratopsids collectively) of the approximately 64 currently recognized species of ceratopsian dinosaur. Twenty-five type 1 and 2 homologous landmarks were plotted on photographs and published reconstructions in order to capture shape variation of the preorbital facial skeleton, and this was in turn used to plot the distribution of taxa in cranial morphospace. Preliminary results indicate that ceratopsian craniofacial architecture predominantly varies in relative anteroposterior length and dorsoventral height of the narial region, including the size and orientation of the external naris. Early-branching, small-bodied ceratopsians (e.g., *Yinlong*, *Psittacosaurus*) occupy a restricted zone in cranial morphospace, with later-branching, large-bodied ceratopsids differentially plotting in distinct areas. The distribution of taxa in cranial morphospace appears to be strongly influenced by phylogeny, with clades (e.g., Centrosaurinae, Chasmosaurinae) generally clustering together. Considered together, these results illustrate key aspects regarding morphological evolution of the craniofacial skeleton of ceratopsians, and suggest that phylogeny, not biting function, was the predominant factor driving narial shape. Finally, this work sets the context for assessing additional functional (e.g., size- or feeding-specific) hypotheses related to craniofacial evolution in the group.

Grant Information
Jurassic Foundation Research Grant
Paleontological Society, Rodney M. Feldmann Award

Colbert Prize (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

A NEW CISTECEPHALID DICYNODONT THERAPSIDA, ANAOMODONTIA) FROM THE MID-ZAMBEZI BASIN (ZAMBIA) AND ITS FOSSORIAL ADAPTATIONS

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Dicynodonts were one of the most abundant and successful clades of Permo–Triassic synapsids, and provide early examples of evolutionary innovations into new ecomorphologies. For example, cistecephalid dicynodonts are interpreted to have been specialized scratch diggers, with mole-like forelimbs and highly modified, box-like skulls. Here we describe and interpret a new Permian cistecephalid from the Mid-Zambezi Basin of southern Zambia. The specimen was collected in the Lower Madumabisa Mudstone Formation, but the exact age of the horizon is uncertain. However, the discovery of the specimen in strata containing fossils of dinocephalians and the dicynodont *Endothiodon* suggests a tentative correlation with the lower portion of the Middle–Upper Permian *Pristerognathus* Assemblage Zone of South Africa. Despite its likely low stratigraphic occurrence, the specimen shows derived cistecephalid characters, including relatively small orbits and a flared snout. Micro-CT scan data reveal that the specimen includes at least one and likely two scapulae, coracoids, two humeri, the proximal ends of the right and left radius and ulna, and numerous ribs and vertebrae. The scapula is strap-like and lacks an anteriorly-projecting acromion process. The humerus possesses a distinct, well-ossified trochlea and capitellum and is massive throughout its entire length, with only minimal constriction in the mid-shaft region. The insertion of the subcoracoscapularis muscle is enlarged, but not drawn into a distinct process, counter to the morphology present in other cistecephalids. The ulna bears a large olecranon process. Surprisingly, this olecranon process is a distinct ossification, a feature otherwise known only in a small number of Triassic kannemeyeriiforms. Although the forelimb slightly differs from those of other cistecephalids, its function was still optimized for very powerful movements, especially at the level of the elbow joint. If the inferred *Pristerognathus* zone-equivalent age is correct, the Mid-Zambezi Basin specimen would be the oldest known cistecephalid. Further, its derived features imply that the diversification of the Cistecephalidae was well underway earlier than previously recognized and that a transition to fossorial habits occurred early in the clade's history.

Grant Information
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Symposium 2 (Friday, October 16, 2015, 1:45 PM)

ADDRESSING THE CHALLENGE OF MAKING PALEOZOOLOGY RELEVANT TO CONSERVATION POLICIES AND AGENDAS

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Making conservation paleozoology policy-relevant is a tractable challenge. Most modern conservation challenges concern individual species in specific spatio-temporal contexts, though the broader conservation framework typically takes place using more general terminology and policy-focused questions (is a species native or exotic?, is a species recolonizing or invading?, should conservation focus on biodiversity at the species or genetic levels?). The U.S. federal definition of an exotic taxon (one that owes its presence in an area to anthropogenic causes) can contradict the federal definition of a native species (one that presently occurs or once occurred in an area as a result of nonanthropogenic ecological processes) because with a deep temporal perspective, both characterizations may apply to a particular taxon. Terminal Pleistocene remains of bison (*Bison* sp.) in western Washington state indicate bison must, by definition, be considered 'native' to the area; in the absence of historic records, the above definitions would prompt bison to be declared 'exotic' were it to be introduced there today. Modern red fox (*Vulpes vulpes*) in eastern Washington are thought to be descendants of exotic escapees from fur farms, but zooarchaeological remains indicate this species is native to the area and occurred there throughout the Holocene. Harbor seals (*Phoca vitulina*) are characterized as invasive to the lower reaches of the Columbia River in Washington, yet archaeological remains indicate this marine mammal ascended the river 300 km throughout the Holocene and today is recolonizing previously utilized habitats. Wapiti (*Cervus elaphus*) were thought to be invading shrub-steppe habitats of central Washington in the 1970s, but archaeological remains of this ungulate indicate it is recolonizing previously occupied habitats. Traditionally, biodiversity metrics concern taxonomic or genetic richness; phenotypic diversity within taxa tends to be unevaluated. The Holocene record of wapiti in the Portland Basin indicates late prehistoric morphotypes were larger than modern individuals. The 1930s introduction of the Rocky Mountain subspecies (*C. e. nelsoni*) resulted in hybridization with native wapiti (*C. e. roosevelti* [?]), genetic introgression, and diminution of body size. Paleozoological perspectives indicate a need to rewrite policies and redefine key conservation biology concepts (e.g., native vs. exotic species, invasion vs. recolonization, numerous biodiversity metrics) to account for dynamic histories and long time spans.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

WHEN IS ENOUGH ENOUGH? EVALUATION OF DNA SEQUENCE LENGTH IN *MARTES AMERICANA* WITH APPLICATION TO ADNA EXTRACTIONS

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The evolution and extinction of populations from the Pleistocene to the present have been topics of much concern in light of Recent extinctions and conservation efforts. *Martes americana*, the American marten, is one species whose distribution has changed since the Pleistocene. By studying its population genetics from the mid-Pleistocene to the present using ancient mitochondrial DNA (mt aDNA), I want to understand how *M. americana* survived both the end Pleistocene extinctions and anthropogenic factors.

To identify ancient populations accurately, it is necessary to determine the number of base pairs (bp) of mt aDNA that must be obtained. I analyzed the population topologies of *M. americana* and its position in *Martes* using cytochrome b (1140bp) sequences obtained from GenBank, by mathematically subsampling and running a maximum likelihood (ML) analysis on the subsampled sequences. I cropped the sequences in 100bp sections from the 3′ and 5′ end to determine ideal length. I also used a sliding method, which removed 100bp in 100bp increments so that the sequence was always 1040bp, to reveal which bp region was the most phylogenetically informative. I ran each ML phylogeny using the model with the highest Akaike information criterion value and 500 bootstrap replicates. To determine if there were any statistical differences between likelihood distributions of the ML analyses, I evaluated each distribution using a Shimodaira-Hasegawa (SH) test (α=0.05). Removing base pairs from the 3′ and 5′ ends resulted in a different population topology at 640bp, although the SH test revealed that only likelihood distributions created with ≤ 440bp were statistically different from the 1140bp distribution. No significantly different likelihood distributions were found using the sliding method and the best fit tree occurred when the 600–700bp region was removed, likely since this region has no mutations and is thus phylogenetically uninformative. The phylogenetic topologies remained the same when at least 840bp were present and the SH test found distributions with ≤540bp statistically significant in both the 3′ and 5′ croppings. The sliding method produced the same topologies and again the SH test found the best fit tree when the 600–700bp region was removed.

It is, therefore, necessary for me to obtain a sequence of at least 440bp for population studies and >540bp to determine the phylogenetic position of extinct *Martes* taxa, such as *Martes nobilis*. Previous studies using mt aDNA from other mammal taxa obtained sequence lengths ranging from 57–741bp, suggesting the necessary sequence lengths I have predicted are not unobtainable.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

FOSSORIAL ADAPTATIONS IN EARLIEST STEM TURTLES DROVE THE EVOLUTION OF THEIR UNIQUE BODY PLAN

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Turtles have one of the most distinctive body plans of any tetrapod with a shell largely composed of broadened ribs and vertebral spines, a tri-radiate shoulder girdle, and skull roof bones lacking fenestrae among their most characteristic features. However, the environmental context in which these features originated has previously been unknown, obscuring the adaptive significance of the changes underlying the highly modified turtle body plan. Here we show that the origins for each of these features are present in the oldest stem turtle, *Eunotosaurus africanus* (mid Permian of South Africa, 260 Ma), and each structure undergoes pronounced ontogenetic changes, indicating an important functional role for these features throughout the animal's life. Broadened ribs are associated with significant costs to locomotion and respiration, so they must have had even greater advantages to have been favored by natural selection. We propose the following were adaptations to digging and living in underground burrows: expansion of the ribs counteracts rotational forces generated during forelimb digging in sprawling taxa and initiates the division of function between the ribs and abdominal muscles in the evolution of both the shell and lung ventilation apparatus; secondary closure of the upper fenestrae in the skull rigidifies the skull, allowing the use the head as a brace during digging, the initial step in the construction of an 'anapsid' skull; and development of the acromion process on the scapula increases shoulder mobility and strengthens the muscles that power the forelimb digging apparatus, an important step in the evolution of the tri-radiate shoulder girdle. Additional osteological correlates, including limb bone histology, support these findings.

A fossorial stage in the early history of the turtle stem lineage provides a synthetic explanation for the origin of the complex turtle body plan. The current functional roles for both the shell (protection), and the acromion process (increasing stride length and speed), are shown to be exaptations that were initially adaptations for stiffening the skeleton while simultaneously providing more mobility to the shoulder girdle and

strengthening the muscles that power the forelimb digging apparatus – functional requirements for fossorial animals. The functional advantages conferred by the modified morphology, placed within their environmental context, provides the initial impetus for the origin of the distinctive turtle body plan and represents a crucial stage in the evolutionary history of turtles.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

RECONSTRUCTING THE CRANIAL MUSCULOSKELETAL ANATOMY OF TWO MANIRAPTORAN THEROPOD DINOSAURS AND IMPLICATIONS FOR AVIAN EVOLUTION

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Haplocheirus, from the early Late Jurassic of Xinjiang, China, is currently considered the most basal member of the Alvarezsauroidea, a clade that is frequently placed at the base of Maniraptora (coelurosaurian avian and non-avian dinosaurs that are more closely related to birds than to *Ornithomimus velox*). *Sinovenator* is a basal troodontid theropod dinosaur, a member of the Deinonychosauria, sister group to the Avialae (collectively termed Paraves). Understanding the musculoskeletal anatomy of basal members of maniraptoran clades can help clarify our understanding of hard and soft tissues character evolution on the lineage leading towards birds. Using computed tomography (CT) scans of *Haplocheirus* and *Sinovenator*, here we present a reconstruction of the retrodeformed cranial anatomy of both taxa. Then, using osteological correlates preserved on the original specimens or visible in the CT scans, coupled with information from the 3D topological relationships of muscle groups, we reconstruct the adductor musculature anatomy of both taxa. Both specimens are preserved in three dimensions rather than flattened, but both contain missing elements and suffer postmortem distortion. During retrodeformation, well preserved parts of the cranium were mirrored where possible and where bones were absent, anatomical relationships were inferred from related taxa. It may be predicted that, due to its more basal position in maniraptoran phylogeny and its relatively more robust skull, *Haplocheirus* possessed cranial musculoskeletal anatomy that was more similar to non-maniraptoran taxa. In contrast we find that both taxa have a similar arrangement of adductor muscles to non-maniraptoran theropods in terms of osteological correlates on the skull surface and the subsequent arrangement of reconstructed muscles. However, the small size and slim bones of the skull of *Sinovenator* suggest that *Sinovenator*, along with extant birds, reduce muscle mass in their crania. Future biomechanical modelling will further test the functional effects of reducing bone and muscle mass in the skulls of paravian taxa.

Grant Information
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Technical Session III (Wednesday, October 14, 2015, 8:45 AM)

THE UNIQUE PRESERVATIONAL ENVIRONMENT OF CAVE DEPOSITS AT THE RICHARDS SPUR LOCALITY OF OKLAHOMA

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The Dolese Brothers limestone quarry near the town of Richards Spur, Oklahoma is home to an assemblage of Lower Permian (289 ma) tetrapods, with more than 30 described and several more undescribed taxa, all considered to be fully terrestrial, leading to the interpretation that this is an upland assemblage, a rarity in the Paleozoic Era. Despite the large body of work devoted to alpha taxonomy, there has been little integrative work on the geological and paleoecological nature of the locality, its fossiliferous infills, the preservational condition of the fossils, reconstruction of the depositional environment, and possible taphonomic biases. The research presented here uses geological and paleontological samples from both the surrounding limestone and the fossiliferous infills. Numerous karst structures from the fossiliferous areas of the quarry provide compelling evidence that the so-called fissure fills found at the locality are remnants of a vast vertical cave system. Fossil material obtained from the caves of Richards Spur is usually found in disarticulation, in most cases pristinely preserved in the Lower Permian clay infills, but various levels of wear have also been observed, especially when the bones are concentrated in calcite. In contrast, articulated material is relatively rare, and always associated with calcite. We interpret that the fossil material could have come into the caves in two ways. The first involves animals that died outside of the caves, were partly or completely disarticulated, and their remains were washed into the caves. The animals could also have fallen into the caves from the surface, as the caves would have acted as passive natural traps, and would then become partially or completely disarticulated in the cave. Evidence from geological thin sections and carefully prepared fossiliferous samples indicate that once introduced into the caves, various levels of reworking of the skeletal materials occurred, a relatively common phenomenon in karst deposits. The reconstructed environmental conditions of the caves were not conducive to habitation by terrestrial vertebrates, and none of the taxa from this locality were likely native to the caves. The overall preservational environment seen at Richards Spur is likely the result of the interplay of complex factors, making it distinct from all other Paleozoic localities, and a unique window into the early stages of terrestrial vertebrate evolution.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

INTERNATIONAL RESEARCH EXPERIENCE FOR TEACHERS (RET): THE GREAT AMERICAN BIOTIC INTERCHANGE (GABI) IN PANAMA

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Panama is central to documenting New World Tropical biodiversity over the past 25 million years, including the major phases of the Great American Biotic Interchange that have occurred since the formation of the Isthmus during the Pliocene. This poster describes a scientist-teacher partnership (Research Experience for Teachers) doing paleontological field research in Panama. This annual program includes a multi-component professional development program that includes: (1) a pre-trip orientation in May; (2) two weeks of field work in Panama in July; (3) a post-trip online community of practice; and (4) December wrap-up session. Scientists and 25 teachers from CA, FL, and NM have collaborated so far; two additional cohorts are planned for 2015 and 2016. Deliverables so far include research products (fossils collected, meeting presentations, and papers published) and lesson plans aligned with new learning standards, e.g., NGSS (Next Generation Science Standards). Outcomes include increased: (1) appreciation of scientist-teacher collaborations; and (2) knowledge of paleontology and related subjects (e.g., biology and geology), including socially relevant topics of evolution and climate change interpreted from the fossil record in deep time. International field work like the GABI RET scientist-teacher partnership described here provides multicultural, authentic research experiences not typically available from other models of teacher professional development.

Grant Information
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Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

GIS ANALYSIS OF NORTH AMERICAN GIANT GROUND SLOTH (XENARTHRA: PILOSA) PALEOBIOGEOGRAPHY

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Considered to be part of the Great American Biotic Interchange (GABI), giant ground sloths (Xenarthra: Pilosa) first appear in North America 9 million years ago. This study traces the dispersal and speciation of four families of sloths (Megalonychidae, Megatheriidae, Mylodontidae, and Nothrotheriidae) in North America over the past 9 million years using Geographic Information Systems (GIS) to better understand the patterns and variation in geographic range and frequency of the taxa. While GIS is a valuable tool, it is underutilized in vertebrate paleontology. Here, it adds an additional layer of information to previous geographic range maps by quantifying locality information for multiple taxa using a wide range of statistical tools and functions. A database of over 800 localities was compiled from previously published studies and museum collection databases. This was used to generate abundance and frequency maps for species during North American Land Mammal Ages in which sloths were present in North America. Fossil localities range from early Hemphillian to late Rancholabrean, with the majority being Blancan and Rancholabrean. Analysis of the abundance of the most common genera show that the geographic range of the generalist (*Megalonyx* and *Paramylodon*) and specialist (*Eremotherium* and *Nothrotheriops*) taxa vary through space and time. Both generalist taxa are found in the majority of the localities, however, the relative abundance of these taxa vary by region. In the southeast region of North America during the Rancholabrean, *Megalonyx* accounts for 63% of the taxa and *Paramylodon* accounts for only 16%. The opposite trend, 14% *Megalonyx* and 67% *Paramylodon*, is observed in the southwest region during the same timeframe. The abundance of these two taxa increases along the coasts from the Irvingtonian to Rancholabrean, but decreases in the central portion of the continent. The geographic range of both specialist taxa show very little change from the Irvingtonian to Rancholabrean, with *Nothrotheriops* localities mostly restricted to the Southwest, and *Eremotherium* restricted to the Southeast and Central America. The results of this study add to the existing knowledge of giant ground sloths in North America by integrating the visual and statistical capabilities of GIS. Applying new forms of technology, such as GIS, is becoming increasingly vital to scientific research, and should be utilized in all branches of science, specifically paleontology.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

A NEW SPECIES OF *CYNARCTOIDES* (MAMMALIA, CARNIVORA, CANIDAE) FROM THE ARIKAREEAN OF NORTHERN FLORIDA

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The White Springs 3B locality on the bed of the Suwannee River in northern Florida produces a latest Oligocene (ca. 24 Ma), Arikareean three vertebrate fauna. Skeletons of *Mesoreodon floridensis* are common, as are small rodents, such as *Prosciurus* and *Leidymys*. The site is subaerially exposed only during times of exceptional low water flow. The first mammalian carnivore from White Springs 3B was collected in May 2011. It consists of a right partial dentary with p4–m2 and an associated left lower dentition, p2–m3. Because the right and left teeth have the same dimensions, same wear stage, and were found within 20 cm of each other, they can reasonably be assumed to belong to the same individual. Although the teeth are relatively small (the m1 is about the size of that of the least weasel, *Mustela nivalis*) the dental formula and tooth morphology is that of a borophagine canid. This assignment is supported by a basined m1 talonid with a strong entoconulid. In a phylogenetic analysis, the specimen is nested well within the genus *Cynarctoides*, a member of the tribe Phlaocyonini. Referral to *Cynarctoides*, rather than *Phlaocyon*, is supported by a laterally shifted posterior accessory cusp of p4; m2 long relative to other teeth; m1 metaconid high and conical; protostylid of m1 slight but quite pronounced on m2. The specimen represents a new species as the combination of its size and dental morphology differentiates it from all described species in the genus. It is generally more derived than *Cynarctoides lemur, C. roii,* and *C. luskensis*, most notably by the addition of strong stylids on the m1 and even stronger on the m2. Although not as advanced as *Cynarctoides acridens*, the teeth in this new species share the same increasing trends towards hypocarnivory as found in other advanced members of this genus. Notably, this new species appears to be the smallest known borophagine. The m1 length is 5.76 mm and p2–m2 combined length 18.96 mm in the Suwannee River *Cynartoides*. In *Cynarctoides harlowi*, previously regarded as the smallest borophagine, m1 length is 6.6 mm and p2–m2 length is 21.7 mm. Another small species of *Cynarctoides* is *C. roii* with a p2–m2 length of 22.2 mm. While these three are similar in size, the White Springs 3B specimen represents a different species based on additional molar cusps, stark differences in molar trigonid and talonid proportions, and m1 shape.

Technical Session XI (Friday, October 16, 2015, 9:30 AM)

ISOTOPIC ANALYSES OF MODERN AND FOSSIL HOMINOIDS

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Early Miocene Ugandan fossil localities at Moroto and Napak have yielded multiple catarrhine specimens including some of the oldest known hominoids. Isotopic analyses of the enamel of associated herbivore guilds at these sites have indicated water stressed conditions consistent with broken canopy or woodland habitats. To characterize the dietary niches of hominoids within this paleoecological interpretation, we analyzed the isotopic signature of seven fossil catarrhine teeth, including those attributed to *Morotopithecus bishopi*, *Proconsul major*, and cf. *Rangwapithecus*. To further contextualize these data, we also sampled and isotopically analysed 230 modern hominoid teeth from museum collections, including the M_1, M_2, and M_3 of individuals from variable populations of *Pan troglodytes, Pan paniscus, Gorilla gorilla, Gorilla berengei, Pongo pygmaeus, Pongo abelii, Hylobates lar,* and *Symphalangus syndactylus*. In addition, other relevant datasets of hominoid isotopic enamel values were compiled and used for comparative interpretation. There was significant isotopic variation among the molars sampled from individuals. In general, successive molars in modern taxa exhibit increasing isotopic enrichment (up to 4‰) over developmental time, emphasizing the need to control for tooth type in comparing enamel isotopic signatures from variable contexts and taxa. Relative to modern hominoids, $\delta^{13}C_{enamel}$ values of the fossil catarrhines (corrected for changes in atmospheric $\delta^{13}C$) were generally enriched with normalized values ranging from ca. -11 to -13‰, suggesting more water stressed C_3 dietary resources, consistent with the enamel values from some of the associated fossil herbivores. Of all the modern hominoids sampled, the range of values for the fossil catarrhines are closest to those of modern mountain gorillas. The values for the fossil catarrhines overlapped with some values for modern *Papio* populations published in the literature. Of the fossil hominoids, *Morotopithecus* had the most enriched carbon and oxygen values, potentially indicating that this taxon was foraging in more peripheral parts of the canopy where water stress, evapotranspiration, and irradiance were higher. Overall, the fossil isotopic data suggest catarrhine dietary niches with no clear modern analogs, and furthermore, that these Early Miocene taxa were foraging in more arid conditions, with more discontinuous canopy cover or more variable habitats than extant hominoids.

Symposium 3 (Saturday, October 17, 2015, 12:00 PM)

AUTOMATED ASSESSMENT AND IDENTIFICATION OF VERTEBRATE MORPHOLOGY FROM IMAGES AND 3D MODELS: MAKING THE JUMP FROM GEOMETRIC MORPHOMETRICS TO COMPUTER VISION, ARTIFICIAL INTELLIGENCE, AND DEEP LEARNING

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Geometric morphometrics (GM) was developed as an explicit attempt to use geometry as a means of unifying the disparate approaches employed by systematists to quantify and compare patterns of morphological variation. That the number of research reports involving some aspect of GM as a core research tool has undergone a monotonic increase year-on-year since the early 1990s stands as a testament to this toolkit's success. However, GM also suffers from various atavistic holdovers from previous stages of morphometric technique development, notably the need to decide a priori what aspect(s) of form are important for representing the structure of morphological variation, a labor-intensive approach to data collection, and a focus on the issue of ordination rather than identification. As a result, GM represents only a partial solution to the general problem of morphological analysis.

Recent developments in computer vision (CV), artificial intelligence (AI), and multifunction, non-linear approaches to neural network design (= deep learning, DL) have proven impressively successful in creating discrimination systems capable of accurately, objectively, and rapidly identifying large sets (100s to 1,000s) of objects from images and 3D models, even when trained using small sets of reference data. This technology represents step change from the rather limited success GM procedures have had in meeting the challenges of automated identification of organic morphologies to date and can be employed over an extremely wide range of object classes.

Simple datasets of vertebrate bones and teeth can be used to demonstrate the principles, advantages, disadvantages, and expected levels of performance for morphological characterization and identification under GM (landmarks); extended eigenshape, eigensurface, eigenimage (linear); eigenimage (non-linear); and DL protocols operating under both exploratory or confirmatory experimental designs and employing either supervised or unsupervised learning strategies. Results indicate that use of cascades of non-linear transformations delivers superior results in almost every case. Geometric morphometrics will remain a core tool of the quantitative morphologist for a variety of specialist applications (e.g., phylogenetic analysis, comparative method analysis). However, for those problems that require the rapid sorting of complex and highly variable morphologies into either a priori or a posteriori-defined group categories, use of CV, AI, and DL approaches will usually prove to be better choices.

Technical Session XV (Saturday, October 17, 2015, 8:30 AM)

NEW DATA BEARING ON THE EVOLUTION OF THE ENDOCRANIAL CAVITY OF NOTOUNGULATA (MAMMALIA), AND A PHYLOGENETIC ANALYSIS BASED ON CRANIODENTAL CHARACTERS

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The endocranium of notoungulates, a largely endemic group of extinct South American herbivorous mammals, has been studied through artificial and natural cranial endocasts, and more recently via digital endocasts. Although previous works provide descriptive anatomical and volume data on notoungulate endocasts that permit comparative studies on relative brain size, until now such data have not been analyzed within a phylogenetic framework, nor have anatomical differences been examined for their potential phylogenetic utility.

Our study combines data from previously published anatomical descriptions, natural endocasts, previously extracted plaster endocasts-all by other authors-and new data from high-resolution X-ray computed tomographic imaging to provide a broad comparative study of notoungulate cranial endocasts and to enhance understanding of the phylogenetic interrelationships of Notoungulata. A total of 22 characters of the endocranium, 11 of them new, were scored for 20 notoungulate taxa and five outgroups, based on studied specimens and the literature. These data were integrated into a larger character matrix including 99 characters from the dentition (3 of which are new), 72 from the exterior of the skull, 25 from the inner ear, and 41 from the postcranium for a total of 259 characters examined across 64 taxa (56 notoungulates and 8 outgroups). Parsimony analyses were conducted using TNT, applying new technology algorithms to search for the shortest trees and also conducting standard tree bisection and reconnection searches. All characters were considered unordered and no weighting algorithms were used. We obtained 984 most parsimonious trees measuring 922 steps of length each. Branch support was provided by a bootstrap analysis with 1000 replicates.

Using parsimony ancestral state reconstruction in Mesquite, endocranial characters were mapped onto the topology of the strict consensus tree to examine the evolution of the endocranium (brain) of notoungulates. Divergence of olfactory bulbs near their posterior junction with the rest of the cerebrum (just anterior to circular fissure) is identified as a synapomorphy for Toxodontia. Olfactory bulbs that are wider than deep is a synapomorphy for Toxodontidae. Cone-shaped paraflocculars lobes of the cerebellum represent an equivocal synapomorphy for hegetotheriids in our analysis, a feature convergent in some interatheriids.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

SCALING AND FUNCTIONAL MORPHOLOGY OF STRIGIFORM HIND LIMBS

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The Strigiformes are an order of raptorial birds consisting exclusively of owls: the Tytonidae (barn owls) and the Strigidae (true owls), united by a suite of unique adaptations that aid a keen predatory lifestyle. Among these are robust hind limb elements modified for grip strength that contribute to predatory success, and may account for the ubiquitous presence of owls in diverse habitats and latitudes throughout the world. This study analyzed subfossil and modern owl specimens housed in collections at the Page Museum at the La Brea Tar Pits in Los Angeles and the Natural History Museum at Tring, Hertfordshire, respectively. Unbroken adult specimens of the three major hind limb elements: femur, tibiotarsus, and tarsometatarsus, were measured with digital calipers. Maximum length, and the maximum width and depth of the proximal end, distal end, and midshaft were obtained. In order to assess scaling patterns, the robusticity index (RI) of each element was determined (ratio of midshaft width to midshaft length) and plotted against body mass for each species, and then a simple linear regression analysis was performed. While there is no significant difference in hind limb element dimensions or robusticity between the two families of owls, results show allometric scaling of hind limb width and length with body mass. Furthermore, the tarsometatarsus RI scales allometrically to mass 0.28, whilst a weak to non-existent relationship is seen in the femur (mass 0.05) and the tibiotarsi (mass 0.07). We conclude that tarsometatarsi play a more substantial functional role in predation than the tibiotarsi and femora. Larger owls with relatively higher tarsometatarsus RIs can capture and dispatch larger prey items relative to their own body mass such as rabbits and fish, while smaller owls with lower tarsometatarsus RIs predate upon smaller, more manageable prey such as rodents and insects. Given the scaling relationship between tarsometatarsi robusticity and body mass, it may be possible to infer the body mass of prehistoric owl species by analyzing the tarsometatarsus, the element most commonly preserved in the fossil record of owls.

Technical Session XIX (Saturday, October 17, 2015, 2:30 PM)

REEVALUATION OF THE HOMOLOGY OF THE BONES OF THE TETRAPOD CRANIAL VAULT

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Bones of the cranial vault appear to be highly conserved among tetrapod vertebrates, and homologous bones are generally thought to share a common developmental origin. However, recent developmental studies reveal key differences in the embryonic origin of cranial vault bones considered to be homologous on other grounds (e.g., topology) between representatives of two amniote lineages, mammals and birds, thereby challenging this view. In mice, the frontal is derived from cranial neural crest (CNC) and the parietal is derived from mesoderm, placing the CNC–mesoderm boundary at the suture between these bones. In chickens, this boundary is located within the frontal. This difference violates the developmental criterion of homology and renders the assessment of the homology of the avian frontal via this criterion incongruent with that of mammals.

To elucidate this apparent conflict we fate-mapped CNC and mesoderm in the salamander *Ambystoma mexicanum* (axolotl) to reveal the contributions of these two embryonic cell populations to the cranial vault in a non-amniote tetrapod. The CNC–mesoderm boundary in axolotls is located between the frontal and parietal bones, as in mice but unlike chickens. If, however, the avian frontal is regarded as a fused frontal and parietal (i.e., frontoparietal) and the parietal is regarded as a postparietal, then the congruence of the avian cranial vault is improved topologically, as indicated by the inferred position of the frontal-parietal suture, and developmentally with those of salamanders and mammals. This alternative hypothesis is also supported phylogenetically where data from the fossil record reveal separate frontal, parietal, and postparietal bones

are present in all stem lineages of extant taxa, including that of birds (e.g., the stem archosaur *Euparkeria*). Moreover, this alternative hypothesis implies that a postparietal is, or was, present in most non-avian archosaurs, including dinosaurs, but that it likely fused to the parietal, as the bone interpreted here as a postparietal does in chickens and as the postparietal does in many extant mammals. We interpret these findings as revealing, with only one potential exception, a strong conservation of the embryonic origin of bones of the skull across Tetrapoda.

Technical Session VIII (Thursday, October 15, 2015, 3:15 PM)

WHERE'S DINNER? VARIATION IN CARNIVORE DISTRIBUTIONAL RESPONSES TO VALLESIAN FAUNAL TURNOVER

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In the late Miocene, Europe underwent a faunal change. As Eurasia became drier and colder, the Iberian coastal basin of the Vallès-Penedès (V–P) remained a relatively wet area with distinct faunas more adapted to humid conditions and forest environments. The resident middle Miocene forest-adapted taxa in the V–P, including moschid *Micromeryx*, barbourofelid *Albanosmilus*, bovid *Euprox,* and suid *Listriodon*, were complemented with eastern immigrants adapted to arid conditions, such as giraffid *Palaeotragus* and felid *Machairodus*. This coexistence truly enriched the local assemblages, even resulting in a biodiversity hotspot. However, around 9.7 Ma, at the early/late Vallesian boundary (MN 9/10), the last humid-adapted faunal elements disappeared, and with them typical groups, e.g., flying squirrels, tapirs, and the last hominoids of Europe. As seasonality increased, both in temperature and precipitation, subtropical to tropical areas evolved into more open woodlands. This led to a true turnover, marked by the end of this high biodiversity, initially named the 'Vallesian Crisis'.

To discover which role the Vallesian carnivores played in the turnover event, their diversity dynamics are explored here. Data from the NOW database, updated with reviewed V–P material, were used to establish an overview of the origination, extinction, and locomotion of the taxa present in the V–P during the Vallesian. Biogeographical history and species richness were mapped to visualize distribution patterns throughout the middle to late Miocene (16–5.3 Ma). Many scansorial carnivores disappeared in Eurasia during the late Vallesian and more open country-adapted ones survived or appeared during the turnover. Carnivores exhibited a steep decline in scansorial species, with felids such as cf. *Promegantereon*, viverrid *Semigenetta* and ailurid *Simocyon*. Simultaneously, the ursids disappeared. After the Vallesian, only a few remained, including felid *Paramachaerodus* and mustelids like *Martes*. Due to forest reduction and the subsequent lower number of available niches, competition increased and many taxa disappeared. Many carnivores extended their distribution from western to eastern Europe. Considering a longitudinal humidity gradient, the aridification of the west partly explains the eastward movement of these animals. Furthermore, the contrast between the Iberian Peninsula and the rest of Europe is explored, focusing on the differential responses of these eastern immigrants, such as hyaenids *Adcrocuta* and *Hyaenictis* and other cursorial carnivores.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

DESCRIPTION OF THE MOST COMPLETE FOSSIL WALRUS AND ITS IMPLICATIONS FOR ODOBENID PHYLOGENY

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Walruses (Odobenidae) diverged from other lineages of pinnipeds in the early to middle Miocene (>16 Ma). The single extant species (*Odobenus rosmarus*) is restricted to the Arctic, but a diversity of fossil odobenids (20 species, 16 genera) are known throughout the North Pacific, especially in California. Although many fossil walruses have been described, our understanding of the evolutionary history of the Odobenidae is hindered by a lack of described postcranial material, despite the fact that many such specimens exist. Here we report on the most complete fossil odobenid known to date, a ~90% complete skeleton from the upper Miocene Oso Sand Member of the Capistrano Formation of Southern California. The specimen represents a new taxon that includes a combination of plesiomorphic and derived characters previously restricted to different groups of extinct walruses. As such, the Capistrano specimen provides new insights into the morphology and diversity of extinct walrus lineages. Our reassessment of walrus phylogeny reveals two distinct Miocene radiations: a middle Miocene radiation and a late Miocene radiation. Our estimates show that during the middle Miocene radiation, as many as three lineages of walruses existed at one time, and as many as nine species during the late Miocene radiation (including the lineage represented by the Capistrano specimen). Despite the high level of diversity found in the late Miocene, the number of coeval lineages drops to three by the late Pliocene. This decline of walrus lineages occurs as another group of pinnipeds, the Otariidae (fur seals and sea lions), becomes more diverse.

Grant Information
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Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

DIETARY NICHES OF EQUIDS REMAIN STABLE ACROSS THE MID-MIOCENE CLIMATIC OPTIMUM

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In the Miocene, hypsodont equid taxa became more abundant and diverse while brachydont equid taxa went extinct. This pattern is evident in Miocene deposits of Oregon in which the brachydont genus *Archaeohippus* and the brachydont-to-incipiently-hypsodont genera *Desmatippus* and *Parahippus* went extinct while the hypsodont genus aff. *Acritohippus* flourished. This turnover has been attributed to a shift in the environment from a more closed and forested habitat to a more open landscape containing grasses. In addition, during this time, global temperatures rose 4–5°C (mid-Miocene Climatic Optimum) and then dropped, associated with a decrease in precipitation. Here, stable carbon and oxygen isotopes, along with tooth morphology are analyzed to examine the dietary niches of four equid genera in Oregon through this transitional period. First, the dietary niche of each genus was defined and then niche stability and niche breadth were examined in relation to survival of each genus. All genera ate a C3 diet but niche partitioning is evident among them. *Archaeohippus* was a small browser, with a relatively narrow niche, feeding on leafy vegetation from the top of plants in a moderately open environment most likely similar to an open woodland habitat; *Desmatippus* and *Parahippus* were also browsers but ate vegetation in a more open environment than *Archaeohippus*; aff. *Acritohippus*, a larger equid, ate grasses in an open environment as well. No statistically significant shift in dietary niche was observed through time and across the mid-Miocene Climatic Optimum for any genera. Local extinction of the browsing equids, especially *Archaeohippus* with a narrow browsing dietary niche, may have been the result of spreading C3 grasses after the mid-Miocene Climatic Optimum. This is in contrast to the survival of aff. *Acritohippus*, which may be attributable to its broad C3 grass diet.

Grant Information
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Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

A PENNSYLVANIAN 'SUPERSHARK' FROM TEXAS

MAISEY, John G., American Museum of Natural History, New York, NY, United States of America, 10024-5192; MCKINZIE, Mark, Dallas Paleontological Society, Grapevine, TX, United States of America; WILLIAMS, Robert R., Dallas Paleontological Society, Valley View, TX, United States of America

Parts of two gigantic chondrichthyan occipital regions are reported from the Finis Shale (Virgilian, Upper Pennsylvanian, ca. 300 Ma) of Jacksboro, Jack County, Texas. The specimens closely resemble the elongated occipital region observed in other Paleozoic 'ctenacanthiform' and xenacanth chondrichthyans, and are clearly different from the far shorter occipital regions of contemporaneous symmoriiform sharks.

No xenacanth teeth or spines are known from the Finis Shale, but extremely large 'ctenacanthiform' teeth (referred to *Glikmanius occidentalis*) are known to occur at this locality, offering circumstantial support for identifying the 'Texas supershark' as some kind of 'ctenacanthiform', although its true identity will emerge only when other specimens are found in direct association with teeth and/or fin spines.

Nevertheless, based on this preliminary identification, and assuming that the original proportions of these specimens were close to those of more complete 'ctenacanthiform' braincases (e.g., *Ctenacanthus concinnus*, *Tamiobatis vetustus*, *'Tamiobatis*' sp., *Cladodoides wildungensis*), we estimate that the length of the largest braincase probably exceeded 80 cm.

An estimate of the overall length of the 'Texas supershark' was made by comparing cranial and body lengths in two reasonably complete 'ctenacanthiform' body fossils: *Goodrichthys eskdalensis*, from the Lower Carboniferous of Glencartholm, Scotland, and an undescribed Pennsylvanian 'ctenacanth' from Kinney Quarry, New Mexico. In both these forms, the total body length was approximately ten times the cranial length. If the 'Texas supershark' was similarly proportioned, the largest specimen represents an individual whose overall length probably exceeded 8 m (i.e., about 25% larger than the modern great white shark and considerably larger than *Goodrichthys* and the Kinney shark, both of which were approximately 2.5 m long). While this is only half the conservative estimated length of the Neogene lamniform '*megalodon*', the late Pennsylvanian 'Texas supershark' is nevertheless the largest Paleozoic chondrichthyan whose dimensions have been established empirically rather than by guesswork (as, for example, in *Edestus giganteus*). Furthermore, these findings suggest that large (ca. 8 m) predatory sharks appeared much earlier than previously supposed (the next oldest is the Cretaceous lamniform *Otodus obliquus*).

Symposium 1 (Wednesday, October 14, 2015, 2:15 PM)

THE ADVENT OF NORTH AMERICA'S LATE CRETACEOUS FAUNA REVISITED: INSIGHTS FROM NEW DISCOVERIES AND IMPROVED PHYLOGENIES

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A landmark study by Cifelli and co-authors dated and described the fossil diversity of the uppermost part of the Cedar Mountain Formation (CMF), which was subsequently designated as the Mussentuchit Member (MM). At the time, the unit was considered to have the earliest North American record of several dinosaur groups, including tyrannosaurids, pachycephalosaurs, and ceratopsians, and the first global record of hadrosaurids. In the intervening decade and a half, new discoveries from the MM and elsewhere, combined with phylogenetic revisions have altered that picture.

A number of these dinosaur lineages have since been documented in the Aptian-Albian Cloverly Formation of Montana and Wyoming, including ceratopsians and tyrannosauroids. Recent discovery of a large caenagnathid oviraptorosaur from the MM helps fill a gap in the stratigraphic range of the group between the Cloverly taxon *Microvenator* and Campano-Maastrichtian clade members. Another recent discovery, an orodromine neornithischian, is coeval with *Oryctodromeus* from the Blackleaf Formation of Montana, and also connects a Cloverly Formation taxon, *Zephyrosurus*, to Late Cretaceous relatives. The emerging picture of the MM dinosaur fauna suggests greater continuity with the Cloverly Formation and less turnover than previously thought.

In the initial description of the MM fauna, the first occurrence taxa were uniformly interpreted as representing immigrants from Asia. However, when added to recent phylogenetic analyses, our new MM discoveries support an earlier onset of faunal interchange in the Early Cretaceous (Early Cretaceous Laurasian interchange event), coupled with higher rates of dispersal perhaps occurring in both directions. Recognition that the large theropod *Siats* belongs to a cosmopolitan radiation of megaraptoran carcharodontosaurians adds to growing evidence that mid Cretaceous faunas of western

North America were less isolated and perhaps not as depauperate as previously interpreted.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

NEW SPECIES OF *OPISTHIAS* (SPHENODONTIDAE) FROM THE AARON SCOTT QUARRY IN THE BRUSHY BASIN MEMBER OF THE MORRISON FORMATION IN CENTRAL UTAH

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The Aaron Scott Quarry has produced several specimens of sphenodonts, including *Opisthias* and *Eilenodon*. The specimens that were collected were then compared to all known specimens in museum collections in the United States, including the holotype. Most of the specimens of *Opisthias* compared favorably to the specimens in the museums. However, one specimen (CMC VP 8550) shows differing characteristics to the *Opisthias rarus*, previously the only known species of *Opisthias*. The mandibular symphysis is very prominent in specimens of *Opisthias rarus*. However, CMC VP 8550 does not have a prominent mandibular symphysis. Measurements of the jaws included the height of the jaw at the front of the tooth row, the height of the jaw at the back of the tooth row, and the length of the jaw. We then plotted the length of the jaw to the ratio of the front height to the back height. Specimens of *Opisthias rarus* plotted on a regression line, with the shorter jaws having a 1:1 ratio of front to back height and the larger jaws having a ratio of 1:0.8 ratio. All the jaws measured fell on this regression line except CMC VP 8550. This was a shorter jaw with a lower ratio of front height to back height, giving the jaw a curved appearance. We conclude that CMC VP 8550 represents a new species of *Opisthias*.

Grant Information
NKU UR-STEM, NKU Collaborative Faculty Student Project Award, NKU Physics/Geology Student Success Award

Technical Session XIII (Friday, October 16, 2015, 1:45 PM)

NO EVIDENCE FOR SEXUAL DIMORPHISM IN NON-AVIAN DINOSAURS

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The matter of whether non-avian dinosaurs were sexually dimorphic has featured prominently in recent, wider debates concerning sexual selection and the fossil record. Specific instances of sexual dimorphism have been posited in dinosaurs on numerous occasions, though not always with supporting statistical evidence. Most studies that do provide statistical or quantitative support typically do so by arbitrarily dividing ('eyeballing') the dataset into two groups, and testing for significant differences between them. However, this is not an adequate test of the dimorphism hypothesis because even two arbitrary samples, drawn from either tail of a unimodal distribution, can differ significantly. What is needed is to show that the population is best modeled by a bimodal distribution.

This study revisits those original datasets that posit sexual dimorphism in dinosaurs, and subjects them to a combination of Shapiro-Wilk and Anderson-Darling tests for normality, Hartigan's dip test for unimodality, and mixture analysis. The eight surveyed species span all parts of Dinosauria, including theropods, sauropodomorphs, and ornithischians. In no instance does bimodality find statistical support and, in most cases, the data do not deviate significantly from a unimodal distribution. None of this is to say that dinosaurs were not sexually dimorphic–phylogenetic bracketing gives good reason to believe that they were–but the data are presently too sparse to statistically validate such an argument. The criticisms offered here extend well beyond dinosaurs to other vertebrate taxa for which similar arguments have been marshalled.

Technical Session VIII (Thursday, October 15, 2015, 2:45 PM)

USING THE GEOMETRIC PROPERTIES OF JAWS TO CONSTRAIN DIETARY RECONSTRUCTIONS OF EOCENE FAUNIVORES

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In the early Paleogene, diverse mammalian clades were faunivorous. Pantolestids, creodonts, and carnivoramorphans were among the most common small- to medium-sized predators and likely exploited different prey with different physical properties. In order to better understand what range of food types these predators may have exploited, we examined cross-sectional properties of the dentary to assess the capacity of different taxa to potentially process tougher food types (e.g., bone or hard-shelled invertebrates) and test the hypothesis that pantolestids may have incorporated harder food items in their diet by comparison to contemporaneous faunivores and extant carnivorans.

CT scans were prepared for 20 dentaries of seven early Eocene genera (3 pantolestids; 2 creodonts; 1 carnivoramorphan; 1 cimolestan) from southwestern Wyoming. Taxa were selected to represent the most common faunivores in the faunas and range in estimated body mass from approximately 100 g to 1 kg. For each specimen, dentary height and width and cortical thickness were measured at interdental sections along the molar row to obtain measurements of mediolateral and dorsoventral section modulus (a geometric property of beams) comparable to those previously published for extant carnivorans (canids, felids, and hyaenids). In addition to these measurements, we also calculated section modulus ratios, which can be readily compared across taxa of different body sizes.

Compared to extant carnivorans, all taxa have a lower mean mediolateral section modulus, but pantolestids and some creodonts overlap in range for mean dorsoventral section moduli with smaller canids. These values suggest that their jaws were less resistant to torsion than modern carnivorans but were equally resistant to bending stresses. Pantolestids further differed from other taxa in having exceptionally thick cortical bone on the ventral border of the dentary and having the lowest ratio of section moduli, indicating they have the most cylindrical dentaries and thus likely the best resistance to bending stresses among the sampled taxa. Our findings suggest that both creodonts and carnivorans ate prey with similar physical properties, but that pantolestids were able to take prey that were mechanically tougher. Determination of the biomechanical properties of the dentary is an important source of data that can be used in conjunction with tooth morphology, stomach contents, and other lines of evidence to help us make a more informed reconstruction of feeding behavior.

Grant Information
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Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

DEVONIAN VERTEBRATE REMAINS FROM PELEE ISLAND, ONTARIO AND A NEW SPECIES OF *ONYCHODUS*

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The Devonian marine strata of southwestern Ontario, Canada have been well documented geologically, but their vertebrate fossils are poorly studied. Although vertebrate fossils are rare in this stratigraphic succession, they are known from at least four formations that encompass approximately 15 million years in the Middle Devonian. The Dundee Formation, which spans the Eifelian-Givetian boundary (390-387 Ma), crops out on Pelee Island in Lake Erie, and has produced identifiable remains of placoderms and sarcopterygians that have not yet been described in the literature. Here we report on sarcopterygian remains from this unit, including a new species of *Onychodus*, represented by two well-preserved onychodontiform lower jaws. The most complete specimen consists of a large (27 cm), nearly complete right jaw with an almost complete dentition. The dentary has 29 tooth positions, not including the symphyseal tooth whorl, which is poorly preserved but consists of at least three teeth. The anteriormost teeth in the dentary are not complete, but the second tooth is notably procurved. The posterior teeth are conical and approximately equal in size for much of the length of the tooth row. Infradentary one and four are present, but the gular and infradentaries two and three are not preserved.

The Pelee Island jaw differs from the type species *Onychodus sigmoides* in that it has a dorsally curved anterior dentary ramus, and a strong anterior expansion of the dentary. It also differs from *O. jandemarrai* and other onychodonts in its large size and elongated posterior fourth infradentary. We therefore conclude that the Pelee Island jaw represents a new taxon based on morphological distinction from described species. In order to assess the systematic position of the Pelee Island taxon, we placed it into an expanded phylogenetic analysis of Devonian onychodontiforms that includes 9 well-known taxa and 40 morphological characters. Parsimony results suggest that the Pelee Island taxon is the sister taxon to *Onychodus jandemarrai*. This relationship is supported by several synapomorphies, including the presence of a mesial ridge running through the entire dentary, more than 3 coronoids, ribbed enamel on the parasymphyseal teeth, as well as the presence of procurved teeth on the anterior end of the dentary. This study indicates that further analysis of vertebrate remains from Ontario will lead to additional insights into the diversity and relationships of Middle Devonian fish.

Grant Information
Queen Elizabeth II graduate scholarship in Science and Technology.

Technical Session XVII (Saturday, October 17, 2015, 3:00 PM)

THE EARLIEST KNOWN TITANOSAURIFORM SAUROPOD DINOSAUR AND THE EVOLUTION OF BRACHIOSAURIDAE

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Brachiosauridae is a clade of titanosauriform sauropods that includes the well-known Late Jurassic taxa *Brachiosaurus* and *Giraffatitan*. However, there is disagreement over the brachiosaurid affinities of other taxa, and little consensus regarding the clade's composition or inter-relationships. An unnamed partial skeleton from the Oxfordian (Upper Jurassic) of France potentially represents the earliest known titanosauriform and has been known as the 'French *Bothriospondylus*' or 'Damparis sauropod' in the literature. Full preparation and description of this individual (comprising teeth, vertebrae, and most appendicular elements) recognizes it as a distinct brachiosaurid taxon. Along with all putative brachiosaurids, the Damparis sauropod was incorporated into a revised phylogenetic analysis comprising 69 taxa, scored for 407 characters, several of which are novel to this study. After pruning of several unstable and highly incomplete taxa, analysis in TNT produces 18 MPTs of length 1482 steps, and we recover a nearly fully resolved Brachiosauridae, with good stratigraphic fit. The Damparis sauropod and other Late Jurassic European forms are recovered as a paraphyletic array of basal brachiosaurids, with *Brachiosaurus*, *Giraffatitan*, and Cretaceous North American taxa successively more nested within Brachiosauridae. The putative Middle Jurassic brachiosaurid *Atlasaurus* is a non-neosauropod eusauropod that shows some convergence with brachiosaurids, including forelimb elongation. The Late Jurassic dwarf sauropod *Europasaurus* has been recovered either as a non-titanosauriform macronarian or basal brachiosaurid in previous studies. Although the latter placement seems secure, the effects of alternative treatment of scoring paedomorphic character states impacts upon tree resolution. Scoring these as missing data, rather than autapomorphic reversals to the plesiomorphic basal eusauropod condition, produces a well resolved tree congruent with that recovered with *Europasaurus* excluded a priori. Currently, Brachiosauridae is only definitely known from the Late Jurassic of East Africa, western Europe, and the USA (along with a possible South American occurrence), and was seemingly restricted to the USA in the Early Cretaceous. Regardless of whether their absence from the Cretaceous of Africa and Europe, as well as other regions in general, reflects regional extinctions and genuine absences, respectively, or sampling artefacts, brachiosaurids appear to have become globally extinct by the earliest Late Cretaceous.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

CT ASSESSMENT AND PHYLOGENETIC RELATIONSHIPS OF A MIOCENE BEAKED WHALE FROM KENYA

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The enigmatic occurrence of a Miocene beaked whale (Ziphiidae), discovered at 620 m elevation and 740 km inland of the modern Indian Ocean coast, was used to constrain the timing of uplift of the East African Rift and the consequent paleoenvironmental change. The specimen (KNM-LP 52956) comprises the beak of a ziphiid from slightly anterior to the position of the nares to the terminal notch of the premaxillae. Its maximum age is limited by the African Mid-Tertiary Event at about 23 Ma as determined by the occurrence of Eurasian immigrant mammal taxa, and its minimum age is limited by an overlying basalt dated at 17 Ma. It was determined to nest phylogenetically with *Indopacetus*, *Hyperoodon*, and *Mesoplodon*, plus four extinct taxa. Examination of the specimen and CT data shows the rostrum is pachyosteosclerotic with remodeled, non-lamellar bone and longitudinally-oriented secondary osteons. The entire rostral perimeter cortex is fused and growth lines are not visible. The vomer fills the mesorostral groove, which is not closed dorsally by the premaxillae. While the phylogenetic position of KNM-LP 52956 appears stable, new autapomorphic characters suggest it represents a new taxon.

Technical Session XI (Friday, October 16, 2015, 11:15 AM)

GEOMETRIC MORPHOMETRICS OF POCKET GOPHER (*THOMOMYS*) DIGGING ANATOMY: ADAPTATION TO SOIL SEPARATES FROM PHYLOGENETIC SIGNAL

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Northern Californian pocket gophers exemplify the fossorial lifestyle's impact on the mammalian skeleton. Hypotheses explaining the high variation in genus *Thomomys* include differential adaptation to local soil conditions coupled with low gene flow between populations. Previous work on *Thomomys* demonstrated that the primarily claw-digging subgenus *Thomomy*s tends to reside in softer soils with lower bulk density and percent clay. In a relatively short time (7–9 my), however, the subgenus *Megascapheus* evolved increased incisor procumbency for tooth-digging in harder soils. Therefore, the genus *Thomomys* presents an ideal test for understanding interactions between adaptation and lineage divergence. We used 2D geometric morphometrics and Principle Components Analysis (PCA) on 425 crania and 80 humeri to investigate the relationship between shape, soil, and phylogeny in 10 subspecies of *Thomomys*, including six of the subgenus *T. Megascapheus*. The lateral crania view's first two principle components (PCs) captured traits that increase incisor procumbency: the growing radius and position relative to the rostrum, respectively. PC1 separated the subspecies of subgenus *Thomomys* from *Megascapheus* with a small overlap occurring only between *T. (M) bottae canus* and the two subspecies of *T. (T) talpoides*. PC2 separated groups within the subgenera: in *Megascapheus*, the bottae phylogenetic group displayed a more procumbent tooth position than the townsendii group (*T. townsendii* and *T. bottae canus*). These results are consistent with the soil conditions each subspecies inhabits, with the townsendii group occupying softer soils than bottae group. In subgenus *Thomomys*, PC2 dramatically separates the two *T. talpoides* subspecies from the least procumbent *T. mazama* and *T. monticola* species, despite the closer phylogenetic relationship between *T. talpoides* and *T. monticola*. In this case, adaptation to soil drove shape change as *T. talpoides* occupies the heaviest and highest clay soil of its subgenera. The ventral crania view's PC1 captured size of the zygomatic arch relative to the skull and of attachment surfaces for the masseter muscle, modifications for using the jaw to dig. Notably this PCA showed *T. b. laticeps* trending away from the bottae group and more towards the townsendii group, with which they share sandier soil conditions. Overall, our analyses demonstrate the tangible impact local soil conditions have on the functional morphology of fossorial mammal populations often in contrast to, but not independent of, phylogenetic history.

Grant Information

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Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

GO EXTINCT! AN EDUCATIONAL CARD GAME INTRODUCES STUDENTS TO READING EVOLUTIONARY TREES AND ENCOURAGES FURTHER EXPLORATION THROUGH STUDENT-DESIGNED EXPANSIONS

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Evolutionary trees are one of the most important representations of biological knowledge. Scientists frequently use them to compactly convey information and to present new taxa in context with well-known relatives. Students approaching evolutionary trees for the first time, however, often find them difficult to understand because the information is not presented linearly. I designed *Go Extinct!* to capitalize on the sets-within-sets structure of evolutionary trees in order to create a strategically-engaging twist on Go Fish. The game includes a deck of 54 animal cards and a simplified, yet accurate, evolutionary tree board used for reference during play. Instead of collecting sets of numbers as in Go Fish, players collect groups of closely related animals by asking for clades of varying inclusivity. For example, students could get the Human card by asking for the Human specifically or by asking for one of the more inclusive clades humans belong to, such as mammals or tetrapods. Winning requires players to understand the hierarchical structure of evolutionary trees and to identify common ancestors. The game's vocabulary emphasizes traits that scientists use to classify vertebrates in the tree. Over 400 students, from 1st graders to undergraduates, have played the game, with the most successful implementations occurring in middle school and up. Afterwards, students can define a clade and make evolutionary observations such as, "Chickens are dinosaurs and we've been eating them!" I worked with the San Francisco Brightworks Academy over two months and challenged middle schoolers to design expansion packs for Go Extinct! as part of a capstone project on evolution. One student group created an expansion with Geologic Age cards that limited the clades you could play based on when they diverged as well as Catastrophe Cards that caused special events. The mechanics they chose for these cards reflected knowledge gained about the timing of animal evolution and how catastrophes might impact one group of animals more strongly than others. Another student created a new Go Extinct!game based on the phylogenetic tree of the cat family, Felidae. She used a recent Science publication for reference, chose cats that best represented the lineages specified by the paper's genetic analysis, then researched facts and creative commons images to complete each card. The Next Generation Science Standards emphasize the Unity and Diversity of life as a core concept and card games like Go Extinct! present a low-tech tool to excite students about evolution.

Technical Session XIX (Saturday, October 17, 2015, 2:00 PM)

MYSTERIES IN THE PHYLOGENY OF EARLY TETRAPODS AND THEIR EVOLUTIONARY IMPLICATIONS

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"Nothing makes sense in biology except in the light of evolution" and "nothing makes sense in evolution without a phylogeny". A robust phylogeny is necessary to test hypotheses about the evolution of individual characters as well as about evolutionary trends. Tetrapod phylogeny has largely been taken for granted by recent research into such problems, but parts of it are shakier than they seem; some widely held evolutionary hypotheses may therefore be without foundation. Based on an improved dataset for phylogenetic analysis as well as new characters and recent publications, I review the current state of open questions and their implications for such problems as terrestrialization. *Ichthyostega* may well be less crownward than *Acanthostega* and represent a very early origin of a seal-/mudskipper-like lifestyle independent of terrestrial tetrapods. Several Devonian and Carboniferous isolated lower jaws can be placed fairly precisely. Anthracosauria (Embolomeri) lies more rootward than Temnospondyli, thus probably outside of a clade that may have plesiomorphically had amphibious adults. *Casineria* seems indistinguishable from *Caerorhachis*, which may be a temnospondyl or slightly more rootward, and may have been more aquatic than previously thought. Temnospondyli seems to consist of an increasingly terrestrial clade (mostly Dissorophoidea sprinkled with "branchiosaurs") and an increasingly aquatic clade (containing Stereospondylomorpha, Dvinosauria, *Eryops* and even Edopoidea), pending further research. "Lepospondyli", which includes *Westlothiana*, is closer to Amniota than Seymouriamorpha is. Diadectomorpha and Amniota appear to be sister-groups as usually thought, but the latter may plesiomorphically have a temporal fenestra, and its early phylogeny is not quite clear. Adelospondyli likely belongs together with Colosteidae rather than "Lepospondyli". "Microsauria" and especially "Nectridea" need to be revisited in detail. Aïstopoda, together with the urocordylid "nectrideans", has an uneasy existence in the "lepospondyl" clade based on published descriptions, but work presented at recent conferences puts at least the former far down on the tetrapod stem, so it could contain another separate origin of terrestriality. The Lissamphibia + Albanerpetidae clade currently appears closer to the "lepospondyl" clades Pantylidae, *Scincosaurus*, *Batropetes*, Lysorophia, *Carrolla*, and possibly *Utaherpeton* than to the amphibamid temnospondyls, but either way there is much convergence between terrestrial to amphibious walkers.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

CLIMATIC INSTABILITY AND ECOMORPHOLOGICAL CHANGE IN *MICROTUS AGRESTIS* AND *MICROTUS ARVALIS* OVER THE PLEISTOCENE-HOLOCENE BOUNDARY

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The interaction between genotype and environment is recognised as a major factor responsible for the generation and maintenance of phenotypic variation within and among populations. As a key component of a species's environment, climate is considered a strong driver of biological evolution and is known to exert selective pressures on particular morphological features. While the contribution of Late Pleistocene climate change to evolutionary and extinction events in mammalian megafauna has been well studied, less is known about the effects that climatic instability over this period had on small mammals. As keystone species largely unaffected by anthropogenic activity, and with rapid generational turnover, small mammals represent an excellent model to use to probe the effects of abrupt climate change on morphology at the population level.

This study focuses on two species, the short-tailed field vole (*Microtus agrestis*) and the common vole (*Microtus arvalis*), collected from cave sediments at a site in southwest England dating from the Late Glacial (c. 15 000 cal BP) to the Holocene (commencing c. 11 500 cal BP). This interval is characterised by extreme and rapid climate fluctuations but the effects of this variation on small mammal fauna remain largely unknown. As coordinated phenotypic variation can provide strong evidence for adaptation to local conditions, any ecomorphological change observed in these species would strongly suggest an adaptive response to climate change.

Particular substructures in the molars of Arvicoline rodents have been shown previously to have a rapidly evolving form. Thus, changes in the shapes of the lower first molars of both species are investigated here. The 3D morphology of the molars was captured by micro-computed tomography (microCT) and a geometric morphometric approach using constellations of landmarks and semi-landmarks employed to capture the 3D geometry of these molars' triangular prisms and structure of the anterior cap. Procrustes alignment, principal component analysis-based dimensionality reduction and canonical variate analysis-based discrimination were used to compare suites of tooth

characters and document their covariation with specific climatic factors against a null hypothesis of random variation.

This preliminary study represents the first time such techniques have been applied to British small mammal fauna of this age. Continued investigation will yield important insights into the effects of rapid climate change on morphological variation and allow elucidation of small mammal population dynamics over the Pleistocene/Holocene boundary.

Grant Information
Natural Environment Research Council

Technical Session X (Friday, October 16, 2015, 8:15 AM)

A COMPREHENSIVE STUDY OF *DILOPHOSAURUS WETHERILLI*: ANATOMY, TAXONOMY, AND EVOLUTIONARY RELATIONSHIPS OF THE FIRST LARGE-BODIED THEROPOD IN NORTH AMERICA

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Even though *Dilophosaurus wetherilli* was discovered in 1942 and described in 1984, the skeletal anatomy and evolutionary relationships of the taxon are poorly understood despite its inclusion in phylogenetic analyses of a wide range of archosaur groups. Combined with the paucity of *Dilophosaurus* fossils, the tendency to co-opt existing matrices has raised important questions about the first large-bodied theropod in North America, including its alpha taxonomy, comparative anatomy, systematic relationships, and stratigraphic and temporal distribution.

This study of the holotype, referred, and previously undescribed specimens of *Dilophosaurus wetherilli* demonstrates the existence of a single taxon of crested, large-bodied theropod from the Kayenta Formation of Arizona. Differences in cranial and limb proportions as well as the presence or absence of co-ossified elements are simply the result of ontogenetic and individual variation. Newly recognized autapomorphies of *D. wetherilli* are found throughout the skeleton. The parasagittal nasolacrimal crest is uniquely constructed by a small ridge on the nasal process of the premaxilla, a dorsoventrally expanded nasal, and a tall lacrimal with a posterior process behind the orbit. A preorbital boss is found on the lacrimal in individuals of various body sizes. In addition to the biceps tubercle, the coracoid includes a ventral tubercle. A scalloped obturator process is present on the proximal portion of the ischium. A notch is located on the posteromedial corner of the distal end of the tibia. Finally, the posterior centrodiapophyseal vertebral lamina bifurcates and reunites down the neck such that the single posterior centrodiapophyseal lamina present on the third vertebra is not homologous to that found on the eighth vertebra.

Dilophosaurus is found in the Silty Facies of the fluvial Kayenta Formation at two main sites in the Navajo Nation of Arizona. These sites are located near the base and middle of the unit. However, the Kayenta Formation is assumed to be time-transgressive and these superpositional relationships must be verified by depositional ages. A multi-crystal U-Pb date from detrital zircons indicates a Pliensbachian age for the Gold Spring quarry, and relocation and sampling of the holotype quarry near Tuba City is in progress. All current data suggest that *Dilophosaurus* is a member of a clade of large-bodied theropods that radiate from Gondwana as the North Atlantic opens during the Early Jurassic.

Grant Information
UT Jackson School of Geosciences and (U-Th)/He and U-Pb Geo-Thermochronometry Lab, and the University of California Museum of Paleontology

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

A SMALL-SIZED SAURISCHIAN DINOSAUR FROM THE LATE TRIASSIC SANTA MARIA FORMATION, SOUTHERN BRAZIL

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The oldest unambiguous fossil remains of early dinosaurs come from Carnian (Late Triassic) strata in Argentina and Brazil. To date, the Brazilian record includes the herrerasaurid *Staurikosaurus pricei* and the sauropodomorphs *Saturnalia tupiniquim* and *Pampadromaeus barberenai*, all from the Santa Maria Formation. Here, we report a new small-sized gracile dinosaur, LPRP/USP 0651, based on an incomplete semi-articulated skeleton, collected from the same site that yielded *S. tupiniquim*. The material includes some vertebrae, i.e. partial caudal trunk elements, incomplete sacral vertebrae, and varied non-articulated caudal elements and a partial chevron. Furthermore, most of the right pelvic girdle and limb is preserved, including an almost complete ilium and femur, partial tibiae, fibulae, metatarsals II, and IV, as well as some phalanges, including unguals. Comparatively, LPRP/USP 0651 differs from *S. tupiniquim* in various key features, such as a marked keel on the ventral surface of the proximal caudal centra, a caudally oriented ischiadic peduncle, a concave ventral margin of the iliac acetabulum, ilium proportionally smaller than the femur, poorly developed trochanteric shelf on the proximal part of the femur, distal tibiae mediolaterally expanded, an overall slender hind limb, and fibula longer than the femur. Preliminary phylogenetic analyses, based on distinct data sources, have consistently recovered LPRP/USP 0651 as a basal saurischian dinosaur, with no clear relationship to less inclusive groups. Yet interestingly, its variable position in the different recovered phylogenetic hypotheses accompanied that of *Eoraptor lunensis*, suggesting a possible affinity to that taxon. On the other hand, the possibility that LPRP/USP 0651 represents a juvenile is not discarded and ongoing histological analysis should provide conclusive information on that matter.

Grant Information
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Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

TRACE FOSSILS FROM THE VALANGIAN–ALBIAN OF VICTORIA, AUSTRALIA AND WHAT THEY TELL US ABOUT VERTEBRATE ADAPTATIONS IN THE EARLY CRETACEOUS POLAR ENVIRONMENTS

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Vertebrate body fossils in Valanginian–Albian clastic strata of Victoria, Australia represent the best Early Cretaceous assemblage of terrestrial and freshwater vertebrates from a formerly circumpolar setting (75–80° S). Most fossils are from two dig sites, Dinosaur Cove (Albian) and Flat Rocks (Valanginian or Barremian) and reflect a moderately diverse fauna. Taxa include lungfish, temnospondyls, turtles, mammals (monotremes, a multituberculate, and possibly eutherians and marsupials), non-avian dinosaurs (mostly ornithopods and theropods), birds, pterosaurs, and plesiosaurs. However, vertebrate remains are normally allochthonous and most are individual bones, teeth, or jaw elements; no skeleton collected thus far is more than 40% complete. Hence body fossils give little direct information about vertebrate adaptations to polar continental environments during the Early Cretaceous.

Fortunately, vertebrate trace fossils-most discovered since 2006-help to fill such gaps. These trace fossils include non-avian dinosaur tracks, avian tracks, and possible lungfish, turtle, and dinosaur burrows. Non-avian dinosaur tracks are attributed to ornithopods and theropods. Ornithopod tracks are likely allied with *Leaellynasaura*, *Atlascopcosaurus*, *Qantassaurus*, or similar taxa ("hypsilophodonts"), whereas most theropod tracks have affinities to oviraptorosaurs or ornithomimosaurs. Large theropod tracks (> 30 cm long) affirm sparse body fossil evidence of tyrannosauroid-sized predators in these polar ecosystems, whereas small tracks (~7 cm long) imply a presence of juvenile theropods. Burrows include structures similar to turtle and lungfish aestivation chambers. Dinosaur burrows are interpreted from one locality, but have not been found elsewhere. Regardless, burrowing must have been an adaptive behavior for vertebrates overwintering in cold, dark ecosystems. Perhaps the most exciting trace fossil discovery was of two bird tracks from Dinosaur Cove, the oldest known in Australia. Relatively large (heron-sized) birds made these tracks on fluvial overbank sediments, and one track is from a bird landing after flight. These tracks raise tantalizing questions about bird migratory abilities to and from polar latitudes during the mid-Cretaceous. Given increased awareness of vertebrate trace fossils in the Valanginian–Albian rocks of Victoria, we fully expect more trace fossil finds in upcoming years, further revealing insights on vertebrate behaviors and adaptations to polar ecosystems in the mid-Cretaceous.

Grant Information
Funding for much of the research was supplied by National Geographic Research and Exploration Grants, and some travel support was provided by Museum Victoria.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

POST-CRANIAL MORPHOMETRIC EVALUATION OF THE GENUS *BISON*: 40,000 YEARS OF BODY SIZE CHANGE IN RESPONSE TO ABRUPT TEMPERATURE SHIFTS, WITH IMPLICATIONS FOR THE *BISON* INDUSTRY

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Influence on the body size of *Bison* has been forced prehistorically by climate, and historically by anthropogenic selection for breeding. Specifically, bison body size appears to be diminishing due to increasing temperatures and/or abrupt climate change. High resolution relative temperature changes occur within centuries and decades in many cases, as understood by the GISP II ice core project research. Unfortunately, previous bison studies have not evaluated direct responses from temperature changes during the late Pleistocene, when average global temperatures were 4°C cooler than today. Furthermore, IPCC AR5 report forecasts temperature increases between 1°C – 4°C by year 2100. Consequently, six calcaneal linear metrics were used as a proxy to body mass from 44 fossil and archaeological sites across the United States; with approximately 1200 specimens over a 40,000 year period. Adaptation response of bison body size is larger during cooler periods and smaller during warmer periods. Correspondingly, bison inversely adapted to these temperature changes approaching century resolution. Preliminary data suggest for each 1°C of temperature change, average body mass changes by approximately 6%; placing total body mass loss at ~25% for a change of 4°C, or an estimated drop from 907 kg (2000 lbs) to 720 kg (1500 lbs).

Conventionally only distinguished by allometric size differentiation, the specific classification of *Bison bison* and *B. antiquus* was also tested to understand the phenotypic evolutionary adaptive capacity of *Bison*. Principal component and discriminant function analyses of both unstandardized and standardized metrics suggest that *Bison bison* and *Bison antiquus* are a conspecific evolutionary chronospecies. As a result, we also propose that the two taxa be considered conspecific (*Bison bison*, Linnaeus, 1758).

Grant Information
This research was supported by the US National Science Foundation Adaptation to Abrupt Climate Change IGERT program grant DGE-1144423.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

RAPID DWARFING IN PLEISTOCENE MUSKRATS OF THE MEADE BASIN FOLLOWING THE LAVA CREEK B ASHFALL

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Lower first molars (m1s) of the North American muskrat, *Ondatra zibethicus*, were recovered from a new locality, Arlene's Ledge, directly above the Lava Creek B ash (0.65 Ma) in Gate Ash Pit 2, Beaver County, Oklahoma. This sample, likely deposited within 25,000 years after the ashfall, is statistically significantly smaller in size than a sample of *O. zibethicus* m1s from directly beneath the same ash in the Cudahy Mine,

Meade County, Kansas, 48 km north of Gate Ash Pit 2. Estimation of body mass from an equation derived from the regression of mass on m1 length in modern arvicolids indicates the Arlene's Ledge muskrats were 31% lighter than their pre-ashfall relatives. A return to the trend towards large size in late Cenozoic muskrat evolution is indicated by a large muskrat m1 recovered from a stratigraphically higher level in nearby Gate Ash Pit 1. These results suggest that, in addition to affecting rodent community turnover, widespread continental ashfalls may act as selective agents for at least size change in small mammals.

Rapid dwarfing in the Arelene's Ledge population also demonstrates the danger of using tooth size change in arvicolid lineages to infer age of deposition (so-called 'vole clocks'). Using the mean value of 5.12 mm for m1 length of the Arlene's Ledge sample and an available polynomial regression of m1 length and time in *O. zibethicus* history, the Arlene's Ledge muskrat sample would be assigned a date of approximately 2.1 Ma.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

NOVEL MORPHOLOGICAL INSIGHTS FROM AN INCOMPLETE, ARTICULATE SKELETON OF A PRIMITIVE AETOSAUR (ARCHOSAURIA, PSEUDOSUCHIA) FROM THE UPPER TRIASSIC ISCHIGUALASTO FORMATION, SAN JUAN PROVINCE, ARGENTINA

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An incomplete, articulated skeleton of a basal aetosaur from the Upper Triassic Ischigualasto Formation of San Juan Province, Argentina preserves several novel features not previously recorded in aetosaurs. We identify the specimen as a basal aetosaur because the few exposed dorsal and lateral osteoderms have a typical ornamentation of radially distributed pits, grooves, and ridges emanating from a 'center of ossification.' The specimen is exposed primarily in ventral view from the sacrum posteriorly and preserves many anatomical features not previously recorded from Ischigualasto Formation aetosaurs, and may be distinct from *Aetosauroides scagliai*, the only species recognized from the unit by most recent authors. Features that differ from the holotype of *Aetosauroides scagliai* include dorsal vertebrae that lack well-developed fossae and femora that are more strongly twisted, with the twisting occurring more distally than in *A. scagliai*. The femora also lack the pronounced sulchus on the anterodorsal face seen in the holotype of *A. scagliai*. The appendicular armor over the hind limbs is extensive and well preserved, showing numerous rhomboid osteoderms in close articulation. Several small osteoderms are in place over the ischia as well. Other noteworthy features of this specimen include extensive appendicular armor and a well-preserved caudal ventral carapace that consists of only two columns of ventral osteoderms, including a large cloacal vent proximally that is accommodated by modifications to the first six rows of osteoderms. Beginning in the 16th row, the ventral osteoderms fuse to form a single element, something that has not previously been demonstrated in aetosaurs. The caudal osteoderms differ from many other aetosaurs in that they decrease in length rapidly, indicating that the specimen had a relatively short tail. Some of these features may represent the plesiomorphic condition for Aetosauria.

Poster Symposia (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

MODULAR EVOLUTION OF THE CARNIVORAN PELVIC GIRDLE: A THREE-DIMENSIONAL MORPHOMETRIC APPROACH

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The pelvic girdle is a key skeletal structure within the appendicular skeleton in quadrupedal mammals. The pelvis anchors many important muscles and connects the hind limb to the axial skeleton. However, unlike other appendicular bones, each hemipelvis is composed of three different girdle bones: ilium, ischium and pubis.

Here we investigate if the functional and developmental interactions among these bones accounts for the integration and modularity of the pelvis in mammalian carnivores. We use carnivorous mammals as a case study because our recent work has demonstrated that their appendicular skeleton is also integrated by functional reasons.

A series of landmarks in 3D on one half of the pelvic girdle were digitized in a wide sample of living carnivorans. The landmarks were divided into four basic developmental units: illium, ischium, pubis and acetabulum. The latter was considered as a different unit because it interacts with the femoral head during development. Later, we tested different modularity hypotheses that consider all possible modules formed by the combination of these four developmental units. For each hypothesis, we calculated the RV coefficient, a proxy for morphological covariation. We compared each specific hypothesis with a distribution of RV coefficients resulting from randomly-defined modules to assess for statistical significance.

One of the hypotheses with more statistical support separates the four original units as modules, which indicates a strong influence of development. Other supported hypotheses clearly point towards an association between the ischium and the pubis, with the illium and acetabulum more or less independent. However, these hypotheses cannot be unequivocally ascribed to functional interactions, because the ischium and the pubis also share some developmental processes. These results clearly indicate that the carnivoran pelvic girdle preserves a developmental modular structure with little modification attributable to functional adaptations, which agrees with previous studies that showed that the pelvis is conservative within each carnivoran family.

Symposium 3 (Saturday, October 17, 2015, 8:15 AM)

GEOMETRIC MORPHOMETRICS AND THEORETICAL MORPHOLOGY

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Geometric morphometrics (GM), the statistical analysis of shape, has revolutionized the way in which phenotypic evolution is assessed, particularly increasing mathematical rigor in the analysis of morphological variation. Less exploited is the ability of GM to search for unity in diversity (constraint), the specific disciplinary landscape of macroevolution in paleobiology, historically inquired using theoretical morphology (TM). TM addresses the possible range of morphologic variability that nature could produce, and in doing so, its unifying criteria comprise both the mathematical simulation of form and the construction of morphospaces, where the possible (theoretical) and the actual (real) can be represented and compared. Morphospace is indeed the major contribution of TM to the study of evolution and represents the common ground where these two disciplines meet. The Procrustes shape data of GM enables the customary statistical assessment of morphological disparity, trends and potential constraints over morphospace (e.g., allometry), as well as the simulation of theoretical (non-existing) geometries, plus the estimation of hypothetical ancestral configurations in combination with phylogeny. Further, any such outcomes can be rendered back into virtual reality, providing the opportunity to test, for instance, the involvement of function and efficiency in morphospace bias under the scope of biomechanics (i.e., structural analysis). Using 3D landmark data from a phylogenetically broad sample of extant bird skulls, we discuss the many conceptual and operational advantages that the merger between these two disciplines affords to paleobiological research. We show that the landbirds (encompassing passerines, parrots, and raptors, among others) cluster within a particular region of morphospace due to a characteristic combination of features such as short and wide facial skeleton, and a bulked cranium. This evolutionary key novelty is a response of craniofacial integration to factors such as allometry and encephalization, and we demonstrate that such constraint compromises aerodynamics by assessing the performance of empirical and theoretical morphs into wind tunnel simulations.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

ONTOGENETIC SHIFTS IN *GORILLA* AND *PAN* WITH HETEROCHRONIC IMPLICATIONS

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African ape biology provides an important comparative framework for interpreting human evolution. When collecting data in museums, researchers group specimens from multiple localities, subspecies and even species. While this allows for larger sample sizes, it invariably averages genetically and morphologically distinct samples. In fact, it is known that morphological differences exist among populations of chimpanzee and gorilla adults. Likewise, adult differences among human populations have been attributed to differing ontogenetic trajectories. However, population-level (i.e., subspecific groupings) ontogenetic trajectories in extant African apes have yet to be studied. Thus, the current framework of ape ontogeny from which we interpret the human fossil record is based on unrealistic and statistically untested biological models. This preliminary study is one part in a broader project which seeks to address population-specific levels of ontogenetic variation in *Gorilla* and *Pan*.

Here, we used the crania of four populations of *Gorilla gorilla gorilla* and four populations of *Pan troglodytes troglodytes* from the Cleveland Museum of Natural History, Powell-Cotton Museum, and Royal College of Surgeons. African ape crania were three-dimensionally scanned with a Breuckmann smartscan3D white-light scanner. Geomagic Design X was used to align and merge the scans into one mesh. The meshes were then imported into Stratovan Checkpoint to collect derived, 3D landmark data.

Once specimens were landmarked, we ran a generalized Procrustes analysis and subjected the specimens to multivariate analyses in order to test whether African ape populations differ in their ontogeny. A multivariate analysis of variance was preformed to determine if there were statistical differences between adult specimens of different populations. Ontogenetic trajectories were studied by regressing shape variables on log(Centroid size). Differences between populations were computed as the multivariate angle between trajectories and tested for significance using permutation tests.

Each specimen in this study retains latitude/longitude information allowing for fine-grained analysis on African ape population divisions. Here, we show that the observed morphological differences among populations of African apes are indeed due to differing ontogenetic trajectories. This research has broad implications for studies of human evolution by characterizing variation with increased biological validity in order to more accurately study heterochrony within our own lineage.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

STRATIGRAPHIC ASSIGNMENT OF DINOSAUR-BEARING EOLIAN SEDIMENTS IN THE GOBI DESERT, MONGOLIA AND ITS APPLICATION FOR A PROGRAM OF DINOSAUR-FOSSIL PROTECTION FROM ILLEGAL ACTIVITIES

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Upper Cretaceous strata in the Gobi desert, Mongolia are considered to be some of the most important accumulations of dinosaur fossils in the world. Many vertebrate fossils from the Djadkhta Formation have been discovered, however tephra and microfossils for geochronological examination have not been identified. Therefore a stratigraphic assignment of the eolian sediments in this region would be useful for paleontological investigations on the evolution of the dinosaurs as well as for a geological study. We focus on the variation in cathodoluminescence (CL) features of quartz grains occurring in the eolian sediments, which can characterize each unit of the sediments. In this study, we clarify the CL properties of quartz grains from the formations including three dinosaur localities (Tugrikin Shireh, Alag Teg and Bayan Dzak) in the Gobi desert, Mongolia.

CL spectroscopy of the quartz grains was made by a SEM-CL system, which is comprised of an SEM combined with a grating monochromator. All CL spectra were corrected for total instrumental response using a calibrated standard lamp. All samples exhibit two broad bands at 400 nm in a blue region and at 600-650 nm in a red region. The deconvoluted components by a Gaussian curve fitting can be assigned to the emission centers derived from structural defects related to trivalent Fe at 1.65 eV,

NBOHC at 1.89 eV, tetravalent Ti at 2.75 eV and trivalent Al at 3.19 eV. Therefore, an integral intensity of each emission component was employed as an indicator to characterize the eolian sediments in this area. It indicates an availability of quartz CL. The results imply that most of quartz grains are relocated in the same group of the layers, suggesting the formation of eolian sediments with lithologically cognate rocks in similar supply and sedimentary processes during a geological age.

Further application of CL spectral analysis in the present study has been made to identify the locality of illegally collected fossils in the Gobi desert using the quartz grains attached to the fossils. Babies from a nest of *Protoceratops* stored in the Mongolian Paleontological Center can be estimated to be from the area around Tugrikin Shireh, judging from the result obtained by a discriminant function analysis of quartz CL. Therefore, this method employed by CL spectral analysis of quartz grains is expected to be applicable to the study of the fossil provenance as well as stratigraphic investigation.

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Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

THE FOSSIL RECORD OF TESTUDINES FROM ANGOLA FROM THE TURONIAN TO OLIGOCENE

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The fossil record of testudines from Angola was poorly known prior to the field work conducted by the PaleoAngola Project, with the exception of the bothremydid pleurodiran *Taphrosphys congolensis* collected about a century ago from Paleocene-Eocene strata near Landana (Cabinda enclave).

Recent collecting efforts provided the basal eucryptodiran *Angolachelys mbaxi* from the Turonian of Iembe (Bengo Province) that represents the first marine eucryptodiran from Africa. The holotype is based on a skull and postcranial fragments. Here we report a new specimen from the type locality with well-preserved skull, and more complete carapace and limbs. Outcrops of the upper Campanian to lower Maastrichtian Mucuio Formation at Bentiaba (Namibe Province) preserve a rich assemblage of marine chelonians, including a very large *Protostega* sp. (with humeri, 2 costals, and plastron; estimated carapace width ~2.0 meters), *Toxochelys* sp. (peripherals, costals, carapace), and *Euclastes* (based on skull, jaw, limbs and peripherals) but distinct from other *Euclastes* based on the possession of anteriorly expanded pterygoids, prefrontals much longer than wide, and prefrontal-postorbital contact excluding the frontal from the orbit. Lower Paleocene deposits near Landana have recently yielded a new chelonioid turtle skull.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

A NEW JUVENILE SUBFOSSIL CROCODILE FROM THE ANJOHIBE CAVE, NORTHWESTERN MADAGASCAR

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Madagascar's subfossil record preserves a diverse community of animals including elephant birds, pygmy hippopotamus, giant lemurs, turtles, crocodiles, bats, rodents, and carnivores. These assemblages give us a window into the island's past from ~80,000 years ago to a mere few hundred years ago, recording the extinction of some groups and persistence of others. The crocodylian subfossil record is limited to two taxa, *Voay robustus* and *Crocodylus niloticus*, found at several localities throughout the island. *V. robustus* is extinct while *C. niloticus* is still found on the island today. Whether these two species overlapped in time or *Voay* was driven to extinction by *Crocodylus* remains unknown. While their size and presumed behavior was similar to each other, little is known about their growth and development, as the overwhelming majority of specimens represent mature adult individuals.

Here we describe a nearly complete juvenile crocodylian specimen from Anjohibe Cave, northwestern Madagascar. The specimen is tentatively referred to *C. niloticus* based on the lack of squamosal horns, oval shaped internal choana, and long narrow snout. However, as there are no juvenile specimens known of *Voay robustus*, it is difficult to eliminate the possibility that some of the defining characteristics of that genus may have changed through time. Fossils include a nearly complete skull and many postcranial elements (cervical, thoracic, sacral, and caudal vertebrae, pectoral elements, pelvic elements, forelimb and hindlimb elements, osteoderms). *C. niloticus* currently inhabits Madagascar but is locally extinct from this region; radiometric dating indicates an age of ~460–310 years BP. This specimen is clearly a juvenile based on the extremely small size and open sutures/detached neural arches. Based on the size of the skull, total body length is estimated to be ~1.1 m in length (modern adults of this species range from ~4–6 m). This fossil represents the only juvenile subfossil crocodilian specimen reported from Madagascar, and helps reconstruct details of crocodylian growth and development that would otherwise be unknown.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

QUANTITATIVE ANALYSIS OF AQUATIC ADAPTION IN OLFACTORY AND OPTIC CHARACTERS IN THE SKULL OF CARNIVORA

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Carnivora includes several clades adapted to aquatic lifestyles. Such clades show various habitats, ranging from fresh water river to deep sea. Previous studies have shown that the skull morphology of aquatic carnivorans is influenced by their lifestyle, which produces variation in the size of sensory organs. Some studies found several features reflecting adaptations to aquatic environments, such as the decreased size of the olfactory bulbs and enlarged optic organs, although most such studies lacked a rigid statistical analysis. A quantitative evaluation of such features in extant carnivorans, especially the correlation between the sizes of these sensory organs and habitats, provides key information on the degree of aquatic adaption in extinct carnivorans. Accordingly, we quantitatively analyzed the relationship between the sizes of the olfactory bulbs and optic organs and the degree of aquatic adaption in extant carnivorans including 43 species of terrestrial, semi-aquatic, and aquatic clades. Based on CT data of skulls of these species, virtual skulls and brain endocasts were constructed using the software Amira. The volumes of the olfactory bulbs relative to the entire brain, the area of the orbit, and the area of the optic nerve canal were measured. The correlation between these morphological parameters and habitat environments was assessed using a statistical method.

As a result, the volume of the olfactory bulbs, orbital area, and area of the optic nerve canal were significantly different between the terrestrial and aquatic species. The olfactory bulbs of aquatic and semi-aquatic species were significantly smaller than those of terrestrial species. Furthermore, the olfactory bulbs of aquatic species were smaller than those of semi-aquatic species. Additionally, the more adapted to an aquatic environment these species were, the smaller their orbital area and area of their optic nerve canal became.

These results demonstrate that the volume of olfactory bulbs, orbital area, and area of optic nerve canal all significantly reflect adaptations to the aquatic environment, with the size of these morphological features becoming increasingly smaller in more aquatic species. Accordingly, the sizes of olfactory and optic organs can be used as reliable proxies of the degree of aquatic adaptations in extinct carnivorans.

Technical Session V (Wednesday, October 14, 2015, 3:45 PM)

BAYESIAN TIP-DATING WITH CONTINUOUS CHARACTERS USING BEASTMASTER

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Bayesian 'tip-dating' is a method for simultaneously inferring the topology and dating of a phylogeny by including fossils as dated tips and conducting a total-evidence analysis, for example in the program BEAST2. Tip-dating is being actively explored, but all work to date has only used discrete (qualitative) characters for fossil tips. However, continuous (quantitative) characters are often available for fossil specimens, and ideally tip-dating analyses would include these as well. To enable such analyses, continuous-data capabilities were added to the R package BEASTmasteR. BEASTmasteR takes a data table of continuous traits and converts them into BEAST2 XML format, adding these characters to any DNA, amino acid, and/or discrete morphological data that is available. The likelihood of continuous traits on the tree is calculated using the Brownian motion model available in BEAST2 through modification of BEAST2's two-dimensional continuous phylogeography model into a one-dimensional model for any trait. Each trait is given a separate rate parameter that is also estimated. To test the validity of the model, continuous characters were simulated on an assumed tree (derived from a dated canid tree) with 22 tips (both fossil and living) under a Brownian motion model. Sets of 10, 25, or 100 continuous characters were generated and BEAST2 XML files were constructed using BEASTmasteR. Each BEAST2 inference was run for 50,000,000 generations. Inference on 10- or 25-character datasets converged quickly on the true tree, with the 25-character dataset showing higher posterior probabilities for many clades (only 4 branches with <50% posterior probability, PP) than the 10-character dataset (10 branches with <50% PP). Dating uncertainty also decreased by about 30%. However, the 100-character dataset failed to converge, perhaps because of the difficulty of jointly searching tree space and 100 rate parameters. The implications for practical analysis will be discussed, including the importance of the assumptions of independence between characters and independent rates. BEASTmasteR performance indicates that it should be helpful to researchers exploring continuous data: BEAST2 XML setup with continuous data takes <1 minute in BEASTmasteR, but at least 4 hours for an experienced user constructing the XML input by hand.

Technical Session VI (Thursday, October 15, 2015, 9:15 AM)

VERTEBRATE DIVERSITY AND OCEANIC ANOXIA IN THE POSIDONIA SHALE OF THE SOUTHWEST GERMAN BASIN (LOWER TOARCIAN, LOWER JURASSIC)

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The early Toarcian Oceanic Anoxic event (e-TOAE), a minor invertebrate extinction event, coincided with the deposition of black shales in epicontinental basins and a marked rise in seawater temperature among other abiotic changes. In the Southwest German Basin, the Posidonia Shale provides a record of this event in marine sediments. We surveyed existing museum collections in the context of a regional stratigraphic framework to examine major biases and assess the relationship between the vertebrate fossil record and documented abiotic changes in the Posidonia Shale of the southwest German Basin. We hypothesize that the e-TOAE will be marked by changes in both the fish and marine reptile faunas, and will have a greater effect on these faunas than the development of benthic anoxia.

The development of oceanic anoxia is positively correlated with preservation potential, and varies through the section. In order to account for this bias, we report changes in the relative abundance of fish rather than absolute number of individuals. A museum acquisition bias in favour of rare genera makes this correction unreliable for the marine reptiles. Throughout the Posidonia Shale, few fish smaller than 50 mm in length have been recovered, implying a bias against either collection or preservation of small individuals. In spite of excellent preservation, systematic biases are present in preservation and recovery of Posidonia Shale vertebrate fossils.

The composition of the fish fauna appears to have been strongly affected by oxygen availability, with changes corresponding to measures of benthic anoxia rather than to the e-TOAE. Larger predators, such as most pachycormids and the shark *Hybodus,* become rare during maximum anoxia. In contrast, small fishes (< 100 mm length) and the small pachycormid *Euthynotus* become proportionately abundant suggesting higher tolerance for dysoxic conditions, possibly related to adult body size. Marine reptiles (ichthyosaurs

and crocodyliforms) become more diverse and are characterized by larger taxa immediately following the extinction horizon. Smaller species are proportionately rarer during development of maximum anoxia.

We conclude that the early Toarcian fish fauna is more sensitive to basinal oxygen fluctuations than to factors directly associated with the e-TOAE, whereas the higher trophic level marine reptile fauna appears to be controlled by a more complex set of variables. Different responses to the same environmental perturbations imply a degree of trophic dissociation between the marine reptiles and fishes.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

MORPHOLOGICAL AND TAXONOMIC DIVERSITY IN ORNITHOMIMIDS REFERRED TO *STRUTHIOMIMUS ALTUS* FROM THE CAMPANIAN OF ALBERTA

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Struthiomimus altus from the late Campanian Dinosaur Park Formation of Alberta has been one of North America's most iconic "ostrich dinosaurs" since the first relatively complete skeleton was referred to this species in 1917. However, although numerous partial skeletons have been referred to *Struthiomimus altus* over the years, substantial anatomical variation in this sample has not been described, and many referrals of material have not been explicity justified by shared derived characters. A relatively small partial skeleton from the lower Dinosaur Park Formation is removed from *Struthiomimus altus* and identified as a new ornithomimid genus and species, characterized by the following autapomorphies: a short contact for the jugal on the maxilla, caudal vertebrae with very reduced neural spines over the transition point, a fully fused and convex contact between the ischia, a larger medial condyle than lateral condyle of the tibia, and a distinctive third metatarsal lacking a distal groove on the flexor side. Another partial skeleton combines a straight distal pubic shaft with a very short anterior process of the pubic boot, differing from more complete material referred to *Struthiomimus altus* but further supporting the presence of *Qiupalong* or a related taxon in the Dinosaur Park Formation. A core group of specimens generally regarded as *Struthiomimus altus* may be diagnosed by a more anteriorly projecting pubis with the pubic boot ahead of the antilium rather than under it, and a more sinuous profile of the third metatarsal. In this group variation is present in the development of a ginglymoid distal articulation of the first metacarpal. Although the fragmentary type specimen of *Struthiomimus altus* exhibits potentially diagnostic characters of the pedal phalanges, the evidence previously used to link it to the referred material is not secure, and the validity of this taxon requires careful reconsideration. The Dinosaur Park Formation contains the most diverse assemblage of Ornithomimidae currently recognized, but their diversity may be underestimated in other formations.

Technical Session XV (Saturday, October 17, 2015, 8:45 AM)

NEW SOUTH AMERICAN NATIVE UNGULATES (LITOPTERNA: MACRAUCHENIIDAE) FROM THE MIDDLE MIOCENE (SERAVALLIAN; LAVENTAN SOUTH AMERICAN LAND MAMMAL AGE) OF QUEBRADA HONDA, BOLIVIA

MCGRATH, Andrew J., Case Western Reserve University, Cleveland, OH, United States of America, 44106; ANAYA, Federico, Universidad Autónoma Tomás Frías, Potosí, Bolivia; CROFT, Darin, Case Western Reserve University, Cleveland, OH, United States of America

The Macraucheniidae are a moderately diverse and long-lived family of native South American ungulates of the order Litopterna. Their fossil range extends from the late Eocene until the late Pleistocene and possibly the early Holocene. The family shows a pronounced evolutionary trajectory throughout the Cenozoic, marked by an increase in body size and a reduction of the nasals, among other features. The basal members of the family (subfamily Cramaucheniinae), such as *Theosodon*, are known from many Oligocene and early Miocene deposits throughout the continent. Macraucheniines, such as the Pleistocene *Macrauchenia*, are known from late Miocene and younger deposits. Unfortunately, the fossil record of this family is poor for the middle and late Miocene, a time during which many of the morphological changes that distinguish the two subfamilies began to evolve. Recently discovered, well-preserved macraucheniid remains from the late middle Miocene (Serravallian age, Laventan South American land mammal age) site of Quebrada Honda in southern Bolivia help bridge this gap by documenting two new species. One of these species (Species A) is represented by a partial hind limb and a nearly complete cranium that preserves most of the upper dentition. It is distinguished from most other macraucheniids by its lack of a complete postorbital bar and lack of a diastema between I3 and C. Species B is represented by a specimen that includes a complete right dentary preserving the entire tooth row and mandibular symphysis, partial fore- and hind-limbs, and parts of the axial skeleton. It differs from other macraucheniids in having a hypolophulid and paralophid of similar size in p4 and a well-developed entoconid on m3. Species B is also smaller than most other macraucheniids (based on m2 length) and about 35% smaller than Species A based on femoral intercondylar and trochlear widths. The two Quebrada Honda species were added to the character-taxon matrix of a recently published phylogenetic analysis of Macraucheniidae to test their evolutionary relationships. Species A plotted within Macraucheniinae, basal to *Oxyodontherium* but crownward of *Scalabrinitherium*. Species B was part of a polytomy of cramaucheniine genera that includes *Cramaucheni*a, *Coniopternium*, and *Pternoconius*. Quebrada Honda may be unique among South American fossil localities in preserving the co-occurrence of both a cramaucheniine and a macraucheniine.

Grant Information
This research was supported by the National Science Foundation (EAR 0958733 to D. Croft).

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

USING A CONSERVATION FRAMEWORK TO EXAMINE LANDSCAPE DIVERSITY, CLIMATE, AND VERTEBRATE RICHNESS

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We have not yet developed sufficient methods for predicting how millions of species will need to shift their distributions to respond to rapidly changing climate. Thus, it is difficult for practitioners to create conservation priorities for maximizing future biodiversity. Some conservation biologists have recently begun utilizing a framework that prioritizes landscape diversity, with the idea that it will provide a rich stage for future biodiversity. In exploring how to best conserve future biodiversity, we have been analyzing the correlations between modern landscape diversity and biological richness. We have thus far found inconsistent relationships between these metrics. We compare the favored method in conservation biology today, which clusters landscape variables into discrete landforms, with random forest models, which use individual, continuous variables. We find that neither method outperforms the other for using landscape to predict vertebrate diversity. The missing factor here, which is not yet being considered by conservation biologists, is climate gradients and how these co-vary with landscape and biological diversity. If we as paleontologists begin framing our analyses about how vertebrate diversity shifts through time in terms of the methodology and needs of the conservation community, our research becomes mutually beneficial for both paleontology and conservation biology. From a paleoecological perspective, we are exploring the basic biology that underlies the interactions between landscape, climate, and vertebrate richness patterns. From a conservation perspective, we are validating and improving upon land parcel prioritization methods that are critical for purchase justifications.

Grant Information
Work on this project was funded by the Doris Duke Foundation.

Colbert Prize (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

CHANGING STRUCTURAL PROPERTIES AND MORPHOLOGY THROUGH EVOLUTIONARY DIGIT REDUCTION IN THE EQUIDAE (PERISSODACTYLA)

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Extant horses are a single genus of large-bodied, monodactyl, cursorial grazers. However, their fossil record shows remarkable diversity in terms of diet, body size, and digit state. Specifically, digit reduction evolved multiple times. Proposed explanations for this reduction include a greater emphasis on straight-line locomotion instead of lateral agility and increased locomotor economy, both in response to the spread of grasslands. As a first step in investigating these and other potential evolutionary drivers, we used micro-CT scanning and linear measurements of the distal limb bones in fossil equids, extant equids, and extant tapirs to investigate 1) intraspecific variation in distal limb dimensions, 2) an appropriate side digit to center digit ratio as a single 'toedness' value, and 3) evolutionary changes in the cross-sectional geometry of digit III, the primary weight-bearing digit.

The least variable distal limb elements were ungual phalanx (proximal width), proximal phalanx (length, proximal width), and metapodial (proximal width). From these dimensions, species-average values were calculated to determine a 'toedness' ratio for each species. Initial results show that these ratios reliably reflect degree of digit reduction, with high values for the tapir, moderate values for the more tridactyl horse species, and low values for *Equus*.

Structural properties of the digit III cross-section give unexpected results. We predicted increased resistance to bending and torsion as side digits were reduced, with the highest values in *Equus*, because a single toe bears the force of locomotion. Counterintuitively, we found that the multi-toed extant tapir had the highest resistance to bending and torsion, followed closely by *Equus*. In contrast, small-bodied fossil horses show significantly lower values than either tapir or *Equus*. This discrepancy may reflect the gracility of these early equids, which have lower body mass relative to digit proportions. Future work on other fossil horse species, including those that attain large body size while retaining side digits and the converse, will shed more light on these patterns of internal geometric bone properties.

Technical Session XV (Saturday, October 17, 2015, 12:00 PM)

RADIATIONS AND EXTINCTIONS OF TEMNOSPONDYLI AND THE AMPHIBIAN RESPONSE TO THE END-PERMIAN MASS EXTINCTION

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The effects of the end-Permian mass extinction, in terms of rates of species origination and extinction, were examined for the clade Temnospondyli. Temnospondyls are a species-rich group of non-amniote tetrapods with an abundant and global fossil record that crosses the end-Permian mass extinction near the middle of the lineage's range (Viséan to Aptian). As non-amniotes tend to be more susceptible to changes in environment and climate than amniotes, temnospondyls are an ideal taxon in which to examine the effects of environmental change at the Permian-Triassic boundary. To do this, a new clade-wide phylogenetic analysis of Temnospondyli was performed using a matrix of 112 ingroup taxa scored for 283 morphological characters, the colosteid *Greererpeton burkemorani* and the lepospondyl *Microbrachis pelikani* were used as outgroup taxa. The resulting phylogenetic hypothesis was then mapped against stratigraphic ranges correlated to the global geochronologic time scale for each taxon to identify ghost lineages and estimate ages of internal nodes. Using these data, origination and extinction rates were calculated per geologic stage and per million years. The effects of sampling bias were estimated by Spearmann's rank correlations between the number of sampled localities and rates of origination and extinction. Results show the largest radiation within Temnospondyli was during the latest Permian and continuing through

the Early Triassic. Unlike modern ecosystems where amphibian populations rapidly decline due to environmental crises, temnospondyl lineages behave almost opportunistically through the mass extinction. Though number of lineages and branching points are increased, lineages have shorter durations than those earlier in the Permian – indicating that temnospondyls were possibly acting as a 'disaster fauna' that briefly filled available niche space before being replaced by new lineages. This study also provides evidence that ghost lineage data should not be ignored in calculating evolutionary rates, as those rates based solely on occurrence data in this study are highly correlated with locality sampling ($p \leq 0.001$), while, rates incorporating ghost lineage data are not.

Grant Information
Evolving Earth Foundation and The University of Iowa Graduate College

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

GEOMETRIC MORPHOMETRIC ANALYSIS OF PEDAL CLAW SHAPE OF THE EARLY CRETACEOUS BIRD *CONFUCIUSORNIS SANCTUS* (AVES: CONFUCIUSORNITHIDAE) INDICATES CLOSE SIMILARITY WITH EXTANT PASSERINES (NEORNITHES: PASSERIFORMES)

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Confuciusornis sanctus is an Early Cretaceous bird from the Liaoning Province of northeastern China. Although much work has been published on this species, details of its habitat and behavior are still unclear. I performed a geometric morphometric analysis of the ungual of the second pedal digit in *Confuciusornis sanctus* in order to determine its relationship to extant birds. In addition to *C. sanctus*, I sampled 72 specimens spanning 59 extant bird species across seven orders (Passeriformes, Strigiformes, Falconiformes, Accipitriformes, Cathartiformes, Phoenicopteriformes, and Sphenisciformes). Three fixed landmarks and 50 sliding semilandmarks were used to define shape, and specimens were grouped by order. A principal component analysis gave three strong axes explaining over 80% of the variation in shape. This analysis determined that the claw shape of *C. sanctus* most closely resembles that of Passeriformes, with the four closest species being *Passer griseus*, *Chlamydera maculata*, *Grallina cyanoleuca*, and *Cracticus tibicens*. One species of Cathartiformes (*Cathartes aura*) was also close in shape. Based on the behavior of these species, these data may indicate that *C. sanctus* spent most of its time in the trees and on the ground in temperate woodland areas, eating plant material and/or insects and other invertebrates. Additionally, *C. sanctus* claw morphology was distant from members of Strigiformes, Falconiformes, and Accipitriformes, indicating that it was unlikely to be an active predator. A preliminary discriminant function analysis classified *Confuciusornis sanctus* as being a member of Passeriformes. Further sampling of orders is necessary to more accurately elucidate similarities in claw morphology.

Symposium 3 (Saturday, October 17, 2015, 11:45 AM)

ASSESSING THE PALEOBIOLOGY OF NORTH AMERICAN RODENTS USING NEW APPROACHES IN GEOMETRIC MORPHOMETRIC ANALYSIS

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Rodents are a taxonomically and ecologically diverse clade with a long fossil record in North America. As part of ongoing efforts to understand the environmental and ecological context of the evolution of modern rodent communities in the Great Plains, we have assembled a large (n<200) and growing library of high-resolution µCT scans of modern North American rodent crania and mandibles that allows us to explore ecomorphology of rodents and develop ecometrics to relate craniodental shape variation to diet, habitat, and potentially climate. Here we focus on Heteromyidae, an endemic North American clade for which we have a phylogenetically broad sample of species. To better understand the relationship between dental and cranial variation, we utilized dental shape descriptors computed from enamel and dentin isosurfaces in combination with a set of 74 homologous landmarks chosen to capture the detailed and variable morphology of rodent crania. A partial least squares approach to co-ordinating cranial landmark data with dental variables revealed both clade-specific patterns of covariation between these datasets as well as patterns that are shared across heteromyids. We also used partial least squares ordination of the landmark data with a matrix of binary indicator variables representing habitat preference in order to examine the response of cranial morphology to different habitat types. When performed on Procrustes-aligned coordinates this method is insufficient: taxonomic differences in morphology predominate the results. When computed from residuals after accounting for differences among clades the results are much more promising. This suggests that members of different clades within the Heteromyidae exhibit similar morphological responses to similar habitat types. Together, these results have important implications for the evolution of rodent morphology and for our ability to leverage data from modern taxa to better interpret the paleobiology of fossil species. Future research will focus on relationships between genetic and morphological distances to identify regions of cranial morphology that deviate from a neutral model of evolution.

Grant Information
NSF EAR-1338262, University of Minnesota Grant-in-Aid

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

NATURAL TRAP CAVE: A PLEISTOCENE TREASURE TROVE

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In the summer of 2014, a team led by Julie Meachen and Alan Cooper reopened Natural Trap Cave, a 25 meter deep sinkhole at the base of the Bighorn Mountains in Big Horn County, Wyoming. This cave was excavated previously by Larry Martin from the University of Kansas and Miles Gilbert from the University of Missouri from 1971–1985. The original excavations unearthed many large mammal fossils that were radiocarbon dated to the Late Pleistocene (12,000 to 30,000 years old). This site is of particular importance because of the constant cool, moist conditions, which are excellent for organic preservation. This report serves to inform the paleontological community about the array of fossils we excavated during our 2014–2015 field seasons. The preservational quality varied, although it was excellent for most of the bones. Many bones had a weathered outer appearance and a bone-colored center. Good collagen levels were detected during sampling for AMS radiocarbon dates and ancient DNA, and initial DNA analyses have been successful. Megafaunal species found in 2014 included: *Miracinonyx trumani* (26 identifiable specimens), *Canis lupus* (34 identifiable specimens), *Panthera atrox* (8 specimens), *Mammuthus* (1 tooth fragment), *Equus sp*. (169 specimens), *Ovis canadensis* (26 specimens), *Antilocapra americana* (8 specimens), *Bison antiquus* (14 specimens), *Bootherium* (6 specimens), and *Camelops* (3 specimens). Additionally, we found incredible numbers of microfauna which were not reported from the original excavations in the 1970–80s, these included: passerine birds, raptorial birds, lagomorphs (especially *Sylvilagus*), rodents (cricetids and sciurids), lizards (phrynostomatids, scincids, and teiids), snakes, fish, frogs, and bats. Many of these microfaunal species were likely raptor detritus since a microscopic analysis shows acid etching on the bones. These microfaunal samples will allow us to fine-tune our reconstructions of habitat and climate beyond those of the original excavation team in the 1970s and '80s, and represent an important part of the total faunal analysis. Over the next two years we will use ancient DNA analyses, AMS radiocarbon dates, and stable isotopic analyses at this site to understand how climate and the end-Pleistocene extinctions affected genetic variation and morphology in a variety of species.

Grant Information
This project was funded by the National Geographic Society and Des Moines University in 2014, and by the National Science Foundation in 2015 and 2016.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

HUGE CRETACEOUS FISH COPROLITE WITH ARTICULATED FISH INCLUSIONS

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The Late Cretaceous fossil record of New Jersey includes a variety of non-teleost fishes: amiids, coelacanths, dipnoans, lepisosteids, acipenserids, and especially selachians, batoids, sclerorhynchids, and chimaeroids. Spiral guts are found throughout non-teleosts, and coprolites of spiral morphology are also common in New Jersey, especially the Upper Campanian Mount Laurel Formation of Monmouth County. A spiral coprolite recently collected from these deposits is among the largest known from New Jersey. Most coprolites from these exposures lack any obvious inclusions but abundant phosphatic inclusions exposed on the surface of this new specimen encouraged CT scanning. Scanning revealed not only abundant bony inclusions but also showed articulated osteichthyan vertebrae, some retaining their delicate spines. Also found are spherical voids that I tentatively identify as gas bubbles, possibly having originated in the gut of the larger fish. The minute size of the fish inclusions and their fragility makes them very unlikely candidates for preservation in the predominantly lag deposit sediments that preserved the cololite itself. The protective envelope of a coprolite can be seen as a special type of biomatrix that should be scrutinized for additional faunal elements that are unlikely to survive high energy depositional environments. Additionally, the different chemical environment of feces could have different taphonomic potential than even gently-deposited host sediments. And finally, coprolites could have been deposited by an animal that fed somewhere other than the environment of deposition, thereby transporting faunal elements not expected locally.

Technical Session XII (Friday, October 16, 2015, 12:00 PM)

QUANTIFYING REPTILE TOOTH COMPLEXITY: IMPLICATIONS FOR RECONSTRUCTING THE DIET OF EXTINCT AMNIOTES

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Recent paleontological discoveries reveal a dramatic range of tooth morphologies in extinct reptiles, with some dentitions rivaling the complexity of extant mammals. Many of these dental morphologies have no modern analogues, inhibiting detailed dietary and ecological reconstructions for ancient ecosystems. Living saurian reptiles exhibit a wide range of diets, from hypercarnivores to strict herbivores. Previous research suggests that the tooth shape of some lizard clades correlates with diet, but this hypothesis has not been rigorously tested. In order to elucidate the diet of extinct heterodont reptiles, I investigated the correlation between tooth complexity and diet in living reptiles by examining the entire dentary tooth row in over 80 taxa comprising all major dentigerous saurian clades. I quantified tooth complexity using orientation patch count (OPC), which does not require the identification of homologous landmarks on each tooth and discriminates diet in living and extinct mammals, where OPC values increase with the proportion of dietary plant matter. OPC was calculated from high resolution CT scans, and I standardized OPC values by the total number of teeth to account for differences in tooth count across taxa. My results suggest that lizards follow the same general pattern as mammals; OPC values for omnivores and herbivores are higher than those of carnivores. In contrast with extant mammals, there appears to be greater overlap in tooth complexity values across dietary groups, perhaps because serrated and multicusped teeth characterize both herbivores and omnivores, and because the herbivorous skinks *Tiliqua* and *Egernia* have particularly simple teeth. Similar to extant bats, insectivorous lizards often have an unusually high tooth complexity given their carnivorous diet. These results suggest reptilian tooth complexity is not as strictly correlated with diet as in mammals, indicating other factors influence dental morphology. Therefore, care should be taken when interpreting the diet of extinct heterodont reptiles, as heterodonty and higher levels of complexity are associated with some small-bodied insectivores in addition to omnivores and herbivores.

Grant Information

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

A NEW THALATTOSAUR FROM THE VESTER FORMATION (CARNIAN) OF CENTRAL OREGON, USA

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Thalattosauria is a clade of secondarily aquatic Triassic reptiles generally found as isolated skeletons from localities in Europe, China, and North America. In North America, four genera of thalattosaurs have been described from two formations: the Hosselkus Limestone of California (Carnian) and the Sulphur Mountain Formation of British Columbia (Lower to Middle Triassic). In 2011, a new thalattosaur locality was discovered from the Late Triassic (Carnian) Brisbois Member of the Vester Formation in central Oregon. This formation records deposition in a nearshore environment in the forearc region of the Izee Terrane. The material consists of one large block of highly concentrated, three-dimensionally preserved, disarticulated skeletons of five or more individuals. Preparation to date has revealed partial crania, including complete braincases, as well as numerous axial and appendicular elements from individuals of varying size.

Preliminary examination of the most complete skull, University of Oregon Museum of Natural and Cultural History F64236, reveals a unique combination of characters including a strong degree of rostral ventral deflection, frontals that are excluded from the orbital margin, nasals separated by a long anterior projection of the frontal, a small degree of contribution by the jugal to the ventral margin of the orbit, the absence of an upper temporal fenestra and diastema, and a peg-like homodont dentition. Based on the morphological similarity of several multiple-sized elements, we interpret that this material represents the first ontogenetic series of any known thalattosaur. The new Oregon material represents the largest thalattosaur species yet found in North America, and is both the oldest vertebrate remains and the first occurrence of a thalattosaur from Oregon. Finally, the quality of preservation, particularly of poorly-known cranial elements, contributes important new morphological data about thalattosaurs for resolving phylogenetic relationships within the clade as a whole.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

REDESCRIPTION AND PHYLOGENETIC AFFINITIES OF *ELOSUCHUS CHERIFIENSIS* (CROCODYLIFORMES)

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Elosuchidae is a clade of longirostrine Crocodyliformes currently confined to Barremian through Cenomanian deposits in northwest Africa and Great Britain. The clade is currently composed of two species of *Elosuchus*, two species of *Sarcosuchus*, *Vectisuchus*, and, by some authors, *Stolokrosuchus*. We investigate this clade and redescribe the assigned and new material for *Elosuchus cherifiensis*. This taxon is confined to terrestrial Cenomanian deposits in Morocco and Algeria and known from multiple relatively complete skulls. The holotype is unknown but the assigned lectotype in the Muséum National d'Histoire Naturelle (Paris, France) is composed of a fragmentary ventral braincase. Referred paralectotype material housed in the same museum includes multiple fragmentary specimens and two nearly complete skulls. Additional material in the Canadian Museum of Nature and Royal Ontario Museum gives us an opportunity to re-examine the taxon. The original and new materials show a number of autapomorphies among crocodyliforms (e.g., a unique contribution of the squamosal and jugal to the postorbital anterolateral process and a highly modified suborbital fenestra that nearly occludes the antorbital cavity from the orbit). The revised diagnosis for *E. cherifiensis* questions the validity of *E. felixi*. The revised description of *E. cherifiensis* is incorporated into a phylogenetic analysis that includes extensive revisions to character scores for relevant taxa. The resulting topologies recover *E. cherifiensis* sister to *Meridiosuchus* within a complex of "Pholidosauridae" that includes elosuchids and dyrosaurids but excludes *Stolokrosuchus*. This phylogenetic revision is used to discuss the evolution of this clade and its contribution to crocodyliform diversity during the Cretaceous.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

NEW DATA ABOUT *CHANGXINGIA ASPRATILIS* (SARCOPTERYGII: ACTINISTIA) WITH COMMENTS ON ITS SYSTEMATIC POSITION IN MAWSONIIDAE

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Changxingia aspratilis is a species of Actinistia (= coelacanth) found in the Changxing Formation, Upper Permian (Changhsingian) of China. All specimens are housed in the Institute of Vertebrate Paleontology and Paleoanthropology, Beijing, China (IVPP V.6133-1, 6133-2, 6133-3a, 3b and 53318). In the present study, we reviewed all these specimens and described new morphological characters. IVPP V.6133-1 is the holotype, the only specimen with a preserved head. Nevertheless, this region is too poorly preserved to allow an accurate identification of bones. Also, IVPP V.6133-1 possesses a well-preserved trunk and tail. We observed in the orbital region a set of bones interpreted as the sclerotic ring. Additionally we noted articulated pectoral fins and epineurals along the abdominal region. IVPP V.6133-2 consists of a partially preserved caudal fin. Although it is fragmented, we identified the position of caudal lobes due to the inclination of the notochord. The specimen possesses an almost complete upper lobe, with about 22 rays, and an incomplete lower lobe with only seven rays preserved. The lepidotrichia of upper lobe are more widely spaced than those of the lower lobe. We also counted around ten hemal spines. IVPP V.53318 is an incomplete plaster mold specimen, preserved in left lateral view, lacking the head. The best preserved parts are the dorsal fins, with eight rays in D1 and 12 rays in D2. We observed scales with prominent ridges. Based on this redescription of *Changxingia aspratilis*, we added new morphological characters to an updated data matrix for actinistian phylogeny, such as: segmentation of caudal fin rays (with two states, proximally segmented rays or unsegmented rays) and denticles/spines on the caudal fin rays (with two states, present or absent). Recently, *Changxingia* was attributed to the family Mawsoniidae, due to the presence of ribs, one of the synapomorphies of the family. As far as we are aware, *Changxingia* has not been included in any previous coelacanthiform phylogeny. This is the first attempt to include it in a cladistic analysis of actinistian interrelationships. The analysis was carried out in TNT software, version 1.1 and resulted in five most parsimonious trees (L= 288, CI=0.41, RI=0.69). In the strict consensus, the node of Mawsoniidae shows the following topology ((*Changxingia* + *Diplurus (Parnaibaia* + (*Chinlea* + (*Mawsonia* + *Axelrodichthys*)))). We confirmed *Changxingia* as belonging to Mawsoniidae, but its systematic position within the family remains unclear in a polytomy formed with *Diplurus* and *Parnaibaia*.

Technical Session I (Wednesday, October 14, 2015, 11:15 AM)

EFFICACY OF DENTAL MICROWEAR IN TESTING PALEODIETARY HYPOTHESES FOR NON-RUMINANT UNGULATES: A TEST CASE USING NORTH AMERICAN MIOCENE RHINOCEROSES

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Dental microwear (DM) analyses assume that DM and diet have the same relationship across species. For ungulates, most DM data are derived from modern ruminants, but many fossil ungulates belong to non-ruminant clades that are now rare or extinct. A catholic DM-diet relationship among species of varied phylogenetic histories is doubtful. We tested the value of extant species as DM models for paleodiets in North American Miocene rhinocerotids. Using an observer blind method with photographs taken under a light microscope, we compared DM from the lingual and labial sides of the occlusal molar enamel of 221 modern specimens, including all living rhinos, other large-bodied browsing and grazing perissodactyls and ruminants, and 208 fossil rhino specimens from six Miocene quarry sites from the central Great Plains and Florida. Grazing and browsing ruminants had statistically different DM with separate browser and grazer data clusters. Perissodactyls had heterogeneous DM with more pits on the labial sides of the molars and more scratches on the lingual sides without separated browser and grazer clusters. Discriminant function analysis (DFA) of modern ruminant DM data correctly assigns diet to individual molars with 90% accuracy. DFA of modern perissodactyl data assigned molars to diet with less accuracy (76%). In an analysis where modern perissodactyls and ruminants were combined, DFA of DM data can correctly assign individual teeth to clade (perissodactyl or artiodactyl) with nearly the same degree of success (70%) that the DFA of DM data can assign individual teeth to diet (73%). We found the same pattern of DM heterogeneity in fossil rhinos with highly pitted labial sides and highly scratched lingual sides. Early Miocene rhinos, *Diceratherium* and *Menoceras*, have densities of DM features in excess of other species, limiting interpretation of diet. All late Miocene rhino DM is more consistent with browsing than grazing. The DM of *Teleoceras* and *Aphelops*, two genera with isotopically different diets, have statistically undifferentiated DM. Dental microwear varied more between localities than between *Aphelops* and *Teleoceras*, suggesting that localized feeding environment (e.g., abundance of sand or dust) may have had more influence on DM than the amount of graze or browse. We conclude that DM contains a significant amount of phylogenetic noise that complicates dietary predictions for rhinos and possibly other non-ruminants. For rhinos, further investigation is likely to show that DM is more informative of environment or aspects of feeding ecology other than diet.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

STRATIGRAPHIC AND PALEOECOLOGICAL DISTRIBUTION OF ANTHRACOTHERES IN THE FAYUM, EGYPT

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Recent work on the spatial and temporal distribution of anthracotheres (Artiodactyla; Mammalia) from the Fayum, Egypt, provides new insight into their paleobiology and systematics. Anthracotheres are among the most common faunal elements in the Fayum, and the assemblage is currently understood as representing seven species in three genera: *Bothriogenys* (4 species), *Qatraniodon* (1 species), and a new and as yet undescribed bunodont genus (2 species). Previous work on the Fayum anthracotheres has focused on assessing their systematic relationships through detailed analysis of dental remains. We undertook the first study of Fayum anthracotheres, which combines morphological data, with stratigraphic control, and geological information. Results indicate that the anthracothere assemblage from Quarry L-41 (46 m level), which represents a long, deep, narrow back-swamp pond that developed distal to a large stream course, all belong to *Qatraniodon*, a taxon which is otherwise rare or absent at other Fayum localities. Quarry V (166 m) likely represents a quicksand deposit that developed on a distal floodplain, and much of the known sample of *Bothriogenys rugulosus*, as well one of the new undescribed bunodont species, come from this single locality. Quarries A and B (65 m), I and M (~ m 241), and L-75 (350 m), all represent gravelly sand, point bar deposits. This kind of depositional environment commonly yields the other new undescribed bunodont species, as well as *Bothriogenys andrewsi* (a very large and rare species), *B. gorringei* and *B. fraasi*, with *B. gorringei* being more common in the lower sequence (A, B), and *B. fraasi* being more common in the upper (I, M). In terms of paleobiology, our results indicate that Quarries L-41 and V represent two disparate, distal floodplain depositional

settings, and this information helps account for the presence at these localities of taxa that are otherwise uncommon or absent elsewhere. Results also suggest that anthracotheres were ecologically more diverse than has been appreciated, and therefore simply describing all of them as, 'hippo-like' may be obscuring more information than it reveals. In terms of systematics, results from this study serve as a cautionary tale about drawing phylogenetic trees without understanding anything about environmental context. For example, *Qatraniodon* occurs at L-41, and *B. rugulosus* at Quarry V, but our results suggest that other localities, even those roughly contemporaneous with these two sites, would be expected to yield other kinds of anthracotheres.

Symposium 2 (Friday, October 16, 2015, 3:45 PM)

ANTLERS OF THE ARCTIC NATIONAL WILDLIFE REFUGE: BASELINES OF BIOLOGICAL VARIABILITY FROM BONES ON THE TUNDRA

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Quantifying natural variability in geographic range (including patterns of landscape use and migration) is a primary concern for evaluating the current status of modern animal populations and planning for their future management and conservation. For most populations, however, this variability is modeled using datasets with limited temporal perspectives. This predicament is exacerbated in arctic settings, where logistical complexities frequently interfere with biological surveys and further complicate available data; including on economically and culturally keystone species, such as caribou (*Rangifer tarandus*). Antlers of caribou accumulating on landscape surfaces have exceptional potential to provide historical ecological data on seasonal landscape use because they are annually grown and shed by both males and females. Male antlers are shed post-mating, while pregnant females shed antlers in conjunction with giving birth (which can be > 10^2 km from mating areas). Thus, the geographic distributions of male and female antlers offer data on migration and calving areas (birthing grounds). Antlers can then survive on arctic landscapes for centuries or more. In collaboration with the US Fish and Wildlife Service, we used bone and antler surveys to quantify the historical variability of landscape use and calving ground distributions along the Coastal Plain of the Arctic National Wildlife Refuge (ANWR). We then evaluated recent landscape use (based on survey data initiated in the 1970s) against historical patterns. On the ANWR calving grounds, tens of thousands of caribou bare young annually within a limited duration and in concentrated areas. The resulting accumulations of shed female caribou antlers can be very large (> 1,000 antlers/km^2). Furthermore, relative to expectations from aerial surveys starting in the 1970s, many regions have higher-than-expected pre-1970 antler inputs. Additionally, the rank-order correlation between modern calving activity and the pre-1970 antler record is low, indicating a lack of congruence between modern and historical calving patterns. Antler surveys have also revealed high concentrations of female antlers (10^3 antlers/km^2) in regions that lack aerial survey or telemetry data, adding novel data on calving geography. Data from bone and antler surveys, which also provide insight into the formational processes of fossil records, place recent calving patterns within an historical ecological context and offer new data with which to contribute to adaptive management planning and policies.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

THE INTERPLAY OF SNOUT LENGTH AND FEEDING ECOLOGY BETWEEN ALLIGATOROIDS AND OTHER CO-OCCURING CROCODYLIFORMS

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Alligatoroids possess numerous hard parts and live in their depositional environment, meaning they have a good chance of entering the fossil record. Their physiology limits them to certain environments and climates based on temperature and freshwater availability. This makes them good indicator species for environmental change through time across their range. Compared to other crocodylian clades, their ecology seems to be more variable, running the gamut from small brevirostrine forms specialized in durophagy to large mesorostrine generalists to very large longirostrine forms of uncertain ecology. To determine if the plasticity of their snouts is due to competition with co-occuring crocodyliforms I compiled the age and crocodyliform faunas of formations containing alligatoroids, using a phylogenetic hypothesis of Crocodylia to determine whether snout length remained stable or changed as alligatoroids came into contact with other crocodylians or persisted after climate change extirpated the non-alligatoroids. I determined snout length category by measuring snout length relative to skull size.

In the warm Late Cretaceous, alligatoroids inhabited all three snout categories and occurred with meso- and longirostrine non-alligatoroids. This pattern persisted into the Paleogene, until non-alligatoroids were extirpated in now-temperate climates. In their absence, the snout length of alligatoroids sequentially increased, with brevirostrine forms persisting. By the time non-alligatoroids came back into contact with alligatoroids, which occurred in the Americas, alligatoroids once again inhabited all three snout categories. In the tropical climate of South and Central America, they continue to co-occur, but in temperate North America, *Alligator* and *Crocodylus* frequent different environments and their ranges barely overlap. This suggests that, in warm climates where more prey is available, more crocodylian species can inhabit each niche. But in temperate climates, alligatoroids are relegated to small, brevirostrine specialists when other crocodylians are present and outcompete them.

Symposium 3 (Saturday, October 17, 2015, 11:00 AM)

THE APPLICATION OF GEOMETRIC MORPHOMETRIC TECHNIQUES TO THE ANALYSIS OF DEFORMATIONS IN FINITE ELEMENT ANALYSIS

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Finite element analysis (FEA) is increasingly used to examine and compare the mechanical behaviour of skeletal elements of fossil and extant species. These studies usually result in strain contour maps of bones under various loading conditions. However, the interpretation of strain maps in terms of modes of deformation is not intuitive and the results of different loading on the same specimen, or similar loadings on different models, are not easy to compare. Issues of homology also arise when trying to compare strains at similar locations on different specimens/models. Geometric morphometric (GM) analysis is well developed in relation to the analysis of differences in, and covariations with, form in studies of evolutionary and ontogenetic change and of motion. The application of GM analyses to whole bone deformations predicted by FEA under different loading conditions enables deformations to be compared quantitatively, and so, the testing of hypotheses about how loads deform skeletal elements. This paper considers the bending of long bones and how deformations (strains and global changes in bone size and shape) due to loading scale with force, material properties, and size. The first uses a model of an armadillo femur to demonstrate how GM can be used to test hypotheses about the action of muscles attaching to the 3rd trochanter. The influence of longitudinal loading, hip abductor, and 3rd trochanter muscles on the deformation of the whole bone model can be directly compared. This example is also used to illustrate the effects of doubling the load and combining different loads in GM analyses. Further, the effect of similar loading on different models is demonstrated by using GM to compare the performance of a glyptodont femur with that of the armadillo under similar loading conditions. The second provides an example of how biomechanical hypotheses can be tested by using a model of a curved bone and comparing its performance with that of a straightened version of the same model obtained through warping. Finally, we alter the size a model to explore the relationships, in size and shape space as well as Procrustes shape space, between bone size, load magnitude, Young's modulus, and global deformations. This may lead to a method for examining allometry in relation to functional loading.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

INCREASED MAMMAL BETA DIVERSITY IN NORTH AMERICA DURING MIOCENE STRENGTHENING OF THE LATITUDINAL TEMPERATURE GRADIENT

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Faunal provinces are made up of geographically adjacent regions united by the presence of similar taxa. Environmental factors, such as the latitudinal temperature gradient, affect the distribution of biomes and preferred habitats of faunal constituents, thereby governing much of what distinguishes one faunal province from another. According to paleobotanical and paleoclimate data, the latitudinal temperature gradient gradually strengthened during the Miocene-Pliocene until biomes settled at near-modern latitudes, potentially resulting in more latitudinally-dissimilar faunal provinces and higher beta diversity overall. We tested this hypothesis via least-squares regression and cluster analyses of extant and fossil mammalian occurrence data from North and Central America, organized into regional collections corresponding to modern states and provinces. Fossil generic occurrences from the Hemingfordian and Hemphillian North American Land Mammal Ages (NALMAs) were compiled from the Paleobiology Database and MIOMAP, supplemented by primary and secondary literature, whereas modern generic occurrences were gathered from the Map of Life project. Pairwise faunal similarities were calculated using the Simpson coefficient and regressed upon corresponding latitudinal differences between regional collections. Confidence intervals for the respective slope coefficients indicate a significantly stronger negative correlation between faunal similarity and latitude in the Hemphillian relative to the Hemingfordian and no significant difference in slope between the Hemphillian and modern datasets. Cluster analyses revealed statistically significant agglomerative coefficients, a measure of the degree of clustering structure, in both the Hemingfordian and Hemphillian datasets, indicating the presence of distinctive faunal provinces during both NALMAs. The agglomerative coefficient for the Hemphillian dataset, however, is significantly greater than that of the Hemingfordian, suggesting greater dissimilarity between Hemphillian faunal provinces than Hemingfordian provinces. Taken together, these results indicate greater latitudinal dissimilarity between faunal provinces (i.e., higher beta diversity) as the latitude temperature gradient strengthened during the Miocene. Furthermore, our results contrast with a recent study indicating low beta diversity during the Hemphillian NALMA. This contrast could be potentially due to greater incorporation of low latitude occurrence data in our study.

Grant Information

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Technical Session XV (Saturday, October 17, 2015, 11:30 AM)

DEATH OF A COMMUNITY: SPECIES EXTINCTIONS ARE NOT INDEPENDENT

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Of all the evolutionary questions that paleontologists address, extinction is unique. Other evolutionary biologists lack not only the data, but even the potential to obtain the data, necessary to truly investigate the patterns and processes of extinction. When discussing extinction dynamics verbally, we often talk about complex ecological processes, like trophic cascades or competition; however, when estimating extinction intensity, or plotting extinction rates through time, the discussed processes are nowhere to be found. Instead, we treat extinction in formal models as if each species were independent, with the extinction of a species being solely the result of its traits and the time in which it lived. However, if two species with extremely similar morphologies co-exist in an environment, and that environment is perturbed to such a degree that both are threatened with extinction, should the two be treated as independent? Intuitively, at least in certain situations, the extinction of a competitor with similar morphologies should reduce the extinction risk of the remaining species around it. Likewise, if all of the prey species go extinct, the extinction of the predator should be treated as a certainty. If

competition for resources is strong enough to structure communities, then there should be a signature in the non-independence of extinction risk in co-existing species. To investigate this, I used datasets from the Karoo basin leading up to the end-Permian mass extinction, and the Hell Creek Formation, and modeled the extinction risk of predatory species as a function of their prey using a Bayesian Network Model adapted from theoretical ecology. I compared the results of this model to more traditional analyses, such as habitat-, size-, and ecology-biased extinction as well as a random "field of bullets" model. Preliminary data show that the network model predicted extinction risk as well as the best-fit traditional models for the two extinction events (using Akaike weights), while also providing information on other aspects of the extinction, such as the perturbation to primary productivity. This network approach is also readily adaptable to a variety of datasets beyond predators and prey, including morphological distinctiveness.

Technical Session VI (Thursday, October 15, 2015, 11:45 AM)

AN EXCEPTIONALLY PRESERVED EOCENE SHARK AND THE RISE OF MODERN PREDATOR-PREY INTERACTIONS IN THE CORAL REEF FOOD WEB

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Following extreme climatic warming events, the early Eocene Epoch saw a shift toward modern marine faunas characterized by the prevalence of acanthomorph teleosts and a trophic network crowned by carcharhiniform sharks. However, the reliance on tooth morphology has limited the systematic and paleoecological understanding of Paleogene sharks, and predator-prey dynamics in the Eocene marine food web remain poorly understood.

We report an exceptionally preserved fossil school shark (*Galeorhinus cuvieri*) from Pesciara di Bolca, Italy - a lagerstätte documenting a coral reef fish assemblage from near the end of the Early Eocene Climatic Optimum. Museo Geologico Giovanni Capellini (MGGC) 1976 reveals spectacular preservation of soft tissues including the brain, muscles, and visceral organs. The claspers indicate that the shark was a male, and the tooth series does not support sexual dimorphism in tooth morphology purported for this taxon. A growth curve of the living species of *Galeorhinus* fitted to *G. cuvieri* indicates that all six specimens of *G. cuvieri* from the lagoonal deposits of Bolca represent juveniles younger than 5 years in age. This biased representation is consistent with the living species of *Galeorhinus* in which juveniles occupy 'nursery' habitats. MGGC 1976 has stomach contents clearly identifiable as a sphyraenid acanthomorph (barracuda). This association provides evidence that a predator-prey relationship between *Galeorhinus* and *Sphyraena* in the modern coral reefs has an Eocene root.

These paleoecological insights suggest that modern trophic relationships between acanthomorph fishes and carcharhiniform sharks developed in scleractinian coral reef communities following the Reef Gap associated with the Paleogene thermal events. Ecomorphological comparison has identified similar community structures and high functional diversity of primary consumers between the Eocene Bolca and the modern Great Barrier Reef. The similarities were facilitated by anatomical innovations and ecological exploitations. In addition to these factors, the *Galeorhinus*-*Sphyraena* association suggests that predator-prey relationships across multiple trophic levels played a role in shaping attributes of the modern coral reef communities.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

EUTRICONODONT MAMMAL FROM THE LOWER CRETACEOUS KITADANI FORMATION, TETORI GROUP, FUKUI, JAPAN, AND ITS IMPLICATION TO THE FAMILY TRICONODONTIDAE

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The most recently described eutriconodont mammal from the Lower Cretaceous Kitadani Formation of the Tetori Group, Fukui Prefecture, central Japan, is an unnamed species possibly related to the Triconodontidae. It is known from a poorly preserved dentary (FPDM-V9172), which lacks a large part of its body but preserves a thread-like remnant of the Meckelian groove, a fragmentary crown, and the anterior parts of the masseteric and pterygoid fossae. Despite poor preservation, the CT images of FPDM-V9172 indicate that the five alveoli in the dentary belong to three molariforms, tentatively identified as m3–5. The mesial and distal roots of m4 are mesiodistally elliptical in horizontal cross section, and the anterior aspect of the mesial root of m4 bears a faint mesial concavity. The mesial concavity of the m4 root is interpreted to be a part of the interlocking mechanism between the adjacent lower molariforms, although it is slightly faint due to the breakage at the root. The fragment of m4 crown shows only the posterolabial parts of the cusps c and d. The ultimate alveolus in the anterior part of the coronoid is interpreted to belong to a single-rooted m5. It is smaller and shallower compared to the alveoli of the preceding molariforms.

The phylogenetic analysis using dental data matrix of the previous study conducted by a heuristic search of PAUP resulted in FPDM-V9172 being nested in the Triconodontidae as a sister taxon of the monophyletic alticonodontines (36 equally parsimonious trees; each tree has a length of 213 steps, a consistency index of 0.4225, a retention index of 0.7242 and a rescaled consistency index of 0.3060). The provisional result supports a potential affinity with the Triconodontidae, but FPDM-V9172 is not readily assigned to a certain genus of triconodontids; it might be a new taxon of this group.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

SKELETAL ANATOMY OF THE OLDEST KNOWN PARAREPTILE FROM THE UPPER CARBONIFEROUS OF PRINCE EDWARD ISLAND, CANADA

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Erpetonyx arsenaultorum was recently erected for a single, nearly complete, and mostly articulated skeleton of a bolosaurian parareptile collected from the Gzhelian-age Egmont Bay Formation of Prince Edward Island. *Erpetonyx arsenaultorum* is autapomorphic in possessing 29 presacral vertebrae and a relatively small radiale, fifth distal carpal, and pisiform. The skull is characterized by the presence of plicidentine and by the absence of caniniform maxillary teeth. The neural arches closely resemble those of the Early Permian lanthanosuchian *Delorhynchus cifelli* in their broadly tongue-shaped zygapophyses, in which the lateral edges of the anterior zygapophyses pass posteriorly onto the lateral surface of the arch and form a conspicuous shelves, emphasized by an anteroventral pocket. The right carpus is well ossified. The preserved unguals are also well ossified, with a prominent flexor tubercle, a suboval proximal portion, and a stout, slightly ventrally curved tip. Together with the observation that the unguals are longer than their respective proximal phalanges, ungual morphology suggests adaptation to a fossorial or semi-fossorial lifestyle. *Erpetonyx arsenaultorum* is the oldest known amniote with digging adaptations, appearing ca. 3–4 million years after the demise of the coal-swamp forests.

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Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

THE DEVELOPMENT OF BIRD TEETH FROM THE LATE CRETACEOUS OF ALBERTA

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Edentulous beaks are one of many defining characteristics of extant birds, although tooth loss occurred numerous times in coelurosaurs as a whole. Weight reduction for flight and shifts in diet associated with the development of a muscular gizzard have been proposed as potential selective pressures influencing tooth loss in Aves and their transition from carnivorous deinonychosaurian ancestors. Given the multitude of morphological transitions observed across theropods and birds, understanding changes in tooth growth rates will provide valuable information on the evolutionary pathways leading to endentulism in neornithine birds. We described and surveyed dental material from theropods and birds derived from the Late Cretaceous of Alberta and created thin sections in order to observe changes in rates of tooth replacement. Teeth attributed to Aves have been recovered from the Milk River (84.5–83.5 Ma), Dinosaur Park (77–75.5 Ma) and Horseshoe Canyon (72–68 Ma) formations of Alberta. Assignment to Aves is supported by the presence of distinct characteristics including a bulbous crown lacking in anterior and posterior denticles and basal constrictions between the crown and root similar to those in some crocodilians, troodontids, and the posterior teeth of *Microraptor zhaoianus*. Considerable morphological variation suggests the presence of distinct morphotypes that may represent a high degree of bird diversity.

Comparisons between growth line counts in birds and non-avian theropods may indicate different developmental rates that reflect evolutionary and dietary transitions over time. Transverse thin sections of isolated deinonychosaur teeth (*Dromaeosaurus albertensis*, *Paronychodon lacustris, Richardoestesia gilmorei, R. isosceles, Saurornitholestes langstoni,* and *Troodon formosus*) show distinct daily growth lines that establish a minimum rate of development within the jaw among particular species. A minimum of 45 growth lines was observed for *S. langstoni*. In contrast, preliminary results from thin sections of indeterminate avian teeth show a lack of definitive growth lines, suggesting shifts in developmental timing and rates of replacement. However, it is also possible that the degree of preservation may affect the observability of the growth lines in both theropod and bird teeth.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

COMPARISONS OF STABLE ISOTOPE TROPHIC NICHE METRICS IN EXTANT SMALL MAMMAL COMMUNITIES: IMPLICATIONS FOR UNDERSTANDING MAMMALIAN COMMUNITY COMPOSITION AT THE K-PG BOUNDARY

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It is necessary to analyze modern communities of small mammals to recognize the fundamental patterns in community-wide isotope metrics, which give insight into broad ecological composition. Stable isotope ratios of animal remains are an integrated function of all of the trophic pathways in the environment. Much like ecomorphology of a species can be defined in a 'morphospace', stable isotope information from a species or group of species can be positioned in an isotopic 'niche space'. Ecological community structure is difficult to parse out in the fossil record, but by studying characteristics of modern small mammal communities we can recognize markers of features such as niche size and trophic redundancy.

In this study, 'Layman metrics' used to measure trophic structure based on isotope ratios are calculated in the R package siar for all small mammal community studies available in the literature. Previous studies have been conducted in Africa and Asia, and new data are added in this study from small mammals of the British Isles. The general range of isotopes in question tells us the diversity of productivity at the base of the food web (carbon) and trophic levels (nitrogen). Other metrics are calculated-such as mean distance to centroid and mean nearest neighbor distance-which indicate the overall degree of trophic diversity and redundancy in the community, respectively. Results of the meta-

analysis show considerable breadth in the width of community niche structure of small mammals in mixed (open and forested) habitats, while in more homogeneous habitats (e.g., tropical rain forests) much smaller mean nearest neighbor distances (0.5 versus 0.75–1.1) indicate a considerable degree of trophic redundancy. Metrics of trophic redundancy are particularly interesting as they can suggest a lack of resource partitioning and competitive interactions between certain species with overlapping niches. Mean distance to centroid is relatively high (1.2–2.75) in all groups analyzed, indicating a high overall trophic diversity in all communities sampled regardless of habitat type. Communities of mammals shortly following the Cretaceous-Paleogene boundary were likely comprised of syntopic omnivorous, insectivorous, and small-bodied taxa, hence why the study of similar modern communities can give us deep time analogues. Understanding stable isotope trophic niche metrics in extant mammals allows us to have deeper insight into ancient small mammal communities and approach community paleoecology with a more quantitative framework.

Grant Information
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Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

A NEW SPECIES OF THE PHENACODONTID CONDYLARTH *ECTOCION*, FROM THE GAO MINE LOCALITY, (LATE PALEOCENE), PASKAPOO FORMATION, ALBERTA, CANADA

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The Gao Mine locality, a road-cut in the Paskapoo Formation east of Red Deer, Alberta, has yielded a rich assemblage of well-preserved mammalian fossils of late Paleocene age. At Gao Mine, *Ectocion* (Phenacodontidae, Condylarthra) is the most abundant taxon, represented by numerous dentigerous jaws, many nearly complete and containing unique information about dental ontogeny and replacement patterns in this genus. *Ectocion* occurs elsewhere in western Canada, represented by *E. collinus*, *E. osbornianus*, and *E. cedrus*, at sites ranging from early to mid-late Tiffanian (Ti1-Ti4b), but at none of these localities are *Ectocion* fossils as abundant or as well preserved as at Gao Mine. Dental characters imply that the Gao Mine fossils document a new species of *Ectocion*: molar dimensions indicate that this species was smaller in body size than *E. parvus*, hitherto the smallest known species of *Ectocion* with its small size attributed to influx to northern Wyoming of more southerly species at the Paleocene/Eocene Thermal Maximum; there is no evidence of significant temperature change at Gao Mine or correlative horizons elsewhere. In postcanine ratios other than morphological characters, the Gao Mine *Ectocion* most resembles *E. cedrus*, from Ti3-Ti4b localities in Wyoming, Montana and Alberta.

A preliminary phylogenetic analysis suggests that the Gao Mine *Ectocion* is crownward of *E. collinus* and *E. cedrus* and is the basal sister to the remaining species of the genus, helping to resolve a polytomy of *Ectocion* species obtained in previous works. This picture is complicated, however, by sparse evidence indicating the presence of a second, still smaller species of *Ectocion* at Gao Mine, a possibility awaiting the results of our continuing research.

Accompanying *Ectocion* at Gao Mine is a diverse mammalian assemblage, including multituberculates, marsupials, mixodectids, palaeanodonts, eulipotyphlans, plesiadapiforms, "cimolestans", carnivorans, and condylarths, mostly undescribed. Based on comparison with late Paleocene mammalian local faunas age elsewhere, supplemented by palynofloral evidence and paleomagnetic chronology (chron 25R), the Gao Mine local fauna appears to be late Tiffanian (Ti4b-Ti5a) in age.

Colbert Prize (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

NEW CRANIAL MATERIAL OF *BELLUSAURUS SUI* (DINOSAURIA: SAUROPODA) FROM THE MIDDLE-LATE JURASSIC SHISHUGOU FORMATION OF CHINA SUPPORTS NEOSAUROPOD AFFINITIES

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The sauropod dinosaur *Bellusaurus sui* was described in 1990 based on disarticulated juvenile material collected from a quarry in the Middle-Late Jurassic Shishugou Formation of Dinosaur Valley, Xinjiang, China. A joint expedition in 2003 between the Institute of Vertebrate Paleontology and Paleoanthropology and The George Washington University collected additional juvenile *Bellusaurus* specimens, tripling the amount of cranial material and providing significant new information on the morphology and systematics of the taxon.

We redescribe the holotypic cranial material and present new data for numerous referred elements. *Bellusaurus* is distinguished by a small foramen piercing the ascending process of the maxilla at mid-height, and exhibits other potentially diagnostic features (e.g., a tetraradiate squamosal; dimorphic upper and lower jaw teeth). *Bellusaurus* can be differentiated from penecontemporaneous Asian sauropods by a nearly complete crista interfenestralis (absent in *Nebulasaurus* and *Qijianglong*), a stepped palatine process of the pterygoid (absent in *Shunosaurus* and *Mamenchisaurus youngi*), and a frontoparietal fenestra and postparietal foramen (absent in *M. youngi, Omeisaurus tianfuensis,* and *Qijianglong*).

Phylogenetic analysis in TNT recovers *Bellusaurus* as a relatively basal macronarian, a hypothesis also proposed by some recent studies based mostly on postcranial data. Inclusion of new cranial data strengthens this hypothesis: *Bellusaurus* shares with neosauropods a preantorbital fenestra, a stepped palatine process of the pterygoid, and a dorsally flared distal margin of the paroccipital process. Support for specific interrelationships of early-branching macronarians is low. Nevertheless, cranial data suggest a close relationship between *Europasaurus* and *Bellusaurus*, as both possess an anteroposteriorly long frontal and deep penetration of the orbital rim into the skull roof, features previously identified as autapomorphic in *Europasaurus*. It is possible that the juvenile nature of the *Bellusaurus* material affects its inferred phylogenetic position; however, for several cranial characters that vary ontogenetically in sauropods, *Bellusaurus* exhibits the adult/derived state (e.g., deep quadrate fossa; mediolaterally elongate supratemporal fenestrae that are not widely spaced), suggesting stemward drift is unlikely. Our analysis strengthens the hypothesis that neosauropods were present in East Asia in the Jurassic, and we discuss sauropod biogeography in the Middle and Late Jurassic.

Grant Information
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Technical Session XIII (Friday, October 16, 2015, 2:00 PM)

THE EVOLUTION OF DIAPSID REPRODUCTIVE ECOLOGY AND INFERENCES ABOUT EXTINCT TAXA

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Diapsids show an extremely wide range of reproductive ecologies. Offspring can receive no care from their parents, care from only one sex, or care from both sexes. Some taxa have independent, super-precocial young, whereas others have altricial young, needing much care while young. Parents can invest heavily in a few young, or less so in a larger number of young. Here we examine the evolution of these traits across the Diapsida, based on a composite phylogeny spanning Testudines through Aves.

Generalized estimating equation (GEE)-based phylogenetic comparative methods demonstrate significant influences of body mass, parental care strategy and hatchling maturity on clutch volume across the Diapsida. The influence of polygamous reproduction is non-significant despite a large sample size. The results of these models support the hypothesis of paternal care in derived non-avian theropods, previously suggested based on simpler analyses.

The estimated character transition likelihoods across the composite phylogeny provide important data regarding the evolution of diapsid parental care strategies, demonstrating that the evolutionary transitions between biparental and maternal care, biparental and paternal care, and no care and maternal care are common (therefore evolutionarily simpler). Evolving from biparental care to/from no care or maternal care directly to/from paternal care is possible, but unlikely, and there is almost no chance of a taxon evolving from no care directly to paternal care (or vice versa).

Ancestral character reconstruction (ACR) of these care strategies with the character transition likelihoods estimated from the original data gives good confidence at most important nodes. The basalmost diapsids either showed no care or, slightly less likely, maternal care. Basal archosaurs likely showed maternal care, and the basalmost birds likely showed biparental care. Using these data to interpret the reproductive ecology of the Dinosauria suggests either maternal care at the root if pterosaurs can be confidently assumed to show no parental care, or biparental care if not. These analyses further highlight the diverse reproductive ecologies of the dinosaurs.

Technical Session I (Wednesday, October 14, 2015, 11:30 AM)

STABLE ISOTOPE PALEOECOLOGY OF THE EQUID *PARAHIPPUS LEONENSIS* FROM THE EARLY MIOCENE THOMAS FARM SITE (GILCHRIST COUNTY, FLORIDA)

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The importance of the early Miocene equid, *Parahippus leonensis*, in the evolution of modern grazing horses of the subfamily Equinae has long been recognized. Several important characteristics suggest an increase in grass consumption in *P. leonensis* compared to earlier equids, including an increase in molar crown height, presence of cement, increased wear rates, and a dental microwear pattern with an abundance of fine scratches. I used carbon ($\delta^{13}C$) and oxygen ($\delta^{18}O$) stable isotope compositions of a large sample (n=74) of *P. leonensis* tooth enamel, extracted from along the molar tooth row and from the base and apex of each tooth to control for ontogenetic effects. Standard pretreatment techniques were employed to avoid contamination from secondary carbonates and organics. The sampled specimens were recovered from a single early Miocene locality (Thomas Farm, Gilchrist County, Florida) to better document the paleoecology of this potentially transitional taxon as well as to further elucidate the paleoclimate of the important Thomas Farm locality.

Results from stable carbon isotope analyses reveal a significant increasing trend in $\delta^{13}C$ through ontogeny. This is interpreted as a nursing signal and influenced mean $\delta^{13}C$ in four of the six sample locations examined. Values of the unaffected adult $\delta^{13}C$ signals in the base samples of m2s and m3s range from -12.6‰ to -9.4‰ and have a mean of -11.2‰ (V-PDB). This indicates a diet of C_3 with either substantial incorporation of water-stressed C_3 plants or a very minor C4 component. Evidence of a diet based on water-stressed vegetation is corroborated by estimates of the $\delta^{18}O$ value of water ingested by *P. leonensis* that range from -3.2‰ to 3.99‰ with a mean of 1.45‰ (V-SMOW). These values are significantly higher than modern precipitation, river water, and $\delta^{18}O$ samples from modern horses of the same region in Florida. They more closely resemble $\delta^{18}O$ of modern lake water in north-central Florida. The indication of a high evaporation to precipitation ratio indicates a drier paleoclimate than was previously recognized for Thomas Farm.

Grant Information
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Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

EVOLVING EQUIDS: USING FOSSIL HORSES TO TEACH HIGH SCHOOL SCIENCE

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Equid evolution provides a unique platform from which to teach multiple topics within high school science education. The University of Florida has teamed up with high school science teachers to produce a curriculum centered on horse evolution. The curriculum presented here exploits a relatable and charismatic taxon to teach important topics including evolution, intraspecific variability, and climate change.

The first lesson utilizes replicas (i.e., casts and 3D prints) representing fifteen species of equids. The specimens range from the first North American equid, the early Eocene *Sifrhippus sandrae*, to a late Pleistocene horse, *Equus ferus*. Students use scaffolded instructions to measure the anterior-posterior lengths (APL) and crown heights of the fifteen teeth and calculate hypsodonty indices (HI). The students then plot the HIs for all fifteen teeth against geologic age of the horses. By plotting the predominant vegetation for each of the relevant Cenozoic epochs on the graph and identifying an increase in HI toward present, the students observe an evolutionary response of increased grazing as grasslands become more prevalent in the Miocene.

The second lesson provides the students with digital images of six teeth from the labial and occlusal views. The students are told these specimens have been collected from the same locality and are asked to hypothesize whether they are observing teeth from a single species or multiple species. Using newly introduced characteristics from the teeth including the isolation or connection of the protocone to the paracone and the complexity of the enamel plications, as well as previously calculated metrics (i.e., crown height, APL, HI), the class compares these teeth with the measurements to the species observed in lesson one. These comparisons are then used to identify which species the teeth represent. The goal is to demonstrate that intraspecific variability can be large, but is necessary for the adaptation of a species.

The final lesson in the curriculum confronts the common museum misrepresentation of equid evolution as linear, or orthogenetic. Students are given species cards representative of the horses they have studied and asked to integrate what they have learned over the first two lessons to construct a museum exhibit illustrating the complicated phylogeny in Equidae. This summative assessment allows students to synthesize the content they have learned throughout the curriculum and communicate it to their peers in a final presentation.

Grant Information

Frances C. and William P. Smallwood Foundation, National Center for Research Resources Science Education Partnership Award (1 R25 RR023294-01A2), NSF (PIRE 0966884)

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

MICRO COMPUTED TOMOGRAPHY PROVIDES INSIGHTS INTO *AZTLANOLAGUS* (MAMMALIA, LAGOMORPHA, LEPORIDAE) REENTRANT PATTERN

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Aztlanolagus agilis is a small leporine from the Pleistocene of North America. This pygmy rabbit appears in the early Pleistocene at a time of peak leporid diversity and became extinct at the end of the Pleistocene. The genus is a rare example of a small mammal lost in the terminal Pleistocene extinction, posing questions as to its ecology, particularly relative to its contemporaries (*Lepus* and *Sylvilagus*) that were able to survive this extinction event. *Aztlanolagus* appears to have originated from the North American *Nekrolagus progressus*.

The early Pleistocene Roland Springs Ranch Locality 1 (RSR-1) local fauna of Texas produced an isolated juvenile p3 with an *Aztlanolagus*-like occlusal surface pattern and a more *Nekrolagus*-like base pattern. The research focused on confirming the specimen's identity and investigated whether the exhibited patterns of the juvenile p3 could be differentiated from *Aztlanolagus* and whether the base of the tooth reflected the adult pattern. A comparative sample of 31 *Aztlanolagus* p3s (Fyllan Cave, Texas; Cathedral Cave, Nevada) was examined through micro computed tomography to assess the extent of reentrant pattern variation within and among individual p3s. Results demonstrated that pattern variation between the occlusal surface and base of isolated p3s was the greatest in juvenile specimens and a product of the ontogenetic expansion of the tooth surface dimensions. In contrast, adult specimens exhibited stable, relatively unchanging patterns throughout the hypselodont p3. Variation in reentrant size and form was documented within and between the comparative samples.

This combined range of variation demonstrated that the differing pattern forms exhibited by the RSR-1 p3 are well within the variation exhibited by the genus as a whole, confirming the specimen's identity as *Aztlanolagus*. Furthermore, the comparative sample and RSR-1 specimen, combined with additional examples from the literature, documented a chronomorph series defined by temporally concordant morphotypes of simple, moderate, and complex crenulations. This temporal variation is interpreted as an adaptation in food processing related to the changing composition of the grassland. The range of p3 pattern variation illustrated included forms that are comparable to *Nekrolagus progressus* and lend support to the hypothesis of a North American origin for *Aztlanolagus* from *N. progressus*.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

MIOCENE RODENTS (SCIURIDAE, JIMOMYIDAE, HETEROMYIDAE, CRICETIDAE) FROM PANAMA

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More than 70 teeth representing at least 10 species of rodents in four families (Sciuridae, Jimomyidae, Heteromyidae, Cricetidae) have been recovered from screenwashing three Miocene faunas along the Panama Canal in central Panama at about 9° North latitude. These represent the only known Miocene rodents from Central America. The oldest fauna is the earliest Miocene Lirio Norte Local Fauna (LF) from the Las Cascadas Formation, with a mammalian assemblage typical of the late Arikareean (Ar4) North American Land Mammal Age (NALMA) and an associated U-Pb zircon age of 20.93 ± 0.17 Ma. The slightly younger early Miocene Centenario Fauna from the Cucaracha Formation has a mammalian assemblage characteristic of the early Hemingfordian (He1) NALMA, two associated radioisotopic dates-a $^{40}Ar/^{39}Ar$ age of 18.96 ± 0.90 Ma and a U-Pb zircon age of 18.81 ± 0.30 Ma, and magnetostratigraphic data indicating that the vertebrate fauna occurs within chron C5Er (18.78–19.05 Ma). The Lago Bayano Fauna from the Chucunaque Formation is late Miocene (~8–10 Ma; late Clarendonian/early Hemphillian NALMA). Three species in the Sciuridae occur in the early Miocene Lirio Norte and Centenario faunas. A small chipmunk-like species similar to *Nototamias* occurs only in Centenario, whereas undescribed species of the large 'flying squirrel' *Petauristodon* are known from both faunas. A new species of *Petauristodon* from Centenario is the largest known member of this genus. Three species in the extinct family Jimomyidae are known from Lirio Norte and Centenario: the small *Texomys stewarti* from both faunas and two new medium to large species from Centenario that are similar to *Texomys* but probably represent an undescribed genus. *Texomys stewarti* is the only previously described Miocene rodent from Panama, and is the most common small mammal in the Panama Canal early Miocene faunas (>30 teeth). Two or three species of heteromyids similar to *Proheteromys* occur in the Panama Canal early Miocene faunas: one small species at Lirio Norte and a small and medium-sized species from Centenario. Two rodent teeth from the predominantly marine late Miocene Lago Bayano Fauna represent a hypsodont heteromyid similar to the mid to late Miocene North American genus *Cupidinimus* and a large cricetid. The early Miocene rodents from Panama are similar to late Arikareean and early Hemingfordian rodent faunas from southern North America, including the Ar3 Toledo Bend LF in Texas and the He1 Thomas Farm LF in Florida. The abundance and diversity of jimomyids is a unique feature of the Panama early Miocene rodent fauna.

Grant Information

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Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

DETECTING DIFFERENCES IN FORAGE IN C3-DOMINATED ECOSYSTEMS: MESOWEAR AND STABLE ISOTOPE ANALYSES OF MIOCENE BOVIDS FROM NORTHERN PAKISTAN

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The Siwalik Group sediments of the Potwar Plateau preserve a rich record of Middle and Late Miocene terrestrial mammalian evolution. Previous work on paleosol carbonates has documented the development of C4-dominated vegetation between 8 and 6 Ma, and analyses of enamel apatite have indicated the dietary presence of C4 resources in Siwalik equid teeth by 10 Ma. Other herbivorous families do not begin to incorporate C4 dietary resources until 8.5 Ma.

Here we combine mesowear and isotope analyses of Siwalik bovids to evaluate respectively the physical and chemical properties of ingesta. For the mesowear analyses, occlusal relief and cusp shape were assessed on upper molars. These observations were combined into a single mesowear score, ranging from 0–4, with higher values indicating more abrasive forage. Mesowear scores on 170 bovid teeth from fossil localities dating to between 14 and 6 Ma increase over time. For the entire sample, the average mesowear score was significantly higher in teeth from localities that date to <9.7 Ma (t-test, $p<.0005$).

Within the boselaphine *Selenoportax* lineage, the oldest Siwalik species, *S. vexillarius* has significantly lower mesowear scores than the youngest and largest species, *S. giganteus* (t-test, $p<0.002$, $n = 28$). Two time-successive species of the boselaphine *Miotragocerus*, *M. pilgrimi* and *M. punjabicus*, do not show a significant difference in mesowear (n=55), although the data suggest a trend toward increased abrasiveness in the diet of this lineage.

Carbon isotope analyses of more than 140 Siwalik bovid specimens indicate no consumption of C4 dietary resources until 7.5 Ma. These analyses include large samples of *Selenoportax* and *Miotragocerus*; 22 specimens from these two genera were also scored for mesowear.

The introduction of C4 vegetation to the ecosystem around 10 Ma correlates with an increase in the overall abrasiveness of C3 vegetation consumed by bovids. Climatic change resulting in more seasonal rainfall and/or more open habitats may be contributing factors to increased grit on forage detected by mesowear analysis.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

VARIATION IN DENTAL MORPHOLOGY OF MODERN AND FOSSIL HETEROMYID ASSEMBLAGES

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Small mammals are abundant and diverse in both the fossil record and modern assemblages, and can be used to understand the ecological processes that promote high species richness in relation to environmental conditions. Our research focuses on the rodent family Heteromyidae (kangaroo rats and pocket mice), whose diversification history in western North America coincided with significant environmental changes over the last 20 million years and whose extant members include several sympatric species. Modern species of co-occurring heteromyids partition their local microhabitats and dietary resources; however, to what extent niche partitioning occurred among fossil heteromyid species is unknown. We used dental morphology as an indicator of dietary ecology among modern heteromyid species and extinct species from the Middle Miocene of the Mojave Desert. We assessed the Middle Miocene heteromyid assemblage from a single paleosol stratum of the Crowder Formation in southern California. Local heteromyid diversity (six species) reflected high regional diversity in a mixed forest and C_3 grassland ecosystem with rainfall estimates of ~800 mm per year. In contrast, modern communities of heteromyids are most diverse (typically three or fewer species) in desert ecosystems with low precipitation and seasonal variation in food resources. Using linear measurements and geometric morphometrics, we analyzed tooth-crown height and occlusal surface area and shape of fossils from the Crowder Formation and modern species from four communities in Utah. We found greater overlap in tooth shape among fossil species than among co-occurring modern species. Results vary according to the tooth position analyzed, with the upper first molar-lower fourth premolar pair and the fourth premolars having the greatest variation in occlusal shape among the fossil and modern species, respectively. Significant differences in occlusal area and hypsodonty among co-occurring modern species contrast with heteromyid species from the fossil assemblage, which do not vary significantly in either dental trait for most tooth positions. These results suggest that partitioning of dietary resources was less pronounced in the Crowder ecosystem despite greater species diversity. Increased productivity and greater resource availability during the warmer, wetter conditions of the Middle Miocene Climatic Optimum may have reduced competition and niche partitioning among fossil species, although other traits may also be important for ecological differentiation of species.

Technical Session XVI (Saturday, October 17, 2015, 10:15 AM)

EMBRYOS REVEAL NOVEL DEVELOPMENTAL TRAJECTORIES IN THE EVOLUTION OF CROCODYLIAN CRANIAL SHAPE

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Although the evolution of the crocodylian secondary palate and cranium are well understood, the patterns of snout and skull shape evolution among crown crocodylians remain contentious. Specifically, the homology of slender snouts in the genera *Tomistoma* and *Gavialis* have been questioned because molecular and morphological phylogenies consistently disagree. Molecular, discrete morphological, biomechanical, and geometric morphometric (GM) approaches have all been used to test hypotheses about the evolution of crocodylian snout shape, but developmental data are underrepresented. We present new GM analyses that, for the first time, integrate embryonic and post-hatching craniofacial ontogeny with evolutionary transformations informed by fossils to test the homology of slender snouts and their developmental patterns.

To determine the polarity of evolutionary transformations in crocodylian skull shapes, we performed 2D and 3D GM analyses on photographs and µCT scans using both molecular- and morphologically-derived phylogenetic topologies. Our dataset included embryonic ontogenetic series five species (*Alligator mississippiensis*, *Crocodylus moreletii*, *C. siamensis*, *Mecistops cataphractus*, and *Osteolaemus tetraspis*) that represent most of the major adult cranial shapes found in extant crocodylians (i.e., generalized, slender-snouted, and blunt-snouted) as well as post-hatching ontogenetic series for all extant crocodylian and available extinct species. In addition, we performed the same analyses using limited datasets (e.g., using only extant species or only adults of all species).

Our data show that adult alligatorids, crocodylids, and gavialoids possess distinct cranial shapes. However, *Tomistoma* overlaps Crocodylidae and is distinct from *Gavialis*. Embryonic specimens of all species cluster in a unique part of blunt-snouted morphospace. We conclude that slender-snouted forms develop their characteristic morphology after hatching. Slender-snouted crocodylids overlap with *Tomistoma* and have similar ontogenetic trajectories, suggesting a shared developmental pattern. However, *Gavialis* juveniles already cluster with adult conspecifics and their ontogenetic trajectory appears to proceed in the opposite direction. Our study suggests that slender snouts evolved independently several times within Crocodylidae, with or without *Tomistoma*, by co-opting similar developmental trajectories. However, *Gavialis* develops a slender snout in a novel way compared to all other living crocodylians.

Technical Session XI (Friday, October 16, 2015, 8:00 AM)

A NEW SMALL SPECIES OF *ARCTODONTOMYS* (MICROSYOPIDAE, EUARCHONTA) FROM THE PALEOCENE-EOCENE THERMAL MAXIMUM AND THE EFFECTS OF GLOBAL CLIMATE CHANGE ON MICROSYOPINES

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The Paleocene-Eocene Thermal Maximum (PETM) was a brief interval of major global warming beginning ~56 Ma and lasting ~200,000 years. The PETM is associated with changes in the terrestrial biota of North America, including the first appearance of several modern mammalian groups, a decrease in body size in multiple mammalian lineages, and a flora distinct from known plant communities bracketing it. Microsyopidae, a group of euarchontan mammals often considered stem primates ("plesiadapiforms"), is represented during the PETM by the small-bodied uintasoricine *Niptomomys* and the much rarer, larger microsyopine *Arctodontomys*. Here we document the occurrence of a new species of *Arctodontomys* from the PETM of the Bighorn Basin, Wyoming. The crown areas for all known upper and lower teeth of the new species fall below those documented for *Arctodontomys wilsoni* from later in the Wasatchian (Wa1–4) North American Land Mammal Age. The new species is further characterized by relatively low, bunodont premolar and molar cusps and a high degree of enamel crenulation. Compared to *A. wilsoni* the area of M^3 is smaller relative to that of M^2, due mainly to a reduction in M^3 length. This parallels the pattern of relative tooth size difference observed for other small-bodied PETM mammals. Intra-generic body size differences through the PETM have been documented in ~40% of mammalian taxa, with shifts to smaller body size as temperatures increase during the PETM and shifts to larger body size as temperatures cool at the end of the event. Based on estimates from M_1 area, the new species is estimated to be ~40% smaller in terms of body size than later occurring *A. wilsoni*, which falls within the range of intra-generic body size differences described for other PETM mammals. The new species is found only at stratigraphic levels corresponding to the interval of hottest PETM temperatures in the southeastern Bighorn Basin. Specimens of *A. wilsoni* first occur in this area just following this interval, during the terminal portion of the PETM. The distinct dental morphology not related to size of the new species suggests that it may have been a transient immigrant to the Bighorn Basin, possibly tracking plant communities as they extended their range northward. A similar explanation may also apply to the first appearance of the diminutive *Microsyops cardiorestes*, a likely immigrant microsyopine known from middle Wasatchian strata corresponding to the Eocene Thermal Maximum 2 warming event ~2 million years later.

Grant Information

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Technical Session VI (Thursday, October 15, 2015, 12:00 PM)

PHYSIOLOGICAL CONSTRAINTS ON THE HIGHEST PALEOTEMPERATURE RECORDED BY VERTEBRATE FOSSILS 1: LIFECYCLE CONSTRAINTS

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Paleotemperature is usually derived from chemical information captured during mineralization of metazoan hard tissues. Among vertebrates, conodont and, less frequently, fish fossils are used as the source of such information. The highest temperatures recorded by these vertebrates is expected to be constrained physiologically through the upper thermal tolerance of relevant species. The highest paleotemperatures were reached during greenhouse periods near the equator, where temperature fluctuation is expected to have been minimal both diurnally and annually. Vertebrates that recorded these temperatures therefore were able not only to grow but also to complete their lifecycles under such a temperature. We therefore investigated the maximum constant temperature under which actinopterygian fishes can physiologically complete their lifecycles.

Upper thermal tolerance of metazoans is said to be constrained by oxygen supply that decreases relative to metabolic rates at higher temperatures, whereas fishes are most vulnerable to heat during gametogenesis and early embryogenesis. We therefore built a mathematical model of egg oxygen supply to calculate the threshold combinations of egg diameter and temperature at which diffusion can transport minimally sufficient amount of oxygen to sustain the basic metabolism of early embryos.

The model suggests that the thermal tolerance is higher in smaller eggs, and published data of egg size and spawning temperature support this inference. Egg size of actinopterygian fishes is largely conserved across taxa, with a mean diameter of 1 mm for spherical marine eggs. At this size, oxygen supply falls below metabolic demands as the temperature reaches 36°C. Evolving smaller eggs may help raise the tolerance but there is a limit to such shrinkage. Egg size is directly proportional to hatching length, while it is known that too small a hatchling cannot feed properly because of Reynolds numbers. Gametogenesis is even more heat sensitive than early embryogenesis in fishes, by a few degrees. Reflecting these conditions, there is no record of actinopterygian fishes reproducing at temperature higher than 34°C. The same constraints on reproductive temperatures most likely applied to conodonts. We conclude that paleotemperature estimates higher than about 34°C need to be carefully examined.

Technical Session X (Friday, October 16, 2015, 11:30 AM)

MICROSCOPIC AND IMMUNOHISTOCHEMICAL ANALYSES OF THE CLAW OF THE NESTING DINOSAUR, *CITIPATI OSMOLSKAE*

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Arguably one of the most well recognized fossil specimens is *Citipati osmolskae* (IGM 100/979), an oviraptorid dinosaur discovered in a brooding position on a nest of unhatched eggs. When this specimen was described in 1995, a thin lens of white material extending from the manual claw of digit I was proposed to be the remains of the original keratinous sheath covering the ungual, but until now this hypothesis has not been rigorously tested. Three-dimensional preservation of non-biomineralized materials in life position suggests the possibility that original molecular composition may also be retained and recoverable. We used electron and transmitted light microscopy to show similar microstructural organization when compared to the claw sheath of extant birds. Fossil material compared favorably in morphology, microstructure and location to claw sheath tissues from extant birds. In Recent birds, claw sheath material consists primarily of two structural proteins; alpha-keratin, expressed in all vertebrates, and beta-keratin, found only in reptiles and birds. We applied immunological techniques to demonstrate that fossil tissues respond with the same specificity and similar binding patterns to living birds when exposed to antibodies raised against protein extracts of avian feathers. Controls were negative for binding. Furthermore, we show that calcium chelation greatly increased antibody reactivity, signifying a role for calcium in the preservation of similar fossil material. This exceptional specimen suggests that the three dimensional preservation of non-biomineralized material in the rock record may be correlated to molecular preservation.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

THE CETACEAN FAUNA OF THE UPPERMOST MIOCENE SENHATA FORMATION OF CHIBA, JAPAN: INSIGHT INTO PALEOBIOGEOGRAPHY

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The uppermost Miocene Senhata Formation is known for yielding abundant marine vertebrate fossils including cetaceans. This fauna is very important from four points of view. First, the fauna is the only subtropical cetacean fauna of the western North Pacific at that age. Second, geological age of the fauna is well constrained (6.3–5.7 Ma). Third, the fauna include extant genera. Fourth, the fauna is represented by various taxa from coastal to pelagic environments. Except skulls of a ziphiid and a new species of Inioid, most of specimens are fragmentary (e.g., isolated periotic, tympanic bulla, tooth, and rostrum). However, these materials are sufficiently useful for assessing taxonomic diversity. The Senhata Fauna includes at least three mysticete and five odontocete species: Thalassotherii gen. et sp. indet., Balaenopteridae gen. et sp. indet., Physeteroidea gen. et sp. indet. (basal physeteroid), *Kogia* sp., Kogiidae gen. et sp. indet., Ziphiidae gen. et sp. indet., *Mesoplodon* sp., Inioidea gen. et sp. indet., Inioidea gen. et sp. nov., and Delphinoidea gen. et sp. indet. To compare with the late Miocene cool temperate cetacean fauna of Hokkaido, the Senhata Fauna is more diverse in superfamily and family levels; Thalassotherii, Balaenopteridae, basal physeteroids, Kogiidae, and Inioidea are absent in the fauna of Hokkaido, whereas the fauna of Hokkaido includes several diagnosed delphinoid species (Delphinidae and especially Phocoenidae). However, another undescribed cetacean collection of the Senhata Fauna includes several delphinoid ear bones. Hence, the Senhata Fauna probably reflects near the original fauna in superfamily and family levels. Difference of taxonomic composition between the two faunas are probably caused by difference of average annual water temperature and sampling bias. More detailed study of the Senhata Fauna will enable comparisons with faunas in other areas of the Pacific Ocean and will contribute to our understanding of the origin of extant genera within the Cetacea.

Colbert Prize (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

PUTTING THE 'ANCESTOR' IN ANCESTRAL STATE RECONSTRUCTIONS: PHYLOGENIES WITH FOSSIL TIPS REVEAL HIDDEN EVOLUTIONARY PATTERNS IN SMALL MAMMALS

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There has been an explosion of interest in ancestral state reconstruction methods, in which the values of a given trait for an ancestral node are inferred from information present in tip taxa. The vast majority of such studies have been performed using molecular phylogenies that only include trait and genetic data from extant tip taxa. Such practices ignore the rich information present in the fossil record.

To address the contribution that fossils bring to such analyses, we examined a series of independent case studies in Afroinsectiphilian and Eulipotyphlan mammals. We compared the results of ancestral state reconstructions and evolutionary process analyses with and without fossil data. Implementing the new Fossilized Birth-Death Model in BEAST 2.2, we created two separate phylogenies for each focal mammal clade: (1) a molecular phylogeny of only extant taxa, and (2) a molecular phylogeny including both extant and extinct taxa, with fossils assembled as tips. We examined the reconstruction and evolution of both discrete and continuous characters, including body size, dentition (dilambdodonty, zalambdodonty), ecotype, and mandible mechanical potential. Trait data for extant species was drawn from natural history literature and the database PANTHERIA; we calculated the traits of extinct species using independent measurement of relevant characters and published scaling equations.

We found substantial disagreements in the reconstructed traits in analyses with and without fossil tips, highlighting a clear need for the inclusion of fossil data. For example, analyses of body evolution revealed significant differences between nodal values when incorporating fossil taxa, including events of size reversal unseen with extant taxa alone. Analyses of ancestral dilambdodonty/zalambdodonty dentition states further show distinct differences when including fossils. Models of trait evolution vary as a result of fossil inclusion, shifting best-fit models from Brownian to Ornstein-Uhlenbeck, and vice versa.

These discrepancies provide a clear need for paleontologists to be involved in studies of ancestral state reconstruction and trait evolution, and to harness the potential of new phylogenetic methods that facilitate the simultaneous analysis of extinct and extant taxa.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

NEW PTEROSAUR MATERIAL FROM THE LATE CRETACEOUS OF NORTH TEXAS

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Cretaceous strata of Texas have yielded an unexpectedly rich collection of pterosaurs that differ substantially from the prolific, *Pteranodon*-dominated assemblages of the Western Interior. Two new pterosaur specimens from the Upper Cretaceous Eagle Ford Group in the Dallas–Fort Worth area enhance our understanding of the fragmentary record of Texas pterosaurs. One specimen (SMU 76892), discovered in the upper Cenomanian portion of the Britton Formation, consists of the rostral section of an upper jaw that bears a prominent, thin premaxillary crest beginning just above the fourth pair of alveoli. The preserved portion of the jaw contains alveoli for 26 teeth, and there is a subtle lateral expansion at the anterior end of the jaw. This partial rostrum is identified as a new species of *Cimoliopterus*, a monotypic genus previously known only from Cenomanian deposits in England, and represents a significant geographic range extension for this genus. The second new specimen from the Eagle Ford Group (SMU 76942) is a partial upper jaw of *Aetodactylus halli*, heretofore known only from mandibular material. The jaw fragment was collected at the type locality of *A. halli* in the middle Cenomanian Tarrant Formation. The dorsoventrally compressed specimen represents part of the anterior half of the jaw, although the exact position within the palate cannot be determined with certainty. The ventral surface bears a thin palatal ridge, and the dorsal surface preserves no evidence of a premaxillary crest. Patterns in tooth spacing along the upper jaw are similar to those observed in the holotype mandible of *A. halli* (SMU 76383). A phylogenetic analysis of Pterosauria that incorporates the new *Cimoliopterus* species and new codings for the upper jaw of *Aetodactylus* indicates that both taxa are basal pteranodontoids. *Aetodactylus* and *Cimoliopterus* appear closely related, but are clearly distinct from each other. Identification of *Cimoliopterus* in North Texas provides further evidence of paleobiogeographic links between the Cretaceous pterosaur faunas of North America and Europe. Discovery of the upper jaw of *Aetodactylus* confirms that this pterosaur lacked both premaxillary and mandibular crests.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

MAXIMUM GROWTH RATE DOES NOT DETERMINE DINOSAUR METABOLISM

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The growth rate of dinosaurs is interesting in its own right, but an additional motivation for many previous studies is to use growth rates to determine dinosaur metabolism. They compare the allometric scaling of maximum growth rate (G_{max}) with body mass (M) for dinosaurs with that for extant groups in order to classify dinosaur metabolism as endothermic, ectothermic or something in between. Recent studies have focused on improving the metabolism estimate by using larger data sets for both dinosaurs, and for extant species they are compared to. However those studies have not revisited the foundational question – is there any correlation between growth rate and metabolism? Kleiber's Law holds that basal metabolic rate $BMR = a\,M^b$, and previous studies have shown that, with reasonably high correlation, $G_{max} = c\,M^d$ with roughly similar exponents $0.6 < b, d < 0.9$ depending on the taxonomic group. Counterintuitively, it does not follow that G_{max} is related to BMR, because statistical correlation is not transitive. Unfortunate choices in regression variables used in prior studies confounded this relationship with spurious correlation because G_{max} has M as an explicit factor. With the correct choice of variables (maximum mass-specific growth rate rather than G_{max}) the data available show no correlation between growth rate and BMR. In addition, the practice of using regressions across dinosaur taxa as a means to classify all dinosaurs is not valid. BMR and G_{max} are both properties of individual species; if they are correlated then that should occur at the individual species or taxon level. Group-wide regression or averages are inappropriate for classifying metabolism. This is an example of a famous problem in statistical inference known as the 'ecological fallacy'. On an individual basis, the growth rates of dinosaur taxa overlap with those of both endothermic and ectothermic extant animals. The same occurs for extant groups: mammalian growth rates overlap those of other endotherms (precocial birds) as well as ectotherms like squamates and teleost fish. One cannot determine metabolism via growth rate studies for either dinosaurs or extant animals.

Technical Session XV (Saturday, October 17, 2015, 8:00 AM)

PROBOSCIDEAN JAW MUSCLE MECHANICS AND THE EVOLUTION OF FEEDING AND THE PROBOSCIS IN ELEPHANTS

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Proboscis evolution in elephants has been anecdotally suggested to coincide with the initial lengthening of the mandibular symphysis in the more basal gomphothere proboscideans. Secondary shortening of the symphysis in extant elephants likely led to the adaptation of an elongate proboscis acting as a muscular hydrostat. Additionally, the caudally-oriented temporalis in long-jawed gomphotheres has been qualitatively hypothesized to have produced an orthal power stroke, whereas the derived vertical temporalis seen in extant short-jawed elephants forms a sling allowing the masseter and

pterygoids to produce a more proal, or rostrally-oriented, power stroke. This study aims to find evolutionary trends in jaw musculature, mechanics, and the secondary shortening of the mandibular symphysis throughout elephant evolution. With lateral views of the skull in 18 proboscidean taxa representing all levels of the clade, the angle of muscular line of action of both temporalis and masseter were quantified by connecting origin and insertion centroids. 2D lever arm methods were used to quantify and evaluate evolutionary shifts in temporalis, masseter, and resultant muscle vectors and their mechanical advantages in order to interpret their effect on chewing style and bite force. All results of log-transformed least-squares regressions were significant (at $p < 0.05$) and corroborate previous hypotheses of temporalis and masseter lines of action and power stroke orientations. An increased trend is seen from lower temporalis and masseter angles in long-jawed proboscideans to higher temporalis and masseter angles in short-jawed proboscideans. Additionally, there is an inverse relationship between increased resultant muscle vector angle and decreased length of the mandibular symphysis relative to the tooth row. Mechanical advantage with respect to the middle of the tooth row increases with increased vector angle of temporalis, masseter, and their averaged resultant. A much stronger correlation is seen in the relationship between increased masseter angle and its mechanical advantage than in that of temporalis, indicating an increased trend toward masseter use in taxa with a more vertical temporalis. A majority of taxa with high temporalis and masseter angles and short mandibular symphyses show higher mechanical advantage values overall. This shift in jaw mechanics conveys a clear change in feeding behaviors throughout taxa, giving insight into the evolution of feeding as well as the importance of proboscis use in extinct as well as extant proboscideans.

Colbert Prize (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

MOBILITY OF THE NECK OF *NICHOLLSSAURA BOREALIS* (PLESIOSAURIA; LEPTOCLEIDIDAE) FROM THE LOWER ALBIAN OF NORTHWESTERN ALBERTA

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Plesiosaurs are enigmatic marine reptiles that inhabited the Mesozoic seas for 135 million years. This group exhibits one of the most unusual body plans in the fossil record, characterized by an elongate neck and paddle-like flippers. The evolutionary ecology of their elongate neck is poorly understood, and this trait has not evolved in any other marine vertebrate since. To understand the ecological role of an elongated neck, it is important to explore the factors that influence neck mobility. The centra, neural spines, zygapophyses, and ribs are four anatomical constituents of the plesiosaur cervical vertebrae that are biomechanically important because of their interactions during motion. This study aims to estimate the range of movement along the length of the plesiosaur neck by measuring inter-cervical vertebral mobility.

A 3D model of the leptocleidid plesiosaur *Nichollssaura borealis* (TMP 1994.122.0001) was generated using segmented CT scans to assess morphological changes along its cervical series. Landmarks were placed along the model to quantify the morphological variation of the vertebrae. *N. borealis* was an appropriate candidate for CT scanning because of its exceptional preservation, complete articulation, and small body size (2.6 m).

The morphology of the cervical vertebrae of *N. borealis* suggests decreased neck mobility caudally. The centra are amphiplatyan; this condition, paired with increased centrum dimensions reduces intervertebral spacing and room for mobility. An increase in neural spine height and angle caudally may also reduce mobility in this direction by reducing the potential area of movement. The cervical ribs increase in length and size caudally, which likely increases stability from torsional forces. The vertical angle of the zygapophyses also increases caudally, corresponding to decreased lateral mobility between vertebrae in this direction. These observations are consistent with previous work that suggests a similar decrease in lateral and dorsoventral mobility caudally in the neck of closely related elasmosaurid plesiosaurs.

N. borealis was piscivorous, and therefore likely highly maneuverable or else employed ambush predation. The plesiosaur neck may have evolved to become relatively rigid and streamlined to resist hydrodynamic forces, as have the bodies of most marine vertebrates. Understanding neck mobility will illuminate the predation strategies, and ecological role of *N. borealis* and other plesiosaurs during their time in the Mesozoic seas.

Grant Information
NSERC Discovery Grant 307756-2011 to J. Anderson

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

THE CEPHALIC SHIELD OF THE EARLY PLEISTOCENE PAMPATHERE *HOLMESINA FLORIDANUS* (XENARTHRA, CINGULATA, PAMPATHERIIDAE)

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The cephalic shield of cingulates is a structure comprised of sutured osteoderms that is highly variable in overall shape and number of osteoderms across different taxa. Cephalic shields of the extinct giant armadillos (pampatheres) are poorly known. The late Blancan Haile 7G locality in north-central Florida has produced the largest known assemblage of pampatheres from a single site; over 40 individuals of the species *Holmesina floridanus* represented by partial to nearly complete skeletons. Of these, 11 preserved the skull, four with nearly complete cephalic shields. The cephalic shield of *H. floridanus* comprises ~75 osteoderms and is very broad, only slightly longer than wide. The shield is bilaterally symmetrical, with the widest point in the middle at a protuberance along the dorso-posterior orbital margin. The cephalic osteoderms are smaller and thinner than carapacial osteoderms of the same individual. Most interior cephalic osteoderms are polygonal, typically five or six-sided, and asymmetrical. Peripheral osteoderms are four or five-sided with rounded over distal edges that lack a suture. The posterior-most peripheral osteoderms are four-sided, rectangular, and align in a straight row transversely. The majority of osteoderms have a faint central keel dorsally that is most prominent towards the margins of the shield. The anterior edge of the interior osteoderms have a lowered band with pits of varying depth and width for hair follicles and/or sweat glands, while the posterior edge lacks the band. The cephalic shield of glyptodonts differs from that of *H. floridanus* in having fewer cephalic osteoderms with a characteristic rosette pattern. The cephalic shield of *H. floridanus* greatly differs from that of *Dasypus novemcinctus* among extant dasypodids; the latter having a much more narrow head shield with a greater number of osteoderms and posterior peripheral osteoderms that come to a point posteriorly. By contrast, the cephalic shield of *H. floridanus* is most similar to that of *Euphractus sexcinctus* in having a similar osteoderm count and shape, being overall broad and widest medially at the postorbital protuberances, narrowing anteriorly and posteriorly, and having the posterior peripheral osteoderms align in a straight row. An analysis of cephalic shield length and width ratio to cephalic osteoderm count of cingulates indicates that the cephalic shield of *H. floridanus* is most similar to *E. sexcinctus, Chaetophractus*, and *Zaedyus pichiy* and is consistent with previous hypotheses that closely unite euphractines and pampatheres.

Grant Information
NSF Grant CSBR 1203222

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

FIRST OCCURRENCE OF A MIOCENE SQUALODELPHINID (CETACEA, ODONTOCETI) FROM WASHINGTON STATE

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The Squalodelphinidae is a family within the Platanistoidea. The Ganges River dolphin, *Platanista gangetica*, is the only representative of the Platanistoidea today. As they were a group of very early diverging odontocetes, their distribution, morphology, and phylogeny is important to understanding the radiation of toothed cetaceans in the Miocene. The Squalodelphinidae are known from both sides of the Atlantic and Pacific and were a group of dolphins ranging from small (1.2 meters) to medium (2.5 meters) in body size. They possessed single-rooted teeth and an elongate rostrum as well as obvious skull asymmetry. In addition, squalodelphinids possess thickened supraorbital regions, a feature that they share with their sister taxon, the Platanistidae. Here we report the first known squalodelphinid from the Olympic Peninsula of Washington State. Washington's odontocete fossil record is remarkable in its diversity and excellent preservation of specimens. UWBM 87105, from the lower Miocene Clallam Formation, is a partial skull with associated ribs and caudal vertebrae that we refer to as Squalodelphinidae indet. The skull of UWBM 87105 lacks the cranium and associated ear ossicles, but the preserved premaxillae, maxillae, and frontals possess enough characters to ally it with the Squalodelphinidae. UWBM 87105 has single rooted teeth indicated by preserved alveoli on the maxilla. Skull asymmetry is noticeable despite damage to the specimen post-burial: the left antorbital process of frontal projects further than on the right. In addition, there is a large foramen and posterior sulcus that is completely absent on the right side. Like other squalodelphinids, UWBM 87105 has thickened frontals that form a process over the orbit. Newly published cladistic studies have allowed us to quantitatively assess the relationships of the Washington fossil. Placing UWBM 87105 into this tree supports the hypothesis that it is a basal squalodelphid, potentially affiliated with another basal squalodelphid, *Huaridelphis*. Establishing UWBM 87105 as Squalodelphidae indet. adds data to the recessional shallow marine environment preserved in Washington State, and adds to the diversity of extinct dolphins in the northeast Pacific Ocean.

Technical Session XVI (Saturday, October 17, 2015, 9:00 AM)

THE ANATOMY OF *ASILISAURUS KONGWE* (DINOSAURIFORMES: SILESAURIDAE) AND CLOSELY-RELATED TAXA PROVIDES NEW INSIGHTS INTO THE ANATOMICAL AND CHRONOLOGICAL EVOLUTION OF DINOSAURIFORMS

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Asilisaurus kongwe, from the Middle Triassic Manda beds of southwestern Tanzania, is one of the oldest known ornithodirans and provides new insights into early dinosauriform evolution. Originally represented by disarticulated bones and one semi-articulated partial skeleton from a single locality, recent fieldwork has yielded six sites at approximately the same stratigraphic level, with specimens representing nearly the entire skeleton. A new, exquisitely preserved skeleton of a single individual includes much of the skull, pectoral girdle, forelimbs, pelvis, hind limbs, and tail, and confirms that all of the original, largely disarticulated material belongs to *Asilisaurus*. The skeleton of *Asilisaurus* shares several plesiomorphic character states with other dinosauriforms, including a well-developed metatarsal I with a distinct articulation surface for a phalanx, a calcaneum with a clear tuber, a closed acetabulum, and a short deltopectoral crest. Additionally, *Asilisaurus* shares several features with *Silesaurus* and other putative silesaurids (e.g., *Sacisaurus*), such as teeth ankylosed with the jaw, a distinctive scar on the proximal surface of the femur, a bony pointed beak at the rostral tip of the lower jaw, and a notch at the base of the femoral head. Classic 'dinosaurian' character states, such as the upper temporal musculature extending onto the frontal and epipophyses on the cervical vertebrae, must be considered plesiomorphies given the phylogenetic position of *Asilisaurus*. The nearly complete osteology of *Asilisaurus* allows re-evaluation of other problematic taxa; *Agnosphitys* and *Lewisuchus* share apomorphies with *Asilisaurus* and thus represent silesaurids with a carnivorous dentition. Our comprehensive phylogenetic analysis demonstrates that silesaurids are monophyletic and fall just outside Dinosauria (which is diagnosed by very few character states). The most derived silesaurids (e.g., *Silesaurus*, *Sacisaurus*) share features with both ornithischian and theropod dinosaurs,

illustrating the high degree of convergence among dinosauriforms in the Triassic. In addition, the results of our cladistic analysis imply at least three independent transformations towards quadrupedality and herbivory. The frequency of dietary (carnivorous vs. herbivorous) and locomotor (quadrupedal vs. bipedal) shifts within Dinosauriformes appears unique within Amniota.

Grant Information
National Science Foundation EAR-1337569, EAR-1337291, and EAR-1336986

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

REAL TIME OUTREACH BETWEEN PALEONTOLOGISTS AND THE PUBLIC, THOUSANDS AT A TIME, USING THE MODERATED SCIENCE PLATFORM ASKSCIENCE

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AskScience is a forum on Reddit where registered users can post scientific questions answered by experts. Within the social networking site, posts submitted by an individual are voted up or down by multiple users, giving posts greater or lesser visibility; in essence they form a consensus about what the public really wants to know. Important to the integrity of science, forum posts are moderated by a large team of knowledgeable volunteers. By the time of the 2014 Annual Meeting of the SVP, AskScience had 3.8 million subscribers and received ~4 million unique page views each month. AskScience offers scientists a way to interact directly with the public and perform low-cost, high-yield outreach by answering user-prompted questions. As such, we ran a featured Ask Me Anything (AMA) during SVP 2014, with prior approval from the SVP and help of the E&O Committee. For a successfully targeted AMA, pre-scheduled experts included biographies and were able to link to books, social media, or podcasts. Our featured experts included a faculty member, two graduate students, and a science writer. Our goal was to let the public know that professional paleontologists meet regularly to share discoveries and promote best practices for scientific education. For two hours experts enjoyed answering roughly 70 posted questions. The topics included requests for references, questions about evolution, and technical aspects of paleoart. The direct near-real time answers to questions from SVP experts helps the public better understand our science and allows us to better gauge public interest and (mis)understanding about our field, to plan future outreach accordingly. At SVP 2015 we intend to run another AMA as part of an ongoing effort to promote responsible education and outreach in paleontology. Our topic will center on similar themes. Beyond 2015, we hope to encourage past users to share their opinions about their experience with the SVP-AMA. With those data, our future AMAs could include directed media produced by SVP including audio or video responses or other educational material hosted on the official SVP website, facilitating more discussion in a flipped classroom context.

Technical Session XII (Friday, October 16, 2015, 8:45 AM)

THE LATITUDINAL GRADIENT IN MESOZOIC NON-MARINE TURTLES

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The existence of climate-mediated latitudinal gradients in diversity, and changes in those gradients through time, is a major feature thought to control patterns of richness and diversification, especially in the evolutionary history of ectothermic organisms like reptiles. Here we explore the importance of the latitudinal diversity gradient in shaping the early diversification of turtles, which first appear in the Triassic and are represented by at least 17 families and 75 genera by the end of the Cretaceous.

We compiled data on turtle genus- and family-level richness from the Triassic through Cretaceous, grouped into latitudinal bands of 15 degrees each, based on more than 1400 non-marine occurrences. To compare these data with modern turtle distribution, we reanalyzed a recently published data set of Recent occurrences, subsetting them to match the resolution of the fossil data set. Both the fossil and extant data were corrected for land-area, with paleo-land areas estimated from global paleogeographic reconstructions for successive time periods. The fossil data were additionally corrected for sampling by comparison with the geographic spread of the entire tetrapod record for the same latitudinal bands and time bins and using shareholder quorum subsampling (SQS) of richness.

Today, area-corrected species richness is highest at 25°N, but area-corrected genus richness is even from 30°N to 5°S, with a notable drop in richness outside the tropics and subtropics at ca. 30°N and 30°S. In the Mesozoic, raw genus richness is greatest at 30-45°N and is lowest in the tropics and above 60°N and 60°S. In part, this reflects sampling bias, as tropical regions are under-represented in the tetrapod fossil record. However, the absence of turtles at well-sampled high latitude tetrapod localities suggests that low richness above 60°N/S is genuine and the SQS subsampled data bear out this general pattern. Area-corrected genus richness in the Late Cretaceous is not demonstrably greater than that in the modern turtle fauna.

Grant Information
NERC grant NE/J020613/1 to PM Barrett funded DBN

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

THE PHYLOGENETICS OF DERIVED NON-HADROSAURIAN ORNITHOPOD DINOSAURS

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The systematics and implied phylogenetics of iguanodontian ornithopods has been a matter of discussion and debate since the first attempts at cladistic analysis began in the early 1980s. During the 1980s the number of taxa under consideration in such analyses was very restricted. However, over the past two decades, the numbers of new discoveries and new taxa that have been named have increased dramatically. One exemplar of this phenomenon of the increase in taxon names is found in the English Wealden District. A total of nineteen taxa of medium-to-large bodied ornithopod dinosaurs have been established in recent years. Detailed analysis of the material upon which these taxa have been based suggests that there are no more than four nominal taxa of medium-to-large bodied ornithopods. Consideration of the anatomy of these four well-established taxa has prompted a detailed systematic review of these and other closely comparable ornithopods. This new analysis challenges the general consensus view of ornithopod relationships that has been prevalent for several decades and proposes that there are two dominant lineages that can be diagnosed: the re-defined Hypsilophodontia and Iguanodontia. Their implied phylogenetic histories indicate significant levels of anatomical convergence associated with the independent adoption of large body size, and that body size change and cranial form factors are crucial to understanding the transition from derived iguanodontian to basal hadrosaur.

Grant Information
Master and Fellows of Christ's College, Cambridge

Symposium 1 (Wednesday, October 14, 2015, 2:30 PM)

WHAT WAS HAPPENING "ACROSS THE POND"? THE WOODBINE FORMATION AS AN EXAMPLE OF AN EARLY LATE CRETACEOUS APPALACHIAN ECOSYSTEM

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Our understanding of the complex faunal transitions taking place through the Early to Late Cretaceous interval in North America is critical in reconstructing the complex biogeographic and evolutionary forces that drove the reorganization of Late Cretaceous terrestrial ecosystems. However, this record is based almost exclusively on fossil deposits from Laramidia, on the western side of the Interior Seaway. Little is known about faunal dynamics on the eastern landmass of Appalachia, especially during the early Late Cretaceous. The Woodbine Formation of north-central Texas was deposited during the middle Cenomanian (95-96 Ma) and represents a coastal delta ecosystem. Knowledge of the Woodbine ecosystem has been greatly expanded with the recent discovery of the Arlington Archosaur Site (AAS), which preserves an extraordinarily diverse assemblage of dinosaurs, crocodyliforms, turtles, mammals, amphibians, chondrichthyans, osteichthyans, and plants. Sedimentary data suggest a strongly seasonal climate with a monsoonal wet season followed by a pronounced dry season that experienced periodic wildfires. When combined with previously described Woodbine taxa, a picture emerges of a distinct transitional fauna characterized by Early Cretaceous groups including derived allosauroids, nodosaurid ankylosaurs, neosuchian crocodyliforms, and basal cryptodiran turtles. These taxa are mixed with early representatives of Late Cretaceous communities such as basal hadrosauroids, dromaeosaurids, troodontids, eusuchian crocodyliforms, and baenid and trionychoid turtles. Overall, the Woodbine is similar in taxonomic composition to equivalent Laramidian deposits, yet shares few genera in common, supporting a widespread distribution of these groups prior to formation of the Interior Seaway. The Woodbine Formation shows the faunal transition in North America was an ongoing, gradual process that continued throughout the Cenomanian. This suggests that the characteristic Late Cretaceous communities assembled slowly and do not represent a rapid turnover event. Some mid-Cretaceous assemblages may preserve a previously unrecognized community structure unique to this interval, lending new insight to this important transitional period and in need of further study.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

AN OTOLITH-BASED FISH FAUNA FROM THE EARLY MIOCENE OF THE CASTILLO FORMATION, VENEZUELA

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The Miocene appears to be a pivotal moment in the evolution of several lineages of extant fish genera, which appear for first time in the fossil record of South America. For example, some sciaenid genera (e.g., *Plagioscion*) occur in marine environments during the Miocene, but today inhabit the fluvial systems of the Orinoco and Amazonian basins. Since the estimated time of these transitions is uncertain, it becomes necessary to improve our knowledge of the first appearances of these taxa. It is also necessary, in general, to study of evolution of the fish assemblages in the ancient communities of the Proto-Caribbean, and in this regard the study of fossil otolith assemblages are essential. Recently, hundreds of otoliths were recovered from near-shore marine beds of two localities from the Castillo Formation (Cerro La Cruz and Quebrada Agua Viva, Venezuela), which were dated as early Miocene. Previously, the otolith-based fish fauna included just eight species. Here, we report a high diversity of fishes, including *Larimus henrii*, *Larimus steurbauti*, *Pachyurus junki*, *Plagioscion marinus, Paralonchurus schwarzhansi, Paralonchurus trinidadensis, Aplodinotus longecaudatus*, *Aplodinotus hoffmani*, *Equetulus davidandrewi, Protosciaena nerítica, Protosciaena brasilensis, Cantarius nolfi*, *Bagre protocaribbeanus, Orthopristis* sp.1, *Orthopristis* sp.2, aff. *Centropomus* sp., and aff. *Haemulon.* Though it is problematic to assume that the composition of a fossil otolith assemblage truly reflects the structure of the original fauna, the study of the taxonomic composition of a fossil assemblage can provide well-documented information about some physical conditions of a specific paleoenvironment. In this respect, the otolith assemblages of the Castillo Formation mainly reflect a tropical coastal marine environment, with depth estimates ranging between 1−35 m, and probably related to coral reef patches. Finally, the diversity of the otolith assemblages described (17 spp.) is poor compared to other similar localities in Venezuela, such as the Cantaure (61 spp.) or Cubagua (83 spp.) formations, probably due to a taphonomic bias. However, this last hypothesis has to be tested.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

NEW MICROMAMMALS FROM THE MASCALL FORMATION OF OREGON'S MIDDLE MIOCENE

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The Mascall Formation is one of the best-known middle Miocene records in North America; however, it has never been screenwashed, and has a relatively depauperate microfauna. A new Mascall Formation site in the Crooked River Basin contains productive micromammal horizons that are adding a diversity of small mammals to what we know of Oregon's middle Miocene assemblage. In particular, euliptophylan and marsupial mammals that were not previously known from the Mascall Formation are described here. We collected anthills at a new site, Cave Basin and used heavy liquid separation to concentrate the vertebrate fossils. We picked, sorted, and identified the fossils under a microscope, finding occurrences of soricines, talpids, erinaceids, heterosoricids, and even a marsupial. Soricines and talpids were common in the middle and late Miocene sites elsewhere in Oregon, but erinaceids and heterosoricids are known from only two other localities in the state, Quartz Basin and Red Basin. The great diversity of Eulipotyphla in Cave Basin is consistent with work that has suggested high levels of habitat diversity in Oregon's middle Miocene.

Along with new occurrences of Eulipotyphla, we found a new specimen of ? *Herpetotherium* sp. at Cave Basin. The specimen was identified as a marsupial based on the tribosphenic shape, size, presence of a stylar shelf with cusps, and overall asymmetry of the tooth. This is the first and only occurrence of any marsupial in North America during the Barstovian. This genus has great variation in tooth morphology and size, complicating the species level identification. The Barstovian*?Herpetotherium* sp. is a single M3, lacking stylar cusps A and B due to damage. Stylar cusps C and E are present, but exhibit strong wear. There is no evidence for cusp D ever being present. The tooth has an anteroposterior length of 2.53 mm and a transverse length of 2.67 mm. *Herpetotherium* sp. is known from the Late Tiffanian to the Middle Hemingfordian in North America, but the presence of this specimen means the last occurrence was during the Barstovian. Our research continues to shed light on the fauna present during the middle Miocene of Oregon, demonstrating the diversity of small mammals and the last occurrence of herpetotheriine marsupials in North America.

Technical Session I (Wednesday, October 14, 2015, 9:30 AM)

THE HEMODYNAMICS OF VASCULAR RETIA: TESTING A HYPOTHESIS OF BLOOD PRESSURE REGULATION THROUGH THE ARTIODACTYL CAROTID RETE

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Arterial retia have long been thought to function as blood pressure regulators. The small-caliber of vascular segments and the myriad of branches within these convoluted structures may generate increased drag and turbulence that could mitigate sudden increases or decreases in blood flow. The question of whether retia moderate changes in blood pressure is particularly relevant to long-necked vertebrates, e.g., giraffes and sauropod dinosaurs, for which raising or lowering the head to drink water can alter cerebral perfusion pressure by 100 or 200%. The influence of retia on hemodynamics is difficult to quantify in-vivo, so the precise role of these structures as adaptations for cervical elongation remains unknown.

In this study, we use digital anatomical data collection methods (radiopaque vascular injection and CT scanning) to simulate blood flow through vascular retia. We use extant, long-necked artiodactyls as a model, as the majority of intracranial blood is supplied by a carotid rete. Indeed, artiodactyl vascular specializations are also frequently used as functional analogs for sauropod dinosaurs. To test the hypothesis that the rete can adjust flow, we applied simple and complex physical models to 3D surface renderings of the carotid retia of a goat, *Capra hircus*, and a giraffe, *Giraffa camelopardalis*. To ascertain a base-line expectation of retial hemodynamics, we calculated resistance across the carotid rete using an electrical circuit analogy. Because the equations describing fluid flow and electrical flow are analogous, the branching of the rete can be conceptualized as a parallel circuit that is linked proximally and distally to single arteries. This method calculates a near-zero increase in resistance; however, this basic model does not incorporate the drag or turbulence that could be driving resistance, so we also employed computational fluid dynamics to account for these factors. Multiple-grid simulations of blood flow through the rete during high and low pressure portions of the cardiac cycle revealed negligible changes in pressure within the rete (decrease of ~0.94 mmHg). As both simple and complex models demonstrate only minute changes in resistance and blood pressure across the arterial meshwork, there is little evidence to support blood pressure mitigation as a primary function for the artiodactyl carotid rete. These results have wider implications among vertebrates, as the physics of fluid flow through multi-segment vascular retia are not obviously related to resistance modulation or alteration of blood pressure.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

EVOLUTION AND FUNCTIONAL SIGNIFICANCE OF DERIVED STERNAL OSSIFICATION PATTERNS IN ORNITHOTHORACINE BIRDS

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The midline pattern of sternal ossification characteristic of the Cretaceous enantiornithine birds is unique among the Ornithodira, the group containing birds, non-avian dinosaurs and pterosaurs. This has been suggested to indicate that Enantiornithes is not the sister group of Ornithuromorpha, the clade that includes living birds and their close relatives, which would imply rampant convergence in many non-sternal features between enantiornithines and ornithuromorphs. However, detailed comparisons reveal greater similarity between neornithine (i.e., crown group bird) and enantiornithine modes of sternal ossification than previously recognized. Furthermore, a new subadult enantiornithine specimen demonstrates that sternal ossification followed a more typically ornithodiran pattern in basal members of the clade. This new specimen, referable to the Pengornithidae, indicates that the unique ossification pattern observed in other juvenile enantiornithines is derived within Enantiornithes. A similar but clearly distinct pattern appears to have evolved in parallel in the ornithuromorph lineage. The atypical mode of sternal ossification in some derived enantiornithines should be regarded as an autapomorphic condition rather than an indication that enantiornithines are not close relatives of ornithuromorphs. Based on their possible selective advantages and molecular mechanisms, the parallel shifts to midline ossification that took place in derived enantiornithines and living neognathous birds appear to have been related to the development of a large ventral keel, which is only present in ornithuromorphs and enantiornithines. Midline ossification also serves to medially reinforce the sternum at a relatively early ontogenetic stage, which would have been especially beneficial during the protracted development of the super-precocial Cretaceous enantiornithines.

Grant Information

National Basic Research Program of China (973 Program, 2012CB821906), National Natural Science Foundation of China (41172020, 41172016, 41372014)

Technical Session XIV (Friday, October 16, 2015, 2:45 PM)

CRANIAL ANATOMY OF *MORTURNERIA SEYMOURENSIS* AND THE EVOLUTION OF MYSTICETE-LIKE FILTER FEEDING IN AUSTRAL ARISTONECTINE PLESIOSAURS

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Aristonectine elasmosaurids of the austral Late Cretaceous have puzzled paleontologists since the description of *Aristonectes* from the Maastrichtian of Patagonia in 1941. The skull is fragmentary, but the large, hoop-like mandible is very derived. The recent description of new *Aristonectes* material from Chile has greatly augmented our understanding of this taxon, confirming that it is a large elasmosaurid, but one with compressed cervical vertebrae and large flippers. In this study we synthesize new Chilean cranial material, the Patagonian material, and Antarctic material to offer the first confident reconstruction of aristonectine skull anatomy. The reconstruction relies on the holotype of *Morturneria seymourensis*, an aristonectine from the Maastrichtian of Seymour Island, Antarctica. Our analysis indicates that *Morturneria* is certainly a valid taxon, smaller than *Aristonectes*, and that its cranial morphology is less derived than other members of the clade. The skull also has the most complete palate of any known aristonectine.

The skull reconstruction reveals unique cranial adaptations indicating that aristonectines were filter feeders. The occlusal surface of the mandible is covered with bone and the lower teeth project laterally from the jaw in a comb-line structure. The maxilla holds a dense battery of teeth that projects laterally and ventrally; the upper teeth overlap the lowers at a very low angle, lateral to the side of the skull. The cranium is also highly derived. The quadrates lie far behind the occipital condyle, and the braincase is near the center of the skull. The quadrates are carried by massive, dish-shaped extensions of the pterygoids, and the palate is deeply arched to both sides of the midline. These palatal chambers, when combined with the enormous mandible, create a voluminous oral cavity unprecedented among marine reptiles. A large volume of gulped water in the oral cavity would be cleared by movements of the pharynx, hyoids and tongue, expelling the water through the closed tooth batteries and straining out food particles. The internal naris is shielded behind a flange of the pterygoid and vomer, protecting it from water leaving the oral cavity. In summary, new cranial material from Chile has provided the perspective needed to confidently reconstruct the skull of *Morturneria* for the first time. The skull carries a suite of radical oral adaptions that clearly indicate that aristonectines were mysticete-like filter feeders. They are unique among all Mesozoic marine reptiles in adopting this feeding style.

Technical Session II (Wednesday, October 14, 2015, 11:30 AM)

DIGITAL PTEROSAURS: BUILDING A VIRTUAL WING FROM SURFACE SCANS TO TEST AERODYNAMIC HYPOTHESES IN *PTERANODON*

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We present a novel reconstruction of a *Pteranodon* wing with implications for its aerodynamic properties, using new fossil specimens and recently developed digital tools. Previous *Pteranodon* reconstructions heavily approximated the shape of certain areas of the wing, specifically the wrist and elbow, potentially underestimating the complexity of the wing shape at these locations.

This analysis was based on fossil specimens at the Los Angeles County Museum of Natural History. Preparation (and improved cleaning) of specimens and jackets from the 1960s has recently revealed excellent new limb material from *Pteranodon* at the LACM. Of particular note is the excellent preservation of the elements in and around the joints, including the carpals and the flexor tubercle of the proximal wing phalanx in multiple specimens.

Initially, simple measurements of the dimensions of these elements were conducted using calipers (to help provide reference distances and validation of the later 3D models). Digital methods were then used to build a digital model and reconstruct life positions of elements in virtual space. Using the program "123D Catch", an accurate digital 3D model of the fossilized materials was built from photographs. These digital models capture both the current shape and surface color of the specimen. CAD programs were then used to estimate the original shapes of the elements before fossilization. CAD tools allowed for scans of the crushed areas to be lifted and smoothed out to more accurately represent the original shape of the wing. These tools can also be used to examine the possible extent of fairing around the wing.

Future work will map estimated muscle volumes to the model. However, the digital models already suggest that the complex topography of the joints would tend to result in higher average lift and drag coefficients (and slower flight) than previously predicted.

Extensive fairing might have reduced these effects, resulting in a higher lift to drag ratio and greater best glide speed. While computational fluid analysis will provide more detailed results, we note that the wrist and elbow include features that could increase effective camber and entry angle of the wing. These features could increase average lift generation on the wing, though their presence reduces some of the smoothness of the wing and could therefore also yield higher drag.

Technical Session III (Wednesday, October 14, 2015, 11:00 AM)

A CHIMAERIC EMYDOPOID DICYNODONT (THERAPSIDA, ANOMODONTIA) FROM THE MIDDLE PERMIAN OF ZAMBIA

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In 2010, our team rediscovered a fossil site in the lower Madumabisa Mudstone Formation (Mid-Zambezi Basin) of Zambia that was only briefly examined in the 1950s. Over the course of three field seasons, we discovered numerous new productive localities in the area and our knowledge of the fauna from this formation has progressed rapidly. Tapinocephalid teeth indicate that at least part of the lower member of the formation is Middle Permian in age, likely equivalent to either the *Eodicynodon* or *Tapinocephalus* biozones of South Africa. The Mid-Zambezi fauna also includes gorgonopsians, temnospondyls, at least one new burnetiamorph, and several dicynodont skulls that represent a new taxon. This species can be differentiated from other dicynodonts by a unique combination of features found in several different dicynodont groups. It shares several palatal characters with basal dicynodonts, such as a long, medially set row of 'postcanine' teeth, an unfused vomer, and a large ventrally-directed transverse flange of the pterygoid. It has a few characters typically seen in emydopoids, such as a prominent lateral dentary shelf, a broad intertemporal region, and a pineal foramen located towards the rear of the skull roof. It also exhibits traits exclusive to endothiodonts, including elongate palatine pads with paired ventral depressions, premaxillary teeth, a rugose shelf lateral to the upper tooth row, a boss on the ventral edge of the anterior dentary and a sharply pointed dentary symphysis. A preliminary phylogenetic analysis places the new taxon as the sister to the Emydopoidea, a diverse group of dicynodonts primarily known from the Late Permian. This taxon may be the earliest and most primitive emydopoid yet discovered, and the features it shares with endothiodonts suggest that it may help to elucidate the evolutionary origin of the highly derived skull morphology seen in *Endothiodon*.

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Technical Session VIII (Thursday, October 15, 2015, 3:45 PM)

ECOMORPHOLOGY OF AUSTRALIAN CARNIVORE GUILDS

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Carnivorous mammals are crucially important members of fossil and modern ecosystems across the globe. The top-down controls imposed by predators play a major role in shaping these ecosystems, meaning that understanding the variables that drive carnivore evolution are crucial to refining models of ecological change through time. Are these variables primarily biotic in nature? Do climatic variables play a larger role in driving carnivore evolution? Or has the diversity of carnivores throughout the Cenozoic been shaped by phylogenetic effects? The majority of previous research addressing these questions has focused on the carnivoran predators of the northern continents, but the metatherian predator guilds of the Southern Hemisphere provide potentially valuable comparisons. In particular, the predatory marsupials of Australia offer an opportunity to compare the well-studied carnivore guilds of other continents to a guild of predators (dasyuromorphs, hypsiprymnodontids, and thylacoleonids) with a very different evolutionary history. Previous work comparing Australian predators to carnivorans has focused mainly on large-bodied, extant taxa and has been based predominately on dental and cranial morphology. These analyses have generally supported the hypothesis that Australian predators are broadly convergent with carnivorans, possibly suggesting that physical environmental interactions play a major role in shaping predator guild structure. I tested this hypothesis by using morphological indices calculated from dental, cranial, and postcranial measurements to reconstruct the morphospace occupied by both large- and small-bodied extant Australian predators. These results were compared to similar ecomorphological analyses performed on modern North American carnivorans (to test for convergence) and on Pleistocene marsupial predators (to test for the effect of warming climate). While some shared morphospace exists between North American and Australian carnivore guilds, each guild occupies a large area of morphospace that is unoccupied by the other (large omnivores in North America, small mesocarnivores in Australia). Comparisons of modern and Pleistocene data indicate plasticity in marsupial predator guild structure through time, though this may be the result of incomplete sampling. These findings do not support the interpretation of Australian carnivores as convergent with carnivorans and may indicate the importance of biotic interactions in shaping carnivore guild structure.

Colbert Prize (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

***ALBANERPETON* REMAINS FROM THE LOWER CRETACEOUS CLOVERLY FORMATION WITH IMPLICATIONS FOR THE BIOGEOGRAPHY, ONTOGENY, AND PALEOECOLOGY OF ALBANERPETONTIDS**

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Albanerpetontids are an extinct lineage of lissamphibians known from the early Bathonian through the late Pliocene. Their remains occur in North Africa, Eurasia, and North America and represent a dozen species, plus at least five additional unnamed taxa. Albanerpetontid phylogenetic relationships are of interest, because the group's long history spans the breakup of Pangaea.

Recent fieldwork has produced numerous specimens representing a new species of *Albanerpeton* from the Cloverly Formation of Wyoming. Although disarticulated, they are consistent with the presence of a single taxon. The specimens exhibit a unique combination of synapomorphies with *A. arthridion* (and other, more derived, North American forms) and symplesiomorphies with the more primitive European genera *Celtedens* and *Wesserpeton*.

Phylogenetic analysis places the new taxon as the basal-most species of *Albanerpeton*, and its late Aptian-middle Albian age supports the hypothesis that *Albanerpeton* evolved from a European immigrant to North America during the Early Cretaceous. Younger *Albanerpeton* occurrences in Europe likely represent a re-immigration from North America.

A growth series of premaxillae also provides insights into albanerpetontid ontogeny that might have evolutionary relevance. Ontogenetic changes in the shapes of the pars dorsalis and pars palatinum in the Cloverly species mirror those observed between older and younger species. Younger species, especially *A. nexuosus*, exhibit a more paramorphic combination of features, specifically strengthening of the maxillary process and further expansion of the premaxillae. The direction of these interspecific changes suggests the evolution of increased burrowing ability. Although the Cloverly species may have engaged in some burrowing, based on its expanded and modified frontals relative to *Celtedens*, its predominant occurrence in marginal lacustrine paleoenvironments suggests a more amphibious existence.

Technical Session XV (Saturday, October 17, 2015, 11:45 AM)

DINOSAUR AND MAMMALIAN EXTINCTION DYNAMICS AND THEIR DEPENDENCY ON BODY SIZE AND LIFE HISTORY

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We analyze the influence of body size and life history on the extinction dynamics of mammals and dinosaurs. Several workers since the 1950s have surmised that the greater reproductive output of non-avian dinosaurs made them less vulnerable to extinction than large mammals. This extinction 'advantage' would explain why large dinosaur taxa were common but mammals have rarely evolved to equivalently large size. The underlying ecological logic of this prediction is that species with a life history having a greater average potential for population increase (dinosaurs) have a lower risk of extinction as compared to species with a lower average potential for population increase (mammals). This difference would imply that dinosaur species tended to have sufficient evolutionary time to evolve to large body size; in contrast, mammalian species longevity generally would not allow for the evolution of large size. We analyze extinction dynamics for a variety of model life histories for dinosaurs and mammals using stochastic density-independent and density-dependent models of population growth. We show that finite-time and ultimate extinction probabilities increase with the average potential for population increase. These results suggest that dinosaurs had higher ultimate and finite-time extinction probabilities as compared to those for mammals. Accordingly, we suggest that the evolution of large body size in dinosaurs is not explained by greater species longevity of dinosaurs as compared to mammals.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

MESOWEAR ANALYSIS OF A NEW PARAHIPPINE EQUID FROM FLORIDA

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A new species of low-crowned parahippine equid from the Suwanee River of Florida possesses the most primitive known form of equid crown cementum. This equid is dated to the early Hemingfordian, around 19 Ma. During the late Oligocene and early Miocene, increased rates of erosion of the Appalachians resulted in increased quartz sand deposition in Florida. With quartz induced abrasion driving selection for increased dental durability (as suggested by the advent of crown cementum), is there any evidence of increased rates of wear in these equids? A mesowear study was performed to assess just that. The mesowear technique is a macroscopic method of assessing dental wear in herbivores. By applying established mesowear observation and interpretation protocols, we were able to document differences in both average mesowear index (2.83) and standard deviation (1.47) of this index in the new species versus early equine taxa including late Arikareean *P. nebrascensis* and *P.* sp. (originally referred to as *P. cognatus*), early Hemingfordian *P. pawniensis*, *P. tyleri*, and *P.* sp. (originally referred to as *P. cognatus wyomingensis*), and late Hemingfordian *A. blackbergi*, *P. leonensis*, and *P. barbouri.* In its relatively high average index and standard deviation, this new species was distinct from all other taxa in the study except the early Hemingfordian *Parahippus* sp. (previously *P. cognatus wyomingensis*), a more heavily cemented taxon from the Great Plains. Therefore, even with its modest amount of crown cementum, this new taxon was already exhibiting a commitment to enduring a high degree of dental abrasion.

Grant Information
2014 Dana Grant, University of Tampa

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

POST-CRANIAL FUNCTIONAL MORPHOLOGY OF *QUETZALCOATLUS* (PTEROSAURIA: AZHDARCHOIDEA)

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Quetzalcoatlus northropi was named on the basis of a few incomplete post-cranial bones that suggested a wingspan of 11-13 m; a morph about half this size is represented

by numerous bones and partial skeletons, on which most anatomical studies are based. The 9th and 8th cervical vertebrae could pitch dorsally and the 7th pitched ventrally; the 6th and anterior cervicals pitched dorsally. This bend mitigated horizontal compressive load of the neck on the dorsal column. Some lateral movement was possible at all cervical joints. Dorsal movement was restricted to only three or four mid-dorsals and was mainly lateral.

The scapulocoracoid could be protracted and retracted in an arc of about 25°, allowing the glenoid to move anterodorsally and posteroventrally. The humerus could have rotated in the glenoid about 25°; elevated about 45°, and depressed about 25-35°. When soaring, the distal humerus would have been about 20° above the horizontal, and the distal radius and ulna about 15° below it. The angle at the elbow in dorsal view would have been about 115°. The humerus could move no more than 3-5° anterior to the shoulder, at which point vertical mobility is limited to about 5° above the horizontal and about 10° below it. When the humerus is fully pronated, protraction-retraction is limited to 40-45°. Oriented approximately laterally, the humerus could be elevated above the horizontal about 35°. The radius and ulna could flex to about 75° at the elbow but no rotation was possible at either end. When flexed, the radius slid distally over the ulna and retracted the wrist and outboard bones up to 60° (depending on the humeral position). Very limited rotation of the wing metacarpal against the distal syncarpal was possible. The asymmetrical distal 'pulley' joint of the wing metacarpal depressed the wing-finger during retraction.

All joints of the hind limb are hinges except the hip, a ball-and-socket offset by a neck oriented dorsally, medially, and posteriorly. The hind limb was positioned in walking as in other ornithodirans, and whether it could be elevated and retracted into a batlike pose incorporated into a hypothetical uropatagium is questionable.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

PALEOECOLOGICAL IMPLICATIONS OF A FAUNAL ASSEMBLAGE FROM "DUNCAN'S MICROSITE" IN TH KAIPAROWITS FORMATION (UPPER CRETACEOUS), SOUTHERN UTAH, U.S.A.

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The Kaiparowits Formation (~76–74 Ma) preserves a diverse Upper Cretaceous continental assemblage from southern Utah, particularly for macrovertebrate remains (e.g., dinosaur skeletons). Microvertebrate fossils (i.e., small teeth and bones) are comparatively less studied, particularly at the individual locality level that may provide more detailed paleoecological and taphonomic insights. Duncan's Microsite (Raymond M. Alf Museum of Paleontology locality V200811) is from the upper part of the middle unit of the Kaiparowits Formation, within Grand Staircase-Escalante National Monument. Specimens were sampled via surface collection and limited screenwashing, yielding over 1,000 identifiable vertebrate elements. Fossils originate in a carbonaceous mudstone, interpreted as an overbank environment, perhaps a pond. This is consistent with freshwater gastropods in the assemblage (e.g., *Lioplacodes subtortuosa*). Vertebrate coprolites are abundant, with many containing fish elements. Fish, particularly Lepisosteidae, are the most abundant clade within the overall sample. Turtles are next most abundant, represented by shell fragments assignable to Trionychidae, Kinosternidae, Chelydridae sp., *Basilemys* sp., *Derrisemys* sp., *Compsemys victa*, and *Adocus* sp. Crocodyliforms are represented by teeth, osteoderms, and other elements. Lissamphibians include cf. *Scapherpeton* sp. and one anuran, and squamates are represented by osteoderms. Several teeth are assignable to Multituberculata. Among non-avian dinosaurs, hadrosaurids are by far most abundant (~87% of identifiable dinosaurian teeth), followed by theropods (dromaeosaurs and tyrannosaurs, ~9%) and finally ceratopsids (< 4% of identifiable teeth). The apparent scarcity of ceratopsids is matched by the macrofossil record in this part of the stratigraphic section, which is also dominated by hadrosaurids. Most ceratopsid macrofossils from the Kaiparowits Formation are known from stratigraphically lower intervals; this may reflect local ecological changes through time, but needs to be verified with additional sampling.

Colbert Prize (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

EXCEPTIONAL SOFT-TISSUE PRESERVATION IN A NEW MARINE PYTHONOMORPH FROM THE UPPER CRETACEOUS (CAMPANIAN) OF SOUTHERN ITALY

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A new pythonomorph lizard gen. et sp. nov. with exceptional soft-tissue preservation was found in Upper Cretaceous marine sediments of the Apulia platform (Southern Italy). Phylogenetically related forms ('dolichosaurs', e.g., *Pontosaurus* and *Adriosaurus*) have been described from Upper Cretaceous deposits of the Middle East (Lebanon) and the Balkan Peninsula (Croatia, Slovenia). This is the first record of this group of marine lizards from southern Italy, and extends the known paleobiogeographic distribution of 'dolichosaurs' towards the center of the Tethys. This taxon also extends the known temporal range for these marine lizards both globally and from the Tethyan realm; the new taxon is Campanian in age, while related taxa are Cenomanian – Turonian.

The new specimen consists of an almost complete, articulated skeleton, most of which is exposed in ventral view. Pachyostotic dorsal vertebrae and ribs suggest aquatic adaptations. The slender and elongate humerus and femur are indicative of a basal degree of aquatic adaptation. The presence of unfused epiphyses and unfused pelvic girdle elements may be indicative either of paedomorphosis in an adult form, or of a juvenile condition. The preservation of the bones is unusual, as the elements retain a 'fresh brittle look' despite being about 80 million years old. Spectroscopic analysis (EDX/SEM) of the specimen revealed that the original composition of the bones is likely retained, and that there is very little calcification (high phosphorous content).

Different types of squamation are also preserved: 1) deeply imbricated polygonal scales (close to the trunk and forelimbs); 2) large diamond-shaped scales (in the trunk and tail regions); and 3) broad ventral scales similar to those of *Pontosaurus kornhuberi* and some snakes (visible in lateral view along the ventral margin of the tail). This specimen also preserves portions of mineralized epaxial and hypaxial musculature along the trunk and tail. Due to its exceptional state of preservation this specimen provides new information about the anatomy of dolichosaurs.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

THE ONSET OF TROPHIC DOWNGRADING IN NORTH AMERICA: BIOTIC RESPONSES OF CANIDS TO THE TERMINAL PLEISTOCENE MEGAFAUNA EXTINCTION

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The largest consumers across the vast majority of ecosystems have become rare or extirpated, leading to concern over losses in ecosystem function. This phenomenon, called trophic downgrading, is not unique to modern communities. The extinction of 34 genera of megafauna from North America about 13,000 years ago undoubtedly led to widespread changes in terrestrial ecosystem function. To date, most studies that have examined the consequences of the event address impacts on vegetation, small mammal communities, nutrient cycling, and fire regimes. Less attention has been paid to effects higher in the food chain.

Here, we modeled the climatic niche of canids, including the extinct *Canis dirus,* over the last 20,000 years. Quantifying the climatic niche provides a null expectation for species distributions due solely to climate change; deviations from expected responses likely reveal changing biotic factors. We quantify relative niche conservatism and interspecific overlap to assess species and community responses among canids. We also include in our analyses an invasive predator, *Canis lupus familiaris*.

Our study finds that endemic canid species display low abiotic niche fidelity through time, and do not expand into space presumably vacated by extinct carnivores. Moreover, surviving canids increasingly partition niche space through the Holocene. We conclude that the loss of megaherbivores coupled with human impacts likely outweighed the potential advantages conferred from the loss of closely related competitors. Our results suggest that human activities and trophic downgrading have been impacting communities for thousands of years. Additionally, we note an apparent overlap between the niches modeled from fossil domestic dogs and human archaeological remains, but not wolves. This suggests a distinctive relationship between wolves, dogs, and man; despite successful domestication, wolves and humans have primarily interacted as competitors since man invaded the North American continent.

Technical Session XIX (Saturday, October 17, 2015, 3:30 PM)

PHYLOGENETIC RELATIONSHIPS OF RECUMBIROSTRAN 'LEPOSPONDYLS' INFERRED FROM NEUROCRANIAL MORPHOLOGY

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'Microsaurs' are a diverse group of miniaturized early tetrapods from the Carboniferous and Permian of North America and Europe. The majority of 'microsaur' diversity is encompassed within the Recumbirostra, a group characterized by a heavily-constructed skull and overhanging snout that were likely associated with a fossorial lifestyle. The relationships of this group to other 'microsaurs', other 'lepospondyls', and other early tetrapods, are uncertain, and are likely confounded by convergences associated with small size and simplification of the dermal skull.

To investigate the phylogenetic relationships of the Recumbirostra, we surveyed recumbirostran neurocranial morphology using µCT. We then assembled a large matrix of neurocranial morphology across early tetrapods, with an emphasis on the morphology of 'lepospondyls'. Phylogenetic analysis does not support lepospondyl monophyly, and instead recovers Recumbirostra within crown-amniotes, along the reptile stem. This position is supported unambiguously by a number of characters of ossifications within and surrounding the ethmoid trabeculae, cranial circulation, inner ear, and occipital arch. This phylogenetic result simplifies hypotheses concerning the evolution of the axial skeleton, humerus, and ankle, providing external support for this heterodox phylogeny. Our results greatly upset recent phylogenetic scenarios of amniote origins, and suggest that the origin of amniotes, rather than lissamphibians, is the major unresolved question of early tetrapod phylogeny.

Grant Information
NSERC Discovery Grant 327756-2011 to J.S. Anderson.

Technical Session XVI (Saturday, October 17, 2015, 8:45 AM)

IMPROVED PHYLOGENETIC RESOLUTION TRACKS AETOSAURIAN (ARCHOSAURIA: PSEUDOSUCHIA) DIVERSITY THROUGH LATE TRIASSIC EXTINCTION EVENTS

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Aetosauria is an early-diverging clade within Pseudosuchia (crocodile-line archosaurs) that had a global distribution and high species diversity as a key component of Late Triassic terrestrial faunas. It is one of only two Late Triassic clades of large herbivorous archosaurs, and thus played a critical ecological role. Nonetheless, aetosaur phylogenetic relationships are still poorly understood, owing to an overreliance on osteoderm characters, which are often poorly constructed and suspected to be highly homoplastic.

I conducted a new phylogenetic analysis of Aetosauria, comprising 27 taxa and 83 characters including more than 40 new characters that focus on better sampling the cranial and endoskeletal regions. I also applied Partioned Bremer Support (PBS) for the first time to a strictly morphological dataset to test potential of character conflict between different anatomical regions. Parsimony analysis recovered three most parsimonious trees; the strict consensus of these trees displays an Aetosauria that is divided into two

main clades: Stagonolepoidea, which includes the Desmatosuchinae and the Stagonolepidinae, and Aetosaurinae, which includes the Typothoracinae. The small-bodied aetosaurs, typified by *Aetosaurus ferratus*, are recovered at the base of the Aetosaurinae, consistent with the hypothesis that they may represent juvenile forms of larger typothoracine taxa.

Overall support for some clades is still weak, and Partitioned Bremer Support demonstrates that this is partly because of conflict in the phylogenetic signal of cranial versus postcranial characters. PBS helps identify homoplasy among characters from various body regions, presumably the result of convergent evolution within discrete anatomical modules. It is likely that different body regions are evolving at different rates, and may be under different selective pressures. Nonetheless, this dataset is the most comprehensive phylogeny of the Aetosauria to date.

Placing the new phylogenetic hypothesis in a temporal context indicates that Stagonolepoidea disappeared after the mid-Norian (~215 Ma), and that the later Norian-Rhaetian assemblages consist solely of aetosaurine lineages. This reduction in diversity is completed by the end-Triassic extinction when the Aetosauria become extinct. This suggests that extinctions during the mid-Norian event may have had just as profound an effect on archosaur diversity as the extinction at the end of the Triassic.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

OSTEOLOGICAL EVIDENCE FOR THE BIOMECHANICAL FUNCTION OF THE DROMAEOSAURID FORELIMB IN FLIGHT

PARSONS, William L., Buffalo Museum of Science, South Wales, NY, United States of America, 14139; PARSONS, Kristen M., Buffalo Museum of Science, South Wales, NY, United States of America

Withdrawn

The morphology of some dromaeosaurid humeri is more closely similar to those of non-avian theropods than to those of birds, but the fossil feathers found on dromaeosaurid forelimbs indicate a potential for flight similar to that of extant avians. Although the dromaeosaurid humerus could not rotate like that of extant avians, the glenohumeral ligament fossa in the dorsal edge of the scapular glenoid on *Deinonychus antirrhopus* indicates the humerus could be raised and lowered in a vertical flapping arc. The power of this flapping that primarily originated from muscles inserted on the sternum was enhanced by muscles inserted on the broad flat surface of the dromaeosau[illegible] coracoid. Two differences between the *Bambiraptor feinbergorum* humer[illegible]at of an enantiornithine are the straightening of the [illegible]aft and the diffe[illegible] of [illegible]lci for the two tendons of the M. humerotricipitis a[illegible] M. s[illegible] can white pelican (*Pelecanus erythr[illegible]chos*), [illegible] sulci [illegible] tha[illegible] muscles contribute to ra[illegible] edge [illegible] ai[illegible]hich is necessary to maint[illegible] g. The lack of these sulci on the dr[illegible] either a poor glider or that control of the forwa[illegible] ction of the manus. In juvenile *Deinonychus* specim[illegible] is disproportionately exaggerated in comparison to adults [illegible]xa. The robust feathering on the first manual digit as well as the excepti[illegible]lly long primary feathers on *Microraptor gui* may have possessed an aileron-type function in the control of the edge of the dromaeosaurid airfoil. The articulating morphology of the *D. antirrhopus* first metacarpal as well as the semi-lunate carpal allowed for a 190° rotation of the wrist and a broad lateral extension of the first manual digit. This indicates that the *D. antirrhopus* manual region could have been cranially extended much farther than in many current reconstructions. The weight of these robust manual digits, especially the first manual digit, would have enhanced the efficiency of the dromaeosaurid wrist rotation of the manus by increasing the centrifugal inertia. This same weight would have detracted from the efficiency of any shoulder-based rotation. The loss of manual digits, the last major evolutionary dromaeosaurid/avian morphological modification, would have increased the efficiency of shoulder-based humeral rotation.

Technical Session VI (Thursday, October 15, 2015, 10:45 AM)

PHYLOGENETIC PREDICTIVE BODY SIZE ESTIMATES OF EXTINCT SHARKS

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Obtaining biological information, such as body size, for extinct sharks is notoriously difficult given that so few anatomical structures preserve in the fossil record. Teeth are by far the most common, but their utility as a body size predictor is potentially limited by their ecomorphological variability compared to other structures such as vertebrae. However, their abundance throughout the geologic record and their seeming diagnostic importance relative to vertebrae demonstrates their paramount utility for understanding macroevolutionary patterns of body size in extinct aquatic species. Prior attempts to estimate body size in extinct sharks, such as *Carcharocles megalodon*, applied simple length:width ratios based on a single extant model, *Carcharodon carcharias*. Accordingly, a broad, interspecific extant model investigated within a phylogenetic context is lacking. Our approach utilized a combined molecular-morphological topological framework within the predictive models in BayesTraits to estimate the body length of several fossil taxa using a phylogenetic generalized least squares model of 15 modern shark species (nine carcharhiniforms, five lamniforms, and *Hexanchus grisseus* as an outgroup). Fossil shark taxa estimated in our study include the Cretaceous species *Cretalamna appendiculata*, *Cretoxyrhina mantelli*, *Squalicorax* sp., and *Scapanorhynchus* sp., the Eocene-aged *Carcharodon auriculata*, and the Mio-Pliocene taxa *Hexanchus* sp., *Isurus hastalis*, and *C. megalodon*. An initial multiple regression model between total body length and five linear measurements on teeth throughout the jaws of only modern species revealed strong correlations with mean R^2 values of 0.966 (mid-dentary teeth have highest correlation R^2 of 0.98) and a moderate mean lambda (phylogenetic signal, 0.7). Fossil taxa were then included in the regression analysis using the phylogenetically informed model saved from the previous run in order to inform the body size predictions. Our results predict a body length of 13 m for *C. megalodon*, using a 132 mm dorsoventral length mid-maxillary tooth, which is not the largest specimen documented from the fossil record. This estimate is consistent with early size predictions for the species, yet much smaller than recent assessments hypothesizing lengths >16 m. Another large-toothed shark *I. hastalis* is predicted at 5 m from the same tooth position. Our approach supports the use of shark teeth as size estimators, provided that estimates are generated within a phylogenetic context.

Grant Information
NSF MSP 1319293

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

WE'RE GONNA NEED A BIGGER BAG: MICROFOSSIL SAMPLING ADDS SUBSTANTIAL DIVERSITY TO THE MIDDLE TRIASSIC NTAWERE FORMATION OF ZAMBIA

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The Ntawere Formation of Zambia has been an important source of Middle Triassic (Anisian) vertebrate fossils since the 1930s. Expeditions in the 1930s, 60s, and 70s yielded biostratigraphically informative therapsids (*Diademodon*, *Kannemeyeria*, *Sangusaurus*) and temnospondyls (*Batrachosuchus*, *Stanocephalosaurus*) that helped place the Ntawere in a regional context, with correlations to the Lifua Member of the Manda beds in Tanzania and to subzones B and C of the *Cynognathus* Assemblage Zone in South Africa. The Ntawere Formation represents an arid floodplain with several standing water bodies, as evidenced by thinly laminated dark red mudstones with stromatolitic carbonate horizons and abundant lungfish teeth, temnospondyl fragments, spiral coprolites, and shells of the freshwater bivalve *Unio*. Starting in 2009, our research group began exploration of the Ntawere and recovered several new taxa, most notably gomphodont cynodonts and members of crown Archosauria, including shuvosaurid and large "rauisuchian" pseudosuchians, as well as abundant remains of silesaurids (*Lutungutali sitwensis*). In 2014, we initiated a search for microfossils at a site near the village of Sitwe and found a number of species-level taxa new to the Ntawere Formation, and likely new to science. The interpreted depositional environment is a playa lake setting. In addition to silesaurid elements and much larger fragments of temnospondyls, we discovered several atlantes and vertebral centra of at least one small temnospondyl that is distinct from the brachyopoid *Batrachosuchus* known from the area. Three morphotypes of serrated archosauriform teeth were recovered: a short, blunt type that is oval in cross-section, a straight, mediolaterally compressed type, and a conical, recurved type. These teeth add important information to the archosaur record, which currently consists of mostly postcranial elements. The most surprising discoveries were dorsal fin spines of a freshwater hybodontiform shark. The specimens show characteristic longitudinal costae on the lateral and anterior surfaces and two offset rows of pointed denticles on the posterior surface. The diversity added by our microfossil survey is substantial and similar sampling would be extremely useful to employ more broadly in upper Permian and Lower–Middle Triassic rocks in order to better understand vertebrate recovery from the largest-ever mass extinction.

Grant Information
This research supported by National Science Foundation EAR-1337569, EAR-1337291, and EAR-1336986.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

SMALL LIPOTYPHLAN TARSALS FROM THE EOCENE OF SAN DIEGO COUNTY, CALIFORNIA

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Early and late Uintan (middle Eocene) strata in San Diego County, California have produced rich mammalian faunas including numerous small eutherians, primarily referable to Lipotyphla, Rodentia, and Primates. Included in these samples are numerous small isolated tarsal elements. Using a combination of size, abundance, and morphology, many of these elements can be reassociated with taxa known from dental remains. This is particularly true of the relatively larger, more abundant taxa, including many rodents and members of the possible erinaceomorph lipotyphlan subfamily Sespedectinae.

In addition to sespedectine tarsals, several astragalar and calcaneal morphs document the presence of smaller lipotyphlans. The most abundant of these astragalar and calcaneal morphs are characterized by their very small size and broad distribution across both early and late Eocene faunas. On the basis of size, abundance, and distribution, these morphs can be tentatively reassociated with the geolabidid *Batodonoides*. This material represents the first known tarsal material referable to Geolabididae. The elements are surprisingly similar to published tarsals of nyctitheriid lipotyphlans. Astragalar similarities include a very shallowly grooved tibial facet and a kidney-bean shaped sustentacular facet that does not have a proximal extension. Calcaneal similarities are particularly striking and include a short tuber, elongate, narrow fibular facet, large sustentacular facet that does not overlap the ectal facet, and a prominent peroneal tubercle situated halfway between the cuboid and ectal facets.

Additional small lipotyphlan tarsal morphs are more difficult to confidently reassociate with specific taxa known from dental remains. These elements show considerable morphologic diversity, particularly the structure of the astragalar body, but most remain more similar to nyctithere tarsals than to those of other living and extinct lipotyphlans. Combined with the nyctithere-like morphology of *Batodonoides*, tarsal evidence suggests that nyctitheres were part of a more extensive radiation of early lipotyphlans than has been previously suspected.

Technical Session XVIII (Saturday, October 17, 2015, 2:30 PM)

DRIVERS OF FAUNAL TURNOVER OF EARLY PALEOCENE MAMMALIAN COMMUNITIES IN THE SAN JUAN BASIN, NEW MEXICO, USA

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The San Juan Basin (SJB) in New Mexico, USA contains one of the best early Paleocene records of mammalian evolution, making it an ideal location to examine ecosystem response following the Cretaceous-Paleogene (K-Pg) extinction. The mammalian record is punctuated by faunal change and turnover represented by the type Puercan and entire Torrejonian North American Land Mammal Age biozones. However, relatively little is known about the early Paleocene plant communities, paleoenvironment, or paleoclimate. This makes it difficult to assess if changes between the mammalian biozones are driven by climate change or other factors, such as rapid evolution following the K-Pg extinction. Here we reconstruct early Paleocene fossil plant communities, paleoclimate, and paleoenvironment in the SJB to assess possible drivers behind mammalian turnover.

Collections of fossil leaves from Puercan and early Torrejonian strata indicate that early Paleocene plant communities were relatively diverse, heterogeneous across the landscape, and dominated by angiosperms. Interestingly, the Puercan floras are considerably different than Torrejonian floras, suggesting the possibility of synchronous turnover of plant and animal communities. Analyses from fossil leaves, paleosols, and stable carbon and oxygen isotopes from mammalian tooth enamel suggest little variability in paleoenvironment or paleoclimate between the Puercan and Torrejonian. Isotopic data from tooth enamel through all of the Puercan and Torrejonian biozones indicates relatively little variability in paleoclimate through the early Paleocene succession. These results suggest that early Paleocene climate in the SJB was relatively stable, and the similar climatic reconstructions for the Puercan and Torrejonian suggest that mammalian turnover is not related to environmental or climate change. Instead the documented faunal turnover through the Puercan and Torrejonian is more likely the result of factors intrinsic to the San Juan Basin mammalian communities, such as rapid evolution, and/or faunal migration in and out of the basin.

Grant Information

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Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

IDENTIFYING AND EVALUATING THE ROLE OF PALEOGEOGRAPHY FOR MARINE MAMMAL DISPERSAL ACROSS OCEAN REGIONS USING BETA DIVERSITY METRICS

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We tested the roles of several intraoceanic connections, including the Strait of Gibraltar, Central American Seaway, Bering Strait, and Arctic Ocean in the dispersal of marine mammals from their points of origin to their existing distribution. A comprehensive dataset of occurrences, derived from the Paleobiology Database (paleobiodb.org), was compiled for all seven groups of marine mammals (Cetacea, Sirenia, Pinnipedimorpha, Desmostylia, *Thalassocnus*, *Ursus maritimus*, and marine Mustelidae). The Cenozoic oceans were divided into thirteen distinct regions and each occurrence was assigned to a region based on its paleogeographic location. Overlap among regions was measured using the Sørensen-Dice Coefficient for all possible combinations of ocean regions in each time frame.

Results confirm the hypothesis that the Strait of Gibraltar served as the avenue through which cetaceans and sirenians left their sites of origin in the Tethys Sea. Results also support the hypothesis that the Bering Strait is a key route through which several groups of marine mammals disperse across the Pacific Ocean. Conversely, the Central American Seaway is found to play only a minimal role in dispersal across the Atlantic and Pacific. We demonstrate that the high overlap values between the Atlantic and Pacific of the present day are achieved in the Quaternary, well after the closure of the Central American Seaway. We suggest the Arctic Ocean as an alternate route and demonstrate the viability of this hypothesis.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

THE VERTEBRATE FAUNA FROM THE UPPER CAMPANIAN SITE OF ARMUÑA (SEGOVIA PROVINCE, CENTRAL SPAIN)

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The Upper Cretaceous (upper Campanian) outcrops of Armuña (Segovia Province, Central Spain) yielded relatively abundant material of vertebrates in the second half of the 1980s. However, scarce information on these remains was hitherto available-most of these specimens remained unpublished, and only a few of them had been preliminarily analyzed. A thorough study of all the specimens from Armuña reveals a high diversity of reptiles, and a faunal association identified as exclusive to this site.

Most of the ichthyofauna represented is composed of undetermined gars (Lepisosteidae). Turtles are represented by at least a solemydid (stem Testudines), and by two members of Pan-Pleurodira: the bothremydid *Iberoccitanemys convenarum*, being identified for the second time outside its type locality in Southern France; and the dortokid *Dortoka vasconica*, recognized for the first time outside its type locality in Northern Spain. The presence of Lepidosauria is reported in Armuña for the first time. This clade is represented by one of the very few worldwide occurrences of Mosasauridae in continental deposits, and by a new anguimorphan lizard with possible xenosaur affinities. The finding of the latter has interesting paleobiogeographical implications because of its phylogenetic affinity with North American taxa. A new eusuchian crocodyliform is also recognized, represented by cranial material of several individuals. Several clades of Dinosauria are identified: lithostrotia titanosaurs; theropods, including a probable undetermined ceratosaur; and rhabdodontid ornithopods. These three clades are represented by teeth and postcranial remains (axial and appendicular elements), and the association is consistent with other Southwestern European Upper Cretaceous sites.

In conclusion, new taxa are identified in Armuña, coexisting with other forms previously known in the Iberoarmorican Realm. The diversity of vertebrates from Armuña is composed of a mixture of European endemic clades and lineages that migrated from other continents such as North America (e.g., xenosaur anguimorphs, if correctly identified) or Africa (e.g., bothremydids).

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

PALEOECOLOGY INFERENCES USING CARBON AND OXYGEN STABLE ISOTOPES FOR THE RANCHOLABREAN MAMMALS FROM DEPRESSION CENTRAL OF CHIAPAS, MÉXICO

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Using the carbon and oxygen isotopic relationship of dental enamel and osteodentine, the diet of three horse specimens (*Equus conversidens*), four gomphotheres (*Cuviernonius hyodon*), one bison (*Bison* sp.), one mammoth (*Mammuthus columbi*), one ground sloth (*Eremotherium laurillardi*), and one American lion (*Panthera atrox*) was inferred. Fossil teeth were recovered from flaviolacustrine sediments in three sites on Depression Central of Chiapas, southeastern Mexico, all of Rancholabrean age. The environmental conditions that existed in the region during the Late Pleistocene were also inferred. The analysis showed that oxygen isotopic values for horses were -1.6‰ to -1.3‰, while *Cuvieronius hyodon* showed a -8.9‰ to 1.3‰ range of $\delta^{18}O$. The bison had a -4.7‰ value of $\delta^{18}O$, and the ground sloth 3.9‰; whereas the mammoth was -0.5‰ and the American lion showed a -2.6‰ value of $\delta^{18}O$. We concluded that the horses, mammoth and bison fed on C_4 plants ($\delta^{13}C$:-1.8‰ to -1.0‰), the ground sloth was a mixed feeder on C_3/C_4 ($\delta^{13}C$: -7.7‰), and the gomphotheres ate C_3 plants ($\delta^{13}C$: -9.4‰ to 11.4‰), while the American lion fed on C_4 herbivores ($\delta^{13}C$: -5.5). These diverse signals show that in Depression Central there were grasslands with some trees, and the climatic conditions were colder and more arid than present day.

Poster Symposia (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

THE INFLUENCE OF SKULL SHAPE MODULARITY ON INTERNAL STRUCTURES: A 3D-PILOT STUDY USING BEARS (MAMMALIA, CARNIVORA)

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In order to capture the phenotypic variation of the internal skull structures, such as the sinuses or the brain, it is necessary to perform CT scans in a large number of specimens, which is difficult and expensive. Therefore, while the external morphology of the mammalian cranium has been the subject of many morphometric studies, the internal structures of the cranium have been comparatively less studied. Here, we explore how the variation of external shape reflects the morphology of internal structures. We use the family Ursidae (Carnivora, Mammalia) as a case study because bears have a wide variability of cranial morphologies in part associated with different trophic ecologies. To do this, we digitized a set of landmarks in 3D with a Microscribe G2X from the external surface of the cranium in a wide sample of bears. Additionally, the crania of seven bear species were CT-scanned and prepared digitally to visualize the 3D models of the external cranium morphology and of internal structures. Subsequently, we divided the landmarks into two modules, splanchnocranium and neurocranium, and we perform a two-block partial least squares analysis (2B PLS) to explore the intraspecific (static) morphological changes associated with the covariation between them. These morphological changes were visualized using the morphing technique with the 3D models, looking at both the external shape and the internal structures. In addition, we inferred the volume of the sinuses and of the brain in each hypothetical model. Our results show that the first two PLS axes are associated externally with changes in the basicranial angle, face length and cranium height and width. Concerning the internal structures, there are parallel changes in dorso-ventral and medio-lateral expansion of sinuses and brain, accompanied by their corresponding changes in volume. In contrast, the third PLS axis is related to opposite changes in the volume of sinuses and brain. These preliminary results suggest that the opposite relationship between sinuses and brain volumes in the bear cranium is not as evident as expected, at least at intraspecific level.

Grant Information

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Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

FIRST BAT (MAMMALIA: CHIROPTERA) REPORTED FROM THE OLIGOCENE OF NORTH DAKOTA

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The reported vertebrate fauna of the Brule Formation within North Dakota is largely based on preliminary faunal lists presented without detailed discussion. An effort is underway to refine our knowledge of that fauna, including a thorough review of the microvertebrates collected in the Little Badlands area (Stark County, North Dakota) and held within the North Dakota State Fossil Collection (NDGS). We report a right maxilla fragment with P4–M3 (NDGS 1691) collected from the Fitterer Ranch locality. The labial edges of M1 and M2 are damaged, but the size (tooth row length 5.11 mm) and overall morphology (M1–2 lack a hypocone; M3 with reduced parastyle,and mesostyle, no metacone, metastyle, or metacristae; P4 non-molariform, unicuspate and triangular) of this new specimen compares favorably with *Chadronycteris rabenae*, which was previously known only from a left maxilla fragment with P4–M3 collected from the Raben Ranch local fauna of northwestern Nebraska (Chadron Formation). Taxa found in association with NDGS 1691 include *Eumys elegans*, *Leptomeryx* cf. *evansi*, *Paradjidaumo trilophus,* and *Palaeolagus haydeni*, indicating that these specimens are referable to the middle to late Orellan 'age' (Or2–Or4). *Oligomyotis casementi* is the only bat taxon definitely reported from the Oligocene of North America; however, the type and only known specimen consists of the distal portion of a humerus that cannot be compared to any known material of *Chadronycteris*. This new occurrence not only extends the geographic and biostratigraphic range of *Chadronycteris*, but fills an important gap in our current understanding of early chiropteran evolution.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

SEXUALLY SELECTED BRIDGES IN THE FITNESS LANDSCAPE AND IMPLICATIONS FROM THE FUNCTIONAL HISTORY OF FEATHER EVOLUTION

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The conceptual metaphor of the morphological fitness landscape depicts all conceivable morphologies expressed across a two dimensional plane and the fitness value of those morphologies plotted across a vertical axis. The result is a hill and valley terrain, where the most beneficial morphologies are the tallest peaks. In the context of modern vertebrate macroevolutionary thought, saltatory evolution, which formerly proposed that a single or a rapid sequence of mutations could propel a lineage through the landscape from one hill to another, has been largely abandoned. According to present thinking, once a lineage has reached a particular peak, it is then impossible for the lineage to make its way to another, unless the landscape itself becomes altered. We suggest that sexual selection, which often favors morphologies that are detrimental to survival, offers one way by which lineages may traverse the landscape and occasionally bridge the gap between one peak and the slope of another. Once sexual selection has driven a lineage to a foreign slope, natural selection then has the potential to take over and to drive the lineage up the slope. In such cases, a formerly sexually selected morphology becomes evolutionarily coopted to serve a different or additional function. Among extant animals, morphologies that now serve an observable function beneficial to survival but are hypothesized to have previously functioned solely as sexual display structures include the manes of male lions and the elongated necks of giraffes. However, these and similar examples are based strictly on speculation regarding potential early functions. It is the challenge of vertebrate paleontology to identify definitive instances where formerly sexually-selected traits underwent a functional shift. We suggest that one of the best and most dramatic examples can be found in the evolution of feathers within non-avian theropod dinosaurs. A new ornithomimid specimen with preserved branching feather filaments establishes that type III feathers evolved for the probable function of insulation, and multiple theropod lineages record the first presence of type IV feathers as sexual display structures. This suggests that type IV feathers were only later coopted for the function of flight. Thus, sexually selected bridges in the adaptive landscape may explain one of the most significant transitions in vertebrate evolution.

Technical Session V (Wednesday, October 14, 2015, 1:45 PM)

A NOVEL NON-DESTRUCTIVE METHOD FOR SKELETOCHRONOLOGY AND ITS PALEONTOLOGICAL AND PALEOECOLOGICAL APPLICATIONS

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We report the first morphological character that can reliably be used estimate age without destructive sampling: LAGs preserved on the zygantral facet of snake vertebrae. Because postzygapophyses grow posterolaterally away from the vertebrae, longitudinal zygantral facets on their medial faces record easily observed LAGs in compact bone inaccessible to remodeling. Zygosphene-zygantra, as elaborations to the zygapophyseal surfaces, are accessory intervertebral articulations unique to lepidosaurs, and diagnostically developed in snakes. They are not to be confused with accessory joints in saurischians, a few 'rauisuchians', or those in younginiforms and sauropterygians, so this feature may prove useful in non-destructive age estimation in these taxa as well.

An individual of *Bogertophis subocularis* (Trans-Pecos Rat Snake) raised under near-constant conditions demonstrates that the zygantrum record reflects annual cycles in day length. Nevertheless, comparisons to wild-caught extant and extinct snakes indicate that the width of and distinctiveness between these annual growth rings may indeed vary with fluctuations in temperature, rainfall and food availability. This enables paleontologists to use isolated snake vertebrae not only to estimate population structure and environmental shifts, but also to test species status and facilitate referral of disarticulated remains screen-washed from the same quarry to a individual organism.

We used these parameters to show that: a) isolated vertebrae attributed to the Eocene boine booid snake *Boavus occidentalis* assigned the same Yale Peabody Museum specimen number are unlikely to derive from the same organism as their LAG patterns do not match; b) conversely, disarticulated *B. occidentalis* vertebrae from the same quarry with the same LAG patterns, but given different specimen numbers, may well belong to the same organism; and c), vertebrae referred to *Boavus* from the San Diego are unlikely to represent the same species as those from Wyoming, given that similar-sized vertebrae of the former are invariably from younger individuals – and thus from a much larger species - than are those referred to the smaller-sized *Boavus occidentalis* of Wyoming.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

NEW DETAILS ON THE PLUMAGE AND COLORATION OF AN EARLY CRETACEOUS ENANTIORNITHINE BIRD

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Melanosomes, organelles that house the ubiquitous pigment melanin, have recently been identified in the exceptionally-preserved integument of fossil vertebrates. The size and shape of melanosomes often correlates to color in extant avian species due to the high morphological disparity of melanosomes in feathers. A similar variability occurs in melanosomes preserved in fossil maniraptoran dinosaurs, allowing for the extrapolation of color in these extinct animals. Here we describe a new specimen of an Early Cretaceous enantiornithine bird from the Jiufotong Formation, Liaoning Province, northeastern China, and present new information on its plumage and coloration. Pennaceous feathers are preserved throughout the body, including elongate feathers along the tibiotarsus, long crown feathers, and two extended rectrices that lack barbs. Feathers are not preserved along the pedal digits. White matrix surrounds the skeleton, obscuring details of the proximal articulation of the feathers with the bones. Scanning Electron Microscopy (SEM) of samples removed from the feathers shows aligned assortments of thin, elongate bodies that are interpreted as melanosomes. We further test this affinity using Raman spectroscopy, a fast, non-destructive chemical technique. Raman peaks from the fossil samples are similar to a natural eumelanin standard from *Sepia officinalis* and extracted eumelanin from extant feathers, suggesting that eumelanin is indeed preserved in the new fossil. Preliminary measurements of the fossil melanosomes suggest that they are similar in size and shape to melanosomes from extant iridescent feathers. Further, melanosomes in both extant iridescent avian taxa and the fossil feathers show a dense end-to-end alignment that contrasts the random orientation of elongate melanosomes in black and grey feathers. Iridescence in fossil and extant maniraptoran dinosaurs may serve a function in intraspecific communication.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

MACROEVOLUTIONARY PATTERNS OF THE LOCOMOTOR SYSTEM IN NON-MURAENOID EELS (TELEOSTEI: ELOPOMORPHA)

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Living eels (Teleostei, Anguilliformes) are characterized by a high diversity in cranial morphology indicating shifts in morphospace occupation during their evolution and multiple divergence events. However, changes in the locomotion performed by the musculotendinous system and the respective tendons of the trunk having the potential to indicate shifts in swimming performance have not been evaluated up to now because exceptionally preserved fossils displaying delicate soft-tissues are rare in the fossil record. Here, we present non-muraenoid anguilliforms from Late Cretaceous, Palaeogene, and Neogene conservation Lagerstätten allowing a definitive assessment of their musculotendinous system and interpretation of their swimming performance in a phylogenetic framework. The increase of the myoseptal length follows largely the evolutionary arrangement of taxa with stem anguilliforms displaying the shortest lateral tendons, which are characteristic for CH-fishes (those preferring complex habitats) while the lateral tendons in anguilloids and congroids are longer. Our results in comparison with an Eocene muraenoid from Monte Bolca support that non-muraenoid crown anguilliforms are IH-fishes (those preferring habitats of intermediate complexity) contrary to previous assumptions, in which anguillids were considered CH-fishes. Macroevolutionary changes in the musculotendinous system from short to long tendons indicate a continuous adaptation of non-muraenoid anguilliforms to open water habitats, which occurred in the aftermath of the third oceanic anoxic event (OAE3) during the Coniacian-Santonian.

Technical Session XV (Saturday, October 17, 2015, 9:45 AM)

THE FIRST AMERICAN BIOTIC INTERCHANGE: FINDING CONGRUENCE IN FOSSIL AND MOLECULAR DATA

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Conventional understanding of biotic interaction between the North and South American continents posits direct land connections only subsequent to the Plio–Pleistocene Great American Biotic Interchange (GABI). The GABI has been extensively studied, and both biotic dispersals and their geological setting are well documented. Less attention has been given to faunal interchanges hypothesized to have occurred prior to the GABI, particularly during the latest Cretaceous and into the early Paleogene. Evidence for the existence of this interchange, known as the First American Biotic Interchange (FABI), has principally been based on fossils of several taxonomic groups which have long been suspected to have dispersed between North and South America, including phylogenetically distinct taxa such as hadrosaurids, several lineages of metatherians, and booid snakes. A more complete understanding of the FABI has been limited by the absence of a comprehensive analysis focused on the problem; most studies have addressed pre-GABI inter-American immigration as a biogeographical footnote in the description and systematic analysis of fossil specimens. Also, few studies have incorporated time-calibrated molecular phylogenetic analyses of extant taxa as evidence.

We compiled time-calibrated phylogenies using molecular and morphological data along with fossil evidence from all geographically relevant taxonomic groups in the first integrative study attempting to elucidate the pattern of interchange between South and North America from 80 Ma to 50 Ma. Our results demonstrate a far more complex model of interaction between the North and South American continents than has been historically presumed, one that is consistent with emerging geological data. We conclude the most parsimonious explanation for observed patterns is the presence of direct land connection, probably ephemeral, between North and South America from 80–50 Ma.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

CRANIAL ANATOMY OF THE ZAMBIAN DICYNODONT *SYOPS VANHOEPENI*

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The Upper Permian Madumabisa Mudstone (Luangwa Basin, Zambia) has yielded a rich assemblage of dicynodont therapsids. Among the 14 currently recognized dicynodont species from this assemblage is *Syops vanhoepni*, previously known from three partially preserved skulls. This taxon was originally described as a species of *Dicynodon*, and even following its recognition as a separate genus, *Syops* was previously thought to be a dicynodontoid (the group of dicynodonts including *Dicynodon* and its closest relatives). More recent analyses have recovered *Syops* as a cryptodont, more closely related to geikiids such as *Aulacephalodon* than to dicynodontoids. However, support for this position has remained weak, due in large part to the large amount of missing data on this taxon.

Here we describe a new specimen of *Syops vanhoepeni* collected in the Luangwa Basin in 2009. The new specimen is a partial skull (broken into three parts) associated with three pieces of the lower jaw. This specimen preserves previously unknown characters of the palate, brain case, occiput, and lower jaw, significantly improving our understanding of *Syops* anatomy. Important morphological details revealed by the new specimen include the strong naso-frontal crest, absence of a true labial fossa and a robust dentary shelf. Diagnostic characters of the species also include a relatively long, low snout, anteriorly projecting massive tusks, postcaniniform crest, a thick median ridge, elongate nasal bosses, and a narrow intertemporal bar with postorbitals extensively overlapping the parietals. The presence of a strong naso-frontal crest further supports the placement of *Syops* within the geikiid clade.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

GIANT AYE-AYE (*DAUBENTONIA ROBUSTA*) PALEOECOLOGY AND BIOGEOGRAPHIC RANGE-A PROXY FOR MODERN AYE-AYE CONSERVATION

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The aye-aye (*Daubentonia madagascariensis*) is a highly derived Lemuriform that has developed rodent-like incisors, modified ear structures, and specialized phalanges/metacarpals. It is the world's largest extant nocturnal primate. The only known extinct member of the family Daubentoniidae is *D. robusta* (the 'giant aye-aye'). Fossil incisors and postcranial specimens of *D. robusta* have been discovered from southwest Madagascar in Lamboharana, Anavoha, Tsirave, and the sinkhole pit in Ankilitelo. A partial tibia was reported from Ampasambazimba (in central Madagascar). It would appear that *D. robusta* had a much larger paleogeographic range than modern *D. madagascariensis*: including all of the southwest and the Central Highlands. Morphologically, the giant aye-aye was merely a larger, 10 kg version of the modern form. Dental microwear and skeletal comparisons between the two species show similar food, and likely, ecological niche space usage between the two species. *D. robusta* became extinct within the last 1,000 years. Skeletal morphology also suggests similarities with extinct Indriidae that also suffered anthropogenically caused extinction within the last millennium. The modern aye-aye's geographic range has been shrinking due to anthropogenic causes. Detailed geological mapping of the known fossil localities will provide a temporal component to compare range areas over time. The giant aye-aye is a useful proxy for conservation efforts of its modern descendant. It is vitally important to understand paleo-range dispersal to aid in conservation of this highly endangered species.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

ACANTHODIANS FROM THE EIFELIAN/GIVETIAN BOUNDARY BEDS OF THE LEMOVZHA RIVER (NW RUSSIA)

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The section along the Lemovzha River, situated in the south-western part of the Leningrad Region, north-western part of European Russia, comprises Eifelian deposits of the Narva Regional Stage (represented mainly by marls, clays and siltstones) as well as Givetian deposits of the Aruküla Regional Stage (represented mainly by sandstones). The position of their boundary hasn't been traced yet. The isolated acanthodian spines and scales, described here, occur in two layers of marls and sandstone intercalation. The only species from the diverse assemblage of vertebrates within this interval known exclusively from the Narva Regional Stage is *Schizosteus splendens*. The new data on the acanthodian diversity of the mentioned deposits confirms the attribution of the studied deposits to stratigraphic unit, specifically to the Kernave Substage of the Narva Regional Stage. The assemblage of acanthodian scales includes the index species of the *Nostolepis kernavensis* Biozone, corresponding to this substage. It also contains one characteristic species of this zone, *Cheiracanthus talimae*, known only from Kernave Substage. Among the transitional taxa that appear in the Kernave Substage and survive into the lowermost part of the Aruküla Regional Stage is *Markacanthus costulatus*. However, common acanthodian taxa belong to transitional species with wide stratigraphic ranges: *Cheiracanthus longicostatus*, *C. brevicostatus*, *Ptychodictyon rimosum*, *P. distinctum*?, *P. sulcatum*, *Rhadinacanthus balticus*, and *Acanthodes* spp. One of the remarkable features of the assemblage is the presence of scales that combine the different morphological characters of several genera: *Cheiracanthus*, *Rhadinacanthus* and *Diplacanthus*. The isolated spines belong to *Haplacanthus marginalis* and *Archaeacanthus quadrisulcatus*. The acanthodian assemblage allows us to define the Narva/Aruküla boundary.

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Romer Prize Session (Thursday, October 15, 2015, 10:45 AM)

MULTI-PROXY DENTAL MORPHOLOGY ANALYSIS: A NEW APPROACH FOR INFERRING DIET

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Dietary inferences are a key foundation for paleoecological, ecomorphological and macroevolutionary studies because they inform us about the direct relationships between the components of an ecosystem. Although there are many informative dietary proxies, they represent different temporal scales, from minutes of an animal's life to many millions of years of evolutionary history. Therefore, a few considerations need to be addressed before choosing a dietary proxy: a) what is the scale of the research question we are attempting to answer (e.g., climate change or macroevolution), and b) what is the range of dietary variation we want to investigate and characterize?

The goal of my Ph.D. research is to design an approach that can be applied to macroevolutionary questions such as morphological evolutionary responses to environmental perturbations and through geological time. To do this, I needed a quantitative phylogeny-free method to infer the typical diet of a species. Additionally, my previous research suggests that diet is far more complex than a traditional herbivore-omnivore-carnivore classification, which masks important feeding specializations. Therefore, I have developed a multidimensional ecometric method to capture the variability of diet and dietary morphospaces.

I 3D scanned 165 extant mammalian dentitions covering 141 species and seven taxonomic orders and designed an approach called Multi-Proxy Dental Morphology Analysis (MPDMA). First, multiple variables are estimated from the 3D scans (i.e., orientation patch count, slope diversity or relief index). Principal component analysis is used to differentiate ecomorphological specializations. This procedure makes it possible to draw accurate dietary inferences based on the resultant ecomorphospaces, which correlate well with major dietary specializations. Additionally, MPDMA highlights evolutionary changes within a given phylogeny. The coverage as well as movement across the plots of species belonging to different paleocommunities serves as a proxy for processes of diversification and for ecomorphological evolutionary patterns such as niche competition or occupation of functional optima.

Grant Information
Ph.D. program in Macquarie University, Sydney, Australia

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

ARMATURES OLD AND NEW FOR VERTEBRATE FOSSIL MOUNTS IN THE FOSSIL HALLS OF THE NATIONAL MUSEUM OF NATURAL HISTORY

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Armatures for mounting fossil vertebrate specimens in life positions are complex structures and are inherently tied to the strength, stability, and scientific usefulness of a specimen over its period of display. While many nuances of armature design are proprietary to a builder or team of builders, the general design, materials, and appearances of mounting armatures can be grouped into categories useful for their identification and strategizing reverse engineering during the uninstallation of a mount.

Using specimens dismantled during the renovation of the Fossil Halls at the Smithsonian Institution National Museum of Natural History (NMNH) as examples, armature designs are categorized into internal, external, and plaque mounting styles. The structure of armatures is diagrammed across several mounts, forming a useful 'road map' to armature structure of mounts still existing. The advantages and disadvantages of each mounting style in relation to the scientific use of mounted fossils during and after public display are described. Common mount materials including metals, paints and coatings, padding materials, fillers and aesthetic additives, and adhesives are described and the consequences of their use to fossil chemical and physical stability are examined. The presence of hazardous materials in mount structures such as asbestos plaster and lead paint are known from mounts constructed in particular periods of time, and means of testing for and working with these substances are discussed. Armature designs and materials used in the past are compared with those preferred today, to show a shift towards archival materials and designs that reduce the chance of physical damage to specimens from weight loading, abrasion, and seismic activity.

Included in this presentation are lessons learned from the NMNH vertebrate fossil preparation team during the process of dismantling a number of different types of mounts, including the process of strategizing reverse engineering of mounts and tools useful in mount dismantling. This information can serve as a reference to preparators and exhibit designers when working to remediate issues with old mounts, disassemble old mounts, or design new mounting structures.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

A NEW PARVICURSORINE ALVAREZSAUROID SPECIMEN IVPP V20341 (DINOSAURIA: THEROPODA) FROM THE UPPER CRETACEOUS GOBI BASIN: A SPECIMEN OF *LINHENYKUS* OR AN EIGHTH GENUS?

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Upper Cretaceous rocks from the Gobi Basin of China and Mongolia have yielded alvarezsauroid theropod dinosaurs with impressive specialized body plans, including the uniquely monodactyl parvicursorine alvarezsauroid *Linhenykus monodactylus*. The latter taxon is the only parvicursorine species from the Upper Cretaceous Chinese Gobi Basin and belongs to the Wulansuhai Formation of Bayan Mandahu, Inner Mongolia. We compare a new fragmentary disarticulated parvicursorine specimen IVPP V20341 from the same formation and locality with *Linhenykus* and find that they have different origination points for their anterior caudal transverse processes: in IVPP V20341, this is the anterodorsal corner of the centra whilst in *Linhenykus* it is the posterior end of the prezygapophyses. There are also a number of tentative differences observed, but these require further information from future finds to confirm – particularly with regards to anatomical variation along the parvicursorine spine as many of these differences relate to vertebral elements that have similar, but not identical, vertebral numbers. IVPP V20341 lacks any of the known autapomorphies of other Asian parvicursorines, but this is partly because many relevant elements are missing from the specimen. IVPP V20341 is seemingly unique amongst alvarezsauroids because of the presence of cervical procoely and its relatively larger semi-circular neural canals. However, these features can be plausibly explained as anatomical variations of the parvicursorine cervical series because similar degrees of variation are actually observed in the dorsal and caudal series of these animals. Thus, erring on the side of caution IVPP V20341 is not identified as a new taxon, although future discoveries, particularly of vertebral elements, may warrant a taxonomic revision. As a parvicursorine specimen without any autapomorphies, IVPP V20341 does not contradict the hypothesis that the Bayan Mandahu fauna is unique compared to other localities within the Upper Cretaceous Gobi Basin. Thus, despite the description of this specimen there are still seven parvicursorine species in the latter basin (*Linhenykus*, *Albinykus*, *Ceratonykus*, *Kol, Mononykus*, *Parvicursor,* and *Shuvuuia*). This study represents an extreme example of making anatomical comparisons when precise vertebral position data – vertebral number along the spine – is lacking. It is hoped that this example can serve as a valuable case study for vertebrate palaeontologists conducting work on similarly-preserved material, particularly younger students.

Grant Information

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Technical Session XIV (Friday, October 16, 2015, 3:30 PM)

TETHYAN AND WEDDELLIAN BIOGEOGRAPHIC MIXING IN THE MAASTRICHTIAN OF ANGOLA

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Field work performed by Projecto PaleoAngola recovered a rich and diverse marine amniote fauna of mosasaurs, plesiosaurs, and turtles from Maastrichtian age sediments in Angola. Although some taxa appear to be endemic and others cosmopolitan, the mosasaur fauna is taxonomically most similar to the Tethyan assemblages of North Africa and the Middle East; faunas in which mosasaurs are the dominant component and plesiosaurs are rare. Conversely, plesiosaur remains are common in the Angolan deposits, comprising about half of the specimens. The relative abundance of plesiosaurs is exceeded only in Antarctic localities of comparable age, in which plesiosaurs are the dominant component, followed by mosasaurs and an absence of turtles. Of the five mosasaur genera reported from Antarctica, two are also known from New Zealand, three from Patagonia, and two from Angolan localities. Of the two recently described plesiosaurs from Angola, one shares a relationship with northern hemisphere elasmosaurs, and the other, an aristonectine, shares a close relationship with southern hemisphere forms reported from Patagonia, New Zealand and Antarctica. Recently published paleotemperature data for the Angolan locality indicates relatively cool (~18°C) sea surface temperatures, while a mosasaur producing locality in Morocco, at ~25° North paleolatitude, has a paleotemperature of ~25°C, and Antarctic temperatures range from ~4°C–~10°C in the Maastrichtian. Given previously published estimates of thermoregulation in these forms, the taxonomic distribution of marine amniotes may reflect thermally mediated ranges. Mixing of Tethyan and Weddellian Biogeographic Provinces has also been suggested for marine amniote localities in Australia and Patagonia; however, the Angolan localities, at ~25° South paleolatitude, are the most northward extension of this phenomenon.

Preparators' Session (Thursday, October 15, 2015, 8:30 AM)

EXCAVATION AND COLLECTION OF A NINE-TON FIELD JACKET CONTAINING FOSSILS OF NUMEROUS IGUANODONT AND *UTAHRAPTOR* DINOSAURS FROM THE EARLY CRETACEOUS YELLOW CAT MEMBER OF THE CEDAR MOUNTAIN FORMATION IN EASTERN UTAH

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In 2005, the Utah Geological Survey began excavation of a site in the Early Cretaceous upper Yellow Cat Member of the Cedar Mountain Formation. This site, located high on a cuesta in eastern Utah, contained a number of well-preserved bones of iguanodont and *Utahraptor* dinosaurs. Because of the number of delicate elements preserved in close association with one another, efforts to isolate and collect individual elements became unfeasible so an effort was made to isolate larger blocks. In 2006, a roughly 1000-pound (450 kg) block was jacketed and flipped off of the top of this dense accumulation of fossils and slid down the cuesta on a car hood. In subsequent years, efforts were made to isolate blocks of a size that were practical to collect by hand but the number of bones present made this difficult to achieve. We decided that the only way to proceed was to collect a very large block. During excavation it became apparent that the bones were confined to a lensoidal-ovoid shaped green sandstone mass within a red mudstone unit that we hypothesize was a dewatering feature (quicksand) that trapped, killed, and preserved at least two iguanodont and numerous *Utahraptor* dinosaurs. A massive amount of hand digging and rock removal using an electric hammer drill was accomplished over a number of field seasons, resulting in the isolation and plaster jacketing of a large block from the surrounding unfossiliferous mudstone. The block measured over 10' x 9' x 3' (3 m x 2.7 m x 0.9 m), too large to be transported by all but the largest helicopters, so we decided to construct a temporary track to the site, and build a wooden frame under the block. A wooden frame was designed, pre-assembled off site, and disassembled for transport. We bolted four 10" x 10" (25 cm x 25 cm) crossbeams to two underlying 8" x 8" (20 cm x 20 cm) beams at the base, and reinforced the assembly by using three 6' x 1.5" (180 cm x 3.8 cm) steel rods encased in 2" (5 cm) diameter pipe. We pedestalled the jacket and then tunneled under the center so that it was sitting on two pillars, allowing us to slide two crossbeams through the center. Once the frame was constructed the pillars were removed, additional wood and plaster were used to shim the block, and heavy-duty strapping was used to secure the block. The block and frame were then pulled down the steep temporary track using a hydraulic excavator (track hoe). At the base of the hill, the rocky terrain was damaging the wooden skids so metal guard rails where attached under the skids, for the remainder of the 1.6 km journey to where it could be loaded onto a semi truck trailer for transport to Salt Lake City.

Poster Symposia (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

FORM, FUNCTION, AND CLADE SORTING: A PHYLOGENETIC AND ECOLOGICAL ANALYSIS OF CARNIVORAN TARSAL EVOLUTION USING 3D DATA

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Mammalian ankles have complex, interlocking surfaces whose form is functionally related to a repertoire of locomotor movements that vary widely across clades. The shapes of the tarsals constrain movements at the upper ankle joint, at the transverse tarsal joint, and at the interface between the calcaneum and astragalus. We used 3D morphometric analyses of calcaneal and astragalar shape to characterize the morphological correlates of locomotor variation in extant carnivorans. These results show that the curvature of their interlocking facets, the proximo-distal position of the sustentaculum, and the proportional length of the calcaneal process are correlated and vary functionally in a spectrum ranging from digitigrade leapers and scansors (primarily felids), digitigrade cursors (primarily canids and hyaenids), semidigitigrade scansors (primarily mustelids and herpestids), to plantigrade terrestrial and semiarboreal taxa (primarily ursids and procyonids). While tarsal morphology and locomotor style show some homoplasy, both form and function have a strong phylogenetic correlation such that each living carnivoran family has its own characteristic locomotor style.

The locomotor specializations of carnivoran communities vary with environment: open habitats are dominated by cursorial and fossorial species; closed forest habitats contain a mix of semicursorial, scansorial, and arboreal taxa; and highly heterogeneous habitats, such as basin and range, are also mixed but with a higher proportion of ambush predators and cursors. Using morphometric data in a phylogenetic framework, we show that these differences in the locomotor repertoire of carnivorans between habitats are due to clade sorting. Furthermore, the taxa composing New World tropical forest communities have, on average, a more recent common ancestor than other habitats because carnivoran arboreal specializations in North and South America are found almost exclusively in procyonids (scansoriality is more widespread, especially in small felids). Thus, the ancestral carnivoran conditions of scansoriality and arboreality were lost in the New World during the Neogene and re-evolved as carnivorans occupied the emerging neotropical forests of Central America.

Romer Prize Session (Thursday, October 15, 2015, 11:00 AM)

PHYLOGENY OF IGUANODONTIA (DINOSAURIA: ORNITHISCHIA) AND BIOMECHANICAL ANALYSIS OF THE CARPUS-DIGIT I COMPLEX

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Non-hadrosaurid iguanodontian dinosaurs (hereafter iguanodontians) were abundant and widespread, yet their phylogeny has been poorly resolved. Three key morphological changes occur in the postcrania during their evolution: (1) extensive fusion of the carpals and digit I, (2) enlargement of the first manual ungual, (3) a shift to a quadrupedal stance. The aim of this study is to construct hypotheses of iguanodontian phylogeny, trace the evolution of quadrupedality using osteological correlates, and use Finite Element (FE) methods to test whether carpal fusion was driven by the function of the first digit or by the novel weight-bearing function of the forelimbs.

A character matrix was created for 66 taxa using 329 characters (194 more than any published matrix). Parsimony analysis using New Technology searches in TNT yielded 35 most parsimonious trees. The majority rule consensus largely agreed with time-calibrated Bayesian trees found using relaxed clock methods in MrBayes. Several monophyletic subgroups of iguanodontians arise in this tree, replacing the pectinate topologies of previous analyses, though there is no single clade of 'iguanodontids'.

Osteological correlates for quadrupedality found in other definitively quadrupedal ornithischians were mapped onto the majority rule parsimony tree: a cluster of these change near the base of Ankylopollexia, between *Camptosaurus* and a clade containing *Mantellisaurus*, *Iguanodon*, *Hypselospinus,* and *Barilium*.

CT scans of the carpal elements were obtained for two specimens of *Camptosaurus* with differing degrees of carpal fusion, and one fully fused specimen referred to *Barilium*. Three dimensional models were created using Mimics, and FE analyses were performed in FEBio. When a force was applied to the articular surfaces of metacarpals II-IV, representing a ground reaction force, peak stresses were seen along the area of fusion between the radiale and metacarpal I in *Camptosaurus*, though stress remained low on most of metacarpal I. In *Barilium*, almost no stress was observed on the first digit or its suture with the radiale. When the distal end of the first digit was loaded, representing use of the ungual, high peak stresses were found propagating from the first digit into the radiale and intermedium in all specimens. This indicates the carpal fusion seen in iguanodontians was likely in response to a function of the first digit. The fusion of the radiale and metacarpal I in *Camptosaurus* suggests that this behavior was likely present at the base of Ankylopollexia, before the pollex ungual became enlarged.

Grant Information
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Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

EARLY AND MIDDLE CENOMANIAN ELASMOBRANCHS FROM THE VOLGA REGION, RUSSIA

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Elasmobranchs from the Cenomanian Melovatka Formation of the Volga region (Russia) have been known since the mid-19th century and were studied by L. Glickman between 1950 and 1970. Up to now, only one middle- and numerous late Cenomanian elasmobranch assemblages have been recognized. Recent collecting and bulk sampling from a single early Cenomanian locality (Melovatka-5) as well as four middle Cenomanian localities has provided new data on Late Cretaceous elasmobranch distribution and diversity.

The early Cenomanian assemblage is dominated small to mid-sized lamniform sharks (*Archaeolamna* cf. *kopingensis*, *Eostriatolamia subulata*, *Palaeonacorax volgensis*, *Kenolamna gunsoni*, *Pseudoscapanorhinchus compressidens*; each taxon comprising 30% down to 2.5% of all specimens). Less common shark taxa (*Paraorthacodus recurvus*, *Synechodus dubrisiensis*, *Squatina cranei*; taxa comprising 1.5-1% of specimens), rare species (*Cretoxyrhina vraconensis*, *Cretolamna catoxodon*, *Protolamna sokolovi*, '*Eorhincodon'*, *Johnlongia*, *Anomotodon*, *Polyacrodus*, *Acrodus*, *Protosqualus*, *Heterodontus*, *Cederstroemia*; taxa comprising less than 1% of specimens). Batoids are very rare and restricted to two taxa (*Squatirhina*, *Turoniabatis*).

The middle Cenomanian assemblage is similar to that from the early Cenomanian, but shows more ecological differentiation and contains more taxa: *Palaeoanacorax obliquus* (absent or common at different localities), *Ptychodus* spp. (absent, very rare or common), *Cretoxyrhina denticulata* (instead of *C. vraconensis*), *Cardabiodon* cf. *ricki* (very rare), *Protoscyliorhinus* (rare), ? *Carcharias* and ? *Telodontaspis*. Some taxa are totally (*Cretoxyrhina vraconensis*) or occasionally (*Kenolamna gunsoni*, *Palaeoanacorax obliquus*, *Protosqualus*, *Protoscyliorhinus*, *Squatirhina*, *Turoniabatis*) absent in different localities at this time.

The early-middle Cenomanian elasmobranch communities demonstrate an initial faunal invasion and a trend of increasing diversity resulting from regional marine transgressions which provide locally varied environmental conditions during the middle Cenomanian. Overall, the Cenomanian elasmobranch fauna in the region is a low-energy community occupying the boreal epicontinental sea of the Russian Plate.

Grant Information
RFBR grant 14-05-00828.

Technical Session XIX (Saturday, October 17, 2015, 2:15 PM)

ANATOMY AND THREE-DIMENSIONAL RECONSTRUCTION OF THE SKULL OF THE STEM TETRAPOD *CRASSIGYRINUS SCOTICUS*

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The stem tetrapod *Crassigyrinus scoticus*, a large aquatic predator from the mid-Carboniferous of Scotland, features an unusual skull exhibiting primitive characters alongside unexpected and bizarre specializations. Previous reconstructions of the skull were based on five known specimens, all of which are either incomplete and/or strongly deformed. In this study, skull material from three *Crassigyrinus* specimens was microCT scanned and visualization software used to digitally strip matrix from bone and separate individual bones from each other. Our work reveals new anatomical details of the *Crassigyrinus* skull, including detailed sutural morphology. We confirm the presence of an elongate adsymphysial bearing a fang pair in the lower jaw and demonstrate that the overlapping arrangement of the adsymphysial and coronoid bones is identical to that exhibited by *Eusthenopteron, Acanthostega*, and *Greererpeton*. Contrary to previous studies, CT data demonstrates that all three coronoids bear teeth. We confirm lack of contact between the prearticular and postsplenial, posterior exposure of the articular, and demonstrate that the anterior process of the prearticular passes medial to the lamina of the splenial as in other early tetrapods, such as *Acanthostega*. Finally, CT scans reveal that various bones of both the cranium and lower jaw were misidentified in earlier studies. Damage to specimens was digitally repaired and missing elements duplicated across the sagittal midline; bones were then articulated to create a 'retrodeformed' 3D reconstruction of the skull of *Crassigyrinus*, permitting greater understanding of skull morphology and function in this key taxon.

Grant Information
This work is funded by a Marie Curie International Incoming Research Fellowship ("Tetrapods Rising", 303161) to LBP.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

HOW DID THE ARCHAIC UNGULATE *MENISCOTHERIUM* GROW? BONES AND TEETH TELL DIFFERENT TALES

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Meniscotherium was a small to medium-sized Eocene mammal of uncertain affinities. It is often included within the Phenacodontidae, part of the poorly resolved, paraphyletic group of "condylarths". Previous research using molar perikymata and enamel growth increments indicates that crown formation times in *Meniscotherium chamense* were between 1 and 1.5 years. At an estimated mass of 5–17 kg, this is a relatively long molar formation time and has been suggested to imply a slower life history.

I use new data from long bone histology of *Meniscotherium* as an independent assessment of pace of life. Histological samples were prepared from the femoral mid-shaft of *M. chamense* from the Wasatchian San Juan Formation of New Mexico. The locality (AMNH Q150) preserves a mass death assemblage, with an ontogenetic range previously assessed by tooth eruption and wear of the fourth premolar. At least two growth stages of femora have been recovered. A small specimen (UCMP 76287) shows rapid growth (well-vascularized fibrolamellar bone lacking uniform fiber direction). It has no discernible lines of arrested growth (LAGs), but does have a thin band of parallel-fibered bone around the periosteal surface. The larger UCMP 76284 similarly lacks LAGs, and has a layer of more lamellar bone outside less ordered fibrolamellar bone. The larger specimen is also distinguished grossly by size and fused distal epiphyses, which remain unattached in UCMP 76287. Despite these and other differences, both specimens show a similar histological profile, that of fast growth followed by a sudden change to deposition of more parallel fibered bone. If this latter tissue represents the imminent cessation of growth, the adult size disparity may have several causes (e.g., sexual or taxonomic difference). Whatever the cause, the bone tissue profile and its apparent growth duration of less than one year appears inconsistent with the slow molar growth inferred for *Meniscotherium*. Modularity or other complexities of growth may have been involved in its developmental mode, but further samples of both teeth and bone are required to assess the question fully.

Growth dynamics and life history strategies of early Cenozoic mammals remain poorly known. This initial work demonstrates the utility of combining developmental data from tooth and bone histology. Further research, especially expanding the knowledge of early mammal histology, will allow contextualization of *Meniscotherium* life history within placental mammal evolution.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

SKELETAL VARIATION IN *GEHYRA* GECKOS

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The Quaternary fossil record of squamates is characterized by disarticulated and fragmented specimens. Paleontologists who work on such fossils are met with challenges like inadequate sources of comparative material and a lack of important elements recovered from the fossil record. Therefore most descriptions of squamate fossils from the Quaternary are largely limited to fragmentary dentigerous elements, frontals, and parietals. The paucity of comparative specimens led many paleontologists to identify fossils of squamates based on overall morphological similarity and modern biogeography. Such methods may lead to misinterpretation of data. Even a single representative of every possible species would be inadequate as a comparative collection. The morphology of a species can vary depending on a number of factors including ontogeny, sex, habitat, teratologies, and differing levels of genetic relatedness. By limiting a comparative sample to one individual it is not possible to assess variation. Additionally, without understanding the degree of intra- or interspecific variation it is impossible to assess the degree of polymorphism in, and phylogenetic significance of, the characters in question. I attempted to investigate the effect of osteological variation on phylogenetic signal for squamates using Australian geckos of the genus *Gehyra* as a model. I explored the degree of intra- and interspecific osteological variation in two species by examining 125 extant specimens from known populations, accounting for several sources of variation. Using neontological data has the added benefit of providing a reliable perspective on some questions related to behavioral traits of the organisms. For example, I used two focal species with significant differences in documented habitat specificity. *Gehyra pilbara* is a habitat specialist that is only documented on or in termite mounds, whereas *Gehyra variegata* is a widespread habitat generalist that is found in almost any Australian environment. By using these two geckos I am able to study the relationship between the level of habitat specialization and morphological variation. It has been argued that the most reliable method for identifying fossils is an apomorphy-based approach; however, with an incomplete understanding of the full range of polymorphisms for an organism, even this method is limited. Studies such as this are a step toward developing a greater understanding of morphological variation and how it affects the interpretation of fossils.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

LONG- AND SHORT-TERM ABRASION EFFECT IN THE DIET OF *EQUUS CONVERSIDENS* FROM LATE PLEISTOCENE LOCALITIES IN CENTRAL AND SOUTHERN MEXICO

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The long- and short-term abrasion effect in the diet of samples belonging to *Equus conversiden*s is explored by means of dental wear patterns at macro- (mesowear) and microscopic (microwear) inspections. The sample consisted of 68 adult individuals represented by 94 teeth that were recovered from late Pleistocene localities in central (Estado de Mexico and Hidalgo states) and southern (Oaxaca and Chiapas states) Mexico.

The mesowear score (MS) in the sample from the Estado de México (MS=3.3) is similar to that of the extant antelope *Alcelaphus buselaphus*, which is an abrasion

dominated mixed feeder. The samples of Oaxaca (MS=4.2), Hidalgo (MS=4.73) and Chiapas (MS=5) have mesowear scores that are similar to the extant zebras *E. grevyi* and *E. burchelli*, which are dedicated grazers. The average number of scratches (AS) and pits (AP) in the sample from the Estado de Mexico (AS=23.5, AP=18.5), as well as the high frequency of large pits (100%), are indicative of an abrasion-dominated diet with some dirty browse. The average number of scratches and pits in the samples from Hidalgo (AS=23.6, AP=12.7), Oaxaca (AS=23, AP=13.4) and Chiapas (AS=24.79, AP=10) are within the morphospace considered for the extant grazers. Particularly, the sample of Oaxaca is characterized by a high number of fine scratches (scratches width score, SWS=0.3) and large pits (88%), suggesting browsing in its diet.

The dental wear patterns at micro- and macroscopic scales in the samples of *Equus conversidens* from central and southern Mexico are related to diets consisting of an important intake of abiogenic and biogenic abrasive resources at short- and long-term, suggesting that a high and continuous abrasive effect occurred across the lifespan of these horses. However, it is likely that the abrasion-effect was reduced in the samples from the Estado de Mexico and Oaxaca, considering that their dental wear patterns indicate partial browsing into its diets. Our results indicate that abrasive food resources dominate the average trophic practices and the last meals content in some Mexican populations of *E. conversidens*. This pattern is consistent with the dietary behavior proposed in other populations of *Equus* from the late Pleistocene of temperate and tropical North America. Therefore, it seems that members within the genus, such as *E. conversidens*, commonly have diets consisting primarily of abrasive sources.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

ON THE ANATOMY AND RELATIONSHIPS OF THE SAUROLOPHINE DINOSAURS FROM CARELESS CREEK QUARRY (MONTANA, USA)

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The Careless Creek Quarry was a multitaxic bonebed from the Campanian Judith River Formation of Wheatland County, south-central Montana, USA. It produced hundreds of disarticulated bones representing a diverse assemblage of vertebrates, including dinosaurian clades like ceratopsians, pachycephalosaurids, and both lambeosaurine and saurolophine hadrosaurids. Here, we highlight the informative characters of the saurolophine specimens and infer their phylogenetic affinities. In the cranium, the prefrontal shows a subsquared and thick orbital margin, an extensive rostroventral region, and a broad and slightly depressed dorsal surface. The subtriangular lacrimal extends rostrally, showing a broad jugal notch, a gently convex ventral margin, and a tall caudodorsal process. The squamosal displays a shallow caudal region, a quadrate notch with straight dorsal margin, and a prequadratic process that is approximately as long as the quadrate notch is wide. The position of the wedge-shaped groove for reception of the caudal ramus of the postorbital indicates that this ended rostral to the level of the quadrate notch of the squamosal. In the postcranium, the ilium shows a relatively shallow central plate and a long subrectangular postacetabular process; the supraacetabular crest is extremely developed, extending lateroventrally to overlap part of the ischiadic process. The prepubic process of the pubis shows a moderately long narrow 'neck' and a longer, ventrally deflected and subrectangular distal blade. Maximum parsimony analysis indicates that the Careless Creek saurolophine is a member of Kritosaurini. Specifically, it forms a polytomy with species of *Gryposaurus*. This position is unambiguously supported by a postacetabular process of the ilium that is at least 10% longer than the central plate. Boostrap proportions, however, indicate poor repeatability for this placement for the Careless Creek saurolophine within kritosaurins. Given the known current distribution of *Gryposaurus* species, the Careless Creek kritosaurin may represent the first occurrence of *G. notabilis* in the Judith River Formation or a new species within the clade, cogeneric or not with *Gryposaurus*.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

NEW ANATOMICAL DATA ON AN OLIGOCENE MORID FISH *EOPHYCIS* (GADIFORMES) FROM THE CENTRAL PARATETHYS (POLAND)

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Articulated fossils of Moridae (Gadiformes) are very rare. Although some species were historically classified within this group, only very few of them can be confidently assigned to this family. Today living representatives of the Moridae are marine deep-water fish also infrequently found in brackish water, while the fossil record is limited to marine sediments. The group is well defined by an otophysic connection, horizontal septum of the gas bladder, specific morphology of otoliths, unique architecture of the caudal skeleton, and a parasphenoid with transversely aligned ascending processes.

Three species of the genus *Eophycis* were described from Oligocene strata of different parts of the Paratethys basins. Their affinity to Moridae was confirmed by otoliths in situ at the Caucasian specimens. Newly collected well-preserved material of *E. jamnensis* species from the Hermanowa site (lower Oligocene; Polish Carpathians) show numerous previously unknown (or uncertain) important characters, such as: relatively hypo-ossified neurocranium, head of the vomer does not show presence of any teeth, small conical teeth in two or three rows developed at the margins of the dentary and premaxilla, two visceral interosseous openings, i.e., a dorsal (in between of hyomandibula and preoperculum) and ventral one (among of preoperculum, quadratum and symplecticum), 'V'-shaped opercle, moderately developed supraoccipital crest and its articulation with neural spine of the first abdominal vertebra, in comparison to other morids remarkably short vertebral column, especially in the abdominal region, single dorsal and anal fins with numerous rays, neither dorsal nor anal fins coalesced with caudal fin, pectoral fin is supported by a relatively low number of elongated rays, elongated filamentous-like ventral fins located anteriorly to the pectoral fins, and a rounded caudal fin.

The newly collected specimens were compared with type specimens of the species and with published data regarding both fossil and recent morids. It is possible to say that many anatomical aspects are comparable to Recent Moridae (e.g., general body architecture, otoliths, reduced ventral fins), but numerous previously undescribed (or misinterpreted) features are unique within Moridae. This might help better understand this species, but also early morids in general, and their relationships within order Gadiformes.

Grant Information
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Romer Prize Session (Thursday, October 15, 2015, 11:15 AM)

RESOLVING THE FIRST RADIATION OF CROWN REPTILES

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Since the earliest Triassic, saurian reptiles have been critical components of terrestrial ecosystems. However, molecular and fossil evidence indicates that the divergence between the two constituent lineages (Lepidosauria, Archelosauria) took place deep in the Permian Period. A large number of early-diverging stem-archosaur and stem-lepidosaur clades have been described from the Permian and Triassic, exhibiting an extraordinary range of bauplans. However, the interrelationships of these stem taxa are poorly resolved, owing to fragmentary records and poor preservation in many groups. As such, the timing of both the initial taxonomic and morphological diversifications of Sauria remain poorly understood.

To resolve this phylogenetic uncertainty and the first radiation of crown reptiles, a new phylogenetic data matrix was constructed from a broad sample of Permo-Triassic diapsids. New, three-dimensionally preserved fossils from a number of poorly understood stem groups (e.g., long-necked Tanystropheidae, chameleon-like Drepanosauromorpha) allowed coding of many previously unknown morphologies. Iterations of this data matrix were subjected to both standard parsimony analysis and Bayesian tip-dating methodologies.

The results of this analysis suggest that at least ten distinct lineages of Permo-Triassic diapsids survived the PTE, substantially more than went extinct at that time. They do not form a monophyletic Protorosauria clade, a group traditionally considered to include most long-necked, small-headed early archosauromorphs. Instead, these taxa include no fewer than six separate Permo-Triassic diapsid lineages. Indeed, character optimizations strongly suggest that a long-necked, lizard-like bauplan was ancestral for Archosauromorpha. The inclusion of fragmentary fossil material from Early Triassic archosauromorphs indicates that a great deal of morphological diversity existed in saurian groups within the first five million years of the Triassic.

Grant Information
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Technical Session II (Wednesday, October 14, 2015, 10:45 AM)

FLIGHTLESS WING-PROPELLED DIVING AND THE EVOLUTION OF BODY SHAPE IN PENGUINS

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Wing-propelled diving represents one of a multitude of locomotor strategies utilized by birds, and has evolved multiple times independently. The greater density and viscosity of water relative to air imposes divergent functional pressures on avian anatomy and biomechanics, including wing shape and size, body shape and size, bone density, and flight stroke mechanics. Flightless wing-propelled divers are released from these contrasting pressures; the only extant flightless wing-propelled divers, penguins, possess derived morphology, posture, and biomechanical attributes relative to other birds, particularly when compared with their close relatives, petrels. We utilized whole-body CT scans of Emperor Penguins and wing-propelled diving *Puffinus* shearwaters to investigate shifts in body shape and proportions associated with the evolution of flightless wing propelled diving. We also examined shifts in biomechanical parameters such as center-of-mass to understand how this transition affected functional attributes such as posture and terrestrial locomotor capability. We additionally employed CT scans of extensive skeletal material of the extinct penguin *Waimanu* from the Paleocene of New Zealand to produce 3D digital reconstructions of body shape and biomechanical parameters for the earliest known penguin, providing a more nuanced view of this transition. We recover significant changes in body shape and biomechanical shifts in the evolution of penguins resulting from changes to the pectoral girdle, and find that many of these shifts were present early in penguin evolution. Contributions from shifts in the pelvic girdle to overall body shape evolution, while present in *Waimanu*, are more pronounced in extant penguins. Overall, these data provide additional context for understanding the evolution of ecological and morphological disparity in birds, as well as for investigating the effects that novel locomotor strategies have upon whole-organism form and function. Specimens for scanning were provided by the Natural History Museum, London, UK and the Canterbury Museum, Christchurch, NZ.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

THE HESPERHYINE PECCARIES: IMPLICATIONS OF THEIR UNEXPECTED DIVERSITY FOR PALEONTOLOGICAL DATABASES

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The Hesperhyinae is a monophyletic group of primitive peccaries that have long been plagued by confused systematics, invalid taxa, incorrect generic assignments, and poor specimens. Even though the currently published literature recognizes only one genus, *Hesperhys* (and sometimes *Desmathyus*), new fossils show that there are seven distinct genera (four new) and seven species (two new). Hesperhyines are now defined by a distinctive suite of unique characters in the choanal region of the skull. The earliest hesperhyines include a primitive new genus and species, *Lucashyus coombsi*, from the late Arikareean of Wyoming, along with "*Cynorca*" (now *Marshochoerus*) *socialis* from the late Arikareean of the John Day Formation. *Floridachoerus olseni* from the early Hemingfordian of the Thomas Farm local fauna in Florida is a slightly more derived

hesperhyine, as is the new genus *Stuckyhyus siouxensis* from the late Arikareean of Wyoming. The most derived taxon is *Hesperhys vagrans* (from the late Hemingfordian and early Barstovian). New material demonstrates that *Hesperhys* is a very distinctive large robust peccary with inflated cheek teeth. *Hesperhys* is dramatically different from the smaller more gracile *Desmathyus pinensis* (from the late Arikareean of South Dakota) and the new taxon *Wrightohyus yatkolai*, from the late Arikareean-early Hemingfordian of Nebraska and Wyoming. All three of these taxa were incorrectly lumped into *Hesperhys*. This revision of all the new material and mistaken systematic assignments reveals a significant evolutionary radiation and a much greater taxonomic diversity of peccaries in the early to middle Miocene than the older literature had ever suggested. It also substantiates the importance of this large monophyletic clade that was completely unrecognized by earlier scientists. Such undescribed diversity in places like the Frick Collection is a serious problem for databases which compile taxonomic and diversity data of North American Miocene mammals. This is true not only of the peccaries, but also in understudied groups like the camelids, pronghorns, and mastodonts, which probably have many more undescribed taxa in their immature taxonomy. The PBDB and MIOMAP assume that bad taxonomy in their data is not a problem, and do not address the issue of immature taxonomy in their analyses.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

THE FROZEN MUMMY OF THE WOOLLY RHINOCEROS, *COELODONTA ANTIQUITATIS* BLUM., 1799 CALF: A NEW DATA ON EARLY ONTOGENESIS OF THE EXTINCT SPECIES

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The new woolly rhino calf ‘Sasha' was found thawed out from the bank deposits of the unnamed tributary of the Semyulyakh River in Abyi District of Yakutia (Sakha) Republic in September 2014. It represents the first find of a frozen mummy of the extinct species of such a young age.

The woolly rhino comprises about a half of the animal’s body, which is covered by light brown hair. The preserved specimen retained the head, with some missing skin on its back, the left ear, eye lids, the tightly attached nasal and frontal horns, the left fore and hind limbs, and a large piece of skin from the torso. The missing parts may still remain in the sediments of the Sasha locality.

The horns are very small in size: the nasal horn is relatively narrow from the base to the tip, has a rounded, smooth top and is taller than the frontal horn. The frontal horn has the appearance of a 'tower', with rounded edges on the dorsal surface worn to the flat plateau. This wear may have been the result of rubbing against its mothers belly since birth while nursing.

The CT scan of the head revealed few preserved internal organs, including the tongue, brain tissue, the complete right eye with supporting tissues, the completely intact and intricate nasal concha with un-ossified nasal septum, and internal morphology of the foramens and canals containing blood vessels and soft tissues (? nerves). The calf also possessed two sets of the maxillary and mandibular deciduous incisors and four deciduous premolars in each jaw quadrangle. Three crowns of unerupted permanent M1 in different developmental stages are in the alveoli. The deciduous premolars and M1 development and wear places the specimen in the early phase of the group IV (1–1.5 years) of the modern white rhinoceros (*Ceratotherium simum*) dental stages and in the early phase of the group C-I (1–1.5 years) of the woolly rhinoceros. At this age, Sasha would have still been nursing.

Sasha’s infantile age determination is supported by visible sutures between most of the skull bones, including the occipito-squamosal, basioccipital-basisphenoidal, basisphenoid-pterigoidal, premaxillae-maxillary and palatals. The fore limb epiphyses are not completely formed and not fused, but at least two terminal phalanges (hoofs) are ossified.

The definite cause of Sasha's death is not yet detected. However, the presence of some sediment in both nasal airways over the upper deciduous DI1-Dp3, and sediment completely blocking the left nasal airway over the Dp2-Dp4 indicate the baby’s entrapment in the mud hole, and a possible cause of death by asphyxia from drowning.

Technical Session XI (Friday, October 16, 2015, 8:15 AM)

TAKING A BITE OUT OF THE COMPETITION HYPOTHESIS: USING DENTAL TOPOGRAPHY TO EXAMINE RESOURCE OVERLAP BETWEEN NORTH AMERICAN STEM PRIMATES AND RODENTS

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In North America, the Paleocene-Eocene boundary (~56 Ma) marked a period of mammalian turnover that included the first extinction event affecting multiple families in primate evolutionary history, specifically the decline of North American plesiadapoids (stem primates or plesiadapiforms). The diminution of these groups has been attributed to competition over resources with ischyromyid rodents, which first appear in the latest Paleocene (latest Clarkforkian North American Land Mammal Age). This study investigates similarities and differences in molar morphology between plesiadapoids and contemporaneous rodents to assess whether all taxa were capable of consuming foods with the same physical properties with similar efficacy. We evaluated molar morphology using Dirichlet normal energy (DNE), a dental topographic metric. Dirichlet normal energy is well suited for studies combining disparate taxonomic groups as it is a homology free measure of tooth shape. M_2s of plesiadapoids (n=173) and ischyromyids (n=13) were micro-CT scanned and DNE values were computed and assessed at the family level, and species level for members of Plesiadapidae. Comparisons of DNE values for plesiadapoids and rodents show that rodents shared functionally similar dental morphology with at least some members of Plesiadapidae, and thus were likely capable of processing foods with similar physical properties. However, DNE values for both Carpolestidae and Saxonellidae contrast markedly with rodents, suggesting that these groups possessed adaptive features for processing a range of foods that were not accessible to rodents. As such, it is unlikely that competition with rodents over food resources could alone explain the disappearance of these families. Although several plesiadapid species overlap with rodents in their range of DNE values, only three also overlap in time. One of these (*Plesiadapis cookei*) is estimated to have been too large to be in direct competition with rodents, another (*Plesiadapis dubius*) has DNE values that are substantially higher than those of rodents, while the third, *Chiromyoides,* has teeth that are similar in size and DNE values that are within the range of Clarkforkian rodents. Therefore, if competitive exclusion by rodents played a direct role in the decline of plesiadapoids it can only have potentially done so for *Chiromyoides*. This study provides a framework for the assessment of hypotheses of competitive exclusion more generally in the fossil record.

Grant Information
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Technical Session VI (Thursday, October 15, 2015, 11:15 AM)

RETHINKING EDESTOID JAWS AND SPECIES WITH LARGE DATA SETS

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Cartilaginous fish in the Edestoidae clade have unusual spiral dentitions that are concentrated at the symphysis of the jaw. Edestoid fossils span Pennsylvanian–Triassic time and are found primarily along the margins and inland seas of ancient Pangaea, from the Russian platform to the Arctic and Western Interior of Laurentia. The curious arrangement of teeth coupled with the usual lack of anatomical context has made the edestoids fodder for a wide range of artistic reconstructions. Renewed investigation of *Helicoprion* and *Edestus* using morphometric and CT analyses is improving anatomical reconstructions and allows for refinement of species concepts. These two genera combined account for 24 nominal species. Morphometric analyses of hundreds of *Edestus* and *Helicoprion* teeth demonstrate that no more than 3 *Helicoprion* and 4 *Edestus* species can be adequately defined or distinguished. CT scans of jaw material from *Edestus* and *Helicoprion* reveal stark differences in their growth, form, and inferred function. *Edestus* has opposing upper and lower arcs of forward-shedding teeth that are set relatively distant from the jaw joint; whereas, *Helicoprion* has a single lower whorl of permanent teeth that spirals internally and is close to the jaw joint. In both animals, the curvature of the whorl and its proximity to the jaw joint control the rotation of teeth during jaw closure. Enlarged supporting structures found lateral to the *Helicoprion* whorl are not observed in *Edestus*. These jaws present divergent end members of the edestoid clade that may help place contemporaneous genera which lack a record of jaw morphology, such as *Toxoprion*, *Campyloprion* and *Sinohelicoprion*, in better context. Longstanding taxonomy of the edestoids has emphasized the orientation of the base of teeth, but differences in tooth fusion, tooth count, spiral curvature and growth may further support phylogenetic trajectories observed in the crown members of the clade.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

CONVERGENT TAPHONOMY AND MACROECOLOGY IN THE EVOLUTION OF MARINE TETRAPODS FROM THE TRIASSIC TO THE ANTHROPOCENE

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Since the Permian, more than 30 different lineages of amphibians, reptiles, birds, and mammals have independently invaded oceans ecosystems. These marine tetrapods have occupied apex roles in ocean food webs, in a range of different marine environments. As tetrapods, they share a common developmental bauplan, and, over geologic time, many distantly related lineages have converged on similar aquatic body forms (e.g., ichthyosaurs, sirenians, and cetaceans), including hind limb reduction, and forelimbs modified as paddle-shaped hydrodynamic control surfaces. Marine tetrapod fossils are abundantly preserved in marine sediments worldwide, and geologic megabiases have a demonstrable impact on reconstructions of their species richness through time. However, questions remain about the scale and modes of taphonomic biases in the marine tetrapod fossil record. Convergent body plans drive many of the similar taphonomic patterns observed in death assemblages in the fossil record from the Permian to the modern day. For example, dismemberment and decay pathways are similar across marine tetrapods, across a range of body sizes (e.g., < 1 to > 30 m in length), despite proportional differences in skeletal body plans. The vast majority of the marine tetrapod fossil record consists of isolated, disarticulated skeletons, and the depositional environment at the time of burial (i.e., water depth, dysoxia) provides a strong control on the type and degree of bone modification (e.g., bioencrustation, scavenging). Fossil lagerstätten, such as the Triassic Berlin-Ichthyosaur State Park, in Nevada, U.S.A., or the Neogene fossil site Cerro Ballena, in the Atacama region of Chile, provide unique windows for comparative taphonomic studies that connect marine tetrapod accumulations with mechanistic hypotheses about their origin. Ongoing large-scale changes to ocean and climate will continue to alter the ecological fates of living marine tetrapods, and the environments in which they live. Taxonomically broad live-dead studies, for example, inform broader macroecological patterns in extant marine tetrapod diversity, including the rampant shifted baselines from histories of human hunting. In some cases (e.g., gray whales repopulating the Atlantic Ocean), these histories can predict future ecological distributions. A synthesis of marine tetrapod evolution through geologic time provides an essential context for asking comparative taphonomic questions at a variety of scales.

Grant Information

Smithsonian Institution Peter Buck Postdoctoral Fellowship, SI National Museum of Natural History Small Grant Award, Remington Kellogg Fund, and Basis Foundation

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

NEW PSEUDOPALATINE PHYTOSAUR SPECIMENS FROM THE SONSELA MEMBER OF THE CHINLE FORMATION OF NORTHEASTERN ARIZONA INDICATE INCREASED REVUELTIAN PHYTOSAUR DIVERSITY

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The genus *Machaeroprosopus* (Archosauriformes: Phytosauria) is a common component of Triassic faunas in the American Southwest. New pseudopalatine phytosaur specimens attributable to *Machaeroprosopus* sp. have been recovered in northeastern Arizona from the Revueltian biozone in the Martha's Butte Beds of the Sonsela Member of the Chinle Formation. The site is located on private land adjacent to the Petrified Forest National Park. This study examines the morphology of the squamosals of six individuals from a single horizon. Two divergent squamosal morphologies were identified. All specimens show features diagnostic of the squamosals of *Machaeroprosopus,* as typified by the type species *M. buceros*: a comparatively (to more basal leptosuchomorph phytosaurs) broad squamosal; a bulging lateral and an elevated dorsal surface of the posterior process; a lancet-shaped sculptured area on the dorsal surface; and the presence of a lateral squamosal ridge. Specimens with squamosal morphotype A match the squamosals of *M. buceros* and the majority of described species within this genus, but differ from these species in having an exceedingly long postorbital-squamosal bar in the more complete specimens. Specimens with squamosal morphotype B are characterized by a very short posterior process, a unique feature of the species *M. mccauleyi*, but differ from this species in having a laterally bulging terminus of the squamosal with an elevated dorsal surface as in *M. buceros*, rather than the thin, dorsoventrally compressed squamosal tip of *M. mccauleyi*. Thus, the conflicting combination of squamosal characters does not allow for referral of the specimens with confidence to any of the nominal species of *Machaeroprosopus*.

This study identifies a greater diversity in squamosal morphology among *Machaeroprosopus* than previously recognized, which is consistent with multiple pseudopalatine morphotypes observed at other localities in the western United States. The character combinations within the two squamosal morphotypes identified here, i.e., the diversity within a squamosal morphotype, suggests that either multiple taxa are present or a large amount of intraspecific variation exists within known species of *Machaeroprosopus*. It seems unlikely that these disparities are due to sexual dimorphism or ontogenetic development. We conclude that the current alpha taxonomy of Revueltian-age North American pseudopalatine phytosaurs requires revision.

Symposium 1 (Wednesday, October 14, 2015, 4:00 PM)

BIOGEOGRAPHICAL AND ECOLOGICAL PATTERNS DURING THE PEAK OF TURTLE DIVERSIFICATION IN THE MID-CRETACEOUS

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The 'middle Cretaceous' was a key period for the diversification of major crown-turtle lineages and saw the transition from a stem-turtle dominated period to a crown-turtle dominated world. Recent molecular divergence estimates suggest the second half of the Early Cretaceous for the origin of hard-shelled cryptodires, chelydroids, americhelydians and pelomedusoids, as well as the split between Australian-South American chelids and potentially between North American and Asian softshell turtles. The first half of the Late Cretaceous witnessed the divergence of kinosternoids, emydids and testudinoids. Fossils of these taxa, however, are usually not recorded until the Late Cretaceous, likely due to sampling bias.

A 50% expansion of previous global morphological phylogenetic datasets on extinct turtles provides a novel interpretation of the biogeographic history of the group. The timing and order of divergence within the major crown-turtle lineages generally coincided with the mid-Cretaceous fragmentation of Laurasia and Gondwana. Mid-Cretaceous turtle distribution preserved a primarily vicariant pattern hardly overwritten by dispersals, which in turn were more important factors during the Late Cretaceous and Paleogene. Europe serves as an example for being influenced by dispersals from Gondwana and less evidently from Asia during the mid-Cretaceous.

Ecological novelties during the mid-Cretaceous involved the development of the highly specialized soft-shell turtle body-plan, the heavily-ossified, generalist testudinoid morphology (the most common morphotype in modern aquatic ecosystems), and the earliest case of secondary adaptation to a terrestrial lifestyle in the form of nanhsiungchelyids. Representatives of the extinct clade Nanhsiungchelyidae often possessed bizarre skull and shell morphologies, some of which lack modern equivalents among extant turtles. Osteological correlates in the triturating surface nevertheless clearly suggest that at least the basal-most members were herbivorous. In fact, the timing of nanhsiungchelyid diversification coincided with the spread of angiosperm plants, which likely opened up new food sources for turtles and made terrestrial habitats more exploitable. The obvious preference of angiosperms over gymnosperms and ferns among extant herbivorous turtles furthermore implies that pre-Cretaceous Revolution times (i.e., before the mid-Cretaceous spread of angiosperm plants) did not favor the emergence of terrestrial herbivorous turtles.

Grant Information
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Technical Session I (Wednesday, October 14, 2015, 8:00 AM)

TESTING FOR PHYLOGENETIC SIGNAL IN MORPHOLOGICAL DATA USING GENOTYPE-BASED PHYLOGENIES

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Obtaining robust phylogenetic frameworks from which to study important macroevolutionary questions about extant and extinct groups is crucial, but morphological data of many taxa can be incongruent with the results of analyses using genotype data. Phylogenetic signal in morphological data can be tested using a range of methods that have been developed over the past several decades, such as Blomberg's K statistic and Pagel's lambda. Here, we present the results of three pilot studies using scleractinian corals, artiodactyls, and cetaceans, which are all groups exhibiting high levels of morphological homoplasy. We show that certain anatomical subsets of the morphological datasets contain more signal than others. For example, in the case of scleractinian corals, partitions of character types that were microstructural and micromorphological contained significantly more phylogenetic signal, given the molecular trees, than macromorphological characters. We hypothesize that this result may be due in part to poor assessment of primary homology in characters describing macromorphological features of scleractinians. Similar subsets of data partitioned by region (such as soft tissue, pectoral, facial) for artiodactyls and cetaceans showed differing levels of phylogenetic signal as well, possibly resulting from similar issues with primary homology. This work represents important stepping-stones to using morphological data from fossil species to reconstruct phylogenetic relationships, and to eventually understanding broader questions about macroevolutionary patterns.

Grant Information
Funding was provided by National Science Foundation grants DEB 1331980 and PLR 134175 to Nathan Smith.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

DIETARY RECONSTRUCTION OF THREE EOCENE PRIMATES FROM THE SOUTH OF FRANCE

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The Eocene-Oligocene transition was a time of major climatic change and faunal turnover. It is also marked by the disappearance of primates from the fossil record in Europe and in North America, at a time when temperatures were cooling down and environments were becoming more open. How did primates cope with the changing environmental conditions of the latest Eocene, in the run-up to the faunal turnover at the Eocene-Oligocene transition? To help answer this question, this study focuses on the dietary reconstruction of three large-bodied adapids, which occur from MP 17 to MP 19, i.e., leading up to the Eocene-Oligocene transition: *Leptadapis magnus* (N = 6; body mass = 4000 g) from Perrière (MP 17b, 37 Ma), *Cryptadapis tertius* (N = 6; body mass = 2500 g) from Sainte Néboule (MP 18, 36 Ma), and *Adapis parisiensis* (N = 7; body mass = 1300 g) from Rosières (MP 19, 35 Ma). Diet is characterized using dental microwear texture anaylsis, the study of the scar patterns left on the enamel surface as a result of tooth–food abrasion. Here, we use scale-sensitive fractal analysis together with confocal microscopy to analyze dental microwear texture in 3D. This analysis is carried out on phase II crushing facets. Individual analyses of variance coupled with post hoc multicomparison tests are used to pinpoint sources of significant variation.

Leptadapis was most probably a leaf eater, incorporating a small amount of fruit in its diet. *Adapis* was also a leaf eater, but would have incorporated a larger amount of fruit in its diet than *Leptadapis*. These results contrast with previous views that have described this taxon as exclusively folivorous. Anisotropy is higher in *Cryptadapis* than in *Adapis* and *Leptadapis,* indicating *Cryptadapis* might have had a tougher diet than the other large adapids, i.e., including a higher quantity of leaves in its diet than both *Leptadapis* and *Adapis*. Heterogeneity is higher for *Adapis* and *Leptadapis* than for *Cryptadapis,* which could point to more variability in their diet. If *Adapis* and *Leptadapis* did indeed show more plasticity in their diet than *Cryptadapis,* such a capacity could have conferred an advantage to cope with the harsher seasonal environments of the end of the Eocene.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

TAXONOMIC AND PROVENANCE ANALYSIS OF A LEGACY COLLECTION OF FOSSIL FISH BONES FROM LIVE OAK COUNTY, TEXAS

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Prior to about 1980, hundreds of disarticulated fossil fish bones were collected from a uranium pit near Three Rivers, TX (Live Oak County), and added to the teaching and research collections of St. Mary's University. This region of the South Texas Coastal Plain is covered by Tertiary sediments, but because of sparse documentation, the exact collection location is not known. This collection of fossils is potentially significant because of the scarcity of published reports of Tertiary fish from South Texas. Our study aimed to: (1) determine the likely rock formation origin of these specimens; (2) identify the fossils to the most restrictive taxonomic group using an apomorphy-based approach; and (3) estimate the minimum number of individuals (MNI) present.

Associated rock matrix was removed from the fossils and collected for analysis. The mineralogy of the matrix sample qualitatively matches reported mineralogy for the Miocene Oakville Sandstone, a uranium-bearing unit in Live Oak County. A grain size analysis of the matrix sample, however, shows better sorting and skewing towards a coarser median grain size than the Oakville. This difference may be due to sampling bias in that the fine fraction has been preferentially lost from the matrix samples, and is therefore not representative of the host rock formation.

To determine if the sample comprises a single or multiple species, we sorted 286 vertebrae into trunk and caudal centra, and measured length, width and height of each. A coefficient of variation analysis based on these measurements compared to published data

from a single extant species suggests that our vertebral sample represents a single species. Besides vertebrae, we have identified isolated ribs and several skull elements including hyomandibulae, edentulous maxillae, parasphenoids, basioccipitals, preoperculars, operculars, cleithra, dentaries with teeth, angulars, and various pharyngeal elements with teeth. The pharyngeal elements with ankylosed teeth, edentulous maxillae, and hyomandibulae are characteristic of the Cypriniformes, a mostly freshwater group including carps, minnows, loaches, and their relatives. However, the presence of dentaries containing teeth indicate that at least one other taxon is also represented in this sample. Element counts taken from the hyomandibulae, maxillae, and parasphenoids provide a MNI of 26. With few exceptions none of the bones are articulated but several delicate structures such as vertebral hemal arches and neural spines remain intact, suggesting minimal transport of the fossils.

Grant Information
St. Mary's Faculty Research Grant

Poster Symposia (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

RECONSTRUCTING THE LOCOMOTORY ECOLOGY OF THE AMERICAN CHEETAH, *MIRACINONYX TRUMANI*, WITH LINEAR AND 3D ANALYSIS OF VERTEBRAL MORPHOLOGY ACROSS LIVING AND FOSSIL CATS

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Members of the mammalian family Felidae (living and extinct cats) display a considerable range in body size, from <1 kg to >300 kg. However, unlike most other mammals, larger felid species do not display increased limb erectness. Rather, limb posture is remarkably uniform from small to large cats. Here, we have conducted quantitative analyses of morphology and scaling in the presacral vertebral column to determine how postcranial function changes with body size in Felidae.

An initial Principal Component Analysis (PCA) of linear measurements of the presacral vertebrae of 22 species showed that specialisation to distinct locomotor behaviours (i.e., arboreal, scansorial and terrestrial) separate species in morphospace. These results also show clear regionalisation of scaling patterns along the vertebral column suggesting that anterior (cervicals and thoracics) and posterior (lumbar) vertebrae may form distinct evolutionary modules.

Following our results for linear data, we gathered between 16 and 20 3D landmarks for 17 out of the 27 presacral vertebrae for 10 species of living and fossil felids, including a CT scan of the fossil 'American cheetah' (*Miracinyonyx trumani*). We then used morphometric analysis to compare *M. trumani* to two of its closest living relatives, the puma (*Puma concolor*, 13 specimens) and cheetah (*Acinonyx jubatus*, 13 specimens). The Pleistocene cheetah-like fossil *M. trumani* has been phylogenetically aligned with modern pumas, but shows skeletal morphological characters more similar to cheetahs and is associated with adaptations to fast running. Our results showed clear differentiation of vertebrae of modern cheetahs (more cursorial) and pumas (more scansorial) in the morphospace, and subsequent MANOVA analysis. In most vertebral morphospaces, *M. trumani* plotted either most closely to cheetahs or intermediate between modern cheetahs and pumas.

Similarly to our linear scaling results, scaling analyses of 3-D data showed the presence of allometry as a component of vertebral shape. However, allometric scaling only explained from 15–29% of the variation of the vertebral three-dimensional shape, and species differed in which vertebrae exhibit allometric scaling: while only the axis, T8 and L1 presented allometry in pumas; the vertebrae C7, T1, T10, L2, L4 and L6 of cheetahs showed allometric scaling with centroid size.

Thus, vertebral morphology strongly supported inferences of specializations related to fast running in *Miracinyonyx*, and a palaeoecology more similar to cheetahs than pumas.

Technical Session VI (Thursday, October 15, 2015, 8:00 AM)

RECONSTRUCTING RELATIONSHIPS OF FOSSIL JAWLESS FISH (PTERASPIDIFORMES, HETEROSTRACI)

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Fossil jawless vertebrates (stem-gnathostomes) are central to our understanding of vertebrate evolution, yet lack of understanding of their inter- and intrarelationships makes interpretation problematic. Key amongst these are the Heterostraci, for which no reliable phylogenetic framework exists. For example, the inclusion of the Psammosteidae within the larger Pteraspidiformes has long been debated, altering interpretations of heterostracan evolutionary histories. Here, a comprehensive analysis is made of the largest and most iconic clade of heterostracans, the Pteraspidiformes. Combining discrete and continuous characters and data collected from museum specimens and the literature, a cladistic analysis has been implemented using Mesquite and TNT. All described Pteraspidiformes genera (43) are included along with four out group taxa (*Anglaspis, Nahanniaspis, Drepanaspis* and *Psammosteus)*. Psammosteidae are found to belong with the Pteraspidiformes, nestled with the Spitsbergen *Doryaspis, Woodfjordaspis* and *Xylaspis*. This new phylogeny sheds light on a poorly understood clade, central to understanding of evolution of jawed vertebrates. Utilizing this new phylogeny, stratigraphical and geographic occurrence of the taxa, dispersal histories are reconstructed in light of recent discussions regarding limited dispersal and endemism.

Technical Session IX (Thursday, October 15, 2015, 2:45 PM)

PATTERNS OF DIVERSITY AMONG LATEST CRETACEOUS MAMMALIAN ASSEMBLAGES FROM NORTH AMERICA

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Although the presence of mammalian provinciality within North America during the latest Cretaceous is commonly cited, few analyses have actually centered on mammalian occurrences from this interval. In fact, the vast majority of these studies have inferred that the geographic distributions of mammals during the latest Cretaceous were likely similar to those from stratigraphically older or younger intervals (i.e., Late Cretaceous [Campanian] or Early Paleocene), times in which faunal provinciality is better established. However, there are no reasons to suspect that the distributions of these animals remained the same across these intervals, particularly with the dramatic events that characterize the latest Cretaceous, including the regression of the Western Interior epicontinental seaway, intensive volcanism, and changes in global climate. In this study, we compiled occurrence and relative abundance data for latest Cretaceous mammalian genera from eleven localities across North America and employed non-hierarchical cluster analysis, non-metric multidimensional scaling, and minimum spanning networks to examine patterns of mammalian provinciality. We explicitly defined a biogeographic province as containing at least 25% endemic taxa and also assessed suggestions for the occurrence of a faunal barrier near paleolatitude 50°N during the latest Cretaceous. Despite the disparity among the different approaches, there is little quantitative support for mammalian provinciality during the latest Cretaceous. Taxa endemic to localities north or south of the proposed barrier comprise a comparatively small proportion of the dataset, both in total taxonomic richness and number of specimens, and the pattern of occurrences cannot be differentiated from gradual change across a latitudinal range. Moreover, differences among geographically closely spaced assemblages suggest that latest Cretaceous mammals behaved individualistically, rather than undergoing coordinated changes. These findings are consistent with lower latitudinal thermal gradients, and the absence of any major geographic barriers between the northern and southern regions of the Western Interior of North America during the latest Cretaceous.

Grant Information
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Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

DIGITAL RESTORATION OF THE CRANIAL MUSCULOSKELETAL ANATOMY OF *MORGANUCODON OEHLERI*

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Morganucodon is a basal mammaliaform found in Upper Triassic and Lower Jurassic deposits of Europe, China and North America. The genus comprises four species, among which *M. watsoni* from Glamorgan, Wales and *M. oehleri* from Yunnan Province, China are the best documented. Although both species are represented by numerous fossils, these are mostly restricted to isolated teeth and fragmentary cranial and postcranial elements, whereas fully or even partly articulated material is rare. A handful of articulated, albeit distorted and incomplete, cranial skeletons of *M. oehleri* form the exception. The morphology of individual elements, in particular isolated teeth, has been studied in great detail in the past, yet reconstructions of the cranial skeleton of *Morganucodon* have been limited to two-dimensional interpretive drawings. Based on high-resolution CT scans of a nearly complete and articulated skull of *M. oehleri* (FMNH CUP 2320), a digital restoration of the cranium was performed. Taphonomic artefacts, such as breaks and holes, were removed digitally. Bilaterally symmetric elements that were only preserved on one side were supplemented by reflective duplication. Distorted parts were retrodeformed using a landmark-based approach. As the specimen lacks the squamosal, parts of the zygomatic arch and parts of the dentary condyle, these elements were supplemented by scans of isolated elements of *M. watsoni* from the Glamorgan collection. The newly restored cranium shows several distinct differences to previous reconstructions that have functional consequences. The supraoccipital region is laterally convex and characterised by a distinct sagittal crest, suggesting the presence of a well-developed temporalis muscle. The coronoid process of the lower jaw is positioned posterior to the alisphenoid and its dorsal-most surface extends almost to the parietal, thus reducing the length of the temporalis muscle. The temporal region is wider than previously reconstructed due to lateral expansion of the squamosal and jugal, thus permitting larger adductor musculature than previously realised. The new, hypothesized restoration resembles more basal taxa, such as *Probainognathus* or *Sinoconodon*, and provides new information on the evolution and function of the musculoskeletal system at the cynodont-mammaliaform transition.

Grant Information
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Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

A NEW VERTEBRATE MICROFOSSIL LOCALITY IN THE UPPER TWO MEDICINE FORMATION IN THE VICINITY OF EGG MOUNTAIN

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The Upper Cretaceous (Campanian) Two Medicine Formation of northwestern Montana is composed of fully terrestrial, upland sediments representing the more proximal portion of a large clastic wedge that thins into the Judith River Formation to the east. The Two Medicine Formation exposed on the Willow Creek anticline near the town of Choteau has been a focus of paleontological and geological investigations due to the fossiliferous exposures found in this area, most famously the discovery of nesting sites of both the hadrosaur, *Maiasaura*, and the theropod, *Troodon*.

Here we report the taxa recovered from one of the few vertebrate microfossil localities (i.e., microsite) known from the upper Two Medicine Formation and the only microsite known in the vicinity of two important dinosaur nesting localities, Egg Mountain and Egg Island. Less than 75 identifiable skeletal elements were recovered

from 1.4 metric tons of matrix processed using number 20 and 32 mesh screen. Theropod teeth were the dominant element recovered. The majority of the identifiable theropod teeth belong to the Tyrannosauridae (likely *Daspletosaurus* or *Albertosaurus*), but teeth referable to *Saurornitholestes*, *Troodon*, *Paranychodon*, *Richardoestesia*, and other indeterminate theropod morphotypes were also recovered. The microsite also yielded *Cimexomys judithae* teeth, partial lizard jaws, a single scale of *Lepisosteus,* a partial anuran ilium, salamander vertebrae, and multiple hadrosaur and ankylosaur teeth.

Lepisosteus, anurans, and salamanders have never previously been documented in this part of the upper Two Medicine Formation (Lithofacies *d* of Lorenz and Gavin 1984). As has been noted before, elements of crocodilians and turtles are still remarkable absent from this part of the Two Medicine Formation, though they have been documented in the lower part of the formation in an area called Seven Mile Hill, 17 kilometers to the southeast of Egg Mountain. The discovery of additional microsites in the Two Medicine Formation will be critical to better characterizing this unique upland assemblage and provide an important comparison to the better documented fauna of the more coastal Judith River Formation.

Technical Session III (Wednesday, October 14, 2015, 8:30 AM)

A NEW EARLY PERMIAN CAPTORHINID REPTILE (AMNIOTA: EURETPTILIA) FROM RICHARDS SPUR, OKLAHOMA, SHOWS REMARKABLE DENTAL AND MANDIBULAR CONVERGENCE WITH MICROSAURS

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The Lower Permian fossiliferous infills of the Dolese Brothers Limestone Quarry, near Richards Spur, Oklahoma, have preserved the most diverse assemblage of terrestrial vertebrates, including small-bodied reptiles, lepospondyl microsaurs, and dissorophoid temnospondyls. Many of these taxa were previously known only from isolated dentigerous jaw elements and numerous skeletal elements. For example, one taxon that was previously only known from isolated jaw elements at the locality was the microsaur *Euryodus primus*. Although it is known from more complete material elsewhere, other remains of *E. primus* have remained elusive at the Dolese Brothers Quarry.

The recent discovery of partial articulated skulls and skeletons of a small reptile at Dolese permits the recognition that the dentigerous elements that were previously assigned to *Euryodus primus* from this locality belong instead to a new captorhinid eureptile. The new captorhinid represents a major departure from other members of this clade in the unique anatomy of its jaws and dentition, which are characterized by their bulbous maxillary and dentary teeth. Three enlarged teeth are present on the maxilla, one in the anterior and two in the posterior region, whereas the premaxillary dentition is homodont and small. In addition, the largest dentary tooth is present along the posterior half of the bone. The dentary is characterized by the presence of a large well-developed coronoid process and deep lateral excavation in the posterior one-quarter of the bone. A phylogenetic analysis of captorhinid eureptiles yields two most parsimonious trees, with one in which the new captorhinid is recovered as the sister taxon to *Concordia*, this clade in turn being the sister to all other captorhinids, and a second in which the new captorhinid is the sister to all other derived captorhinids, to the exclusion of *Concordia* and *Thuringothyris.*

This new captorhinid not only adds to the diversity of eureptiles found at the Dolese locality, but provides important insight into the paleoecology of Early Permian tetrapods. The previous mistaken identification of this small captorhinid points to a dramatic level of convergence in mandibular and dental anatomy in two distantly related and disparate clades of terrestrial tetrapods and sheds light on the earliest instance of durophagy in eureptiles.

Grant Information
NSERC Discovery Grant to R. Reisz

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

MORPHOLOGICAL COMPARISON AND TAXONOMIC STATUS OF TWO EARLY EOCENE HORSES FROM THE WESTERN USA: *MINIPPUS JICARILLAI* AND *SIFRHIPPUS SANDRAE*

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Hyracotherium is the earliest (Eocene, Wasatchian) known genus of Equidae and is well represented by fossils from the San Jose Formation of New Mexico. In 2001, a cladotaxonomy subdivided *Hyracotherium* into nine new genera by using cladistic analysis of 121 morphological characteristics. We analyzed nine proposed diagnostic characteristics of the lower molars as well as individual tooth sizes of two genera, *Sifrhippus* (*S. sandrae*) and *Minippus* (*M. jicarillai*). These are two of the smallest and most primitive species of equids. The specimens involved in this study were the *M. jicarrillai* holotype (NMMNH [New Mexico Museum of Natural History] 9239), four *M. jicarrillai* paratypes (AMNH [American Museum of Natural History]: 4637, 16761, 48022, 48069), and a cast of the holotype of *S. sandrae* (UM [University of Michigan] 83567). Compared to *M. jicarillai*, *S. sandrae's* lower molars have an anterior fovea, which is created by the paracristid curving up the metaconid. Also, *S. sandrae* has comparatively weak lophids. These specimens did not show the diagnostic characteristics consistently; some characteristics were difficult to measure, and others were too subjective to replicate. Often, characteristics were unobservable due to wear and weathering. The size of each tooth falls within or close to the size range previously proposed for *S. sandrae*. The anterior fovea is difficult to distinguish, and the lophid is the same size on all specimens with only very minor variation. Overall, the holotype and paratypes of *M. jicarillai* appear no different from *S. sandrae*. The differences observed are very minor and due to individual variation. We thus conclude that the proposed diagnostic characteristics show intraspecific variation rather than taxonomically significant variation, so *S. sandrae* and *M. jicarillai* are the same species. Past studies show that speciation of *Hyracotherium* is due to differences in body size, and while tooth characteristics vary, they are rarely consistent within a single species. The other small species of *Hyracotherium*, *Minippus index*, was not analyzed in this study; however, this species is likely not taxonomically different from *M. jicarillai* or *S. sandrae*. *Sifrhippus* and *Minippus* are not separate taxa, and should be classified under the same genus and species. Specimens of the other early equid groups should be analyzed to determine if further taxonomic changes are necessary. If the results are similar to this study, all genera should be classified as *Hyracotherium*, and their phylogenetic relationships should be reexamined.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

DESIGNING A HOLISTIC INTERNSHIP FOR UNDERGRADUATE STUDENTS IN COLLECTIONS CARE

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As workers in curatorial divisions of public trust museums and similar repository organizations, we are charged with the responsibility of caring for objects of primary scientific data, namely vertebrate fossils and their associated records. The tasks of acquiring collections, revealing the morphology of a specimen, applying treatments to a vertebrate fossil, safely storing these specimens, maintaining records for current and future generations, and conveying that information to the public and academic communities for whom they are maintained, requires not only a knowledge of best practices and training, but also practical experience handling and working with collections. For the student aspiring to pursue a career in the field of vertebrate paleontology, such as a preparator, collections manager, curator, or educator, there are generally limited opportunities available to build up the requisite experiential knowledge prior to graduation. Building a holistic internship for undergraduate students requires some thoughtfulness and time on the part of the collections staff so that the experience is mutually beneficial for the student and the needs of the collection. Attention to recruitment, assessment, training, workflow, and evaluation are all important aspects of a well rounded program. A case study will be presented on the building of the Vertebrate Paleontology Internship program at the Natural History Museum of Los Angeles County with reflections on how this model can be adopted by other institutions.

Technical Session III (Wednesday, October 14, 2015, 9:00 AM)

COMMUNITY HISTOLOGY IN THE LOWER PERMIAN LOCALITY RICHARDS SPUR, OKLAHOMA

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Paleohistological studies have provided valuable insight into understanding the physiology, ecology, and growth of extinct species of vertebrates. Histology on a community-wide scale has never been studied before, however. A comprehensive comparative study into the bone histology of concurrent members of a community would enlighten the lifestyles and growth dynamics of those extinct animals, which in turn would provide important information about the paleoenvironment of this community, as well as the interrelationships between its taxa. Richards Spur, Oklahoma–a Lower Permian (Sakmarian) locality–is an ideal locality for this study as it contains a rich and diverse faunal assemblage of well preserved fossils from which to perform a comprehensive survey of the community. In addition, most paleohistological studies have concentrated on dinosaurs and other Mesozoic reptiles, whereas examinations into the bone structure and growth dynamics at the earliest stages of tetrapod evolution are more rare, making a survey of an Early Permian community valuable. For this study, representatives of all major taxa from the Lower Permian in Richards Spur were reviewed and compared. Long bones of two anamniotes (a large dissorophid temnospondyl and a small dissorophid temnospondyl), three eureptiles (all captorhinomorphs), and two synapsids (a mycterosaurine varanopid and a varanodontine varanopid) were sectioned at mid-diaphysis and ground down to optical translucency for histological analysis.

All histological thin sections displayed parallel-fibered compact bone, which is indicative of relatively slow-growing animals. Additionally, all thin sections show poor vascularization with minor bone remodeling, which indicates relatively slow metabolic rates-potentially ectothermy-as one would expect of the early tetrapods of the time. The relative compact bone thickness is comparable with what is found in terrestrial vertebrates, which confirms that the Richards Spur locality was terrestrial during the Lower Permian-something that has been previously determined based on paleosol studies. Evidently the fast-growing fibrolamellar bone that is seen in dinosaurs, birds, and mammals had not evolved yet at this early stage of terrestrial vertebrate diversification. All taxa have at least one line of arrested growth (LAG) except for the captorhinids, indicating that these animals employed a different growth strategy from the other early tetrapods of the locality.

Grant Information
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Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

NEW PARTIAL SKELETON OF LATE EOCENE *PALAEEUDYPTES*-LIKE PENGUIN FROM CENTRAL OTAGO, NEW ZEALAND

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A new late Eocene fossil penguin from Central Otago, near the southernmost margin of the Canterbury Basin, expands the penguin record from New Zealand. The specimen is a partial skeleton that includes parts of the coracoid, ulna, humerus, clavicle, scapula, vertebrae, femur, tibiotarsus, possible tarsometatarsus, and patella; it is thus an important addition to local Eocene penguins.

One complete humerus is similar in length and morphology to described humeri from the upper Eocene Burnside Formation (New Zealand) referred to *Palaeeudyptes antarcticus*, and humeri from Seymour Island referred to *Palaeeudyptes gunnari*. Similarities involve both size and shape of the head, relatively small tricipital fossa, slight preaxial angle, minor anterior angulation, slight sigmoidal shaft, and distal features.

Differences include the form of the internal tuberosity and capital incisura. To indicate size, the humerus is about 84% as long as that of the late Oligocene *Kairuku grebneffi* for which standing height was about 1.28 m.

The locality, in the Kyeburn region of Central Otago, is close to the southwest extent of the Cretaceous-Cenozoic Canterbury Basin. Matrix from the penguin is a gypsiferous, pyritic, decalcified glauconitic sandstone, from a marine shelf setting below wave base. Formational name is uncertain because the local lithostratigraphy needs revision. The matrix produced no foraminifera, but a nearby fossiliferous horizon produced foraminifera consistent with local Kaiatan to Runangan stages, late Bartonian to Priabonian (late Eocene). The association of bones from one individual suggests a quiet setting, with minimal postmortem disturbance.

Grant Information
Benson Fund

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

RARE DIRECT EVIDENCE OF ANGIOSPERM CONSUMPTION BY DINOSAURS BASED ON COPROLITES FROM THE KAIPAROWITS FORMATION OF UTAH

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Although the ecological relationships between dinosaurs and angiosperms have long been debated, very little direct evidence of angiosperm consumption has been found to date. We report the discovery of two coprolites recovered from the Campanian Kaiparowits Formation of southern Utah that contain fragments of angiosperm wood. One of the angiosperm coprolites was discovered as a group of associated float fragments, the other was found in situ and removed intact. Both coprolites were found near other herbivore coprolites that contain conifer but no angiosperm wood. Specimen inclusions and ground mass were characterized by visual examination of exposed surfaces and thin sections. Several lines of evidence support the conclusion that these specimens are coprolites including: (1) specimen ground mass is composed of disaggregated plant cells in a calcareous matrix, which is distinctly different from the clastic lithology of the host sediment; (2) inclusions include mm-scale fragments of plant tissue and isolated angiosperm vessels; and (3) extensive bioturbation is present, including many back-filled burrows. These indicators suggest feeding-induced comminution and post-depositional reworking in a manner characteristic of coprophagous insects.

The volume of the fragmented coprolite was at least 0.88 L, and the in situ coprolite appears to be comparable in size. Other than ornithischian dinosaurs, no other large- or medium-bodied plant eating animals have been found in the Kaiparowits Formation assemblage to date that would have been capable of producing these coprolites, and only ornithischians had dentition capable of the observed fine degree of comminution.

The coprolites contain inclusions indicating a diet that was not wholly herbivorous. Fragments of mollusk shell and one lizard dentary are embedded in interior surfaces of the coprolites and therefore were most likely not introduced after deposition.

Angiosperms first appeared during the Early Cretaceous and diversified rapidly throughout the Late Cretaceous. This time period also had great dinosaur diversity, especially the Late Cretaceous Laramidian ecosystem represented by the Kaiparowits Formation. The coprolites presented here reveal trophic interactions between angiosperms and dinosaurs in the Kaiparowits. Moreover, their co-occurrence with conifer-bearing coprolites may reflect ecological niche partitioning.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

NEW EARLY MIOCENE CAMELIDS (ARTIODACTYLA, FLORIDATRAGULINAE) FROM PANAMA AND THE RELATIONSHIP OF FLORIDATRAGULINES TO CAMELINAE

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Floridatraguline camels are a tropical-subtropical North American clade with an elongate rostrum and a shallow, narrow symphysial area. ? *Poebrotherium franki* from the late Eocene of Texas is recognized as the oldest floridatraguline based on its moderately elongate rostrum and laterally positioned upper incisors. Otherwise, floridatragulines are restricted to the early Miocene, with *Floridatragulus dolichanthereus* (~18.5 Ma; Hemingfordian) from Florida the best known. Primitive camelid characteristics of *F. dolichanthereus* include brachydont dentition, posteriorly open orbits, square upper molars, ectostylids on lower molars, and a divided /m3 hypoconulid, providing evidence that floridatragulines might represent a distinct group only distantly related to the Arikareean 'higher camelids' with distinctive metastylids on the lower molars (e.g., *Gentilicamelus* and *Oxydactylus*). Phylogenetic analysis based on dental characters allies the Hemingfordian species of *Floridatragulus* from the Gulf Coast with late Arikareean-Hemingfordian species of *Aguascalientia* from tropical Central America. Both genera may have subtropical origins linked to early Arikareean higher camelids from the Gulf Coast. A new partial skull of *Aguascalientia* from Panama (~21 Ma) not only has the distinctive floridatraguline morphologies listed above, but it also has unique characteristics that are absent in *F. dolichanthereus* but shared with late Arikareean higher camelids (e.g., nearly complete postorbital bar, double rooted P1/, shallow maxillary fossa) suggesting the possibility that Floridatragulinae might be paraphyletic with respect to Camelinae. Additional evidence suggesting a paraphyletic Floridatragulinae comes from the first known partial dentitions of *Floridatragulus* from Panama (~19 Ma) that are referable to *F. nanus*, otherwise only known from the early Hemingfordian of the Gulf Coast. In contrast to the single-rooted /p1 of *Aguascalientia* and *F. dolichanthereus*, *F. nanus* from Panama has a double-rooted /p1, further suggesting that the skull elongation in both genera might be a result of convergence. Panamanian floridatragulines also share cranial characteristics with even more derived camelines (e.g., moderately elongate rostrum in *Aguascalientia* and proximal co-ossification of the metapodials in *F. nanus*) found in the later Barstovian suggesting that this radiation might be critical for understanding the evolution of crown Camelidae.

Grant Information
U.S. NSF Partnerships in International Research and Education grant 0966884 (OISE, EAR, DRL), EAR 0824299, EAR 0418042

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

RIO YUCA FORMATION: A NEW EARLY MIOCENE VERTEBRATE ASSEMBLAGE FROM VENEZUELA

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Early Miocene localities with vertebrate remains in northern South America are scarce. This interval of time is crucial for our understanding about the general assumptions of different biogeographic scenarios for this part of South America, such as the changing course of the Paleo-Orinoco River. Recent geological explorations of the mollassic beds of the Rio Yuca Formation (Portuguesa State, Venezuela) resulted in the recognition of a new vertebrate assemblage. Previously, the only known fossil mammal from this formation is the enigmatic sloth, *Pseudoprepotherium venezuelanum*. The new faunal assemblage includes mammals, cf. *Nesodon* (based on an isolated broken upper premolar with the primary lingual enamel fold completely isolated, the presence of a broad anterior enamel band, apparently an enamel band on the posterior cingulum, straight ectoloph, oblique protoloph, and a transverse metaloph), an indeterminate member of the Dasypodidae (based on a small osteoderm with a central figure enclosed posteriorly); freshwater fishes, *Phractocephalus* sp. (based on a coarsely ornamented fragment of skull with reticulating ridges and surrounding pits), an indeterminate Pimelodidae (based on a partial skull which is unfortunately poorly preserved); and a crocodile, *Purussaurus* sp. (based on an isolated tooth, compressed laterally, crown strongly conical in outline, circular in cross section, and not very acutely pointed). The age of the Rio Yuca Formation has been an object of discussion in the literature with age estimates ranging from early Miocene to Pliocene. The presence of cf. *Nesodon* and a pollen assemblages attributable to the *Verrutricolporites rotundiporis* zone strongly suggests an early Miocene (Santacrucian SALMA) age for this Formation. Several of these taxa are recognized for first time from Venezuela (e.g., Dasypodidae [the family Dasypodiae has been known for a long time, it is the specific taxon based on the osteoderm that may be new] and cf. *Nesodon*). If the early Miocene age of the Rio Yuca Formations is correct, the fauna also includes the oldest records of *Phractocephalus* in South America). The currently known diversity of the vertebrate assemblage of the Rio Yuca Formation is poor compared to the coeval fauna of the Cerro La Cruz Formation (Lara and Falcón State, Venezuela), however both localities are similar in terms of environments indicative a humid tropical climate.

Grant Information
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Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

THE LATE CRETACEOUS LAS AGUILAS DINOSAUR GRAVEYARD, COAHUILA, MEXICO

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The latest excavation campaign at the upper Campanian Las Aguilas locality 40 km west of Saltillo, Mexico not only yielded a partial skeleton of a medium-sized hadrosaur, but also skeletal remains of an ornithomimosaur discovered by an amateur palaeontologist close to our site including cranial elements that allowed for a secure identification. A new microsite was discovered by us with abundant hadosaur bones of several individuals, that yielded teeth of a tyrannosaurid theropod, a pelvic fragment of a lambeosaurine hadrosaurid, longbone fragments and a phalanx of dromaeosaurid theropods, remains of a small bird, four different species of turtles, vertebrae of small eusuchian crocodylians that were not longer than one meter, and two small plesiosaur phalanges. Geological investigations revealed that the dinosaur remains result from 13 distinct layers, which were deposited in a rapidly oscillating delta system. The abundance of bone material in association with dinosaur tracks and plant remains makes this site unique and allows for a detailed reconstruction of the palaeoecology during the late Campanian of the southernmost area of the North American continent.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

***ICTITHERIUM VIVERRINUM*: FIRST CARNIVORE FROM THE MIOCENE IN KYRGYZSTAN**

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The Cenozoic terrestrial record of Kyrgyzstan has, to date, seen very little study, with only a few publications by early Russian teams surveying regional geology. However, tectonically-driven sedimentation from the rise of the T'ian Shan Mountains has preserved a record of the terrestrial vertebrates over the last 10-12 million years. While age constraints are challenging in the absence of volcanic activity, this fauna is still important to our understanding of the evolution of Asian mammals in association with the dramatic landscape changes associated with the rise of the Tibetan Plateau. Several of the sites reported by early Russian geologists are in the Kochkor Valley, where we have focused our efforts. Those studies presented preliminary faunal lists, but the specimens are not described in detail and can no longer be located in any museum or

repository. Although our work is at an early stage, we report the first occurrence of a late Cenozoic carnivore found in Kyrgyzstan. We recovered the specimen, which has been preliminarily diagnosed as *Ictitherium viverrinum*, from a site only a mile from the town of Kochkorka, in rocks believed to be late Miocene or early Pliocene in age. The ictithere specimen is a lower left mandible containing p3, p4, m1, and m2. The diagnosis was based on the reduced m2, a short p4, a relatively large m1 trigonid, and an m1 talonid one third the size of the trigonid. *Ictitherium viverrinum* is often described as a generalist civet-like hyaenid that inhabited forests, forested steppes, and open savannas. The diet of the species was varied and included both large and small vertebrates. No small vertebrates have yet been recovered in Kyrgyzstan, indicating that we are still missing a significant piece of the late Cenozoic record for the region. There has been speculation that ictitheres acted as pack animals to hunt large prey. If so, ictitheres were likely the dominant predator during the Kyrgyz late Cenozoic. A disarticulated p4 from a hyena has also been recovered from much lower in the section at the same site, but a species-level diagnosis has not yet been made. We have also recovered specimens of *Chilotherium, Dorcas dorcadoides, Sivatherium*, *Hipparion*, and a tortoise from the late Cenozoic sites in the Kochkor Valley. All of these taxa are associated with open habitats, suggesting that the current paucity of closed habitats has roots well back in the Miocene. Our ongoing collecting efforts in this site are already producing a diverse fauna, which will contribute to the growing body of knowledge about the Cenozoic evolution of central Asia.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

AN ALMOST COMPLETE ISTIODACTYLID (PTEROSAURIA, PTERODACTYLOIDEA) FROM THE CRETACEOUS OF CHINA PROVIDES THE FIRST INFORMATION ON THE TAIL OF THIS CLADE

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The Istiodactylidae is a clade of Early Cretaceous pterosaurs which possess very distinct teeth, with crowns triangular in shape and strongly compressed labiolingually. They were first described based on specimens from deposits in England, with reports dating from the early 20th century. More recent excavations in the Jiufotang Formation of China showed that the group also lived in eastern Asia, broadening their known geographic distribution. To date, five species of istiodactylids are known from the Chinese deposit. A new specimen from this unit is here reported and comprises the most complete istiodactylid found so far. It is an almost complete skeleton of a young animal, with skull, mandible, most of the vertebral column, pectoral and pelvic girdles, most forelimbs and part of the hind limbs. It is confidently referred to the Istiodactylidae based on dentition and skull features. Besides providing information that will enable comparison of the limb proportions, it presents the first information on the tail of the Istiodactylidae. The tail is very well preserved and almost complete. There are four disassociated caudal vertebrae, and the last 11 ones preserved in articulation such that it gives a minimum length of 15 caudals. All caudal centra have an elongated cilindrical shape and show no pneumatic foramina. The vertebrae in the caudal series get gradually thinner. The last nine vertebrae show a gradual reduction in length as well, with the second to last vertebra being the smallest. The last caudal is longer than the preceding one but it is the thinnest, with a posterior end a mere 0.3 mm wide. The istiodactylid tail, as expected from pterodactyloids, is short, but it differs from the tail of *Pteranodon*, which has duplex centra and ends in a caudal rod.

Grant Information
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Technical Session IX (Thursday, October 15, 2015, 3:45 PM)

PATTERNS OF PRESERVATION IN ANCIENT COASTAL WETLANDS: TAPHONOMY OF VERTEBRATE MICROFOSSIL BONEBEDS IN THE UPPER CRETACEOUS (CAMPANIAN) JUDITH RIVER FORMATION, MONTANA

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Vertebrate microfossil bonebeds (VMBs) are concentrated deposits of small, disarticulated, and taxonomically diverse vertebrate hard parts. Fairly common in Mesozoic and Cenozoic terrestrial records, VMBs have been exploited to recover otherwise rarely found small-bodied taxa as well as to estimate relative abundance and species richness in ancient vertebrate communities. Nevertheless, their taphonomic origins and attributes are poorly understood. The Campanian Judith River Formation (JRF) of Montana preserves abundant VMBs in both lacustrine and fluvial facies. Study of VMBs in the JRF has clarified that initial accumulation of vertebrate hard parts transpired in wetlands, where background mortality over periods ranging from hundreds to thousands of years produced enormous concentrations of fossils. These assemblages are time-averaged (a good thing if the goal is to reconstruct community membership) and are not transported out of life habitat. Reworking of preexisting VMB concentrations best explains VMBs in fluvial sandstones, which are intercalated with the finer-grained facies that host wetland VMBs. Data indicate that while fluvial VMBs are reworked and out of facies context, they are not transported far from source facies.

An automated sieving system that minimizes damage and maintains associations was used to process matrix from ten VMB sites in the JRF. All bioclasts > 0.5 mm were separated by hand picking under light microscopy, yielding over 56,000 vertebrate specimens from 230 kg of matrix. Surface collections from the same sites yielded ~17,000 specimens. This sizeable sample permits detailed taphonomic analysis of VMB formation. Most fossils are unidentifiable fragments in the 1–2 mm size range, but ~20% of recovered specimens are identifiable. Teeth, vertebrae, fish scales, and osteoderms dominate the identifiable fraction. Image analysis software was used to recover size data from sieved samples, and size sorting is comparable regardless of facies context. Shape data (compact, platy, elongate, conical) were documented for sieve and surface collections, and both are dominated by compact and platy elements. Taxonomic representation was also compared within sites in relation to collection strategy, and here there is clear distinction, with sieve samples dominated by fish remains (95+%). Surface collections yield a more diverse array of animals. This taphonomic inquiry into the nature of VMBs is ongoing, with the goal of understanding the origins and biases of these spectacular fossil deposits.

Technical Session XI (Friday, October 16, 2015, 10:30 AM)

EFFICIENT QUANTITATIVE MEASUREMENTS OF ENAMEL OCCLUSAL WEAR WITH A WATERSHED SEGMENTATION ALGORITHM

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Tooth wear has become an integral part of understanding the natural history and paleoecology of ancient mammals, providing insights into diet, feeding habits, and mastication. The current best-practice for measuring tooth wear is highly manual and subjective, leading to problems with use on large datasets, replication of results, and comparison across studies. To address these systematic issues we present a new, semi-automated program to measure tooth wear with both high efficiency and fidelity. Measuring Enamel Occlusal Wear (MEOW) treats photographs of fossil teeth as topographic relief maps, and then employs a watershed segmentation algorithm to automatically separate the image into regions of enamel, dentin, and background/other based on sample regions identified by the user. The ratio of enamel to dentin is then automatically calculated and saved for later analysis. MEOW presents a simple user interface, and implements several keyboard shortcuts for rapid analysis. It is also capable of analyzing multiple teeth in a single image, as well as iterating through multiple images in a single run of the program. To illustrate the power of MEOW, we performed a case study using mammals from the Eocene of Wyoming to examine the possible effects of volcanic and volcaniclastic sediment on tooth wear. In order to make a statistically valid statement about volcanic influence on tooth wear, we gathered over 350 samples of teeth from museum collections. Quantitative measurements produced with MEOW show statistically significant differences in wear before and after the onset of volcanism in the area. MEOW grants the ability to dramatically expand the dataset of available mammal tooth measurements, enabling for the first time meaningful, large-scale comparisons across time, space, and habitats.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

MORPHOLOGICAL DISPARITY OF INSECTIVORES (MAMMALIA, EULIPOTYPHLA) ACROSS RAPID ENVIRONMENTAL CHANGES DURING THE PALEOCENE-EOCENE THERMAL MAXIMUM

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The Paleocene-Eocene Thermal Maximum (PETM, ~56 Ma) is a period of rapid increase in global temperature (5–8°C over ~175 kyr) that corresponds to changes in mammalian faunas including intercontinental dispersals, a shift in trophic structure, and an increase in diversity including the first appearance of Euprimates, Artiodactyla, and Perissodactyla into North America. Other immigrants include the erinaceomorphs *Macrocranion junnei* and cf. *Colpocherus* sp., whose size, dental morphology, and inferred diet are similar to those of endemic North American putative eulipotyphlans. Community morphological diversity can be quantified as morphological disparity. It can be additively decomposed into partial disparity (PD), a metric that measures the contribution a particular taxon makes to the total disparity. Partial disparity provides information on the phenotypic distinctiveness of a taxon. If initial ecological overlap results in subsequent shifts in tooth shape as a proxy for dietary ecology, then PD of those taxa might be expected to change through time. In order to test whether these taxa changed in partial disparity from when they first appear in the fossil record to just afterwards, we quantified morphology of lower molars from the PETM of the Bighorn Basin, WY, of immigrant taxa (cf. *Colpocherus* sp., *Macrocranion junnei*, n = 27) and endemic taxa (species of *Wyonycteris*, *Plagioctenoides*, *Talpavoides*, *Leptacodon*, n = 24) using the recently published Automated Three-Dimensional Geometric Morphometric method (auto3dgm). Each tooth was aligned and quantified using 1024 correspondence points. Partial disparity was calculated using size-standardized point clouds for each tooth. In both the onset and body of the PETM, immigrant and native taxa had similar PD. From the onset to the body of the PETM, PD increased in each group but not significantly. Results are inconsistent with the hypothesis that these immigrants, after arrival, had a different response to ecological change compared to long-endemic taxa. Stasis in eulipotyphlan immigrant vs. endemic ratios of PD may be due to empty niches immediately occupied by immigrant taxa on arrival or perhaps niche partitioning that is not being reflected in molar morphology.

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Technical Session V (Wednesday, October 14, 2015, 2:30 PM)

IDENTIFICATION OF MUSCLE ATTACHMENT SITES IN FOSSILS: PRESUMPTIVE VERSUS SURFACE MICROSCOPIC LOCALIZATION

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Muscle attachment localization is fundamental to the mycological reconstruction so critical to projecting vertebrate functional anatomy. Phylogenetic bracketing has been utilized for extinct animals for which in situ muscles have not been preserved. While likely correct in attribution for closely related animals, localization could be confirmed if all muscle attachments could actually be identified. As tendinous (indirect) attachments are not always recognizable macroscopically or histologically, and fleshy (direct) muscle attachments are more elusive, there is need for a technique that can reproducibly identify both. Previously, surface microscopy proved effective for identification of vascular and neurosensory structures and Sharpey's fibers. Given that Sharpey's fibers are integral to entheses, it was suspected that identification of their distribution would allow mapping of tendinous muscle attachments.

In pursuit of phylogenetic bracketing, skeletal muscle and tendon attachments were localized by direct dissection of turkey, rabbit, and alligator femurs. Epi-illumination microscopy (200x magnification) was performed on those specimens and on conspecific defleshed skeletons in the collections of the University of Kansas and on *Tyrannosaurus rex* KU VP 155809.

Distribution of bony rings surrounding round apertures, specific for Sharpey's fibers, identified the full extent of puboischiofemoralis internus, puboischiofemoralis externus, and caudofemoralis longus tendon (indirect muscle) attachments. A linear wave pattern (undulating appearance) characterized the full extent of femorotibialis anterior, femorotibialis posterior, adductor femoris, ischiofemoralis internus, ischiofemoralis externus, and ischiofemoralis direct muscle attachments. No such rings or undulating areas were present outside of the documented attachment zones. As the appearance of these identifying "markers" was indistinguishable among turkey, rabbit, and alligator femurs, it is presumed that they have the same significance in *Tyrannosaurus rex*.

Surface microscopy reproducibly distinguished direct and indirect muscle attachments and allowed identification of their position and extent in a manner independent of phylogeny (avian, mammalian, and reptilian).

Technical Session XVIII (Saturday, October 17, 2015, 3:45 PM)

LATE PLEISTOCENE BIOGEOGRAPHY AND CLIMATIC NICHE EVOLUTION IN PLAINS ZEBRA *EQUUS QUAGGA* AND BLUE WILDEBEEST *CONNOCHAETES TAURINUS*

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The Late Pleistocene of Africa was characterized by climatic changes that led to major redistributions of terrestrial vegetation biomes during the transition from glacial to interglacial conditions over the last ~ 26 ka. Most notable are the particularly cold and arid Last Glacial Maximum (LGM) ~ 26-20 ka, and the warm and wet African Humid Period (AHP) ~ 9-6 ka. These two periods of environmental change likely affected the biogeography of primary consumers, such as ungulates, in very different ways. Here we use species distribution models (SDMs) of two abundant Late Pleistocene ungulate species, plains zebra *Equus quagga* and blue wildebeest *Connochaetes taurinus*, to investigate faunal responses to LGM and AHP climatic change. Presence-absence data were acquired from the Global Biodiversity Information Facility and the Paleobiology Database for modern and fossil occurrences, respectively. Climate rasters for 19 bioclim variables were downloaded from the WorldClim Database for the present, AHP, and LGM. Modern species occurrences and climate rasters were used to build maximum entropy SDMs of *E. quagga* and *C. taurinus* in MaxEnt 3.3.3, which were then used to hindcast the distribution of these species for the AHP and LGM. The hindcast projections were compared to the known fossil record of each taxon to assess the model's predictive ability. Our results show that SDMs successfully predict the historical distribution of *E. quagga* but fail to predict the historical range of *C. taurinus* for the AHP and LGM. Posthoc comparisons of climate data for each species from 26 ka to the present suggest climatic niche stability for *E. quagga* since the LGM (only 2/7 climate variables significantly different, $p < 0.001$), while the climatic niche of *C. taurinus* has undergone significant change since this time (7/9 climate variables significantly different, $p < 0.001$). Our results find support in recent phylogeographic data that have suggested range stability for *E. quagga* during the Late Pleistocene, while the range of *C. taurinus* has changed dramatically since ~ 26 ka. Together, these results have important implications for biodiversity management of ungulate species in the face of anthropogenic climate change and highlight the need to incorporate fossil data into such strategies.

Technical Session III (Wednesday, October 14, 2015, 11:45 AM)

ORIGIN OF ORTHO-RETRONASAL OLFACTION IN BASAL CYNODONTS AND ITS ROLE IN MAMMALIAN CORTICAL EVOLUTION

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An innovation in stem-tetrapods enabled the naris to communicate to the oral chamber via the choana. This endowed tetrapods with 'orthonasal' olfaction, in which external environmental odorants are drawn over the olfactory epithelium by inhaling or sniffing. Mammals and their extinct relatives among Cynodontia are unique among tetrapods in augmenting orthonasal olfaction with 'retronasal' olfaction, in which an entirely new domain of volatile information is liberated from food via the actions of chewing, the tongue, and saliva, as the new volatiles pass over the olfactory epithelium with exhaled air. In living mammals, this larger system of 'ortho-retronasal olfaction' combines smell, taste, and other stimuli, in the neocortex to produce the compound sensation of flavor. The structural keys to ortho-retronasal olfaction are an occlusal dentition and secondary palate, which trace to Early Triassic cynodonts, such as *Procynosuchus* and *Thrinaxodon*. Correlated transformations in basal cynodonts affected head movement and ventilation, and suggest evolutionary coupling of these seemingly separate anatomical regions into the larger integrated system of ortho-retronasal olfaction. Evidence from paleontology and physiology suggests that ortho-retronasal olfaction played a critical role at several stages of mammalian evolution. The size and evolutionary plasticity of the olfactory receptor subgenome mirrors the structural diversity of the mammalian dentition, adding strength to hypotheses of olfactory ecology as a driving mechanism in mammalian diversification. Cortical development in early cynodont and mammalian brain evolution was driven in part by ortho-retronasal olfaction; the bauplan for neocortex had higher-level association functions derived from olfactory cortex; and human cortical evolution was enhanced by ortho-retronasal olfaction.

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Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

SYSTEMATIC AND FUNCTIONAL SIGNIFICANCE OF THE ANTERIOR HINGE OF THE MALLEUS IN LAGOMORPHA (MAMMALIA)

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The anterior process of the malleus (processus gracilis or Folii) is mainly formed by the dermal bone praearticular (gonial). Recent comparative ontogenetic studies show that in a number of placental mammals (mainly Cetartiodactyla) the praearticular produces a prominent internal process ('ossiculum accessorium malleoli'); this process almost inevitably brakes off when the ear ossicles are removed, and therefore the malleus is normally depicted in an incomplete form.

In order to elucidate this character complex in Lagomorpha we investigated histological serial sections of perinatal stages of *Oryctolagus cuniculus*, *Lepus europaeus*, and *Ochotona* sp. as well as µCT scans of adult skulls of 28 extant species of Leporidae and Ochotonidae.

In the perinatal stages of Leporidae, the praearticular has a prominent process articulating as a tongue with a groove at the underside of the tegmen tympani thus forming a hinge joint. In the adult hares and rabbits, the tip of the processus gracilis is always connected to this groove by an extremely thin processus internus. However, this delicate process appears to be synostosed anteriorly with the tegmen tympani inside the groove. In a fetal *Ochotona,* the praearticular is very short and has no contact with the tegmen tympani. The ectotympanic bulla as well as the tegmen tympani become extensively pneumatized in postnatal age; adult ochotonids show a relatively short and delicate processus internus that is continuous with single trabeculae of the tegmen tympani bony network.

The different patterns observed in Leporidae and Ochotonidae are clearly restricted to the family level and therefore represent new groundplan features; both look highly autapomorphic, but *Ochotona* seems to be more specialized. Future studies on fossil Lagomorpha should help to elucidate the ancestral morphotype of Lagomorpha.

Functionally, the anterior process of the malleus in Lagomorpha represents a highly modified 'transitional type' that still allows the malleus sufficient amplitudes during sound transmission by the thin and elastic bony pedicle of the processus internus of the praearticular. At present it is difficult to bring this 'transitional type' -malleus into line with hearing abilities of, e.g., rabbits, which are sensitive to a broad range of frequencies between about 2 and 16 KHz. According to common dogma the structural specializations of the ochotonid middle ear should represent adaptations to low frequency-hearing, but this does not seem to be in good agreement with their specific high-pitched vocalization.

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Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

POSSIBLE NON-AVIAN DINOSAUR FOOTPRINTS FROM THE CRETACEOUS ATANE FORMATION OF GREENLAND

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East Asia and western North America (Laramidia) are known to have been intermittently connected during the Late Cretaceous (100–66 Ma). Although inferences of faunal interchange between these landmasses during this time are well substantiated, our understanding of possible paleobiogeographic connections between Europe and eastern North America (Appalachia) is hampered by the scarcity of Cretaceous continental vertebrate fossils from the latter. The Nuussuaq Group, exposed along the coast of West Greenland, consists of continental, paralic, and marine sediments that range in age from Early Cretaceous to Paleocene. Although numerous plant, macro- and micro-invertebrate, and fish fossils have been recovered from this unit, no terrestrial tetrapod remains have previously been reported. In 2014, a collaborative research project investigated the 'middle' to Upper Cretaceous (Albian–Campanian) Atane Formation on the southeastern part of the Nuussuaq Peninsula and Disko Island in central West Greenland. The formation consists of stacked channel sands that were deposited in a deltaic setting approximately 35 km from the paleoshoreline, making it an ideal setting for the potential preservation of continental vertebrate remains. Although no vertebrate body fossils were recovered, a series of small, isolated, possible dinosaur footprints were discovered in previously commercially-worked coal seams at the Nuussuaq and Skansen localities adjacent to Disko Bay; these sites also produced plant fossils, including leaves, stems, and abundant wood. The putative footprints are consistent with the morphology of previously-described iguanodontian ornithopod tracks, and fall within the size range of the 'Stage 2' age class of footprints reported from a Late Cretaceous tracksite in Denali National Park, Alaska, which are thought to have been made by young, rapidly-growing hadrosaurs. If verified, the Atane Formation footprints will constitute the first evidence of Cretaceous dinosaurs in Greenland and will add to our limited understanding of non-avian dinosaur communities inhabiting paleoecosystems between Appalachia and Europe.

Grant Information

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Preparators' Session (Thursday, October 15, 2015, 11:00 AM)

GETTING 2D X-RAY SYSTEMS TO YIELD 3D IMAGES VIA CONE BEAM COMPUTED TOMOGRAPHY

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X-ray computed tomography (CT) has rapidly become commonplace as a nondestructive imaging and research tool in paleontology. Many researchers benefit from their own CT systems or have costly access to off-site medical facilities, but two-dimensional (2D) X-ray imaging systems are affordable, common, and accessible in remote locations. We present techniques and best practices for using a 2D X-ray imaging system to generate tomographic images for the construction of three-dimensional (3D) models. Since 2010, the Field Museum's Siemens Axiom Multix MT 2D digital X-ray has been used by the anthropology department to investigate the internal materials of mummies and wooden statues, and by the geology department to identify fish fossils from the Green River Formation and field jackets that are missing proper labels from the Cedar Mountain Formation. The resulting images from the 2D X-ray lack z-axis depth and clarity to assist in diagnoses. We overcome this limitation by rotating a specimen on a turntable to generate a series of 2D X-ray images, which are used to compute the tomographic image data, and generate a 3D digital model. Our tomographic slices were computed from the 2D X-ray images using a cone beam approach with the Bruker microCT freeware NRecon v1.6.9.18. For successful computation, several variables need to be held constant throughout the 2D image collection: the distances from the X-ray source to detector, and from the X-ray source to specimen, the axis of specimen rotation relative to the X-ray source, and the rotation angle of the specimen. Imaging the Cedar Mountain Formation material is most successful when the specimen to detector distance is minimized, and a 360 degree scan in 10 degree increments, at 60kv, 22mA, 220ms exposures are used to produce a 0.002 mm^3 voxel size. The workflow for our protocol from the initial X-ray scan set-up to the rendered 3D digital model is on the order of one to two hours, much faster than if we used an off-site CT facility. In summary, the protocol unites common low-tech resources and free programmatic solutions to produce a highly effective and accessible 3D imaging solution. The resulting 3D data is of sufficient quality to aid the triage, planning, and preparation of vertebrate fossil material.

Preparators' Session (Thursday, October 15, 2015, 9:45 AM)

PREPARATION OF DESICCATED IVORY: CASE STUDY OF *MAMMUT AMERICANUM*

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Ivory is high in organic content and because it is hygroscopic it is especially vulnerable to fragmentation in arid environments. In particular, poorly mineralized subfossil ivory from *Mammuthus columbi, Mammuthus exilis,* and *Mammut americanum* from the marine terraces of southwest California and the Channel Islands are often too fragmented to prepare with conventional methods.

Subfossil ivory is different from permineralized bone because of its unique physical properties. Including its light-sensitive color, luster, relative softness, and sensitivity to temperature and humidity. Though durable in life, tusks fracture in three distinct patterns following desiccation in an arid environment. The most prominent of these fracture regimes cleaves the tusk into a series of concentric conical laminae. Irregular transverse fractures and radial fractures intersect these concentric laminae and collectively reduce it to myriad tabular units.

The restoration of a highly fragmented subfossil tusk from *M. americanum* inspired the development of new preparatory techniques. By replacing and rejoining the most surficial tabular units with an Auqazol-200 based filler, the fractures of the outermost conical lamina can be sealed and the interior can be consolidated without any leaks. Final consolidation with Butvar B-72 dissolved in acetone left our tusk rigid enough to be moved and bear its own weight. Removing debris from the surface finishes the preparation process. By developing new preparatory techniques, we have restored structural integrity to desiccated ivory tusks, so that they can be available for researchers, artists, and exhibition.

Grant Information
Winslow Maxwell Charitable Trust

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

REVISED TAXONOMY AND BIOSTRATIGRAPHY OF LAGOMORPHA FROM THE JOHN DAY FORMATION, OREGON

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The John Day Formation of Oregon spans over 20 million years of time (~39 – 18 Ma) and has one of the richest and best studied mammal faunas in North America. Despite 150 years of study, only a single species of lagomorph, the leporid *Archaeolagus ennisianus*, has been described to date. Here we describe three additional species of lagomorphs from the John Day Formation, based on previously unpublished and newly discovered specimens. New material includes very complete remains of *A. ennisianus*, allowing revised diagnosis and documentation of variation within the species. A second *Archaeolagus* species, *A. primigenius*, is also present and represented by more complete material than previously described. Both of these species display a variably present premolar foramen, a structure that had until recently been considered characteristic of ochotonids. In addition to those leporids, new material allows the recognition of the first *Palaeolagus* occurrences from the Pacific Northwest. An 'archaic ochotonid' species (*Hesperolagomys*?) is also noted, represented by a number of fairly complete specimens. Biostratigraphic ranges of the newly described materials allow more direct comparison of the John Day faunas with contemporaneous faunas from North America. Particularly noteworthy are Whitneyan occurrences of *Archaeolagus* (~31 Ma), which are the earliest record of the genus. The earliest Arikareean records of an 'archaic ochotonid' (~29.5 Ma) in the John Day Formation predate records of similar North American taxa such as ? *Desmatolagus*, *Gripholagomys*, *Hesperolagomys*, and *Russellagus*. Abundance patterns of leporids and small browsing artiodactyls likely reflect changing climate and habitat conditions in the Oligocene of Oregon. Hypertragulids, which are the most common mammals in the Whitneyan and early Arikareean of Oregon, become rarer through time, while *Archaeolagus* increases in abundance to be one of the most common animals present in the more open habitats of the later Arikareean. Interestingly, this reciprocal abundance pattern seems to be driven by the decline in smaller hypertragulids (*Hypertragulus minutus* and *H. hesperius*) during the later Arikareean.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

A MULTI-SPECIFIC SHARK NURSERY AREA IN THE LATE MIOCENE OF CAUJARAO FORMATION, VENEZUELA

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Modern shark nursery areas are geographically discrete locations in the spatial distribution range of a species, where gravid females give birth to their young or lay their eggs, and where juveniles spend their first weeks, months, or years of life. Three criteria define a modern shark nursery: (1) juvenile sharks are more commonly encountered in the area than other age classes; (2) juvenile sharks have a tendency to remain or return to the area for extended periods; (3) the area or habitat is repeatedly used across years. These criteria are difficult to identify in the fossil record, and previously have been doubtfully reported from distinct localities in the Caribbean. Intensive field works in the Caujarao Formation (late Miocene to early Pliocene; Falcón state, Northwestern Venezuela), allowed the recognition of hundreds of shark teeth of different species and different sizes. We compared the size of the tooth assemblage of Caujarao Formation with other six Miocene assemblages in Venezuela using statistical analysis (Kruskal Wallis and Tukey tests), finding significant differences ($p = 0.037$) in tooth size of the genera *Carcharhinus*, *Isurus* and *Negaprion*. The Caujarao assemblage is dominated by neonate and juvenile specimens, with poor representation of adult individuals. In addition, the assemblage comes from three different bone-beds, suggesting a long-term multi-specific shark nursery area. We recognize the three mentioned criteria for modern nursery areas in the Caujarao Formation, representing a well-defined multispecies nursery area in the Neotropics. Finally, this reproductive strategy is consistent with the long-term evolutionary stasis of the chondrichthyan fauna since the Miocene in the Caribbean area.

Technical Session XIV (Friday, October 16, 2015, 3:00 PM)

THE EVOLUTION OF PLESIOSAUR BONE HISTOLOGY: EVIDENCE FROM LONG BONES AND VERTEBRAE

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Considering that Plesiosauria are the most diverse clade of Mesozoic marine reptiles, their bone histology and microanatomy has received remarkably little study. As in other marine tetrapods inhabiting open waters, a cancellous bone structure has been reported for plesiosaurs. This microanatomy represents a decrease in skeletal mass as an adaptation to fast swimming and deep diving. An extensive histological sample of long bones and vertebrae now reveals more complex patterns and unexpected evolutionary trends. The sample includes the only Triassic plesiosaur skeleton as well as a diverse sample of European Jurassic taxa and Japanese Cretaceous taxa. Plesiosaurs show distinctive histological differences between long bones (humerus and femur) and vertebrae. Vertebrae exhibit cancellous bone in most taxa, revealing the expected bone mass decrease. Long bones, however, more commonly show an osteosclerotic or even pachyosteosclerotic condition, representing bone mass increase. Only one Jurassic plesiosaur in our sample also has a cancellous midshaft region. Plesiosaur long bones show the radial vascular pattern and lack of perimedullary resorption activity already present in stem Pistosauria such as *Pistosaurus*. Plesiosaurs differ from stem Pistosauria in the low number of growth marks and better developed primary osteons in a woven bone matrix (fibrolamellar bone), suggesting higher growth rates in the plesiosaurs. In addition, plesiosaur long bones show light to sometimes extensive cortical bone remodeling, absent in stem Pistosauria, with secondary osteons either being developed inside the radial primary ones or as longitudinal Haversian canals. Cortical bone remodeling increases with age, contributing to the maintenance or increase of high cortical density. Most plesiosaurs studied preserve a complete growth mark record in their long bones because of the lack of perimedullary resorption activity and only light bone remodeling. Growth marks always start at a relatively large size and give low counts (< 5), consistent with large, K-selected offspring and fast growth. In some plesiosaurs, growth marks, particularly the first one, are highlighted by an abrupt change in orientation of the radial vascular canals, from curving in one direction to curving in the other. This appears to be linked to a rugose midshaft surface. Plesiosaur histology thus shows many peculiarities, attesting to the convergent evolution of fibrolamellar bone in this group, otherwise seen in synapsids and avemetarsalian archosaurs.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

TAXONOMIC, DEVELOPMENTAL, AND EVOLUTIONARY IMPLICATIONS OF MORPHOLOGICAL EVALUATION OF ARCHAIC LATE MIOCENE ELEPHANTS FROM THE BAYNUNAH FORMATION, ABU DHABI EMIRATE, UNITED ARAB EMIRATES

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Baynunah Fm. localities in Al Gharbia, Abu Dhabi Emirate, U.A.E. have produced a diverse late Miocene vertebrate fauna, including a large assemblage of proboscidean fossils. Except for single deinothere and gomphotheriid molars, all specimens in this assemblage belong to an archaic, tetrabelodont elephantid previously assigned to *Stegotetrabelodon syrticus*, among the oldest evidence of the family. The elephant sample is comprised of abundant gnathodental, cranial, and postcranial fossils, representing juvenile and adult individuals. The formation also preserves an extensive set of elephant trackways, manifesting evidence of modern-elephant-like herd composition and social behavior. Because many new fossils have recently been added to the assemblage and the early elephant fossil record is now better documented since preliminary investigation of the original sample, a new study of the sample was undertaken. Data collected include observations on occlusal features (e.g., accessory conules, conelets per plate, number of plates, crown height, enamel thickness, transverse plate shape and spacing). Regression analysis of long bone dimensions indicates average body masses larger than those of modern elephants (>10,000 kg). Particularly important are newly recovered mandibular specimens preserving combinations of deciduous teeth and permanent premolars and molars. From these, the dental emergence pattern is reconstructed as dp2, dp3, dp4, p3, m1, p4, m2, m3, with permanent premolars erupting anterior to and after their accompanying molars, permitting a horizontal molar displacement mechanism similar to that in modern elephants. Comparison with other primitive Mio-Pliocene elephants indicates that the Baynunah elephants display a unique mix of primitive (extreme brachyodonty, retention of lower tusks and premolars, few conelets per loph(id), very thick enamel, wide spacing of pyramidal-shaped plates, accessory conules throughout intermediate molars, little cementum) and derived (slight increase in lower molar lophid numbers (five–six in dp4–m1), postcranials like those of modern elephants) features. We conclude that they share no special affinity with *S. syrticus* of North Africa and belong in their own species, revealing evidence of Afro-Arabian geographic diversification of elephants soon after their origin.

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Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

KAYAKING FOR PALEO – RELOCATING AND DOCUMENTING THE TURLOCK LAKE FOSSIL SITES, UPPER MEHRTEN FORMATION (EARLY PLIOCENE; HEMPHILLIAN LMA), STANISLAUS COUNTY, CALIFORNIA

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The upper Mehrten Formation (early Pliocene; Hemphillian LMA) is exposed at Turlock Lake, a reservoir in eastern Stanislaus County, in the low foothills of the Sierra Nevada Mountains. The Mehrten consists of volcanic-sedimentary deposits representing lahar flows, stream, lake, and floodplain deposits. Numerous sites are exposed in and around the reservoir; some can only be reached by boat. Hundreds of fossil leaves and vertebrates were collected by Dennis Garber, are curated in the University of California Museum of Paleontology (UCMP) and the Los Angeles Museum of Natural History, and were described by Hugh Wagner in his dissertation. All sites are noted on topographic maps, but no field notes, photographs, or descriptions of the sites have been located. We are re-locating and re-examining the major sites via kayak in order to provide better sedimentological context, paleoenvironmental interpretations, and stratigraphic and age control for these important sites. We are documenting sites with photographs and GPS, describing their lithology, and measuring stratigraphic sections. We have re-located and documented the following important fossil sites: 1) the giant, tusk-toothed salmon site, *Oncorhynchus rastrosus*; 2) the Galapagos-sized tortoise, *Hesperotestudo* cf. *H. orthopygia*; and 3) the plant sites. We have made several important discoveries, listed from lower to higher in the section. First, the deposits of Axelrod's Turlock Lake Paleoflora were mis-identified as bentonites. Based on 30 fossil leaf samples in the UCMP, they are laminated, tuffaceous silty- shales, probably representing a lacustrine environment. This interpretation is supported by the presence of the pond turtle *Actinemys marmorata* and the cyprinid Sacramento blackfish *Orthodon,* which lives in quiet waters. Second, the tortoise fossils are from tuffaceous fine sandstones, directly below a sharp, erosional contact. Third, the salmon site overlies this contact, and is from cross-bedded, medium to coarse sands containing pebble lenses, cobbles, and cobble-sized, rip-up clasts of the fine sandstones. This represents a fluvial deposit from a fast-flowing river, possibly a large, proto-Tuolumne River. The unconformity represents significant missing time and change in depositional setting. This may also indicate the start of the uplift of the Sierra Nevada Mountains to the east.

Technical Session V (Wednesday, October 14, 2015, 4:00 PM)

PHYLOGENY AND EVOLUTIONARY HISTORY OF MAMMALS UNDERMINED BY RELIANCE ON DENTAL MORPHOLOGY

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Phylogenetic trees underpin reconstructions of evolutionary history and tests of evolutionary hypotheses. They are inferred from both molecular sequence and morphological data yet the relative value of morphological data has been questioned in this context; developmental and functional linkage purportedly result in suites or modules of non-independent morphological characters and misleading patterns of homoplasy. Nevertheless, the data provided by fossils are almost exclusively morphological, often limited to certain subsets of morphology, for example teeth in mammals. Here we show that dental and osteological data of mammals convey significantly different phylogenetic signals, and that of the two, osteological characters are significantly more compatible with molecular trees. Furthermore, the application of palaeontological filters (removing osteological data) results in significant loss of phylogenetic signal. Our meta-analysis of 40 datasets comprising a combined total of 1234 taxa and 7403 characters indicates that dental data are not reliable for phylogenetic reconstruction. Application to contentious fossil mammals (the Triassic *Haramiyavia*, disputed primate *Darwinius* and the putative hominid *Sahelanthropus*) results in more stratigraphically congruent placements and dramatically alters evolutionary interpretations, including molecular clock analyses. More generally, these findings highlight the need for meta-analyses to test for distributions of homoplasy, as well as the non-independence and oversaturation of characters. Without these tests, and the subsequent adjustments to analyses, any evolutionary hypotheses based on any interpretations of morphology and the fossil record, including molecular clock studies, are at risk.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

THE MOST ONTOGENETICALLY ADVANCED SPECIMEN OF *DESMOSTYLUS* AND IMPLICATIONS FOR ONTOGENY AND SENESCENCE OF DESMOSTYLIANS

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Ontogenetic sequence and life stage determination among the desmostylians is poorly understood and known mostly from the study of their teeth eruption. Understanding of the elderly life stages is nearly unknown. A new specimen of *Desmostylus* from Orange County, California, represents the most ontogenetically advanced described specimen of the genus and helps characterize a more complete ontogenetic sequence. The material consists of a partial mandible that exhibits bony swelling, indicative of *Desmostylus,* but also lacks cheek teeth (dental senescence). The development of an ontogenetic sequence based on juvenile and adult *Desmostylus* shows that the Orange County specimen is that of an elderly individual and allows us to develop a complete eruption pattern for the teeth of the lower jaw. Beginning with juvenile stage specimens that exhibit p1–p2 or p3–p4–m1, the sequence is followed by a sub-adult stage with p4–m1–m2, an adult stage with m1–m2–m3, and lastly by the proposed advanced age stage when molars are heavily worn or lost completely. The study of this advanced aged specimen indicates the previously unknown length and complexity of *Desmostylus* lifespans, as most mammals do not have lifespans long enough to survive to a stage where cheek teeth are completely worn and lost. Additionally, the development of the mandible and tooth eruption sequence in *Desmostylus* is similar to the characteristic ontogeny of Afrotheria. In Afrotheria, the eruption of the final set of molars is delayed until the mandible has grown to maximum length. Desmostylia has been placed in Afrotheria, suggesting that the similarities in ontogenetic sequences may derive from a shared ancestry. Recent studies that place Desmostylia as stem perissodactyls suggest that the Afrotheria-like dental ontogeny may be independently derived within Desmostylia, or *Desmostylus*.

Technical Session VII (Thursday, October 15, 2015, 2:15 PM)

OSTEOHISTOLOGY SUGGESTS ONE IGUANODONT TAXON IN THE LOWER YELLOW CAT MEMBER OF THE CEDAR MOUNTAIN FORMATION (CRETACEOUS), UTAH

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Doelling's Bowl (DB) is highly productive, multi-taxon bonebed in the lower Yellow Cat Member of the Cedar Mountain Formation (?Barremian, Early Cretaceous), Eastern Utah, dominated by a single taxon of basal iguanodontian dinosaur. At least ten individuals are represented by vertebrae, limb and pelvic elements. Based on their broad size range, these specimens were originally hypothesized to be an ontogenetic series of a single (unnamed) taxon. However, this has not yet been tested using osteohistological criteria. Such a test is particularly important given the occurrence of the basal styracosternan *Iguanacolossus fortis* from a different site in the lower Yellow Cat Member, Don's Ridge. The holotype and only known skeleton of *Iguanacolossus* represents a much larger individual than the smallest material from DB, and is still considerably larger than the biggest material from DB. Although more DB material remains to be excavated and prepared, preliminary comparisons of the scapulae, ilia, and pubes suggest that the material might be referable to *Iguanacolossus*.

Here, we examined the osteohistology of humeri (n=5), femora (n=4) and tibiae (n=3) from the DB iguanodont, including the smallest and largest examples of each element. Transverse sections were taken from each shaft at the level of least circumference. The smallest specimens show characteristics of very juvenile bone, such as knitted texture, which is indicative of rapid growth. By contrast, the largest specimens show characteristics of a later ontogenetic stage, such as fibrolamellar bone and

increasing proliferation of secondary osteons. This is consistent with the specimens representing an ontogenetic series. However, the largest specimens are not yet skeletally mature, as indicated by lack of an external fundamental system or equivalent structure. Moreover, regular, widely spaced lines of arrested growth suggest that it was still growing at a fairly high rate. Given this, it is reasonable to conclude that this taxon could have reached the size of *Iguanocolossus* by the time of skeletal maturity, and may represent that taxon.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

ONTOGENY OF *YUNGUISAURUS* (SAUROPTERYGIA; PISTOSAUROIDEA)

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Triassic pistosauroids are the closest relatives of the Jurassic and Cretaceous plesiosaurs characterized by the distinct body plan with four flipper-shaped limbs and a wide range of neck lengths. *Yunguisaurus* is the only Triassic pistosauroid represented by multiple articulated specimens, and provides a rare opportunity to understand the origin of the unique plesiosaurian body plan. We analyzed ontogenetic changes in *Yunguisaurus* based on the morphological and morphometric data of six well-preserved individuals of different sizes.

The six individuals are preserved as mostly articulated skeletons embedded in slabs, and came from the Triassic of Yunnan-Guizhou area in southern China. The smallest individual is 45% of the size of the largest one in the combined length of the last four dorsal vertebrae (= 'standard length'), which was employed as a measure of the absolute body size. Fifty-two linear measurements per skeleton were defined, of which 39 were available in all specimens and subjected to statistical analysis of relative growth using standard major axis regression. All measurements were log-transformed so that the allometric relationship of $Y = BX^A$ is expressed as logy = AlogX + logB where A is the allometric coefficient.

Notable morphological changes include the closure of neurocentral sutures and enlargement of the pectoral girdle elements. The number of ossified carpals and tarsals increases slowly and progressively in general, whereas the phalangeal formulae in the manus and pes are mostly established early in the growth series. Despite the very small sample size, correlation was statistically significant ($P < 0.05$) in 38 measurements and strong ($r > 0.9$) in 33 of them. In general, the growth of axial units (e.g., skull and neck length) is nearly isometric, indicating that the proportion of the axial skeleton did not change considerably. Negatively allometric growth of the skull is known in many different amniote taxa including Triassic sauropterygians, and the nearly isometric growth in the studied series of *Yunguisaurus* suggests that they may represent later stages of the growth. Meanwhile, strong positive allometric coefficients ($A > 1.2$) were obtained for the measurements of forelimb epipodials, whereas the distal end of the femur is the only measurement which yielded a strong negatively allometric coefficient ($A = 0.669$).

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

TOOTH FORMATION AND REPLACEMENT PATTERN OF DIPLODOCID SAUROPODS FROM THE TENDAGURU FORMATION (LATE JURASSIC, TANZANIA)

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The Late Jurassic (Tithonian) Tendaguru Formation of Tanzania offers one of the richest sauropod faunas known. The diplodocoid material from Tendaguru treated in this study includes left and right premaxillae, incomplete left and right maxilla, and the left as well as the right dentary from different locations within the Tendaguru Hill area that, historically, had been subsumed under the term *Barosaurus africanus*. Recent re-examinations have demonstrated that the material belongs to different taxa within Diplodocoidea, and it is henceforth described according to its provenience of different quarries. CT scanning of the separate tooth-bearing bones of the upper and lower jaws allow detailed reconstructions of tooth formation pattern.

The quarry at Kijenjere, Upper Saurian Beds, yielded two premaxillae, with four replacement teeth present in each of the four tooth families. The left maxilla bears eleven alveoli, the dental fragments show eleven alveoli. The number of replacement teeth decreases from four to two per tooth family. Formation times can be calculated to between 96 and 162 days for the premaxillary teeth. With calculated replacement rates of between 23 and 33 days, this material corresponds well with the rates of Diplodocus (34 days), Camarasaurus (62 days), and Nigersaurus (14–30 days). The reconstruction of a of rather high tooth replacement rate in Diplodocoidea corresponds well with the recovered vegetation, dominated by woody browse in the Tendaguru Hill area.

Symposium 3 (Saturday, October 17, 2015, 9:15 AM)

THE INVISIBLE FOSSIL: RECONSTRUCTING INTERMEDIATE MORPHOLOGIES USING GEOMETRIC MORPHOMETRICS

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Species identification and the possible existence of hybrid zones or individual hybrids are routinely assessed in extant organisms by means of both molecular biology and phenotypic analyses. However, this is rather difficult in fossils because they do not typically provide enough material for molecular-based identification. For this purpose, the tools of geometric morphometrics can be used to characterize morphological differences, and so be useful in identifying hybrids and intermediate morphologies and ultimately aid in delineation of species. Among extant mammals, seals provide many examples of potential hybridization. For example, studies in the wild have reported mating behaviors between grey seals (*Halichoerus grypus*) and harbor seals (*Phoca vitulina*) and also between southern elephant seals (*Mirounga leonina*) and Cape fur seals (*Arctocephalus pusillus*). Genetic markers have confirmed wild hybrid offsprings between species as disparate as the hooded seal (*Cystophora cristata*) and the harp seal (*Pagophilus groenlandicus*).

Here, we present a geometric morphometric case-study of a newborn hybrid seal. This specimen is the only described hybrid between two different genera of seals, the grey seal and the ringed seal (*Pusa hispida*). Observations of the skull and particularly the dental anatomy suggest that this specimen is a phenotypic intermediate between these two genera, which possess markedly distinct sizes and phenotypes. We use landmark-based geometric morphometric methods for the shape and size analysis of the skull and teeth of the hybrid. We compare this specimen to newborn males and females from the parental types to determine their common features and morphological uniqueness.

Preliminary analyses suggest the hybrid lies within the size range of female newborn ringed seals. The shape differences detected show that the hybrid has longer frontal bones, shorter and wider nasal bones, and a shorter maxilla than ringed seals. These features resemble more the snout of grey seals with the absence of an inflection at the premaxilla that is characteristic of ringed seals. The hybrid also shows a tilt of the palate that flexes in a convex direction at the basisphenoid that is not observed in the parental groups. Finally, we analyze growth series of the two parental species and discuss the potential of geometric morphometrics for identifying intermediate and hybrid morphologies in the fossil record.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

SEVERE CRANIAL PATHOLOGIES IN *TRICERATOPS* FROM THE HELL CREEK FORMATION, MONTANA

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Bone pathology in fossil animals can provide a glimpse into the lives of individuals long after death. A recent survey of the uppermost Cretaceous Hell Creek Formation of Montana has produced a large sample ($n > 100$) of the chasmosaurine ceratopsid *Triceratops*, including several specimens exhibiting cranial abnormalities. Two specimens preserve particularly severe lesions which these individuals were able to survive for at least a moderate period of time. MOR 3010 is a young adult in which the right postorbital horn core is intact, however the left horn core is severely truncated. Only ~3 cm of the horn core is preserved above the rostral margin of the orbit and ~13 cm is preserved caudally. The pathologic horn core consists of a semi-circular rim of bone surrounding a depressed area representing the cornual diverticulum of the supracranial sinus. The surface of this postorbital rim exhibits areas of highly rugose surface texture. Horn pathology is often described as resulting from trauma (through combat or other means). The MOR 3010 horn core lesion is so extensive that if it were to have been induced by trauma it could have arisen either by horn avulsion or by a non-union fracture held in place by the horn. One alternative explanation for this pathology includes osteomyelitis due to an anaerobic infection, as is commonly seen in crocodilians. MOR 2924, a subadult *T. prorsus*, exhibits significant alteration of the premaxillae with much of the rostro-ventral margins missing and absence of the interpremaxillary fenestrae. Sections of dentary and the predentary are preserved for this specimen, but the rostral bone is missing. This could indicate post-mortem loss of this bone, however the condition of the premaxillae suggests that the rostral may have been lost (or at least severely compromised) pre-mortem, drastically altering the morphology of the rostrum. Possible causes for this condition include a pox viral lesion, fungal granuloma, a psittacine beak and feather disease-like lesion, or another cause of focal decreased blood flow and necrosis. The absence of interpremaxillary fenestrae may indicate differing forces during feeding in this individual which affected bone growth and remodeling in the premaxillae. These specimens expand the record of abnormalities in ceratopsids and provide evidence that individuals could survive (for at least some time) with very severe cranial pathology.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

TAPPING A NEW SOURCE: THE ANATOMY OF A SUCCESSFUL CROWDFUNDING CAMPAIGN FOR VERTEBRATE PALEONTOLOGY

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Since the start of modern crowdfunding close to decade ago, the industry has experienced phenomenal growth, exceeding $5.1 billion dollars in 2013. Artists and entrepreneurs adopted crowdfunding early, now commonly relying on it as a mainstream funding source. Scientists, and particularly paleontologists, have been exceedingly slow to tap this resource.

Here we report a case study of three recent successful paleontology crowdfunding campaigns. They are: (1) Sidor-excavation of dinosaur remains ($2,395 goal); (2) Wilson-earth science teachers' participation in fieldwork ($10,000); and (3) Schein-excavation of dinosaur remains ($5,985). The financial goals of each project were exceeded, with 101 donors pledging $19,665 total.

Crowdfunding websites emphasize the importance of a robust campaign start; our results suggest that this is not critical for success. The Schein project followed this model, but the Sidor project experienced its most significant progress near the campaign midpoint, and the Wilson project only made significant strides near the end. Both Schein and Sidor projects reached their goal near the campaign midpoint, while the Wilson project met its goal on the last day. In general, donors pledged steadily until the raised totals approached the goal, at which time there was a sharp increase in number of pledges. After reaching the goal, campaigns experienced little activity for the duration. The average donation for each project was strongly proportional to its goal. Each

campaign relied heavily on a few large cornerstone donations; ten donors contributed over 50% of the total funds raised.

In the Schein project, donors fall into seven categories: (1) past field workers, their family and friends (PP); (2) family and friends of campaign organizers (FF); (3) staff of the campaign host company (St); (4) avocational groups (AG); (5) professional paleontology and earth science colleagues (Co); (6) museum support groups (SG); and (7) other individuals with no known ties to the campaign (Ot). Of the $6,800 raised from 64 donors, PP contributed the greatest percentage of funds (30%) from the greatest number of donors (22). Four AG donors accounted for 23.6% of the total, ten FF donors contributed 17%, and five SG donors contributed 15%. The smallest average donations came from Co and Ot; Co contributed the least amount of funds (2.4%). In an age of shrinking government support, crowdfunding presents a viable alternative to fund mission critical aspects of paleontological research, with the added benefit of raising public support and awareness.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

HEAD POSTURE IN PLEISTOCENE RHINOCEROSES

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The Pleistocene was marked by interchanging cold glacial and warmer interglacial periods with distinct floral and faunal elements. Among the rhinoceroses distributed in Europe in this time, the woolly rhinoceros (*Coelodonta antiquitatis*) was adapted to the cold climatic conditions of the glacial periods. As indicated by stomach content, it was mainly feeding on low vegetation. During the warmer interglacial periods, members of the genus *Stephanorhinus* immigrated from warmer regions into the landscapes and replaced the woolly rhinoceros, which moved to refugial colder regions. It is known that some species of *Stephanorhinus* were browsers, while others were grazers living in open environments. The different feeding habits on low or higher vegetation are related to different head postures. In rhinoceros skulls these postures are reflected in different shapes of their occipital regions. Grazing species carry their heads downward oriented with the muzzle low above the ground and therefore the occipital crest is extended posteriorly. In comparison the skulls of browsers are carried in a horizontal position and the occipital crest is inclined forward.

In this study, skull remains of the Pleistocene woolly rhinoceros and *Stephanorhinus etruscus* from different German localities have been scanned using micro computed tomography with focus on the inner ear. For comparison, the extant white rhinoceros, a pure grazer in Africa, and the Javan rhinoceros, a pure browser in Asia, were investigated. The lateral semicircular canal of the inner ear is assumed to be held horizontal in the habitual head posture. For all investigated specimens these canals have been virtually reconstructed. The horizontal orientation of the lateral canal resulted in the head posture that correlates with their preferred type of feeding. This is distinctly visible in the two grazing species white rhinoceros and woolly rhinoceros, both showing a downgrade head posture. *Stephanorhinus etruscus* was assumed to be a browser, indicated by strong cingula on the teeth and an anterior inclined occiput. The inner ear supports this feeding habit showing a nearly horizontal habitual head posture for this fossil species like it does for the browsing extant Javan rhinoceros.

Grant Information

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Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

TAPHONOMY OF MARINE VERTEBRATES IN THE UPPER CRETACEOUS TROPIC SHALE, SOUTHERN UTAH

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The Tropic Shale was deposited along the western side of the Western Interior Seaway during the late Cretaceous (Cenomanian–Turonian). The formation contains abundant invertebrates, as well as a diverse vertebrate fauna including fish, sharks, turtles, plesiosaurs, and mosasaurs. Stratigraphic position of vertebrate localities have been placed precisely using a combination of laterally extensive bentonite beds and ammonite biostratigraphy. From an examination of the taphonomic characteristics (as well as associated field notes, photographs, and locality information) of a total of 178 marine vertebrate specimens collected from the Tropic Shale, it is clear that physical factors were the dominant influence on preservation. Robust and durable skeletal elements (such as teeth and vertebrae) are far more prevalent in the formation than thinner and less robust skeletal elements (such as plesiosaur girdle bones and cartilaginous skeletal elements from sharks). Additionally, isolated teeth and bones are far more common in the formation than complete or nearly complete skeletons. Skeletal elements had slightly higher levels of abrasion and weathering to the west (in shallower water), although low signals of abrasion, weathering, and compression are common on elements across the region, mainly from post-burial alteration. High levels of fracturing on all bony skeletal elements (not including teeth) also indicate a strong post-burial alteration signal. A lack of evidence for epifaunal or infaunal activity on skeletal remains or bioturbation of seafloor sediments suggest that biological factors did not influence preservation as strongly as physical factors. However, scavenging/predation marks were found on most of the more complete specimens, suggesting that scavengers likely decreased the total number of carcasses that made it to the seafloor to be preserved. Based on the preservation of the marine vertebrate fauna, a detailed paleoenvironment for the Tropic Shale can be reconstructed. Vertebrate carcasses in the Tropic Shale were deposited on a muddy ocean floor with a substrate that ranged from soupy to firm. The environment was low energy, although some weak bottom currents were capable of scattering lighter skeletal elements of more complete skeletons nearby. Varying levels of benthic oxygen and moderate sedimentation rates both served to protect carcasses from destruction prior to a relatively rapid burial.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

DIRE STRAITS IN THE ICE AGE-A MAMMOTH SCAVENGED BY A WOLF IN THE LATE PLEISTOCENE OF KANSAS

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We report a *Mammuthus columbi* bearing tooth marks attributable to a large canid from the Late Pleistocene of Cowley County, Kansas. The markings were discovered during a renovation of the mammoth and mastodon exhibit at the University of Kansas Natural History Museum. Predation markings of any kind on mammoth bones are rare, and this is the first report for tooth marks on a mammoth from Kansas. The mammoth skeleton comprises the upper skull, a single vertebra, the pelvis, and limb elements from the left side. We interpret the carcass as laying on its right side as it was scavenged, based on the preserved material and the occurrence of the bite marks. We suggest that the pattern and distribution of a series of marks on the proximolateral portion of the ulna were made during a single bite. These markings consist of several elongate (1–5 cm) grooves that penetrate the surface of the bone. The deepest grooves are ~2 mm, and they shallow and taper to the opposite end. One series of markings appear in a nearly linear pattern and are attributable to a carnivore's upper canine tooth due to their V-shaped cross section. The remaining markings are asymmetrically V-shaped in cross section, indicating that they were formed by an upper carnassial (P4). The spacing and irregular placement of the carnassial markings suggest the flesh was tough at the time the bite was made, causing the carnivore's skull to skid across the surface of the bone during jaw closure. These bite marks were most likely made during an attempt to strip flesh and connective tissue from the bone during an act of scavenging rather than active predation. This style of scavenging indicates the feeding traces were probably made during a period of resource scarcity. Other tooth markings on the limb elements are additional evidence that the skeleton was scavenged. The mammoth must have been exposed for several months or longer prior to final burial. Contemporaneous large carnivores such as *Arctodus*, *Miracinonyx*, *Panthera*, coyotes, and wolverines can be ruled out based on the pattern and size of the bite marks. The size and pattern of the described marks are consistent with the bite patterns of canids, either *Canis lupus* or a sub-adult *C. dirus*. *Canis lupus* is known to strip flesh down to the bone and crack bones in order to access marrow. A scavenging lifestyle has been proposed for *C. dirus* based on tooth wear, however, this is the first report of canid scavenging of proboscideans based on physical evidence. This suggests a greater role for wolves as scavengers in Ice Age food webs than previously described.

Technical Session XVII (Saturday, October 17, 2015, 2:45 PM)

PALEONEUROLOGY OF *EUROPASAURUS HOLGERI*, AN INSULAR DWARF SAUROPOD FROM NORTHERN GERMANY

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Europasaurus holgeri represents the first unequivocal dwarf sauropod. It is known only from the Langenberg Quarry (Oker, Germany; Kimmeridgian, Jurassic). The hypodigm includes abundant and excellently preserved specimens of various ontogenetic stages, including a large number of cranial elements from at least 15 individuals. The best preserved braincase of *Europasaurus* was CT scanned and 3D renderings of the endocast and osseous labyrinths were generated.

Because of the incompleteness of the braincase anteriorly, the olfactory lobes could not be reconstructed and neither could most of the cerebrum. However, it was possible to create an accurate reconstruction of the most posterior part of the endocast, including most cranial nerves, the labyrinth, and various vascular structures. The trochlear nerve may have found its way out of the braincase through the metoptic foramen together with the oculomotor or, alternatively, through the orbitocerebral foramen. As usual in sauropods and many other amniotes, the trigeminal nerve is large. The abducens nerves penetrate the dorsum sellae close to one another, but then diverge so that they contact the pituitary fossa very laterally. The facial nerve is relatively large. It extends posteroventrally as does the large metotic group formed by the glossopharyngeal and vagoaccesory nerves. The hypoglossal nerve has two rami, the posterior being larger as in the other sauropods in which two hypoglossal branches of different diameter are present. The internal carotid arteries penetrate the pituitary fossa relatively apart from one another. The dorsal-head/posterior-middle-cerebral vein system passes through the occipital plate. The radius of curvature of the anterior semicircular canal of the inner ear is significantly larger than that of the other semicircular canals as in some, but not all, sauropods. The lagena seems to have been short.

The neuroanatomy of *Europasaurus* is reminiscent of that of *Giraffatitan*, both in global morphology and a number of details (e.g., presence of a flocculus), as already suggested by the osteology of the braincase. The development of the vestibular apparatus of *Europasaurus* is also comparable with that seen in *Giraffatitan*. In any case, it is clearly different from the situation in both *Camarasaurus* and derived titanosauriforms, in which the semicircular canals are contracted. Generally, the brain of *Europasaurus* can be described as an isometrically scaled-down version of that of *Giraffatitan*.

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Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

INVESTIGATING MOLECULAR PRESERVATION IN *DREADNOUGHTUS SCHRANI*, AN EXCEPTIONALLY COMPLETE TITANOSAUR FROM ARGENTINA

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The holotype (MPM-PV 1156) of *Dreadnoughtus schrani*, a massive sauropod from Argentina, is remarkably well preserved for its size (~60 metric tonnes), and includes many associated and articulated skeletal elements, representing >40% of the skeleton. Notably, it retains exquisitely preserved muscle scars, which show little to no evidence of degradation. The preservation of well over 100 elements from its skeleton required rapid burial to protect its remains from scavengers and geomorphic processes. Extensive syndepositional deformation in the crevasse-splay lithosome entombing *Dreadnoughtus*, as well as the steeply dipping orientation of many of its elements, indicate that the holotype experienced rapid perimortem burial. Both skeletal completeness and rapid burial have been implicated as factors that may point to other types of 'exceptional preservation' in a specimen, including soft-tissues, original organics, and other labile features commonly destroyed by diagenesis (e.g., skin, feathers, cells, proteins). Thus, we hypothesized that the unusual preservation of MPM-PV 1156 at the macroscopic level may extend to the microscopic and even molecular levels. To test this hypothesis, we employed four independent experimental methods to detect the presence of collagenous tissue in cortical bone samples from the holotype of *D. schrani,* including morphological identification (microscopy), *in situ* antibody-antigen localization (immunofluorescence), immunoreactivity of chemical extracts (enzyme-linked immunosorbent assay), and silver staining of chemical extracts separated by gel electrophoresis. Lab reagents and sediments excavated with MPM-PV 1156 were also tested as negative controls. The results of this study shed light on the taxonomic and environmental extent of soft tissue recovery in ancient fossils and suggest that it's time to reevaluate whether this phenomenon points to an 'extraordinary' taphonomic pathway or an under-sampled biomolecular record.

Grant Information
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Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

ENAMEL ISLETS AND THE DEVELOPMENT OF HYPSODONTY IN FOSSIL AND EXTANT CASTORIDAE (RODENTIA, MAMMALIA)

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Enamel islets on the occlusal surface occur in a wide variety of mammalian orders (e.g., Rodentia, Perissodactyla, Artiodactyla, Gondwanatheria) as well as in several types of teeth (brachyodont, mesodont, hypsodont). Two types of enamel islets can be observed: (1) enamel invaginations from occlusal (infundibula) are present as enamel islets with beginning of wear; (2) enamel invaginations with lingual or buccal openings (furrows) occur as enamel folds on the occlusal surface and can become isolated to enamel islets with progressive wear.

When isolated due to wear the enamel islet loses contact to the surrounding enamel organ and further mineralization of the infundibulum is not possible. Thus, the infundibula have to be completely mineralized before eruption of the tooth and the beginning of wear. Due to the process of mineralization, enamel islets are reduced in euhypsodont teeth and vanish in very early wear stages (e.g., Arvicolinae).

Modern beavers (*Castor*) possess enamel folds as well as islets. However, the teeth are not completely mineralized when erupted. In order to clarify this apparent discrepancy, different ontogenetic stages of fossil and extant castorids were analyzed. Based on µCT data of the investigated specimens, virtual 3D models of the enamel portion of the cheek teeth were reconstructed.

The basal castorid *Steneofiber eseri* possesses mesodont cheek teeth with three infundibula and two furrows in unworn teeth. Erupting teeth lack the full mineralization of the outer enamel band, but all infundibula are closed. With initial wear the enamel of the teeth is completely mineralized.

In contrast, *Castor* shows four furrows, which become isolated very late during wear to form enamel islets. In specimens with erupting permanent premolars, enamel islet formation occurs in the most apical part of the teeth and mineralization is not completed in the still open infundibula. The full mineralization of the enamel portion (closed infundibula, fully mineralized outer enamel band, development of roots) can be found in older individuals with worn premolars.

Our observations clearly indicate an evolutionary trend in the castorid dentition. The apical elongation of the furrows and the delay of the isolation of enamel islets enables *Castor* to have a more hypsodont dentition as other castorids with enamel islets. Further elongation of the furrows and thereby a possible loss of enamel islets could lead to ever growing cheek teeth in *Castor*.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

A NEW, MATURE, AND PATHOLOGIC SPECIMEN OF *TYRANNOSAURUS REX*

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In the summer of 2013, a new specimen of *Tyrannosaurus rex* was discovered in a fluvial sandstone deposit of the Hell Creek Formation (Upper Maastrichtian) south of Jordan, Montana, USA. The specimen comprises an articulated skull, pelvis, much of the vertebral column and rib cage, right leg, left scapula and coracoid, and the furcula. The specimen is exceptionally well-preserved, with hardly any distortion, thanks to rapid burial under a 3.25 m thick blanket of fine to medium grained unconsolidated sand with a high calcium carbonate content. Preliminary magnetostratigraphic data suggest the specimen comes from the C30N chron which coincides with the lower to middle part of the Hell Creek Formation.

The specimen is now in the collection of the national natural history museum of The Netherlands, Naturalis Biodiversity Center in Leiden, registered as RGM 792.000. It is a very large, mature individual, representing a robust morphotype.

The skeleton displays a multitude of pathologies. The skull preserves healed puncture wounds in the left posterior mandibular unit and left premaxilla, a large healed infection in the anteriormost part of the left maxilla, and an unhealed series of scratches on the left maxilla, indicative of multiple episodes of-likely intraspecific-combat or play. Multiple healed rib fractures are also present. The femur preserves an unusual vascular pattern on the anterior aspect, possibly the result of an ossification of the periosteum following major damage to the covering muscles. The proximal caudals show hyper-ossification of the ligaments joining the dorsal spines. The mid-caudal series preserves asymmetrical bone growths on the centra and erosion on the haemal arch.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

THE INNER AND MIDDLE EAR OF JURASSIC PAULCHOFFATIID MULTITUBERCULATES

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The reinvestigation of Jurassic mammalian petrosals from the Guimarota coal mine in central Portugal (Western Europe) provides new insights into early multituberculate inner and middle ear anatomy. Three petrosal bones of two individuals of *Pseudobolodon oreas* were studied by µCT and their endocasts were reconstructed. Additionally, a crushed posterior part of a skull with both petrosals of an unidentified multituberculate was examined. The five reconstructed inner ear endocasts have an anterior semicircular canal that is about 1.2 times the size of the posterior semicircular canal, while the lateral semicircular canal is the smallest. The cochlear canal is curved 180° and exhibits a swelling at the apex, but no bony canal for innervating a lagena as in the extant monotremes *Ornithorhynchus* and *Tachyglossus* is present. No evidence for a supporting bony lamina has been found inside the cochlear canal as it has been reported for the Late Cretaceous multituberculate *Tombaatar*. In each multituberculate individual one stapedial bone is preserved. The footplates of all three preserved stapedial bones are oval shaped (average stapedial ratio = 1.5) with a laterally bending bony rim and a distinct bony ridge on the lateral side. In one specimen the posterior crural part with the articulation for the incus is preserved, which is strongly bent posteriorly. The anterior crural part is forming a hook at the distal end of the posterior crus. The stapedial shape of *Pseudobolodon oreas* differs distinctly from the round footplate present in modern monotremes with only one central (columelliform) bony process, and from the columelliform stapes of the Paleocene multituberculate *Lambdopsalis bulla*. It differs also from the bicrural stapes of the docodont *Haldanodon exspectatus* with a round footplate. In the specimen with the nearly complete stapedial bone, incus and malleus were detected and reconstructed. The incus is a flat square shaped bone with a long bony process on the medial side ending in an oval facet for articulation with the stapes. On the lateral end, a short bony process for articulation with the malleus is present. The malleus is club shaped with a bulbous medial end exposing a groove for the articulation with the incus. The stapes of *Pseudobolodon oreas* is more derived than that of the Paleocene *Lambdopsalis bulla*. This demonstrates that the stapes of *Lambdopsalis bulla* does not represent a general condition for multituberculates as suggested earlier.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

A DIMINUTIVE NEW SPECIES OF *CATOPSALIS* (MAMMALIA, MULTITUBERCULATA, TAENIOLABIDIDAE) FROM THE PALEOCENE OF SOUTHERN ALBERTA, CANADA

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The Taeniolabididae are a family of multituberculates known from the early Paleocene of North America. Taeniolabidids are distinguished from contemporaneous multituberculates not only by their combination of distinctive dental characters (e.g., gigantoprismatic enamel, anteroinferiorly restricted band of enamel on the hypsodont lower incisors, upper and lower fourth premolars that are greatly reduced in size, and enlarged molars), but also by their generally much larger size. Here we report the discovery of a new species of the basal taeniolabidid *Catopsalis* from the latest Torrejonian and earliest Tiffanian (approx. 62–61 mya) of southern Alberta, Canada, and the second known occurrence of the genus in the province. The new species represents not only the smallest species of *Catopsalis*, but is the smallest taeniolabidid yet described. The new species is known from several specimens, all isolated teeth, representing I2/i1, p4, M1/m1, and M2/m2. Phylogenetic analyses using traditional and New Technology searches in TNT, and a data set of 48 cimolodontan multituberculates scored on 35 independent, unordered dental characters suggest that the new species is the most basal known taeniolabidid, despite its comparatively late occurrence. Until relatively recently, the chronological succession of North American taeniolabidids appeared to document fairly straightforward evolutionary trends of increasing body size (as inferred from molar length), an increase in the length of the upper and lower first molar relative to the second molar, and an overall reduction in the size of the upper and lower fourth premolar. The discovery of specimens of a *Catopsalis foliatus*-sized species in putative Late Cretaceous deposits (*Catopsalis johnstoni*), and even more so the discovery of a *Catopsalis calgariensis*-sized species in the mid to late Puercan (*Catopsalis waddleae*) muddies the waters, and suggests that the evolutionary history of *Catopsalis* is significantly more complicated than previously thought. The basal position of the new species in Taeniolabididae, combined with its occurrence relatively high in section, implies the existence of a previously undocumented taeniolabidid lineage during the Paleocene, and that much of the evolutionary history of the family remains unknown.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

FIRST EVIDENCE OF CO-OCCURRING *MAMMUTHUS MERIDIONALIS* AND *M. COLUMBI* FROM VICTORVILLE, WESTERN MOJAVE DESERT, CALIFORNIA

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Extinct mammoths (genus *Mammuthus*) are frequently critical components of Pleistocene assemblages from throughout the Mojave Desert. Columbian mammoths, *Mammuthus columbi*, are the most common species regionally; this species has been interpreted to derive from the Old World *M. meridionalis* via the steppe mammoth *M. trogontherii*. Here we document the presence of both *M. meridionalis* and *M. columbi* from the Victorville area, California, USA. *Mammuthus meridionalis* is represented by a partial skeleton from fluvial sediments in northwestern Victorville. *Mammuthus columbi* is documented by an adult molar from fluvial sediments north of Victorville, and may also be present from deposits in southern Victorville. Sediments yielding these remains are all interpreted to derive from the ancestral Mojave River. The skeleton of *M. meridionalis* is paleomagnetically dated to ~375 ka; the stratigraphic position and absolute age of the fossils of *M. columbi* are not known.

Remains referred to *Mammuthus meridionalis* include a skull, mandible, pelvis and several ribs belonging to a single individual. The upper and lower M3s possess 12+ enamel plates, a lamellar frequency of slightly less than 4.5, and an enamel thickness ranging from 2.3 – 4.0 mm. The mandible exhibits a posteriorly-inclined ascending ramus and a strongly developed, anteriorly-projecting anterior mandibular symphyseal process; the molars possess loxodont sinuses. These features all correspond with characters defining *M. meridionalis*.

Mammuthus columbi is represented by an isolated right M^3 collected in 1934 from along the western bank of the Mojave River, northwest of Victorville. This specimen exhibits features aligning it with *M. columbi*, including 19+ plates, a lamellar frequency of 6.5 – 7, and an enamel thickness of 1.5 – 2.1 mm. Additionally, a subadult mammoth mandible with left and right M_2 was recovered from fine-grained fluvial silts in southern Victorville. This specimen compares favorably with lower jaws assigned to *M. columbi* from Rancho La Brea, and is referred here to *Mammuthus* sp. cf. *M. columbi*.

The presence of both *M. meridionalis* and *M. columbi* in Mojave River sediments of middle to later Pleistocene age is significant, confirming a regional incursion and late survival of *M. meridionalis* in the Mojave Desert region. This demonstrates that the *M. meridionalis –M. trogontherii –M. columbi* clade cannot have evolved anagenetically. *Mammuthus meridionalis* survived as a distinct lineage subsequent to an early cladogenetic separation from the lineage leading to *M. columbi*.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

THE FIRST MONODOMINANT HADROSAUR BONEBED FROM THE OLDMAN FORMATION (CAMPANIAN) OF ALBERTA PRESERVES A COHORT OF *GRYPOSAURUS* JUVENILES, WITH IMPLICATIONS FOR POST-HATCHLING HADROSAUR BEHAVIOR

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The first monodominant hadrosaur bonebed described from the Campanian Oldman Fm (OF) of Alberta is interpreted as preserving the remains of the hadrosaurine *Gryposaurus* sp. based on diagnostic cranial elements. Age-class assessment based on the absolute size of long bones indicates that the individuals present (MNI=3 from 16 completely excavated 1x1 m^2 grids) represent a mixed group of early and late juveniles that were not older than two years at the time of death (estimated body length of ~3.5 m). This growth stage assessment was verified by histologically sampling six tibiae with transverse sections of the mid-diaphysis. Only one line of arrested growth (LAG) was observed in the largest specimens. All specimens lacked an external fundamental system, and secondary remodeling was minimal and typically confined to the medullary and peri-medullary regions. All specimens showed zonation of multiple bone tissue types, with alternating zones of reticular fibrolamellar bone and circumferential fibrolamellar bone. The zones of reticular tissue reflect periods of rapid growth, with the transition to circumferential tissue representing slower bone deposition, possibly due to seasonal controls.

The bonebed is located at the base of a series of stacked, fine-grained mudstones and sandstones, indicative of an overbank deposit, at the base of the lower informal unit of the OF, ~6 m above the Taber Coal Zone. This zone marks the contact between the terrestrial OF and the underlying Foremost Formation, which represents a transitional marginal marine-terrestrial unit deposited during the regressive phase of the Western Interior Seaway. The bonebed is dominated by limb and pelvic elements, but all other regions of the skeleton are represented; some hind limb elements appear to have been associated. Bone density ranges from 2 to 24 bones/m^2. The taphonomic signatures are consistent across the bone bed, including lithostatic compression and associated fracture patterns. The lack of weathering and minimal abrasion suggests a short pre-burial interval with limited transport of the elements.

Juvenile sociality has been suggested for a variety of different dinosaurs. A combination of oviparity and small hatchling-size in hadrosaurs would have required a significant energy commitment from adults for the rearing of hatchlings, resulting in older juveniles possibly congregating together. The taphonomic history of the bonebed suggests that it may represent such a scenario, and gives credence to hypotheses of juvenile sociality in Late Cretaceous hadrosaurs.

Grant Information
Student research grant from the Dinosaur Research Institute

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

STABLE ISOTOPE PALEOECOLOGY OF A DIVERSE LATE TORREJONIAN (EARLY PALEOCENE) MAMMALIAN FAUNA FROM THE SAN JUAN BASIN, NEW MEXICO

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The lower Paleocene record of the San Juan Basin captures a critical interval of mammal evolution as mammals diversified and filled new ecological niches vacated during the Cretaceous-Paleogene mass extinction. Yet, the paleoecology of these early Paleocene mammals is poorly understood. Here we use stable isotopes of carbon and oxygen to infer ecological differentiation within a late Torrejonian (*Mixodectes pungens* biozone) mammalian fauna that lived in an ecosystem dominated by C_3 vegetation. Enamel was sampled from seven species: *Claenodon ferox* (Arctocyonidae, "Condylarthra"), *Mimotricentes subtrigonus* (Arctocyonidae), *Pantolambda bathmodon* (Pantodonta), *P. cavirictum*, *Periptychus carinidens* (Periptychidae, "Condylarthra"), *Psittacotherium multifragum* (Taeniodonta), and *Tetraclaenodon puercensis* (Phenacodontidae, "Condylarthra"). Body mass estimates for these taxa were made using first molar area and ranged from 3.4 kg in *M. subtrigonus* to 178.9 kg in *P. cavirictum*. Based on previous studies *C. ferox* was probably an omnivore, *Pantolambda* spp. were folivores, *M. subtrigonus* and *T. puercensis* were generalized herbivores, and *P. carinidens* was a hard object feeder. Estimates of higher atmospheric carbon values in the early Paleocene and a post-industrial decrease of ~1.5‰ suggest that reported fossil values would be ≤2‰ more negative than in the modern world. Overall mean carbon values indicate a moderate to densely vegetated biome. A general bimodal pattern is present, with low mean values in *Pantolambda* spp. (mean = -14.0‰; n=12) and *Psittacotherium multifragum* (mean = -14.0‰; n=2), and significantly higher values in the other species (mean = -11.5‰; n=24). The low $\delta^{13}C$ values in *Pantolambda* spp. suggest browsing in heavily vegetated, wetter habitats, where water was readily available to plants. A single negative outlier in *P. cavirictum* (-16.8‰) suggests the presence of a dense, closed canopied forest, at least locally. High carbon values in *C. ferox*, *M. subtrigonus*, *P. carinidens*, and *T. puercensis* suggest feeding in more open, drier habitats. Oxygen values help to differentiate species further. *Pantolambda bathmodon* has significantly higher $\delta^{18}O$ values than *P. cavirictum*, which could result from differences in body mass (28.0 vs. 178.9 kg) or by *P. bathmodon* occupying a drier habitat. Across the fauna, neither carbon nor oxygen values are significantly correlated with body mass as might be expected if body mass were driving overall separations. Isotopic differences appear to result primarily from habitat preference.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

ONTOGENY AND BIOMECHANICS OF THE AMERICAN ALLIGATOR SKULL

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The relationship between bony morphology, muscular conformation, and performance is critical to understanding the functional morphology and evolution of the vertebrate feeding apparatus. The main components of jaw muscle, bite, and joint forces are usually oriented dorsoventrally during biting. However, mediolateral and rostrocaudal components of muscle forces are important for platyrostral animals such as crocodylians, as the horizontal orientation of the jaw muscles leads to substantial medially-oriented loads. Accurate three-dimensional anatomical data are therefore crucial to understanding crocodyliform cranial function. This study uses CT-derived biomechanical models to characterize the ontogeny of muscle forces, moments about joint axes, and joint forces in the American Alligator. We made finite element and free body models to estimate how individual muscles contributes to bite force as well as joint forces. Muscle attachment sites were mapped according to dissections and the literature. Our calculated bite forces approach those measured in vivo, validating this method. Results also suggest that the pterygoid buttress is loaded at a similar magnitude to the primary jaw joint. We found that the line of action of the pterygoideus muscles suggests that differential activation of rostral or caudal portions could elevate or depress the mandible, respectively. This method will allow us to make informed inferences about biomechanics in the fossil record. Future work will apply these methods to understand how the skull and jaw muscles underwent coordinated changes in the evolution of crocodyliforms.

Grant Information
Missouri Research Board and NSF IOS-1457319

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

DIETARY RECONSTRUCTION OF FOSSIL PROBOSCIDEANS FROM THE SIWALIK SERIES OF PAKISTAN USING ENAMEL MICROWEAR AND CARBON ISOTOPES

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Molars from fossil proboscidean taxa from the Lower (early–middle Miocene), Middle (late Miocene–early Pliocene), and Upper Siwalik (Plio-Pleistocene) sequences of Pakistan were analyzed using enamel stereomicrowear and carbon isotope techniques to track dietary behavior through time. Results from the Lower–Middle Siwalik genera *Prodeinotherium* and *Deinotherium* were compared to those of extant tapirs to test the hypothesis that Miocene Siwalik deinotheriids had diets similar to modern tapirs. Other taxa studied from the Lower–Middle sequence include gomphotheriids and mammutids, *Anancus*, *Choerolophodon*, *Gomphotherium*, *Protanancus*, and *Zygolophodon*. We also examined two contemporaneous Upper Siwalik sequence species pairs from two different horizons (late Pliocene–early Pleistocene) of the genera *Stegodon* and *Elephas* to test the hypothesis that contemporaneous, sympatric species would display niche differentiation to avoid competition. Lastly, we compared our microwear results with enamel carbon isotope results for select taxa. Microwear results (low-scratch) indicate that both

Prodeinotherium and *Deinotherium* were committed browsers much like modern tapirs, with isotope results indicating consumption of a C3 diet. Microwear resolved that deinotheres displayed enamel food scars more similar to those found in extant *Tapirus bairdii* than to those of *T. terrestris*, suggesting that deinotheres engaged in more leaf browsing than fruit consumption. The Lower–Middle sequence taxa all displayed a dedicated C3 enamel isotopic signal, but microwear scratch results revealed that *Anancus*, *Choerolophodon*, *Protanancus*, and *Zygolophodon* apparently browsed, whereas *Gomphotherium* engaged in some grazing, most likely on C3 grasses, based on carbon isotope results. Such results underscore the importance of employing eclectic methodologies when attempting to accurately reconstruct paleodiets. Microwear scratch results on *Elephas hysudricus* and *Stegodon insignis* from the early Pleistocene and *Elephas planifrons* and *Stegodon bombifrons* from the late Pliocene revealed niche differentiation: *Stegodon* concentrated on browse while *Elephas* engaged in a more diverse mixed feeding diet.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

RANGE OF MOTION IN THE FORELIMB OF THE THEROPOD DINOSAUR *DILOPHOSAURUS WETHERILLI*

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Dilophosaurus wetherilli is a theropod dinosaur from the Lower Jurassic Kayenta Formation of Arizona. To study the range of motion in its forelimbs I used the holotype specimen, UCMP (University of California Museum of Paleontology, Berkeley, California) 37302. Manual manipulation of the bones of each joint, using the edges of articular surfaces as limits to motion, reveals the following: the humerus can be retracted to a position subparallel with the scapula but cannot be protracted further than a subvertical position, and can be elevated no more than 65 degrees. The elbow has a range of motion of approximately 55 degrees, and can be flexed almost to a right angle but cannot be fully extended. Supination and pronation of the radius are prevented by a lack of rolling joints. The palms face medially. Although the range of motion in the shoulder and elbow of *Dilophosaurus* resembles that in other non-coelurosaurian theropods, the range of motion in the fingers is unique. During flexion, the third finger diverges from the second finger, as in other theropods. However, unlike other theropods, in which the thumb also diverges from the second finger during flexion, the thumb moves toward the second finger during flexion in *Dilophosaurus*. The second and third fingers exhibit extreme hyperextensibility; an extended articular surface allows the proximal phalanx of each to be hyperextended into a right angle with its metacarpal. At first this seems to suggest that during resting the animal could manually support the weight of its anterior body, with the palmar surfaces of its fingers on the ground and the metacarpus held subvertically. However, the limited range of motion in the thumb prevents such support. The thumb is capable of less than 20 degrees of hyperextension. Its nearly-straight orientation during full hyperextension therefore prevents the hand from being used to support the body on the palmar surfaces of the fingers. A more likely functional advantage of the extreme hyperextensibility of digits two and three is that it adds to the arc through which the fingers could be passively moved without dislocation by powerfully struggling prey.

Grant Information
Welles Fund

Technical Session X (Friday, October 16, 2015, 9:00 AM)

SWIMMING FUNCTION IN THE CRETACEOUS GIANT *SPINOSAURUS AEGYPTIACUS* BASED ON THE KINEMATICS OF UNDULATORY SWIMMING IN THE AMERICAN ALLIGATOR

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The recently revealed unusual skeletal form and proportions of the giant, semiaquatic theropod *Spinosaurus aegyptiacus* poses immediate functional questions regarding its swimming capability. Unlike other spinosaurids such as *Suchomimus*, the estimated center of body mass is positioned anterior to, rather than over, the hind limbs, the size of the pelvic girdle and length of the hind limb are reduced, and the caudal vertebrae have short centra and markedly reduced zygapophyseal articulations. Conversely, within the hind limb of *Spinosaurus* the trochanter for the caudofemoralis is hypertrophied and the distal limb segments (crus, pes) are relatively longer.

Many of these skeletal features are similar to the condition in extant crocodilians, which employ paraxial swimming involving terrestrial-like limb paddling and tail undulation at slow speeds (>0.5 body lengths/second) and axial swimming involving only tail undulation at higher speeds (>1 body length/second). We present particle image velocimetry data for surface-swimming *Alligator* that show paired, unlinked vortices being shed from tail undulation with minor propulsive input from coordinated hind limb paddling. Finally, during surface swimming in *Alligator,* the dorsal surface of the head is held above the water surface.

The aforementioned data from *Alligator* suggest that main propulsive effector during surface swimming in *Spinosaurus* would have been the laterally compressed tail. Hind limb paddling would have provided minor propulsion and more likely was employed during acceleration or for steering and control of yaw and wind-induced roll. Comparative digital analysis of skeletal reconstructions of *Suchomimus* and *Spinosaurus* highlight many skeletal changes that occurred during the evolution of semiaquatic habits. Centers of mass and buoyancy and areas of the sail and hind limb paddle suggest that *Spinosaurus* was adapted for slow swimming speeds as captured in an animated 3D digital skeletal model.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

ESTIMATION AND CALIBRATION OF AERODYNAMIC PARAMETERS IN MESOZOIC STEM BIRDS

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Wing loading (*WL*) and aspect ratio (*AR*) are two relevant parameters that allow characterization of the aerodynamics of avian flight, as they relate to energy costs and maneuverability. *WL* and *AR* values can be calculated from three basic measurements that can be easily taken in extant neornithines: body mass (*BM*), wingspan (*B*) and lift surface (S_L). However, it is often difficult to retrieve reliable estimates of these parameters for basal birds, which can be subject to sources of error and bias from statistical issues, phylogenetic history, locomotor adaptations and diagenetic compaction.

In this study, we develop a sequential approach for obtaining specific multivariate models that are useful for predicting the aerodynamic parameters of each stem avian taxon. Such a procedure, which is similar to the one developed recently for estimating the BM values of ancient birds, generates robust, accurate and generalized models that provide reliable estimates of *B* and S_L for a set of 42 specimens from the main Mesozoic avian clades. The use in the models of those variables that show similar scaling patterns in modern and Mesozoic taxa and the similarity of our results with those obtained from most published reconstructions of fossil avian outlines give support to the accuracy of the values predicted for extinct birds. Given the reliability of these predictions, we assume that the values of the two aerodynamic parameters (i.e., *WL* and *AR*) calculated from them are also little-biased. In addition, although both parameters are based on *BM, B* and S_L estimates that have an associated error, there is no cumulative error in the calculation of *WL* and *AR*, which show relatively low prediction errors.

This is the first time in which flight parameters are estimated and error-calibrated for a large dataset of stem members of Aves, which constitutes the base of future studies focused on the first stages of avian flight.

Grant Information
Research Project (CGL2011-30334) and FPI PhD Research Fellowship to F. Serrano; Spanish Ministry of Economy and Competitiveness

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

RESOLVING THE HIGHER-LEVEL PHYLOGENETIC RELATIONSHIPS OF "TRIISODONTIDAE" ("CONDYLARTHRA") WITHIN PLACENTALIA

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The phylogenetic relationships among archaic taxa of the Paleocene remain poorly resolved and as such hinder our understanding about how mammals recovered following the end-Cretaceous mass extinction and how extant members of Placentalia subsequently radiated. The "Triisodontidae" are a group of medium sized eutherian mammals known predominantly from the Paleocene of North America.

"Triisodontidae" is characterised by narrow lower cheek teeth with longitudinally aligned and notched cutting crests; molars that feature robust, conical cusps with a reduced paraconid and appressed metaconid and protoconid; and upper molars that are tritubercular in form.

The "Triisodontidae" were moderately diverse during the Puercan and Torrejonian reaching a maximum standing taxonomic diversity (8 species) within ~500 thousand years of the Cretaceous-Paleogene boundary (middle to late Puercan) and as many as five species during the early to middle Torrejonian before going extinct near the beginning of the Tiffanian. "Triisodontids" were among the largest mammals of their time (based on mass estimates from molar size) with the middle to late Puercan *Eoconodon coryphaeus* estimated at ~ 30 kg and the early to middle Torrejonian *Triisodon quivirensis* exceeding 90 kg.

Previous studies have suggested a close relationship between "Triisodontidae" and Mesonychia based on similarities in their dental morphology but the higher-level relationships within "Triisodontidae" and its evolutionary relationship with Arctocyonidae remain poorly resolved. Here we present a comprehensive cladistic analysis assessing the higher-level phylogenetic relationships within "Triisodontidae", and the placement of "Triisodontidae" into Placentalia in order to assess its relationship to Arctocyonidae, other "condylarth" groups and Mesonychia. A cladistic analysis was run using 120 taxa scored for 500 dental, cranial and postcranial characters with *Nanolestes* as the outgroup taxon. Our phylogenetic analysis places "triisodontids" as a basal member of Euungulata within Laurasiatheria. "Triisodontidae" forms a paraphyletic stem of Mesonychia with *Oxyclaenus* most closely related to a monophyletic Mesonychia. "Triisodontids" plus Mesonychia are closely related to a clade comprised of the arctocyonids *Mimotricentes*, *Deuterogonodon* and *Chriacus*. "Triisodontids" were the first large bodied mammals with clear adaptations for carnivory, and were the largest mammalian carnivores during the early Paleocene until the appearance of the mesonychians.

Technical Session III (Wednesday, October 14, 2015, 9:30 AM)

***OPHIACODON* (BASAL SYNAPSID) BONE HISTOLOGY AND THE ORIGIN OF MAMMALIAN ENDOTHERMY**

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The origin of mammalian endothermy has long been held to reside within the early therapsid groups. However, shared histological characteristics have been observed in the bone matrix and vascularity between the "pelycosaur" (non-therapsid synapsid) *Ophiacodon* and the later Therapsida. Historically, this coincidence has been explained as simply a reflection of the presumed aquatic lifestyle of *Ophiacodon* or even a sign of immaturity. However, histological sampling of an ontogenetic series of *Ophiacodon* humeri and of additional juvenile to adult humeri and femora indicates the pervasive occurrence of fibrolamellar bone (FLB) in the autopodia of this pelycosaur. Thus, the findings reaffirm the initial observation of fast growing tissue and disprove that the highly vascularized cortex is simply a reflection of an early ontogenetic stage. The periosteal bone tissue demonstrates the classic histological characteristics of FLB. The cortex consists of dense radially arranged primary osteons in a woven bone matrix and remains highly vascularized throughout ontogeny, providing unequivocal evidence of fast skeletal growth. Overall, the FLB tissue in *Ophiacodon* is more derived or "mammal-

like" in terms of the development of primary osteons, bone matrix, and growth mark expression then what has been described thus far for any other "pelycosaur" taxon. However, long bone histology is inconclusive as to the preferred ecology of *Ophiacodon*, aquatic vs. terrestrial. The findings suggest that the evolutionary beginnings of mammalian endothermy and high skeletal growth rates date back to the late Carboniferous, approximately 35 million years earlier than previously hypothesized.

Grant Information
The Claude Leon Foundation

Symposium 3 (Saturday, October 17, 2015, 9:00 AM)

GEOMORPH: TOOLS FOR ANALYSING HIGH-DIMENSIONAL DATA OF FOSSIL AND MODERN TAXA

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Quantification of morphological variation to provide more objective comparisons is fundamental to comparative anatomy and related evolutionary research such as vertebrate paleontology. Moreover, the recent surge of micro-CT tools to represent and retrodeform fossils facilitates greater opportunity to compare them to other specimens: fossil, modern, or a mixture of both. However, shape data, as quantified using linear distances or landmark-based geometric morphometric tools, are inherently high-dimensional and require specialised software and analysis. Geomorph is an established package in the statistical environment R (CRAN) that provides functions to collect and analyse high-dimensional data. I shall demonstrate several geomorph functions with example datasets comprising landmark-based morphometric data that are of direct relevance for studies of fossil taxa: estimating missing landmarks in 2D and 3D datasets; ANOVA and regression models for analysing trait covariation with continuous and discrete variables (including phylogenetic generalised least squares); phylogenetic two-block partial least squares analysis for covariation between sets of traits; estimating the rate of morphological evolution in multivariate datasets; a generalised K statistic for estimating phylogenetic signal; and measuring morphological disparity. Together, these functions provide a comprehensive and highly versatile platform to test hypotheses of adaptation and phenotypic change in high-dimensional datasets.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

THE OLDEST NORTH AMERICAN RECORD OF THE LATE CRETACEOUS BONY FISH, *PENTANOGMIUS* (ACTINOPTERYGII: TSELFATIIFORMES) FROM DALLAS COUNTY, TEXAS, USA

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Pentanogmius (Actinopterygii: Tselfatiiformes) is a Late Cretaceous bony fish. It is known by two poorly known species from the Cenomanian-Turonian of Europe, *P. furcatus* and *P. pentagon*, and two better described species from the Coniacian-Campanian of North America, *P. crieleyi* and *P. evolutus*. Here, I describe a previously unreported specimen of *Pentanogmius* that is on exhibit at the Perot Museum of Nature and Science in Dallas, Texas, USA. It is cataloged as DMNH PAL 2011-01-01 and comes from the Britton Formation (Cenomanian-lower Turonian) of the Eagle Ford Shale in Dallas County (collected and donated by Joseph Fritsch and Kris Howe). It is significant because it represents the oldest fossil record of the genus in North America, and has important evolutionary implications for the diverse tselfatiiform fishes known from Coniacian-Campanian deposits of the North American Western Interior Seaway.

DMNH PAL 2011-01-01 is a nearly complete skeleton with the approximate total length of 175 cm. Previously reported autapomorphies of *Pentanogmius* seen in this specimen include: a small fifth infraorbital relative to the third and fourth ones; a broad tooth patch of the dentary forming a bony tooth plate with its rim protruding medially; and a low count (7?) of branchiostegal rays. The parasphenoid and dermobasihyal-dermobasibranchial complex are not observable in DMNH PAL 2011-01-01, making its comparison with *P. furcatus* and *P. pentagon* impossible. However, whereas DMNH PAL 2011-01-01 has a dorsoventrally shallower dentary compared to that of *P. crieleyi*, a broad cranial roof that covers the entire mesethmoid, the less dorsoventrally expanded third and fourth infraorbitals, the dorsoventrally elongate opercle, and the small vertebral count (ca. 70) differentiate DMNH PAL 2011-01-01 from *P. evolutus*. The fossil fish had a stout body (ca. 40 cm in body depth) similar to *P. evolutus*, but the most peculiar feature was its dorsal fin where, unlike *P. evolutus*, only the anterior one-third of the fin was elongate (ca. 75 cm long) to form a 'hook-shaped sail.' Given that endemism of species prevailed at different geographic regions throughout the tselfatiiform history, DMNH PAL 2011-01-01 representing the sole Cenomanian-Turonian example of *Pentanogmius* in North America with unique characteristics suggests that it likely represents a new species.

Technical Session III (Wednesday, October 14, 2015, 10:30 AM)

TANZANIA AND ZAMBIA YIELD AN UNPRECEDENTED FOSSIL RECORD OF BURNETIAMORPH THERAPSIDS

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Burnetiamorpha is a clade of therapsids characterized by skulls adorned by various bony crests, swellings, and bumps. For much of its history, the group was known only from *Burnetia mirabilis* and *Proburnetia viatkensis*, from the late Permian of South Africa and Russia, respectively. However, since 2003 at least seven new species have been described. Recent discoveries have extended the temporal range of the clade back into the middle Permian, by virtue of *Bullacephalus* and *Pachydectes* from the *Tapinocephalus* Assemblage Zone, and expanded the geographic coverage of the clade with a find in Malawi. However, burnetiamorphs remain rare fossils, with nearly all of the named genera represented by single specimens, usually skulls.

Since 2007, our team has conducted fieldwork in the Ruhuhu Basin of Tanzania as well as the Luangwa and Mid-Zambezi basins of Zambia. We discovered two partial skulls of a burnetiamorph, possibly closely related to *Burnetia*, from the basal conglomerate of the upper Permian Usili Formation in Tanzania. More importantly, we collected at least 13 partial burnetiamorph skulls from the Madumabisa Mudstone Formation in the Mid-Zambezi Basin. The specimens are mostly isolated, pachyostosed skullcaps spanning a range of sizes, but one is much more complete and preserves a distinct boss above the postorbital bar that indicates a close relationship with the derived subclade including *Burnetia* and *Bullacephalus*. Another specimen includes the first appendicular elements that can be attributed to a burnetiamorph. A nearly complete skull from the upper Madumabisa Mudstone Formation in the Luangwa Basin compares closely with *Lophorhinus* from South Africa. However, the specimen is autapomorphic in its reduced palatal dentition, suggesting that it belongs to a previously undescribed species.

Our collection from the Mid-Zambezi Basin contradicts the longstanding assertion that burnetiamorphs are rare components of the assemblages in which they occur. Furthermore, most of the Mid-Zambezi burnetiamorphs are likely middle Permian in age, which greatly increases the known diversity of the clade from this interval and may help resolve the stratigraphically inconsistent results seen in previous cladistic analyses of burnetiamorph relationships. These results highlight the potential for fieldwork in underexplored areas to yield noteworthy results.

Grant Information
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Technical Session XI (Friday, October 16, 2015, 8:45 AM)

AN EXCEPTIONALLY WELL PRESERVED PRIMATE PETROSAL FROM THE EARLY EOCENE OF INDIA

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The Early Eocene (~54.5 Ma) Cambay Shale Formation at Vastan lignite mine (Gujarat, India) has yielded remains of both adapoid and omomyoid primates. The collection of primates includes not only jaws and teeth, but numerous exquisitely preserved postcranial elements. We report on the first cranial specimen for a primate from these deposits: an isolated left petrosal that preserves a partial stapes in anatomical position. The petrosal is identified as a primate based on the remnants of a petrosal bulla, and the presence of an ossified tube for the stapedial artery. The specimen documents a posterolateral entry of the internal carotid artery to the middle ear and a lateral course for the promontorial artery across the promontorium, characters most consistent with an attribution to Adapoidea. Of the adapoids published from the Vastan mine, body mass estimates based on the radii of the semicircular canals, calculated from high resolution microCT data, are most in line with previously calculated estimates for *Marcgodinotius indicus*, so the specimen is provisionally attributed to that species. Preserved anatomy is largely consistent with that described for *Cantius*. In particular, although the stapedial artery passed through a bony tube, the promontorial artery ran in an open groove from its origin off the internal carotid artery. This contrasts with the condition in omomyoids and most other adapoids, in which the promontorial artery was carried in a bony tube. The identification of an open groove for this artery in *Cantius* has been somewhat controversial, based on the state of preservation of published specimens. The petrosal from Vastan is extremely well preserved, demonstrating a clear opening in the internal carotid artery bony tube for the exit of the promontorial artery, and a well-demarcated groove on the promontorium for the latter artery that was clearly not enclosed. The absence of a bony tube for the promontorial artery in the oldest known adapoids suggests that the tube arose independently, in parallel, in Omomyoidea and Adapoidea. The promontorial artery is always enclosed in modern haplorhines, but when this artery is retained in living strepsirrhines it is often not fully enclosed by bone. Therefore, the primitive adapoid condition is more similar to that observed in Strepsirrhini. The antiquity and fine quality of preservation of this specimen make it relevant to reconstructing auditory morphology near the base of the primate tree.

Grant Information
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Technical Session XII (Friday, October 16, 2015, 10:30 AM)

AN OLD WORLD LIZARD IN THE LATE CRETACEOUS OF SOUTH AMERICA REVISES EARLY LIZARD EVOLUTION IN GONDWANA

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A new lizard from the Cretaceous of Brazil overturns long held hypotheses of lizard evolution in Gondwana. Iguanians are the most diverse group of extant lizards (>1700 species) with acrodontan iguanians dominating in the Old World, and non-acrodontans in the New World, Madagascar, and a few Pacific Islands. How this exact distribution came to be, the origin of both groups, and how non-acrodontans became dominant in the Americas have been the subject of debate in the past, especially due to a poor fossil record worldwide during the time of origin of squamates (Early-Mid Mesozoic), and during the entire Mesozoic of Gondwana. A new lizard species from a new locality from the Late Cretaceous of Brazil represents the first acrodontan ever known from this

continent and challenges our current notion of squamate evolution in Gondwana. In a phylogenetic analysis inclusive of all major groups of squamates, the new taxon is found as a basal acrodontan. It still bears primitive iguanian features, but also an unambiguous combination acrodontan characters. This finding indicates acrodontans migrated throughout Gondwana much earlier than previously thought, and that some of the first South American lizards were more similar to their counterparts in Africa and Asia than to the modern fauna of South America. The new taxon, along with phylogenetic data and previous fossil evidence, indicates acrodontans first dispersed throughout Pangaea before its final break up, and eventual Cenozoic dispersals would be secondary events in their biogeographic history. At some point, non-acrodontan iguanians successfully replaced acrodontans and became dominant in all of the Americas, contrary to what happened on most of the Old World continents. This discovery also expands the diversity of Cretaceous lizards groups in South America, which, with recent finds, suggests sphaenodontians were not the dominant lepidosaurs on that continent as previously hypothesized.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

SUPERSONIC SAUROPODS: THE PHYSICAL MODEL

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Previous work used computer modeling to show that the 'whiplash' tails of the diplodocid sauropods (and several other sauropod groups) could have functioned like a bull whip to make a loud cracking noise by having the tip exceed the speed of sound. We report on the construction of a 1/4 scale physical model of the tail of *Apatosaurus* (modeled after specimen CM 3018) to confirm the plausibility of the computer based finding with a physical experiment. The model has 82 vertebrae constructed using CNC machine tools and 3D printing. Each vertebra has accurate size and joint angle constraints based on the osteology of CM 3018. Neoprene bumpers play the role of intervertebral disks. Each vertebra is weighted to model the mass of the flesh during life. The total model mass is 20 kg, corresponding to a mass during life of 1306 kg. The model is mounted on a tripod with a bearing and equipped with a handle so that a person can supply the motive power to emulate the hindquarters of an *Apatosaurus*. The model produces a supersonic cracking sound; a live demonstration of the tail model on stage will make this evident. This experiment confirms the plausibility of supersonic tail cracking consistent with prior work. The model could also serve as the basis for a dynamic museum exhibit.

Technical Session XVIII (Saturday, October 17, 2015, 3:00 PM)

PATTERNS OF MIOCENE MAMMALIAN DIVERSITY ACROSS SPATIAL SCALES IN THE GREAT BASIN OF WESTERN NORTH AMERICA

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Peak mammalian diversity in the Neogene fossil record of North America occurred during the Miocene Climatic Optimum (MCO; 17–14 Ma) in the intermontane west. Interactions between the development of topographic complexity during tectonic extension and climate warming stimulated diversification during this time period. However, it remains difficult to assess the relative contributions of geographic-range shifts and changes in speciation and extinction rates to species richness in the region. We documented diversity patterns at three different spatial scales in order to evaluate biogeographic processes promoting high diversity in response to landscape and climate change. We compiled species-occurrence records from the NeoMap database of North American fossil mammals, and compared total mammal diversity, as well as rodent diversity, for 1-myr intervals from 20 to 4 Ma within the Great Basin as a whole, within six subregions of the Great Basin, and within formations of the Mojave subregion. Diversity increased during the MCO in the Great Basin and in the four western-most subregions, including the Mojave. The Mojave subregion has the longest and most continuous record of fossil mammals during the Miocene, with elevated species richness in the Barstow, Crowder, and Cajon Valley formations during the MCO. The proportion of rodents in the total mammalian fauna increased in the Great Basin and in the Mojave subregion from the MCO to present. For 1-myr time intervals with a minimum of 10 species per spatial unit of analysis, we calculated a modified Jaccard similarity index for comparing subregions and formations. A greater proportion of species was shared across Great Basin subregions and among formations within the Mojave during the MCO compared to the subsequent cooling interval, although similarity indices for fossil assemblages are much lower than for equivalently scaled comparisons of modern faunas. Increased similarity in mammalian faunas at various spatial scales during the MCO suggests that geographic-range shifts contributed to the peak in species richness. Additionally, we found higher species similarity between formations within the Mojave than between subregions and greater similarity between subregions that are geographically close. A nested pattern of species similarity implies that geographic barriers, environmental heterogeneity, and in situ speciation also contributed to elevated mammalian diversity during middle Miocene global warming and tectonic mountain building.

Technical Session II (Wednesday, October 14, 2015, 11:00 AM)

THE POSITIVE EFFECTS OF COMBINING NEONTOLOGICAL AND PALEONTOLOGICAL DATA ON ESTIMATES OF BODY MASS EVOLUTION: AN EXAMPLE USING THE PAN-ALCIDAE (AVES, CHARADRIIFORMES)

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Hypotheses regarding the evolution of many clades are often generated in the absence of data from the fossil record and potential biases introduced by exclusion of paleontological data are frequently ignored. With regard to body size evolution, extinct taxa are frequently excluded because of the lack of body mass estimates-making identification of reliable clade-specific body mass estimators crucial to evaluating trends on paleontological timescales. Optimal osteological dimensions for estimating body mass in extant species of Pan-Alcidae (Aves, Charadriiformes) were identified and utilized to generate new estimates of body mass for extinct species in the clade. Combination of neontological and paleontological data produced results that conflict with hypotheses generated when data representing extant species are analyzed in isolation. The wing-propelled diving Pan-Alcidae is an ideal candidate for comparing estimates of body mass evolution based only on extant taxa with estimates generated including fossils because extinct species diversity (≥ 31 spp.) exceeds extant diversity, includes examples from every extant genus, and because phylogenetic hypotheses of pan-alcid relationships are not restricted to the 23 extant species. Phylogenetically contextualized estimation of body mass values for extinct pan-alcids facilitated evaluation of broad-scale trends in the evolution of pan-alcid body mass and generated new data bearing on the maximum body mass threshold for aerial flight in wing-propelled divers. The range of body mass in Pan-Alcidae was found to exceed that of all other clades of Charadriiformes (shorebirds and allies), and intra-clade body mass variability is proposed as a diagnostic characteristic of the clade. Finally, comparisons of pan-alcid body mass ranged with that of penguins and the extinct †Plotopteridae, elucidating potentially shared constraints among phylogenetically disparate yet ecologically similar clades of wing-propelled divers.

Grant Information
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Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

ADDITIONAL BRAINCASE MATERIAL FROM THE NORTH AMERICAN THERIZINOSAUR *NOTHRONYCHUS MCKINLEYI* (TURONIAN: MORENO HILL FORMATION, WEST-CENTRAL NEW MEXICO)

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The recovered posterior braincase of the North American therizinosaur *Nothronychus mckinleyi*, from the Cretaceous Moreno Hill Formation of west-central New Mexico, has recently been the focus of extensive morphological and functional research from a number of different perspectives. Unfortunately, the anterior braincase of this theropod remained unknown, so anatomical inferences had to be based upon the braincase of the Asian species *Erlikosaurus andrewsi*. An anterior braincase attributed to the holotype *Nothronychus mckinleyi* (MSM P-2117) was recognized in the Arizona Museum of Natural History (Mesa, AZ) collection.

The available material consists of the right anterior braincase and endocranial cavity. It is possible to CT-scan this specimen, mirror it, articulate it with the previously described posterior braincase, and then digitally recreate a nearly complete braincase and endocranium for *Nothronychus mckinleyi*, making this species the first known North American therizinosaur and only the second therizinosaur for which such material is known.

This specimen clarifies the observed and inferred braincase osteology of *Nothronychus*. It is extensively pneumatized. The sutures are almost completely fused and obliterated. The endocranium possesses well-developed pontine and cephalic flexures, similar to the primitive theropod condition and in contrast to the more linear morphology recently recovered for *Erlikosaurus*. The parietal crest is represented by a well-developed small knob with clear attachment points for the supraspinous ligament and M. transversospinalis capitis. The close association of the median cerebral vein with the trigeminal foramen and enclosed by the prootic is retained and hereby proposed as a therizinosaurian autapomorphy. There is a supraorbital evagination in this specimen that is currently interpreted as accommodating a well-developed nasal gland in the frontal. This development has been observed in some other archosaurs, especially marine birds, where it is associated with salt excretion and is consistent with a beach or other evaporitic paleoenvironmental interpretation.

Symposium 2 (Friday, October 16, 2015, 2:30 PM)

UNRAVELING THE CONSEQUENCES OF THE TERMINAL PLEISTOCENE MEGAFAUNA EXTINCTION ON MAMMAL COMMUNITY ASSEMBLY

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Recent studies connecting the decline of large predators and consumers with the ‘unraveling’ of ecosystems often overlook that this natural experiment already occurred. As recently as 14 ka, tens of millions of large-bodied mammals were widespread across the American continents. Within 1,000 years of the arrival of humans, ~80% were extinct, including all species >600 kg. While the cause of the extinction remains contentious, what has been largely overlooked is the consequence of the loss of millions of large-bodied animals. Here, we examine the influence of the extinction on a local mammal community. Our study site is Hall’s Cave in the Great Plains of Texas, which has unparalleled fine-grained temporal resolution over the past 20 ka, allowing characterization of the community before and after the extinction. In step with continental patterns, this community experienced loss of 80% of large-bodied herbivores and 20% of the apex predators during the extinction. Using a series of tightly constrained temporal windows spanning the full glacial to the modern and comprehensive faunal lists, we reconstruct mammal associations and body size distributions over time. We find changes in alpha and beta diversity and the statistical moments associated with periods of climate change as well as with the extinction event. There is a fundamental change in the composition of herbivores, with grazers being replaced by browsers starting about 15ka; today, they dominate the herbivore niche. Moreover, the null model program PAIRS reveals interesting temporal patterns in the disassociation or co-occurrence of species through the terminal Pleistocene and Holocene. Extinct species formed more significant associations than modern ones, and formed more aggregated pairs than do modern

species. Moreover, segregated associations are > 3 times stronger than aggregated ones, suggesting that competitive interactions or environmental filtering are stronger influences on community structure than predator-prey or mutualistic interactions.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

GROWTH AND SIZE OF THE 200 KG MIOCENE SPIKETOOTH SALMON: EARLY EVOLUTION OF THE PACIFIC SALMON MIGRATORY LIFE HISTORY

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The giant salmon, *Oncorhynchus rastrosus,* was described by Cavender and Miller as *Smilodonichthys rastrosus* from Clarendonian to Blancan shallow marine and large fluvial deposits in California and Oregon. It has been estimated to grow to about 8 ft (2.4 m) long and weigh up to 800 lbs (363 kg). Age and growth estimates and isotopic studies suggest 4 years of rapid growth at sea, followed by up to several hundred km of upriver migrations to spawn and die. Assuming a body shape appropriate for migration up the Sacramento and Columbia rivers, we estimate that the maximum total length was up to 2.4 m (8 ft), the girth would have been 157 cm (62 in), and the maximum weight would have been about 200 kg (440 lb). The estimate is based on an allometric equation for Yukon River King Salmon. The rapid growth rate of *O. rastrosus*, its extraordinary number of gill rakers, and its presence in the Monterey Formation and equivalents argue that this taxon was adapted for growth within a coastal zone of vigorous upwelling and high primary productivity. The presence of a miniature landlocked form of Spiketooth Salmon in the Hemphillian Chalk Hills lake beds of SW Idaho indicates unsuspected evolutionary diversification in the 6 Ma history of the clade. Additional sympatric Miocene salmon in Idaho demonstrate evolution of relatives of diverse extant salmon and their early adaptation to life in lacustrine habitats.

Technical Session VIII (Thursday, October 15, 2015, 2:30 PM)

BERGMANN'S RESPONSE AND DIETARY VARIABILITY IN NORTH AMERICAN BLACK BEARS (*URSUS AMERICANUS*)

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Today, modern black bears have been interpreted to show a negative Bergmann's response (body size decreases with increasing latitude) based upon craniodental measurements of populations along the eastern coast of the United States. Although black bear teeth are often not the best indicators of body size, they are commonly the most abundant element in fossil assemblages. If black bear tooth size is correlated with latitude (temperature), then it may be possible to use fossil black bears to directly reconstruct aspects of paleoclimate, such as paleotemperature. On the other hand, tooth size may be indicative of other environmental parameters, such as diet and/or vegetation quality. If this is the case, black bear tooth size may be useful for paleoecological reconstructions even if they are unreliable paleotemperature indicators.

To test the hypothesis of a negative Bergmann's response, we examined black bear dentitions from 61 extant individuals along a latitudinal gradient of the eastern United States and Canada. Based upon the length and breadth of the lower first and upper second molars for these specimens, there is no discernable trend between latitude and molar size. Thus, one must be cautious when drawing conclusions of paleoclimate based on solely black bear tooth size. As a direct comparison of diet and latitude, we then analyzed the dental microwear textures and isotopic signatures (^{13}C, ^{18}O) of modern black bears from Alaska, California, and Florida. Our results demonstrate a significant positive relationship between the complexity (Asfc) of dental microwear textures and latitude, indicating that Alaskan bears consumed more brittle objects than all southern bears and suggesting that they may have engaged in more bone processing than either the Florida or California bears. Geochemical data suggest that all modern bears in Florida are heavily reliant on forest ecosystems for food resources, but northern populations are more restricted to forests as compared to southern populations. Collectively, these data indicate dietary differences between modern black bears occurring at disparate latitudes. As black bears today demonstrate a broad range in dietary variability, size, and habitat preferences, further work is needed to assess the ubiquity of these results in both extant and extinct populations of ursids and other mammalian taxa.

Grant Information
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Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

MAMMOTH EXPEDITIONS: AN INNOVATIVE RESEARCH AND COLLABORATION PROGRAM FOR 21ST CENTURY STUDENTS

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Fossil remains of mammoths and mastodons are often unintentionally discovered on private property when land is disturbed due to construction or natural erosional processes. Many of these discoveries would be lost to science without the actions of citizen scientists, the property owners, construction workers, and their families who bring these fossils to the attention of research scientists. 'A Mammoth Expedition: Ice Age Extinctions Revealed,' celebrates these discoveries and encourages the participation of citizen scientists in the research process. A Mammoth Expedition is a dynamic 21st century education program developed in collaboration between the Milwaukee Public Museum and the Illinois State Museum. In this program, participating classes in grades five through twelve are each assigned a mammoth or mastodon that was discovered near their school. The task of the students is to investigate the paleobiology, paleoecology, and depositional environment of their fossil. Students learn about their fossil through a variety of activities, moderated through a series of interactive videoconference sessions. These activities include interviewing members of the community, reading scientific literature, measuring virtual mastodon and mammoth bones, and learning how to use invertebrates and pollen as paleoenvironmental indicators. During the videoconferences, students interact with educators, paleontologists, geologists, botanists, and each other to learn about mammoths and mastodons and share information on their fossil. The final videoconference session includes an oral report from each class on their mammoth or mastodon and a question and answer period between students and scientists. The project culminates when students submit a data card detailing what they learned about their fossil to MTUSKS (Mammoths/Mastodons, The United States Known Sites), an online database that archives information on mammoth and mastodon sites in North America; this site is intended to facilitate research, education, and discussion about mammoths and mastodons in the Midwest and beyond. The ultimate goals of A Mammoth Expedition are to connect each student to the geologic history of his or her hometown, and to show him or her that citizen scientists can have an active role in the process of scientific research.

Preparators' Session (Thursday, October 15, 2015, 8:00 AM)

OBSERVATIONS ON PROSPECTING FOR FOSSILS IN EXPANDING CLAYS

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Over the last 85 years, fossil prospecting of vertebrate material within Petrified Forest National Park (PEFO) has been dominated by surface collection or extraction of isolated specimens. There have been relatively few examples of bone bed localities with high concentrations of material that create locally extensive quarries. New evidence suggests this may have more to do with the characteristics of our matrix and the weathering profile rather than lack of resources or effort.

Many paleontologists are used to finding specimens by locating fragments of fossils and prospecting uphill to where the last remnants are found. The next logical step is then to start above the last fragment and excavate down to that level on the slope. This has led PEFO field crews in the past to find relatively few fossils in situ and wonder about the root cause of high surficial concentrations of bone. At PEFO it was recently discovered that expanding clays of the Upper Triassic Chinle Formation, which form 'popcorn' textured low hills, require a different technique of excavation. Counterintuitively it is necessary to dig 15–30 cm below and inward from bone found floating on the surface in order to locate in situ specimens. It was also found that the level of these 'sunken' quarries sometimes coincides with a transition zone between two distinct lithologies that appear on the surface of the hill to be below the fragments of fossils. In one case, the predominance of fossil remains is found directly on such a contact, which might reflect transportation and burial processes of the original fluvial depositional system. Further, bones found at these transition zones can be altered diagenetically owing to the differences in the physical properties of the two lithologies.

Six quarries have been found since 2013 using this technique and some are monodominant bone beds, possibly representing mass mortality events. Bone beds offer different preservational and associational opportunities than surface collection or general excavation and have produced taxa new to the park in only the last few years. This in turn allows researchers to gain a more complete knowledge of the biota in the region during the Late Triassic. Using these new insights may lead to greater quantities of quarry localities not only at PEFO but anywhere with expanding clays.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

FIVE WELL-SUPPORTED FOSSIL CALIBRATIONS WITHIN THE 'WATERBIRD' ASSEMBLAGE (TETRAPODA, AVES)

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The 'waterbird' assemblage (e.g., storks, herons, pelicans, loons, and allies) is a group of aquatic and semi-aquatic birds that are characterized by extremely diverse morphologies, ecologies, and life histories. The group also includes fossil representatives that constitute some of the oldest records of Neoaves, and are critical to calibrating the temporal diversification of modern birds. We provide a set of five well-supported fossil calibrations from the waterbird clade that will serve to provide robust temporal calibrations for the origins of: stem Phaethontes (tropicbirds), which are calibrated by *Lithoptila abdounensis* (OCP.DEK/GE 1087) with a minimum age of 56.0 Ma; stem Threskiornithidae (ibises and spoonbills), which are calibrated by *Rhynchaeites* sp. (MGUH 20288) with a minimum age of 53.9 Ma; stem Pelecanidae (pelicans), which are calibrated by *Pelecanus* sp. (NT-LBR-039) with a minimum age of 28.1 Ma; stem Fregatidae (frigatebirds), which are calibrated by *Limnofregata azygosternon* (USNM 22753) with a minimum age of 51.81 Ma; and stem Phalacrocoracidae (cormorants), which are calibrated by *Oligocorax stoeffelensis* (PW 2005/5022-LS) with a minimum age of 24.52 Ma. We apply stringent criteria to justify both the phylogenetic placement and geochronological context of these specimens, and discuss potentially older records to help focus future research and collection. We also discuss how these calibration data can be stored, accessed, and updated on the Fossil Calibration Database, a newly released open-access resource that provides vetted fossil calibrations to the scientific community. The waterbird fossils described here affirm previous studies in recognizing that most major cladogenetic splits within the group occurred by the Eocene, supporting interpretations of both rapid lineage diversification of waterbirds in the early Paleogene, and also the rapid establishment of body plans and possibly ecologically relevant morphologies during this time period.

Grant Information
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Technical Session IX (Thursday, October 15, 2015, 1:45 PM)

SPECIES DELIMITATION IN THE PROBLEMATIC CRETACEOUS–PALEOGENE GENUS *MESODMA* (MULTITUBERCULATA, NEOPLAGIAULACIDAE) AND THE IMPORTANCE OF DIFFERENTIAL TAXONOMIC DIAGNOSES

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The fossil record of Late Cretaceous and earliest Paleogene (K–Pg) mammals is largely composed of isolated teeth and tooth-bearing elements. Consequently, it is common for mammalian species to be diagnosed based on mandibular, maxillary, or dental characters. For multituberculates, a highly successful mammalian group of this time interval, diagnoses often rely heavily on the bladelike lower fourth premolar (p4); other tooth positions sometimes cannot be identified to taxon unless they are associated with this diagnostic tooth. This is problematic if diagnoses use poorly defined characters. Such a situation is found in *Mesodma* (Multituberculata, Neoplagiaulacidae), a genus present in North America from the Late Cretaceous to the Late Paleocene. Four species of *Mesodma* co-occur in K–Pg vertebrate assemblages in northeastern Montana, where they often compose more than 50% of mammalian specimens from a given locality. Various methods have been employed to distinguish these four species. Meristic characters, such as number of serrations on the p4, exhibit too much intraspecific variation to sufficiently differentiate among species, and size ranges reported for both molars and premolars of *Mesodma* species overlap considerably. The p4 profile shape (high and domed vs. low and flat, for example) has also been used to diagnose species of *Mesodma*, but it has not been adequately characterized for each species.

To test the validity of diagnoses based on p4 shape and size, we conducted a geometric morphometric analysis of 86 p4s of the four K–Pg species of *Mesodma* from Montana. We used landmarks and semilandmarks to represent the shape of the p4 profile and conducted principal components analysis on shape and size data. We also conducted canonical variate analysis on our morphometric data. Our results show that: (1) size is the main source of interspecies variation; (2) the smallest species, *M. hensleighi*, may be distinguished from the others based on size alone; and (3) neither shape, size, nor a combination of the two provides clear differentiation among all four species of *Mesodma*. The lack of clear morphological discrimination among these species underlines the importance of careful selection and precise description of characters used in diagnoses. This work also suggests that when diagnosing new taxa, especially using isolated teeth, consideration of the potential range of morphology present within a single species is essential; in this case, taxonomic decisions may alter our understanding of survivorship and recovery surrounding a mass extinction event.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

NEW EARLY EOCENE MAMMAL ASSEMBLAGE FROM TADKESHWAR LIGNITE MINE, WESTERN INDIA

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The Ypresian Cambay Formation at Vastan and Mangrol mines in Gujarat, western India, has yielded a rich vertebrate fauna with a large proportion of small to middle-sized mammal taxa of European affinities. Here we report a new, approximately contemporary mammal assemblage from the nearby mine of Tadkeshwar. Two fossil layers have been discovered. The older one is a grey clayey sand situated a few meters above the lower major lignite seam and represents a fluvial deposit. The younger layer is a lenticular dark clayey silt, lignitic and rich in organic remains situated just below the upper major lignite seam. This younger layer is sedimentologically similar to the famous fossiliferous lenses known from Vastan. These two fossil layers have yielded a mammal fauna similar to that of Vastan with the co-occurrence of the perissodactyl-like cambaytheriid *Cambaytherium thewissi*, the adapoid primates *Marcgodinotius indicus* and *Asiadapis cambayensis*, and the hyaenodontid *Indohyaenodon raoi*. The presence of these species in both mines and at different levels suggests that the deposits between the two major lignite seams represent a single mammal age. Apart from the aforementioned classic species there are at least two new species. A new smaller but abundant cambaytheriid is represented by upper and lower jaws, many isolated teeth and postcranial bones. A new esthonychid tillodont is described based on a dentary with m3, an isolated m2, two upper molars and two lower incisors. This new fauna from Tadkeshwar also contains the first large early Eocene vertebrates from India including an unidentified perissodactyl-like ungulate, a mesosuchian dyrosaurid-like crocodiliform and a giant madtsoiid snake. This latter group is particularly diversified in Tadkeshwar. Among the Tadkeshwar vertebrates, several taxa are of Gondwanan affinities attesting that the early Eocene was a crucial period in India during which Laurasian taxa of European affinities coexisted with relict taxa from Gondwana before the India-Asia collision.

Grant Information

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Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

CERATOPSIAN DINOSAURS COULD TURN MORE QUICKLY AND IGUANODONTIANS COMPARABLY TO CONTEMPORANEOUS LARGE THEROPODS

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Large neoceratopsid dinosaurs had enormous heads but reduced tails compared with those of other dinosaurs of similar mass, on aggregate resulting in lower calculated mass moments of inertia (MMI) and potentially enabling quicker turns.

We estimated mass, center of mass, and mass moments of inertia in yaw for large adult herbivorous and carnivorous dinosaurs, primarily from the Campanian and Maastrichtian of Laurentia and from the Morrison Formation. Methods include cross-checked 3D mathematical slicing and computer-aided design models, augmented with skeletal measurements and refined with correction factors for varying body cross sections.

The neoceratopsians *Chasmosaurus belli*, *Centrosaurus apertus*, and *Triceratops horridus* had 50-60% of the mass moment of inertia (MMI) of contemporaneous tyrannosaurids when corrected for axial body mass. In contrast, the hadrosaurs *Gryposaurus notabilis*, *Lambeosaurus lambei*, *Edmontosaurus annectens*, and *Shantungosaurus giganteus* had similar or greater MMI than in tyrannosaurids. Adult Morrison Formation sauropods had vastly greater MMI than Morrison large theropods. Surprisingly, MMI was lower in sauropods than in hadrosaurs when equalized for body mass.

Low mass moment of inertia in neoceratopsids suggests the ability to turn quickly to face threats, either from predators or in competitive interactions. With much greater MMI, hadrosaurids probably relied on other defences. These results are consistent with healed bite marks on these herbivores, a correlation testable with greater sample size.

Technical Session XVI (Saturday, October 17, 2015, 8:15 AM)

NEW INFORMATION ON THE BRAINCASE OF *EUPARKERIA CAPENSIS*

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Euparkeria capensis, from the early Middle Triassic South Africa, has, since its discovery, been considered a key taxon for understanding the early evolution of archosaurs. The braincase of *Euparkeria* has been described in detail from a single specimen, but many uncertainties remained. For the first time, all available specimens of the braincase of *Euparkeria* were reexamined and subjected to µCT scanning, allowing additional information on its morphology to be collected. Contrary to some previous work, the parabasisphenoid does not form the posterior border of the fenestra ovalis, but does bear a dorsal projection forming the ventral half of the anterior rim of the fenestra laterally. We confirm that the exoccipitals do not meet at the midline, being restricted to the pillar between metotic foramen and foramen magnum. No pneumatisation of the bone is seen in *Euparkeria*, but shallow recesses such as the ventral basisphenoid-basioccipital fossa and the lateral depression of the parabasisphenoid may have been pneumatic. While the former is present in a number of non-archosauriform reptiles, we find that the latter probably corresponds to the anterior tympanic recess present in crown archosaurs, contrary to previous work. The laterosphenoid of *Euparkeria* largely conforms to that of crocodilians, but shows a greater degree of ossification of the pila metoptica, being in this respect more similar to those of avemetatarsalians. The pila metoptica also ossifies as the prominent anterior inferior process of the prootic, as in other archosauriforms but contrasting with basal eureptilian taxa, confirming a general pattern of increasing ossification of the braincase in the archosauromorph radiation. Increased ossification of the braincase would have improved hearing by reducing energy loss as it promotes acoustic isolation. The much enlarged metotic foramen of *Euparkeria* and its morphological regionalization indicate an increase in its pressure-relief mechanism, although a specialized pressure-relief window is absent. The cochlea of *Euparkeria* is also relatively elongate, indicating an expansion of the hearing range. The trend towards acoustic isolation through braincase ossification and an increase in the efficiency of the metotic foramen indicate that mechanical tuning, the plesiomorphic type of tonotopic discrimination of amniotes still found in mammals, remained an important mechanism in *Euparkeria*.

Technical Session VIII (Thursday, October 15, 2015, 4:00 PM)

EVOLUTION OF THE EUROPEAN MESONYCHID MAMMALS, AND THEIR BEARINGS ON THE EUROPEAN PALEOECOSYSTEMS AND BIOSTRATIGRAPHY

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European mesonychids are represented by few specimens found only in late Paleocene and early Eocene localities. Recent field works in Palette and La Borie (Ypresian of France) resulted in the discovery of new mesonychid specimens. Additionally, our review of the mesonychids housed by European scientific institutions allowed establishing the occurrence of *Dissacus* in Berru (Thanetian) and Sézanne-Broyes (Ypresian). Only the genera *Pachyaena* and *Dissacus* are recognized in Europe. Furthermore, two new *Dissacus* species can be defined from the Ypresian localities of Palette, Sézanne-Broyes and La Borie. We also identified from three localities several postcranial elements that could be referred to *Dissacus*. The preliminary study of this postcranial material suggests a cursorial locomotion. As a result of our study, we propose a scheme of evolution comprising three phases for these particular mammals in Europe. (1) The mesonychid *Dissacus* dispersed into Europe during Thanetian, probably from North America; it survived the PETM event and even possibly experienced a dwarfism during this global warming. (2) The very large mesonychid *Pachyaena* migrated into Europe shortly after the Paleocene–Eocene boundary, but it seems that it did not coexist with *Dissacus*: it was restricted to Northern Europe, while *Dissacus* was possibly present at that time only in southern areas. (3) However, *Pachyaena* rapidly disappeared from the

European environments, while *Dissacus* dispersed subsequently into Northern Europe. These data support the existence of a faunal turnover in Northern Europe shortly after the PETM event: it has been notably proposed for explaining the disappearance from Europe of the carnivorous oxyaenids and hyaenodont sinopines, and their subsequent replacement by taxa from the southern areas. The persistence of *Dissacus* in Europe shows that size was not the main selective factor during this dramatic period. *Dissacus* has evolved endemically during Thanetian and Ypresian in Europe where it reached a very large size, especially in southern France and Spain. Due to its size, dental, and locomotor adaptations, *Dissacus* was probably the top mammal predator in Europe. It survived in Europe after its disappearance from North America, possibly due to its ecologic position and the lack of competitors.

Grant Information
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Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

INSIGHT INTO THE ORIGINS OF THE NEOGENE CROCODILIAN ASSEMBLAGES IN THE NORTHERN NEOTROPICS: EVIDENCE FROM THE EARLY MIOCENE CASTILLO FORMATION, VENEZUELA

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The isolation of South American during most of the Cenozoic resulted in the evolution of a number of distinctive endemic lineages of mammals, and also non-eusuchian crocodiles (e.g., Sebecosuchia). However, throughout the South American Cenozoic, distinct groups of non-marine vertebrate immigrants appeared in the fossil record, such as caviomorph rodents and platyrrhine monkeys during the Eocene. Others taxa, such as eusuchian crocodiles (Alligatoroidea, Gavialoidea), also became abundant in South America, revealing a complex biogeographic history which involved crossing marine barriers. The species richness of crocodilians found in the fossil record of South America was relatively low during the Paleogene, but reached maximum expression during the middle (e.g., Iquitos, Peru; La Venta, Colombia) and late (e.g., Acre, Brazil; Urumaco, Venezuela; Parana, Argentina) Miocene. However, early Miocene localities with crocodile remains are scarce, especially in the northern neotropics. Intensive paleontological fieldwork carried out in the early Miocene beds of the Castillo Formation, south of Baragua Sierra, northwestern Venezuela resulted in the recognition of new specimens of crocodiles. Though fragmentary, the material includes members of Gavialoidea, *Siquisiquesuchus venezuelensis* (based on several skulls and mandible fragments), Alligatoroidea, *Purussaurus* sp. (based on a single isolated tooth), Caimaninae sp. 1 (based on a massive anterior portion of a right mandible), a small Caimaninae sp. 2 (aff. *Caiman*, based on a small partial skull table), another Caimaninae? sp. 3 (with crushing dentition based on isolated globular teeth), and a possible Crocodyloidea, Tomistominae indeterminate (based on an almost complete mandible with triangular anterior teeth). The latter four mentioned taxa are recognized for first time in the early Miocene of Venezuela, and represent new species, increasing the known diversity of early Neogene crocodilian assemblages. Finally, the presence of Tomistominae in the early Miocene of South America represents a first occurrence, and implies that the group probably arrived during at least the late Oligocene.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

MULTIVARIATE MESOWEAR ANALYSIS OF GIRAFFID FEEDING ECOLOGIES IN THE LATE MIOCENE PIKERMIAN BIOME FAUNAS OF GREECE AND CHINA

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The late Miocene Pikermian Biome supported a large number of sympatric large-bodied giraffe species across Eurasia, suggesting a range of dietary ecologies that exceeds in variety the exclusively browsing diets of modern giraffids (*Giraffa* and *Okapia*). To test this hypothesis, we compared mesowear (MW) data from 190 fossil giraffe specimens representing 20 species from four key regions of the late Miocene (Pikermi, Samos, Gansu and Shanxi) to eight extant species of browsing, grazing, and mixed feeding ruminants. Four MW variables were scored on the M2: (1) traditional MW, which evaluates the sharpness and relief of the labial band of paracone enamel; (2) and (3) the flatness of the occlusal edge of the lingual band of paracone enamel mesial and distal to the cusp apex; and (4) the elevation and distinctness of the paracone apex on the inner band of enamel. Pearson Correlation Coefficients found strong correlations between the four MW variables in both fossil and modern species. Mann-Whitney U tests found significant differences in all four MW variables between browsing, mixed feeding, and grazing modern ruminants. These results suggest that all four MW variables are similarly valuable predictors of diet in ruminant dentitions. Discriminant function analysis (DFA) of the modern ruminants using all four variables assigned individual specimens to one of the three dietary groups with greater accuracy (75.9%) than any single MW variable. For the fossil giraffids, all four MW variables had significantly different distributions between Chinese and Greek giraffid faunas (Mann Whitney-U Tests). At Pikermi, the overall MW data more closely resemble browsing ruminants. At Samos, the species span a greater range of the browser-grazer continuum, from browsing to mixed feeding. In both Chinese regions, Gansu and Shanxi, the giraffid species have MW values that all more exclusively resemble mixed feeders. Individual giraffid species that spanned Eurasia were found to have different MW scores in Greece and China. For example, DFA of MW data assigned most *Palaeotragus rouenii* specimens from Shanxi to mixed feeding diets, but mostly assigned browsing diets to specimens of the same species from Greece. No giraffid species were predicted to be grazers; several *Samotherium, Schansitherium,* and *Honanotherium* individuals appear to have been grazing, however these species as a whole were mixed feeding or browsing. Our data supports the hypothesis that giraffids of the Pikermian biome explored a wider dietary range than the extant *Giraffa* and *Okapia*, which are committed browsers.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

A RE-EVALUATION OF SEVERAL CHARACTER STATES IN NON-COELUROSAURIAN TETANURAE (DINOSAURIA: THEROPODA) WITH IMPLICATIONS FOR PHYLOGENY OF BASAL TETANURANS

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A majority of recent phylogenetic analyses of Tetanurae (Dinosauria: Theropoda) place basal (= non-coelurosaurian) tetanurans into clades Megalosauroidea (= Spinosauroidea) and Allosauroidea forming successively closer outgroups to Coelurosauria. However, the positions of genera *Cryolophosaurus*, *Sinosaurus*, *Monolophosaurus* and *Acrocanthosaurus* and clade Megaraptora remain controversial and a few phylogenetic analyses question the monophyly of both Megalosauroidea and Allosauroidea. This presentation re-evaluates the phylogeny of non-coelurosaurian Tetanurae by re-examining highly distinct and size- and ecomorphology-independent states of several characters used in previous analyses.

Cryolophosaurus possesses a narrow lesser trochanter ending distal to femoral head, supporting its placement among non-tetanuran neotheropods (clade or grade Coelophysoidea) by previous analyses. Spinosauridae and Carcharodontosauridae (except Acrocanthosauridae) possess a wide lesser trochanter extending to the ventral margin of femoral head and lack a maxillary fenestra, suggesting that they are the most basal tetanurans. *Sinosaurus*, Piatnitzkysauridae, *Neovenator*, Megaraptora, Metriacanthosauridae (= Sinraptoridae), Megalosauridae, *Monolophosaurus*, Acrocanthosauridae (*Acrocanthosaurus*, *Eocarcharia*) and Allosauridae (*Allosaurus*, *Saurophaganax*) share with basal Coelurosauria (*Zuolong*, *Tanycolagreus*, *Coelurus*, Tyrannosauroidea, *Ornitholestes*, Compsognathidae) a wide lesser trochanter extending to the middle of femoral head (lesser trochanter extends to the dorsal margin of femoral head in Megaraptora and Tyrannosauridae) and (except *Sinosaurus*) – a maxillary fenestra. Megalosauridae, *Monolophosaurus*, Acrocanthosauridae and Allosauridae share with Coelurosauria a posteroventrally extended surangular contact of dentary (resulting in a reduced mandibular fenestra), forming a clade Avetheropoda. *Monolophosaurus*, Acrocanthosauridae, and Allosauridae also share with basal Coelurosauria (*Zuolong*, *Tanycolagreus*, Tyrannosauroidea, *Ornitholestes*) a robust dorsal ramus of quadratojugal (slender in more basal tetanurans), forming a clade Euavetheropoda. Allosauridae share with basal Coelurosauria (*Zuolong*, Tyrannosauroidea, Compsognathidae) a medially open maxillary antrum (evolved independently in Metriacanthosauridae and *Eocarcharia*). Possible causes of homoplasies in basal Tetanurae implied by this tentative revision of tetanuran phylogeny are speculated on.

Technical Session XVI (Saturday, October 17, 2015, 11:15 AM)

THE EVOLUTION OF THE GAVIALOIDEA: A SOUTH AMERICAN PERSPECTIVE

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The Gavialoidea is a stem-based clade defined as all Crocodylia closer related to extant *Gavialis* than to *Alligator* or to *Crocodylus*. No specific phylogenetic study addressing this group has been performed to date, and most cladistic analyses that included gavialoids focused on the Crocodylia as a whole and therefore only incorporated a limited number of representatives of this group. Thus, the evolutionary history of the Gavialoidea and their ingroup relationships and character evolution is poorly understood. Here we present a comprehensive analysis of the Gavialoidea including all known South American taxa, the most complete Indian species and all other gharials from which detailed descriptions or images could be accessed. Only characters that differed between the ingroup and outgroup were selected, elucidating novelties in need of explanation. A total of 29 species were analyzed, using four brevirostrine species as outgroups. From the 85 characters employed in previous analyses, 72 were rephrased and 13 were new. A traditional search was performed in TNT and eight most parsimonious trees were found with 206 steps. The strict consensus cladogram shows that the Gavialoidea is formed by two less inclusive groups. The first is composed of Laurasian and African species, with records from Upper Cretaceous to upper Miocene. This group contains predominantly species related to coastal environments. The second group is composed of the Southwest Asian, Central and South American species, with records ranging from upper Oligocene to the present. This group contains the two most speciose genera: the monophyletic *Gryposuchus* with six species, two new from the upper Miocene Solimões Formation of Brazil, and the extant species of the genus *Gavialis,* and nested within them the genus *Aktiogavialis*. However, the position of the latter is dubious due to its fragmentary nature. Gavialoid biogeography is revealed to be more complex than interpreted previously. The more basal forms conquered the coastal environments of the north of Laurasia and Africa, and during Miocene, fluvial forms started to evolve. The second group occupied the fluvial environments of Gondwana and more recently the south-west portion of Asia. However, mainly for the second group, the ghost lineages are directly related to the "Gharial gap" that must be filled for a better understanding of gharial evolution.

Grant Information
FAPERJ E-26/101.523/2014 to R. Souza, CNPQ 304780/2013-8 to A. Kellner

Technical Session XV (Saturday, October 17, 2015, 10:30 AM)

THE ECOLOGICAL CONSEQUENCES OF LATE-QUATERNARY MEGAFAUNAL EXTIRPATIONS IN SOUTHERN BRAZIL

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The Pleistocene-Holocene transition was marked by the extinction of nearly half of all megafauna globally. The loss of large mammals ('defaunation') can influence vegetation dynamics, as has been documented in modern ecosystems with transitions from grasslands to open woodlands following the removal of megafauna such as elephants and wildebeest. Here we present evidence to suggest that the loss of late-Quaternary proboscideans and perhaps other megafauna could have precipitated the expansion of *Araucaria* forests in the terminal Pleistocene southern Brazil.

We compared chronologies of megafaunal extirpations in this area with marine and speleologic climate proxies and pollen records between 18–7 cal kyr BP using ^{14}C and U/Th-series dates from published literature. *Araucaria* forests are characterized by slow-growing coniferous evergreen *Araucaria angustifolia* and *Podocarpus* spp. These forests are associated with moist climates and are thought to have expanded to their current distribution in southern Brazil when climate became moister around 1 cal kyr BP in the late-Holocene. However, pollen records from this area suggest an earlier spread of *Araucaria* and Atlantic rain forests occurring along with synchronous declines of campos grasslands around 12 cal kyr BP during a time when speleologic and marine proxies indicate local drying and warming, respectively. This pattern is consistent with an ecological release of forest communities along gallery forest refugia following the youngest dates of megafauna in these areas, approximately 12.5 cal kyr BP. These megafauna include potential ecosystem engineers such as *Notiomastodon platensis* and *Eremotherium laurillardi*.

Poster Symposia (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

CT-IMAGING AND VIRTUAL ENDOCAST RECONSTRUCTION IN CARNIVORAMORPHA (MAMMALIA)

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The evolution of the large mammalian brain is one of the classical hallmarks of our class of vertebrates, and this organ has convergently expanded even further within many mammalian orders. Recent work focusing on the evolution of the carnivoran brain revealed that neocortex expansion began not at the base of Carnivoramorpha (the total group of taxa that are more closely related to Carnivora than to other mammalian crown clades or to extinct creodonts within Ferae), as previously hypothesized, but rather within a more restricted subclade-the Carnivoraformes. Viverravidae (the basalmost group within Carnivoramorpha) possess little neocortex expansion relative to carnivoramorphan outgroups, displaying smooth cerebral hemispheres, and no expansion of the cerebrum (posteriorly over the midbrain, anteriorly toward the olfactory bulbs, laterally to expand the forebrain, or dorsally). However, these previous studies on the brains of Viverravidae had been based on either partially damaged natural endocasts or solely on the digital endocast of one of the smallest known members of the clade, *Viverravus minutus,* complicating matters as it is known very small carnivorans have less cerebral sulci than their larger relatives; therefore, these observations could have been evolutionary reversals. Here we confirm the majority of these previous observations via high-resolution micro-computerized tomography (CT) scans that have yielded a digitally extracted endocast for the much larger viverravid *Didymictis protenus* (YPM PU 14917), from the Wasatch Formation of Wyoming, USA. This specimen is roughly equivalent in size to a modern coyote, and its endocast shows no evidence of cranial sulci or anterior, posterior, or lateral expansion of the cerebrum (although minor dorsal expansion is present). This confirms that the Viverravidae (across a range of body sizes) do not have the same degree of cranial expansion observed in Carnivoraformes, documenting that increased encephalization within Carnivoramorpha began after initial diversification of the clade.

In addition to these findings, we detail our methodology for reconstructing digital endocasts, starting with processing of the slices generated from the source CT scans through formatting the resulting products for 3D-printing (for research and education/outreach uses) on a wide variety of rapid prototyping machines. We highlight how manageable, and quick, working with CT data has become with the growing availability of high-resolution CT scans and increasingly affordable computing power.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

THERAPSIDS ARE FROM THE CARBONIFEROUS

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Several sphenacodontids are known from the Pennsylvanian. Hence, their sister-group relationship with Therapsida, forming the Sphenacodontoidea, [illegible]ires the same age for the origin of therapsids. In fact, they are missing in the fossil record before the Middle Permian, with the enigmatic *Tetraceratops* from the late Cisuralian of Texas considered to be the only exception. [illegible] specialized genus was previously interpreted as a stem [illegible], along with *Raranimus* plotting as a basal stage [illegible] However, any hypothesis [illegible] morphology late in the Cisuralian [illegible] for synapsids. The restudy of fragmentary [illegible] revealed a vertebral character combination unique for the [illegible] questionable, this supports an early origin of therapsid morphology. Con[illegible] the detailed revision of *Tetraceratops* could not reproduce its therapsid characters. In a phylogenetic analysis, *Tetraceratops* appeared constantly [illegible] sister to Sphenacodontoidea.

Raranimus shows some resemblanc[illegible] with the [illegible] double canines because of increased replacement [illegible] character as 'unknown' in *Raranimus*, [illegible] plots [illegible] the therap[illegible] most likely as a theriodontia[illegible]

A[illegible] restriction of "pelycosaurs" to the ever-w[illegible] is better understood as a biome shift across [illegible] the ghost lineage and sudden occurrence of therapsi[illegible] fossil record. With the rareness of "haptodontines" in between, the sphenac[illegible] evolution is not biased by the stratigraphic concept of Olson's gap, but a ma[illegible] of ecological tolerances.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

THE AMPHIBIANS AWAKEN: NEW TEMNOSPONDYLS FROM TANZANIA AND ZAMBIA ILLUSTRATE CHANGES IN AMPHIBIAN DIVERSITY BEFORE AND AFTER THE MOTHER OF MASS EXTINCTIONS

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Permian and Triassic temnospondyls from southern Pangea are mostly known from South Africa and Madagascar, where they are represented by various groups such as capitosaurs, dissorophoids, lydekkerinids, rhinesuchids, rhytidosteids and trematosaurs. Consequently, these temnospondyls are often the only ones considered in analyses of the end-Permian mass extinction and recovery. However, similarly-aged strata in other African countries, such as the Ruhuhu Basin of Tanzania and the Luangwa Basin in Zambia, yield numerous synapsids, archosaurs and parareptiles, but few temnospondyls: temnospondyls are represented only by the plagiosaur *Peltobatrachus pustulatus* from the Late Permian of Tanzania, the brachyopoid *Batrachosuchus concordi* and the capitosaurs *Cherninia megarhina* and *Stanocephalosaurus pronus* from the Middle Triassic (Anisian) of Zambia; the latter is also present in the Anisian of Tanzania.

Since 2007, we have conducted extensive fieldwork in the Permo-Triassic rocks of Tanzania and Zambia and discovered many new temnospondyls, synapsids, archosaurs and parareptiles. Our preliminary results show that the rather homogeneous Permian communities of Gondwana became fragmented by the end-Permian crisis. The temnospondyl material is under study but contributes to this emerging picture. New Tanzanian specimens from the Ruhuhu Basin include an occiput of a new rhinesuchid from the Late Permian, and a large isolated intercentrum of a probable giant paracyclotosaur from the Anisian, with an estimated body size of over 4 meters. Temnospondyls from the Paleozoic of Zambia have been found for the first time: these include a pectoral girdle and two complete skulls of a probable new rhinesuchid from the Middle-Late Permian of the Mid-Zambezi Basin. Other Zambian specimens, coming from the Anisian of the Luangwa Basin, consist of numerous capitosaurian elements including large mandibles that have been used for preliminary analyses of the taphonomy of the fossiliferous deposits, and an enigmatic small mandible portion with a denticle patch. These new discoveries increase our understanding of Permo-Triassic amphibian communities in southern Pangea, and offer new insight into how the freshwater component of terrestrial ecosystems was affected by the end-Permian extinction.

Grant Information

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Technical Session II (Wednesday, October 14, 2015, 10:30 AM)

STEM OXYURINE STIFF-TAILED DUCKS (ANSERIFORMES: ANATIDAE) FROM THE EARLY TO MIDDLE MIOCENE OF NORTH AMERICA, AND THEIR IMPLICATIONS FOR THE TEMPORAL ORIGIN, EVOLUTION, AND INTERCONTINENTAL DISPERSAL OF THE CLADE

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Stiff-tailed ducks (Oxyurinae) are a clade of diving ducks that includes several extant species present on all continents except Antarctica. The stem lineage of Oxyurinae has been traced into the late Oligocene of Australia, but the crown clade of *Nomonyx* + *Oxyura* appears to have a New World origin. A new species of stem oxyurine from the middle Miocene High Rock Caldera in Nevada, along with a reassessment of *Dendrochen robusta* from the early Miocene of South Dakota, demonstrate that those fossils are early stem oxyurines in the New World. Phylogenetic analysis of the holotype (and the largely ignored referred material) of *Dendrochen robusta* places it among other extinct stem oxyurines from Australia and New Zealand (*Pinpanetta*, *Manuherikia*, and *Dunstanetta*). The same phylogenetic analysis demonstrates that the new species from the Nevada caldera is more closely related to the crown clade of *Nomonyx* + *Oxyura* than to any known fossil taxon, including *Dendrochen robusta*. The derived diving modifications of a closed ventral pneumotricipital fossa on the humerus, pronounced medial epicondyle on the tibiotarsus, and a reduced M. fibularis sulcus on the tibiotarsus are present in both *Dendrochen robusta* and the new species. The new species lacks a capital shaft ridge on the humerus, indicating its more derived position.

The new Nevada species is represented by a minimum of four individuals, including subadult specimens that lack complete supratendinal bridges on their tibiotarsi. That subadult status points to the High Rock Caldera as a breeding location. The new species and *Dendrochen robusta* are both close to 16 Ma in age and demonstrate the presence of at least two stem oxyurine lineages in the New World by the middle Miocene. Given the

preference of extant stiff-tailed ducks for fresh water environments in temperate to tropical habitats, the path of intercontinental dispersal from their hypothesized origin in Australia/New Zealand to their occurrence in the Miocene of the New World remains problematic. Based on the stratigraphic distribution and phylogenetic pattern of the extinct taxa, it appears that the origin of the oxyurine stem and much of the near crown radiation occurred during the Late Oligocene warming event and the Mid-Miocene Climatic Optimum, consistent with previous molecular clock estimations. Those warming events may have provided the environmental parameters (preferred by the clade) at higher latitudes, facilitating dispersal in the Northern Hemisphere.

Romer Prize Session (Thursday, October 15, 2015, 11:30 AM)

PHYLOGENY AND CHRONOLOGY OF ARCHOSAUR RESPIRATORY AND PNEUMATIC INNOVATION SUGGESTS A COMMON MECHANISM FOR TRIASSIC-EARLY JURASSIC FAUNAL TURNOVER

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The Permian –Early Jurassic record of Archosauromorpha is characterized by the expansion of paranasal, paratympanic, and pleural pneumatic systems as well as faunal turnover across several global climate catastrophes associated with large igneous provinces. This sequence is marked by rapidly declining levels of atmospheric oxygen, which reached a minimum from the Tr–J boundary through the Early Jurassic.

This study tested the hypothesis that elevated transformation rates for respiratory characters and other non-respiratory pneumatic characters are associated with episodic macrofaunal turnover during the early history of Archosauromorpha. Combined-evidence archosaur phylogenies were generated using both parsimony and Bayesian search strategies under a modified pipeline for estimating relaxed-clock chronograms with fossils as terminal taxa. The targeted character transformation rates were measured relative to overall morphological rates using phylogenetic comparative methods over a distribution of topologies and chronologies.

Transformations increasing pneumatic surface area and tidal volume overwhelmingly outpaced decreases until the Toarcian at the latest, regardless of the topology and chronology. Expansions of paratympanic pneumaticity in Crocodylomorpha and of multiple pneumatic systems in Ornithodira appear to have been initiated near the Carnian Pluvial Event, and reached peak rates of per-lineage transformation near the Triassic-Jurassic boundary. The extinction of non-crocodylomorph pseudosuchians, non-averostran theropods, and non-gravisaurian sauropodomorphs are contrasted by the survival of related lineages with comparatively advanced pneumaticity. The early loss of gastralia in ornithischians indicates a Late Triassic transition in respiratory function that may not be manifested in fossilized tissues.

The temporal association of pneumatic innovation with catastrophic climatic events implies that a common selective regime influenced skeletal pneumatization in disparate archosaur lineages, and has implications for respiratory and thermoregulatory function. These findings do not reject mechanical or sensory hypotheses for the origin of archosaur pneumaticity, but rather highlight that functional hypotheses are often limited in taxonomic or anatomical scope and bereft of environmental context. The apparent climatic influence must be part of an integrative evolutionary hypothesis for pneumaticity accounting for structural, behavioral, physiological, and temporal factors.

Grant Information

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Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

A COMPARISON OF MORPHOLOGICAL AND GENETIC PHYLOGENIES FOR AUSTRALIAN AGAMIDAE, WITH IMPLICATIONS FOR THE FOSSIL RECORD

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Isolated skeletal elements of squamates were historically difficult to identify in the fossil record, primarily because there are few detailed studies documenting the morphological variation within squamate lineages. Morphological data sets and genetic data sets yield dramatically different hypotheses of modern squamate phylogeny, posing particular challenges for apomorphy-based identification of fossil specimens. Australian agamids are an ideal group with which to test hypotheses of squamate speciation, diversity, and disparity because they represent a recent radiation (30-10 Ma) within a geographically restricted area (Australia). We compiled and evaluated a list of morphological features previously suggested to be useful for identifying Australian Agamidae for a total of 94 characters. 36 characters lacked sufficient clarity and were excluded from the analysis. We added ten novel characters as well. All characters were ordinal (except for tooth count). Skull width and height were measured as a proxy for body size. We examined the skulls of 133 specimens (26 species) of endemic Australian agamids and 11 outgroup specimens (10 species) of Agamidae. We found that intraspecific variation in some taxa equals or exceeds interspecific variation in a comparative analysis. Ontogenetic differences are an important source of variation. Character states were, however, randomly distributed between sexes, suggesting sexual dimorphism of the skull is limited. Phylogenetic analyses based on morphological and genetic data produced different topologies, and a combined analysis produced a third, completely different, phylogenetic hypothesis. We examined more than 18 specimens each in three species of *Ctenophorus*. Within each species, 15-20% of the morphological characters were polymorphic and related to size (and therefore, presumably age). An additional 20-25% were polymorphic, but appear unrelated to age or sex. Future directions for research on Australian agamids should include documentation of the frequency of character expression within species, adding more individual extant specimens, and incorporating data from the fossil record. Adequate interpretation of data from fossils is hampered by the inadequate state of knowledge about patterns of variation within the skeletal system.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

THE ELUSIVE BAUBELLUM/BACULUM: WOULD YOU KNOW IT IF YOU HAD A GENITAL BONE?

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Many female mammals have a bony baubellum within their clitorides, while males have a homologous organ in their penises called a baculum. Although approximately 80% of extant mammalian species possess os genitale, these bones are rarely reported in the paleontological literature. This is perhaps partially due to taphonomic biases; however, the lack of identification of these elements may be a major contributing factor. Our incomplete knowledge of these bones in extant mammals most certainly adversely affects our ability to recognize them in the fossil record. Even though bacula were known and written about by Aristotle, their distribution and morphology in some groups is still undocumented. For instance, figures and descriptions of lipotyphlan bacula are essentially non-existent, although comparative anatomy books routinely mention they have them. The literature on baubella is even more depauperate, although they presumably have roughly the same diverse taxonomic distribution as bacula. Baubella have only been well figured and described in squirrels.

To rectify these deficiencies, the taxonomic distribution and morphology of os genitale were studied at three museums (USNM, MNHB, AMNH). Results indicated that these osteological collections contain more bacula than baubella. Bacula representing a total of 47 species of carnivorans, 17 rodents, 12 primates, two lipotyhlan, and one chiropteran were found, but only one carnivoran (*Lontra*) and one rodent (*Tamias*) were found to include baubella. Very few specimens were found in main collections associated with post-crania, most were housed within special genital collections that focused on bacula. In order to examine the potential preparational artefacts in osteological collections of os gentiale being absent in smaller taxa, an x-ray study was conducted. A PaxScan 4030R flat panel digital radiography was used to image female and male wet lipotyphlan specimens (both whole specimens and isolated dissected genitalia). This imaging technique was robust in picking up fine skeletal detail except in whole hedgehogs, whose spines resulted in excessive background noise. A total of 79 specimens, representing 28 genera, were imaged including solenodontids, soricids, talpids and erinaceomorphs. No baubella were observed and bacula were only variably found in *Crocidura fulliginosa* and *Talpa europaea*.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

A GAME OF RIDDLES: REASSESSING NEW ZEALAND'S ENDEMIC MOSASAURINE DIVERSITY

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The Campanian of New Zealand has been recognized for a wide diversity of mosasaurine mosasaurs, with six endemic taxa having been assigned to two unique genera, *Moanasaurus* and *Rikisaurus*, or the existing genera *Mosasaurus* and *Prognathodon*. None of the fossils that the new species were founded on were complete, but sufficient overlapping cranial material exists to serve as the basis for a comparative morphological review of the taxonomic diversity of these mosasaurs. Based on similarities including the height of the descending process of the parietal, pinched marginal tooth carinae, and dorsoventrally compressed cervical vertebral centra, we find no significant differences between *Moanasaurus mangahouangae* and *Rikisaurus tehouensis* or *Mosasaurus flemingi*. *Mosasaurus mokoroa* is a discrete species, but based on characters such as a dorsal excavation in the maxilla for the external naris, this species does not share sufficient affinities with the type species, *Mosasaurus hoffmannii*, to support continued assignment to this genus. It is likely more closely related to *Moanasaurus*. Multiple fossils from across New Zealand have also been assigned to *Prognathodon*. While these specimens do have robust skulls, the morphologies of the cranial elements do not agree closely with characters diagnosing this genus. The one exception of a fossil that does share affinities with *Prognathodon*, including the morphology of the mandible and a quadrate with fused supra- and infrastapedial processes, is *Prognathodon waiparaensis*. However, this specimen, which was collected at three separate times over a span of seven years, appears to be a chimera composed of elements with *Prognathodon*-like affinities and others with *Mosasaurus*-like morphologies. Some of the genera that comprise this mosasaur community, such as *Moanasaurus* and the tylosaurine *Taniwhasaurus*, are now recognized from other localities around the world, but the New Zealand species remain unique, showing endemism at least at the species level.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

EOCENE FISH OTOLITHS PROVIDE EVIDENCE OF INTERACTION WITH MARINE INVERTEBRATES DURING THE TAPHONOMIC PROCESS

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Microscopic analysis of 3256 fish otoliths obtained from bulk samples and surface collections from the Moodys Branch Formation (Jackson Group, middle Eocene) at Montgomery Landing, Louisiana, revealed 93 specimens that exhibited evidence of interaction with marine invertebrate organisms during the taphonomic process. The otoliths represented ten marine fish taxa from seven families and strongly indicated their use as substrata by invertebrates. Predation and subsequent excretion by piscivorous animals and the death of fishes were the two primary means by which the otoliths became part of the sediments. Factors influencing the utilization of otoliths were determined to be size, abundance, shape (stability), durability, and surface residence-time. Invertebrates that were found to be interacting with otoliths during taphonomy were cnidarians (scleractinian solitary corals), bryozoans (cheilostome species), mollusks (primarily gastrochaenids), and annelids (serpulids). Invertebrate remains and evidence recognized on the otoliths included settlement by larval forms, encrustation, boring (drilling), and burrowing. The invertebrate remains provided important information and data about the taphonomic process of the otoliths as well as paleoenvironmental data of the site. The size of the scleractinian corals, the time duration of the serpulids, encrustation by cnidarians and serpulids and lack of other epifauna such as bryozoans, and the lengths of

Gastrochaena burrows appear to indicate that the otoliths did not remain exposed on the sea floor for an extended period. Surface residence-time may also explain why the abundant and diverse invertebrate assemblage at the site affected only about three percent (3%) of the preserved otoliths. Several factors, including the bimodal preservation of the otoliths, indicate that part of the otoliths may have been incorporated into carbonate hardgrounds while other otoliths may have been in unconsolidated sediment with some of them exposed on the sea floor and subjected to various invertebrate activities.

Technical Session XIX (Saturday, October 17, 2015, 1:45 PM)

PALEOGENOMICS OF ANCIENT TETRAPODS AND THE IMPLICATIONS FOR TRACKING MAJOR EVENTS OF EXPANSION AND CONTRACTION OF THE MODERN TETRAPOD GENOME SIZE

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Genome size spans a roughly 3,000 fold range among animals. Evolutionary trends in genome size within individual tetrapod groups (notably birds and salamanders, which have small and large genomes respectively) have been analyzed. However, the ancestral tetrapod condition remains unknown, obscuring our understanding of character state polarity and macroevolutionary trends for genome size. Here we re-assess the relationship between genome size and lacunae size in bone tissue and use this relationship to infer genome size in early tetrapods. This study's analysis includes the Late Devonian labyrinthodont Ichthyostega, the early Permian temnospondyls *Acheloma*, *Eryops*, and *Trimerorhachis* , lepospondyl *Cardiocephalus*, and synapsid *Mycterosaurus*, late Permian retiliomorph *Chroniosaurus* and lepospondyl *Diplocalus*, Early Triassic temnospondyl *Wetlugasaurus*, and Middle Jurassic stem salamander *Marmorerpeton*. The Late Devonian sarcopterygian *Eusternopteron* was also analyzed. Extant *Latimeria* and three extant actinopterygians were combined with previously collected histological data from 15 amphibians, 3 testudines, *Sphenodon*, 5 squamates, 2 crocodylians, 11 birds, and 22 mammals. Our results suggest that 12 of the 13 extinct taxa had genome sizes ranging between 4.34 and 6.69 pg (with the exception of *Marmorerpeton*, which had a genome size between 36.60 and 56.26 pg). These results imply that basal tetrapods have genome sizes (and underlying architectures) similar to modern mammals. In light of these findings, early tetrapods had moderately sized genomes that expanded relatively late in the lissamphibian lineage, whereas a stepwise decrease in genome size is inferred in reptiles and birds. Mammalian genome sizes do not appear to have evolved away from the ancestral tetrapod range.

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Symposium 1 (Wednesday, October 14, 2015, 3:00 PM)

ISOTOPIC COMPOSITION OF LOWER CRETACEOUS HEKOU GROUP VERTEBRATES OF LANZHOU PROVINCE, CHINA SUPPORTS COOL CLIMATES IN THE MID-LATE VALANGIAN

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By combining carbon and oxygen isotopic data of tooth phosphate and carbonate from the non-hadrosauriform styracosternan iguanodon *Lanzhousaurus*, crocodilians, turtles, and ganoid fish scales from the Hekou Group, Gansu Province, China we interpret the paleoenvironment and paleoclimatic conditions during the Valanginian of northwestern Asia (139 to 133 Ma) as well as the growth rate of *Lanzhousaurus* teeth. Phosphate oxygen isotopes were extracted by drilling and converting ~300–500 µg of enamel to silver phosphate. Samples were analyzed on a high temperature conversion elemental analyzer connected to an isotope ratio mass spectrometer (IRMS). Additional samples from enamel were analyzed for the carbonate component of tooth enamel for carbon and oxygen isotopes and analyzed via phosphoric acid reaction on a gas bench connected to an IRMS. A one-year seasonal record (winter to summer back to winter) of ingested water is interpreted from two teeth (maxillary and dentary tooth) from the holotype of *Lanzhousaurus magnidens*. The tooth length and isotopic record suggest that *Lanzhousaurus* teeth grew at a rate of 0.28 mm/day. The combined vertebrate data reveal that the Hekou Group in the Zhongpu area south of Lanzhou represents a seasonal cool and dry intermontane climate with a mean annual precipitation of approximately 757.4 mm/year. These interpretations are in agreement with the sedimentologic and trace fossil record from the Hekou Group such as calcic paleosols, rizoliths, and insect burrows. By using co-existing fish, turtle, and crocodile remains we present the first quantitative terrestrial paleotemperatures from the Valanginian as 18–19°C. This is much cooler for this paleolatitude (25°N) relative to times of greenhouse climates within the Cretaceous (e.g. Aptian–Albian of ~22°C). This suggests that the mid–late Valanginian Weissert Event, a perturbation in the global carbon cycle in both the marine and terrestrial record, is indeed correlated to a short-lived global cooling event as suggested by other studies. Global warming and a transition to warm and wet climate in the northwestern intermontane basins of China during the late Valanginian through the Aptian–Albian thermal maximum may have caused rapid climate change and spurred on rapid evolution in terrestrial flora and fauna in the middle Cretaceous known as the Cretaceous Terrestrial Revolution.

Symposium 1 (Wednesday, October 14, 2015, 3:15 PM)

WARM AND WET: LACUSTRINE PALEOENVIRONMENTS AS CRADLES FOR THE CRETACEOUS TERRESTRIAL REVOLUTION IN ASIA

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Recent progress in vertebrate finds of northwest China and associated study of their paleoenvironments suggest lacustrine strata was widespread during the onset of the mid-Cretaceous (Aptian). Abundant lake environments appear to be a result of tectonic settings and global paleoclimatic shift to warm and humid conditions. Temporal constraint of continental strata in northwestern China, specifically Gansu Province, are becoming clearer using carbon (C) isotope chemostratigraphy. Here we present chemostratigraphic records from two localities in Gansu: the "Changma bird" locality (Xiagou Formation) and the "White Pagoda" locality (Zhonggou Formation), showing widespread temporal and spatial distribution of lacustrine and palustrine paleoenvironments.

Carbon isotope excursions (CIEs) represent global shifts in the C cycle and are recognized both in marine and continental strata. These C cycle perturbations likely affected terrestrial and marine conditions. Using both C isotope chemostratigraphy and clumped isotope paleothermometry, we provide the first continental record of quantitative temperature changes across the early Aptian Selli Event from the Changma locality. Paleotemperatures (averaging 31°C) support a very warm paleoenvironment during the early Aptian. Temperatures peak at a negative CIE preceding the Selli Event supporting the scenario that temperature rose due to increased greenhouse gas release, likely from large igneous provinces.

The transition to the mid-Cretaceous greenhouse is marked by a number of episodes of environmental change (EEC). We hypothesize that faunal turnover in China roughly coincides with these episodes. Jehol Dinosaur/Avian Fauna (mainly Barremian) to the Changma Avian Fauna (early Aptian) correspond to the Taxy and Selli episodes. This turnover is characterized by a transition from enantiornithine and other basal birds to ornithuromorph birds. The Mazongshan Dinosaur Fauna (mid-Aptian-mid-Albian) correspond to the Paquier episodes and are characterized by abundant basal hadrosauroids and neoceratopsians, but no psittacosaurs, as is the case with the Jehol Dinosaur Fauna. We propose the possibility that the transition to the warm and wet environments of the mid-Cretaceous and the EEC played an important role in the beginning of the Cretaceous Terrestrial Revolution. We hypothesize that climatic changes (like that associated with the Selli Episode) coupled with the variability in environments associated with lacustrine systems may have spurred evolutionary changes.

Technical Session XII (Friday, October 16, 2015, 8:00 AM)

A MIDDLE TRIASSIC STEM-TURTLE FROM GERMANY AND THE EVOLUTION OF THE TURTLE BODY PLAN

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The origin and early diversification of turtles have long been major contentious issues in the study of vertebrate evolution. This is due to conflicting character evidence from molecules and morphology, as well as a lack of transitional fossils from the critical time interval. The stem-turtle *Odontochelys*, from the early Late Triassic (Carnian) of Guizhou (China), has a partially formed shell and many turtle-like features in its postcranial skeleton. Unlike *Proganochelys*, from the Late Triassic (Norian) of Germany and Thailand, it retains marginal teeth and lacks a carapace. *Odontochelys* is separated by a considerable temporal gap from *Eunotosaurus*, from the late Middle Permian (Capitanian) of South Africa, which has been plausibly hypothesized as the earliest stem-turtle. A new taxon from the late Middle Triassic (Ladinian) of Baden-Württemberg (Germany) represents a structural and chronological intermediate between *Eunotosaurus* and *Odontochelys*. The three taxa share the possession of anteroposteriorly broad trunk ribs that are T-shaped in cross-section and bear sculpturing, elongate dorsal vertebrae, and modified limb girdles. Unlike *Odontochelys*, the new stem-turtle has a cuirass of robust paired gastralia in place of a plastron. It provides evidence that the plastron partially formed through serial fusion of gastralia. The skull of the new stem-turtle has small upper and ventrally open lower temporal fenestrae, supporting the hypothesis of diapsid affinities of turtles. Both the upper and lower jaws bear teeth. Phylogenetic analysis found Pan-Testudines (including the new taxon) as the sister-taxon of Sauropterygia. Together these two clades form the sister-taxon of Lepidosauriformes. The new stem-turtle lends additional support to an earlier hypothesis arguing for an aquatic origin for the turtle body plan.

Technical Session XVI (Saturday, October 17, 2015, 9:45 AM)

A NEW BASAL CROCODYLOMORPH WITH UNEXPECTED SKELETAL AND SOFT-TISSUE FEATURES FROM THE MIDDLE-LATE JURASSIC DAOHUGOU BIOTA OF NORTHEAST CHINA

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The Middle-Late Jurassic Daohugou (or Yanliao) Biota and Early Cretaceous Jehol Biota are successive assemblages from northeast China. The dominant aquatic tetrapods of the Daohugou and Jehol Biotas are salamanders and choristoderes, respectively, and no crocodylomorph has been reported from either assemblage.

However, a basal (i.e., non-crocodyliform) crocodylomorph was recently recovered from the Daohugou Biota site of Mutoudeng, Hebei Province. The meter-long skeleton is nearly complete, but compressed and damaged so that some features are hard to observe. Nevertheless, the Mutoudeng specimen shows crocodylomorph synapomorphies, including elongated carpals, and lacks crocodyliform traits such as an expanded coracoid process. The specimen shares key features with the Chinese basal crocodylomorph *Junggarsuchus sloani*, including vertebral hypapophyses and a slender, rotated metacarpal I. However, the Mutoudeng specimen differs from *J. sloani* in having shorter distal forelimb segments, and in lacking enlarged anterior maxillary teeth. Phylogenetic analysis in TNT of a crocodylomorph matrix including many basal forms, with the Mutoudeng specimen added, recovers this specimen and *J. sloani* as sister taxa slightly outside Crocodyliformes.

J. sloani is known from one individual lacking the hindquarters, but the Mutoudeng specimen preserves two surprising features in this region: the iliac preacetabular process is very long, and the middle and posterior parts of the tail are entirely sheathed in osteoderms. Such extensive caudal armor is common in basal crocodyliforms but rare in more basal crocodylomorphs. The elongated preacetabular process likely gave parts of the iliotibialis and puboischiofemoralis internus musculature a near-horizontal orientation, allowing them to act as strong femoral protractors. This arguably supports prevailing views of basal crocodylomorphs as terrestrial cursors, but soft tissues preserved with the skeleton unexpectedly challenge the conventional wisdom. Scaly skin is associated with the superimposed feet, and with the right hand, forming sheets of small (< 1 mm) polygons defined by dark lines. In the right hand, patches of skin are visible between digits IV and V, extending distally to the second phalanges of the two digits. The presence of skin in this area implies the hand was webbed, which in turn suggests the Mutoudeng crocodylomorph frequented wet environments and was probably at least semi-aquatic.

Grant Information
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Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

THE ORIGIN, EVOLUTION AND BIOGEOGRAPHIC EXTENSION OF CHINESE HIPPARIONIN HORSES, *PLESIOHIPPARION* AND *PROBOSCIDIPPARION*, LATE MIOCENE – PLEISTOCENE OF EURASIA

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Hipparionin equids arose in North America at the base of the Barstovian Land Mammal Age, ca. 16 Ma, underwent a modest middle and late Miocene radiation there, and extended their range throughout the Old World 11.2 Ma. Eurasia and Africa witnessed an extensive radiation of hipparionin lineages in the late Miocene, including several species of the following lineages: *Cormohipparion, Hippotherium, Hipparion* s.s., *Cremohipparion*, *Sivalhippus, Proboscidipparion, Plesiohipparion* and *Eurygnathohippus*. Most species of these Eurasian and African lineages underwent a catastrophic extinction in the latest Miocene, ca. 5.3 Ma. This, however, was not the case with Asian *Plesiohipparion* and *Proboscidipparion* and African *Eurygnathohippus,* which underwent Plio-Pleistocene radiations. We follow earlier work by Qiu and Deng unraveling the origin, evolutionary diversification and biogeographic extension of two hipparionin lineages of Chinese hipparions, *Proboscidipparion* and *Plesiohipparion*. Our research suggests that both *Plesiohipparion* (*Pl.*) and *Proboscidipparion* (*Pr.*) are members of the '*Sivalhippus* Complex', which originated in IndoPakistan ca. 10.4 Ma. *Eurygnathohippus* is likewise a member of the '*Sivalhippus* Complex' and was restricted to Africa throughout its duration. *Plesiohipparion* arose during the late Baodean (latest Miocene, ca. 6 Ma) in the Tibetan Plateau, China (*Pl. zandaense*), and extended its range into North China (*Pl. houfenense* and *Pl. huangheense*), Turkey (*Pl. huangheense*) and southwest Europe (*Pl. crusafonti*) in the late Miocene to earliest Pleistocene (of Turkey). *Proboscidipparion* originated in the latest Miocene of China, where it occurs in the Yushe Basin (*Pr. pater*) at 6-5.5 Ma, and evolved into the larger form *Pr. sinense* in the early Pleistocene (ca. 2 Ma.), where it persisted until about 1 Ma. in China. African *Eurygnathohippus* originated in the latest Miocene of North and Eastern Africa (ca. 7–6 Ma), where it persisted until about 1 Ma, and exhibits a number of shared-derived characters of the skull, maxillary and mandibular dentition with Asian *Plesiohipparion*. Our current study focuses on the resolved chronology of speciation events of these derived *'Sivalhippus* Complex' lineages and the timing of intercontinental dispersion, ensuing isolation, and paleobiology of their Plio-Pleistocene species.

Grant Information
NSF SGP Program

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

MIDDLE PLEISTOCENE VERTEBRATE COMMUNITY FROM KHOK SUNG (NORTHEASTERN THAILAND): FAUNAL COMPOSITION, DIETS, AND NICHE PARTITIONING OF SYMPATRIC MAMMALS

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The Khok Sung sand pit, Nakhon Ratchasima province, has yielded the richest Pleistocene vertebrate fauna of Thailand, where more than a thousand fossil mammals and reptiles (skulls, isolated teeth, and postcranial remains) were recovered in 2005. The age of the Khok Sung fauna, for which a radiometric analysis has never been performed, is tentatively attributed to the late Middle Pleistocene as either 188 ka or 213 ka, based on the paleomagnetic data and on the occurrence of a spotted hyaena, *Crocuta crocuta ultima,* which represents a good biochronological marker. The mammalian fauna consists of at least 18 identified species (12 genera), including a primate, proboscideans, rhinoceroses, suids, bovids, cervids, and carnivores, which are characterized by mostly extant forms and some globally (*Stegodon orientalis*) and locally (*Crocuta crocuta ultima*, *Axis axis*, *Sus barbatus*, and *Rhinoceros unicornis*) extinct taxa. A chital, *Axis axis*, whose distribution is today restricted to the Indian Subcontinent, is reported here for the first time in Southeast Asia during the Pleistocene. Compared to other Southeast Asian Pleistocene and extant faunas, the Khok Sung mammal assemblage yields mostly mainland Southeast Asian (Indochinese) and some Javanese (Sundaic) taxa, supporting the hypothesis that Thailand was a part of the Sino-Malayan migration route from South China to Java. The impact of glaciations on environments can therefore be considered as a key factor of on land dispersal at that time.

An analysis of stable carbon isotopes extracted from the enamel of these fossil mammals has revealed evidence of paleodiets and niche occupation of ungulates and proboscideans. The considerable amount of C4 plants in the dietary use of bovids and cervids indicates that grasslands had significantly expanded in Thailand at that time. Sympatric populations between *Rhinoceros unicornis* and *Rhinoceros sondaicus* are considered to minimize competition by partitioning resources, as deduced from the $\delta^{13}C$ values. The former species foraged preferentially in open habitats, in contrast with the latter one, which occupied a closed canopy. The $\delta^{13}C$ values of *Stegodon orientalis* suggest mixed C4 and C3 plant consumption, but sometimes pure C3 plant resources. A serow, *Capricornis sumatraensis*, appears to have consumed C3 plants in a forested environment. Overall, the results of the stable carbon isotope analysis show that there were great differences in the habitats and diets of the Khok Sung herbivores compared to Thai Middle Miocene and modern mammal communities.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

PRELIMINARY REPORT ON HERPETOFAUNA FROM THE SOLNECHNODOLSK LOCALITY (LATE MIOCENE), RUSSIA

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The locality of Solnechnodolsk (Stavropol Region, Russia; late Turolian, MN 13) yielded one of the most abundant and diverse vertebrate faunas of late Miocene in Russia. Since its discovery in 2009, numerous vertebrate taxa, comprising fishes, amphibians, reptiles, birds, and mammals have been documented. Amphibians and reptiles are the second most abundant vertebrate group after mammals. The preliminary list contains the following taxa: Salamandridae indet., *Pelobates* sp., *Bufo viridis, Hyla* sp., *Rana* sp. 1 and 2, *Emys* sp., *Sakya* sp., Geoemydidae indet., *Testudo* sp., Chelydridae indet., Scincidae indet., Lacertidae indet. 1 and 2, *Ophisaurus* sp., *Varanus* sp., Scolecophidia indet., *Naja* sp., *Eryx* sp., Colubrinae indet. 1, 2 and 3, Natricinae indet., and Viperidae indet. The most numerous remains belong to *Testudo*, lacertid lizard, and colubrine snakes; remains of *Pelobates, Bufo viridis*, *Rana*, and *Ophisaurus* are relatively abundant; other groups are extremely rare. The records of *Ophisaurus*, *Varanus,* Scincidae, Scolecophidia, and *Naja* are reported in Russia for the first time. Lacertids are represented by a large form with bicuspid teeth (Lacertidae indet. 1), and a small form with tricuspid teeth (Lacertidae indet. 2). Colubrine snakes belong to at least three forms, that can be differentiated in size, shape of hypapophyses, and prezygapophysial processes. *Naja* sp. is represented by a single trunk vertebra of a large form with the centrum length of about 10 mm. It differs from *N. romani* in markedly vaulted neural arch and is most similar to *Naja* sp. from Tourkobounia 1, Greece (Upper Pliocene, MN 16) in a relatively broad centrum. Scincid lizards are determined based on several dentaries with a medially closed Meckel's groove. The Solnechnodolsk herpetofauna indicates subtropical climatic conditions, and open landscapes with sandy soils and an existence of at least temporal water-bodies.

Grant Information
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Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

STASIS IN GREAT HORNED OWLS FROM THE LA BREA TAR PITS DURING THE LAST GLACIAL-INTERGLACIAL CYCLE

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Rapid responses of bird populations to climatic and environmental change in body size and shape are well known, including such classic stories of evolutionary biology as the Galápagos finches. The time interval captured in the Rancho La Brea tar pit deposits includes the last glacial maximum, when the local climate was characterized by coniferous forests and snowy winters, as well as the warmer oak-chaparral-dominated interglacials. However, previous studies on several species of large birds from Rancho La Brea have found very little change in shape or size over the interval spanned by the tar pit samples.

We studied the sample of Great Horned Owls (*Bubo virginianus*) from the Page Museum collections from Rancho La Brea to determine if they showed size or shape changes in response to the climate changes of the last 35,000 years. Three linear measurements were obtained from each of the 99 *B. virginianus* tarsometatarsi from pits with good radiocarbon ages. Although living Great Horned 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 no statistically significant changes in length or robustness associated with the peak glacial interval at 18,000–20,000 years ago. These results are consistent with earlier studies on La Brea Condors, Golden Eagles, Bald Eagles, Turkeys, 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 changes in size or limb robustness.

Technical Session XIX (Saturday, October 17, 2015, 3:15 PM)

VARIATION IN THE ADAPTATIONS FOR HEAD FIRST BURROWING IN RECUMBIROSTRAN 'MICROSAURS' (LEPSPONDYLI), AS REVEALED BY MICRO-COMPUTED TOMOGRAPHY

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Recumbirostra (Lepospondyli) is a group of small tetrapods that spanned from the Late Carboniferous to the Early Permian, many of which are thought to have been headfirst burrowers. This lifestyle has been inferred from superficial cranial features, such as the upturned snout and the interlocking atlanto-occipital joint, and has recently been supported by a handful of detailed studies examining select focal taxa. However, the degree of morphological variation within the endocranium of recumbirostrans remains unknown. In order to better understand the range of endocranial morphology of the group and assess the interpretations of headfirst burrowing, we submitted a broad selection of recumbirostran specimens to micro-computed tomography for analysis. We present differences in the endocranial morphology, such as the presence of the "median anterior braincase bone" and the elongate overlapping anterior-posterior suture between the

sphenethmoids and the skull roof. These differences represent novel variation in the morphology of Recumbirostra that is previously undescribed. The complex formed between the dermatocranium and braincase of recumbirostrans is reminiscent of the "cranial box" of modern burrowing snakes, skinks, and amphisbaenids. Variation in the "cranial box" of modern reptiles is associated with differences in burrowing mode and substrate type; similar variation in the suture between the dermatocranium and braincase in recumbirostrans, particularly in the participating elements and the anterior-posterior length of the suture, suggests that recumbirostrans were exploring multiple fossorial niches in a manner similar to modern burrowing reptiles. This new morphology gives new insight into the diversity of lifestyles in Permian tetrapods.

Grant Information
This research was supported by NSERC Discovery Grant 327756-2011 awarded to Jason S. Anderson

Technical Session XIX (Saturday, October 17, 2015, 4:00 PM)

CHANGES IN PRIMARY PRODUCTIVITY AND MEAN ANNUAL RAINFALL IN THE LATE PALEOZOIC AND EARLY MESOZOIC OF AFRICA CORRELATE WITH TETRAPOD DIVERSITY

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Understanding the relationship between climate and vertebrate diversity is a major goal of paleobiological research, particularly as a baseline for understanding the impacts of climate-driven mass extinction. We have worked over the past ~10 years to assess Permo–Triassic (PT) environments and climates through analysis of paleosol morphology and geochemistry in Tanzania, Zambia, and Niger.

Paleosol morphologies in the PT strata of Niger consist of Calcisols, calcic Vertisols, and calcic Protosols with no remarkable differences in the distribution of morphologies through the stratigraphy. In Zambia and Tanzania, there is an important transition in the middle–upper Permian strata from lake-plain systems characterized by generally humid climate and poorly drained soil morphologies (Gleysols, calcic Gleysols) in the lower-Madumabisa/Ruhuhu formations to fluvial and floodplain systems characterized by generally well-drained and sub-humid to semi-arid climates in the upper-Madumabisa/Usili formations characterized by well-drained Calcisols and calcic Vertisols, respectively. Finally, the Triassic strata in Zambia and Tanzania include well-developed Vertisols and calcic Vertisols. Collectively, the paleosol morphological data indicate similar environments/climates through PT times in Niger, whereas there is evidence for a transition from relatively humid to drier conditions in Tanzania and Zambia in middle–upper Permian strata, with a trend toward strong seasonality in the Triassic.

The stable carbon isotope ($\delta^{13}C$) values of paleosol calcite and organic matter ranges from 1.0 to -5.6‰ and -29.4 to -22.5‰, respectively, in the PT strata of Niger, whereas they range from -15.9 to -7.6‰ and -26.7 to -23.4‰, respectively, in the PT strata of Tanzania and Zambia. $\delta^{13}C$ values between soil calcite and soil organic matter ($\Delta^{13}C_{cc\text{-}om}$) exhibit a strong correlation with mean annual precipitation (MAP): MAP(in cm) = ($\Delta^{13}C_{cc\text{-}om}$ – 25.4)/-0.31. Based upon these modern relationships among soils, the $\delta^{13}C$ values of Permo–Triassic paleosol carbonates and organic matter correspond to average MAP values of ~12 cm in Niger (n = 23) and ~37 cm (n = 17) in Tanzania and Zambia. The data from the PT of Niger indicate conditions were always more arid than contemporaneous strata in Tanzania and Zambia. These results suggest that endemic taxa in Niger and cosmopolitan taxa in Tanzania and Zambia may be a product of climate zonation with rainfall seasonality being the main factor during Permian–Triassic time.

Grant Information
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Technical Session XIII (Friday, October 16, 2015, 2:45 PM)

CONSTRUCTION OF A METHOD TO IMPLY FUNCTION OF GASTROLITHS FROM THEIR FEATURES AND ITS APPLICATION TO THE HERBIVOROUS ORNITHOMIMOSAUR *SINORNITHOMIMUS*

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Gastroliths (geo-gastroliths) are known in some extant archosaurs (crocodiles and birds). In birds, the frequencies of gastroliths in stomachs are dependent on their feeding habits (herbivorous birds have a large number of gastroliths grains for digestive support). On the other hand, the function of crocodile gastroliths is not well understood (hydrostatic control, pathological reasons, alleviation of hunger, accidental intake, or digestion). For non-avian dinosaurs, mainly sauropods and theropods, the presence of gastroliths has been treated as strong evidence of herbivory in previous studies; however, gastroliths have been reported from purportedly carnivorous theropods as well, interpreted as an accidental intake. This study compiles data from extant archosaurs to examine relationships between diet and gastrolith features in order to establish a method to verify the function of gastroliths in non-avian dinosaurs. Regression analysis among occurrence frequencies of gastroliths and different food types in crocodiles shows that they are positively correlated with a diet of mammals, reptiles, and fishes ($p<0.05$), while they are negatively correlated with those of insects ($p<0.05$). This demonstrates that occurrence frequency of gastroliths in crocodiles is dependent on feeding behavior and that crocodiles with high occurrence frequencies use gastroliths for digestive support as in birds.

We dissected crocodiles (*Gavialis gangeticus* and *Crocodylus siamensis*) and birds (39 taxa). Gastroliths were present in 6 of 9 specimens of crocodiles and 13 of 47 specimens in insectivorous, piscivorous, herbivorous birds. Roundness of gastrolith grains of crocodiles, birds, and the herbivorous theropod *Sinornithomimus* was measured and categorized into 5 stages. Cluster analysis was conducted on the ratios of roundness categories. Our result shows three clusters, concordant with their diet: herbivorous birds and *Sinornithomimus*, piscivorous birds and *Gavialis*, and carnivorous crocodiles (*Crocodylus*). The averages of roundness indexes among the clusters are significantly different ($p < 0.01$); high (rounded) in herbivores, low (angular) in piscivores, and moderate (sub-rounded to sub-angular) in carnivores. This result shows that roundness of gastroliths reflects their function in aiding digestion and that this method is applicable to non-avian dinosaurs.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

NEW ARTICULATED POSTCRANIAL MATERIAL OF *PARALLIGATOR GRADILIFRONS* (CROCODYLIFORMES) FROM MONGOLIA

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The advanced neosuchian clade Paralligatoridae is a globally distributed group, which occurs from the Late Jurassic of Brazil, the Early Cretaceous of North America, and the Late Cretaceous of Asia. Among them is *Paralligator gradilifrons*, the recently resurrected clade from the Nemegt and Bayanshiree Formations of Mongolia.

Here we report a new specimen of *Paralligator gradilifrons* (WSILS-RHg122), including a partial skull, lower jaw, cervical to caudal vertebrae, cervical ribs, right humerus, right ulna, partial ilium, left femur and osteoderms. This specimen preserves articulated osteoderms in association with vertebrae, most likely in situ. There are two paired parasagittal rows of keeled overlapping osteoderms which are wider than long, and at least one row of accessory osteoderms. Ventral osteoderms are sutured together in parasagittal rows along the trunk region, as seen in *Susisuchus anatoceps*, yet the ventral osteoderms of the lateralmost rows are slightly keeled. In addition, appendicular osteoderms with high keels are preserved in association with the left femur. All osteoderms are ornamented with very small and shallow pits, and where keels develop, they are only restricted to the posterior region of the osteoderms.

Amphicoelous vertebrae and the sutured ventral osteoderms suggest that the trunk region of *Paralligator gradilifrons* was rather rigidly built.

Symposium 3 (Saturday, October 17, 2015, 9:30 AM)

ADDING PHYLOGENETIC TREES TO IMPROVE VIRTUAL RETRODEFORMATION: CERCOPITHECIDAE AS A TEST CASE

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Three-dimensional shape analysis is increasingly used to answer questions about functional morphology, paleoecology, and phylogeny of fossil taxa. Diagenetic shape change is a major obstacle for the use of geometric morphometrics (as well as more standard analytical approaches). Retrodeformation is the process of returning a deformed fossil to its antemortem-or "pre-death"-shape. The techniques of simple reflection and averaging and the more recently published approach of algorithmic symmetrization both adjust for asymmetrical deformation. Symmetrical deformation, however, remains a problem. Here we present a potential solution for addressing symmetrical deformation in fossil crania using three-dimensional morphometric data in combination with assumed phylogenetic relationships to create hypotheses for antemortem shape.

Dense patches of semilandmarks were collected on surface scans of the crania of undeformed extant and fossil cercopithecids and mapped onto a composite molecular phylogenetic tree with estimated divergence dates. Hypothetical landmark configurations representing all ancestral nodes and transformations along branches were calculated using a squared-change parsimony model of (Brownian-motion) evolution. Two mechanically deformed casts of *Papio hamadryas kindae* crania of known antemortem shape were first retrodeformed with algorithmic symmetrization (as in our previous work) and then fit onto the tree by finding the place-or places-where Procrustes distance was minimized. Three-dimensional models were generated based on the landmark configurations at those places and were used as templates to further correct the symmetrical deformation present in the crania, yielding a series of hypothetical reconstructions of antemortem shape. Principal component analyses of a broad sample of extant cercopithecids indicate that the hypothetical reconstructions fall within the range of extant variation of *P. h. kindae.* Permutation tests of pairwise Procrustes distances among the extant taxa and retrodeformed models indicate that the retrodeformed specimens are significantly more similar to other *P. h. kindae* than to members of any other taxon.

Grant Information
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Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

A DIVERSE FOSSIL EGGSHELL ASSEMBLAGE FROM THE LOWER CRETACEOUS SASAYAMA GROUP IN THE HYOGO PREFECTURE OF JAPAN REVEALS THE PRESENCE OF PREVIOUSLY UNKNOWN SMALL THEROPODS

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The Lower Cretaceous (Albian) Sasayama Group, exposed in the eastern Hyogo Prefecture of southwestern Japan, has yielded a high diversity of vertebrate fossils in the past several years. In addition to the skeletal remains of anurans, mammals, lizards, and dinosaurs (i.e., basal hadrosauroids, ankylosaurs, titanosauriform sauropods, tyrannosauroids, therizinosauroids, and indeterminate theropods), fossil eggshells have recently been found. Here we report on numerous eggshell fragments (n > 90) discovered in the Kamitaki bonebed in Tamba City, situated in the lower part of the 'Lower Formation' of the Sasayama Group. Based on macro- and microscopic features, these eggshells are classified into five different ootaxa: *Elongatoolithus* sp., *Prismatoolithus* sp., *Spheroolithus* sp., and two indeterminate theropod ootaxa. This eggshell assemblage indicates the presence of at least one ornithopod and several theropod taxa. Because all Kamitaki eggshell fragments are very small, their egg sizes are predicted from a regression of egg mass against eggshell thickness compiled from ootaxa of known egg sizes. With thicknesses varying between 0.18 mm and 0.57 mm, the Kamitaki eggshells are among the smallest theropod eggs known (28–135 g), which suggests they were laid by small-bodied forms. The Kamitaki fossil eggshells provide evidence for a diverse assemblage of small dinosaurs that were nesting in the region, taxa that are poorly represented by skeletal remains in Japan.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

A NEW SMALL HESPERORNITHIFORM FROM THE UPPER CRETACEOUS PIERRE SHALE OF MANITOBA

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Hesperornithiforms, foot-propelled diving birds, are the predominant predatory large sea-going birds during the Cretaceous and are mainly known from the Western Interior Seaway deposits, especially the Santonian to Campanian of the Niobrara Chalk and the Pierre Shale. Here we report a new small hesperornithiform (V-2487) from the Gammon Ferruginous Member of the Pierre Shale (early Campanian), near the Vermillion River of the Riding Mountain region, Manitoba, Canada. This specimen is represented by the distal end of the left femur and a right patella, left and right tibiotarsi, the distal end of the left tarsometatarsus, proximal end of the right tarsometatarsus, and several pedal phalanges. The ossified distal end of the tibiotarsus and proximal end of the tarsometatarsus suggest that this specimen is adult.

Our phylogenetic analysis shows that V-2487 belongs to the clade of Hesperornithidae (V-2487, *Parahesperornis* and *Hesperornis*) based on the following synapomorphies: large and elongated metatarsal trochlear IV of the tarsometatarsus and specialized articular surface of the robust fourth toe. *Hesperornis* and V-2487 forms a monophyly sharing a prominent intercondylar eminence of the tarsometatarsus. The size of V-2487 is approximately 40% that of *Hesperornis regalis*, one of the most common and largest species of Hesperornithiformes in the mid latitudinal Western Interior Seaway. V-2487 differs from *Hesperornis* in having a medially positioned foramen for M. ambience of the patella in dorsal view and a remarkably flat femur with a strong lateral orientation of the fibular trochlea indicating that this specimen is a new taxon. Hesperornithids include large taxa such as *Hesperornis* and *Asiahesperornis* that are widely distributed in the Upper Cretaceous of North America and Europe. On the other hand, all small hesperornithids, including V-2487, occur only in the mid latitudinal Western Interior Seaway and were a significant component of the marine bird community of this region. Hesperornithid occurrences in the northern hemisphere suggest that the mid latitudinal Western Interior Seaway yielded a wider range of body sizes relative to European forms.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

BRIDGING THE EARLY MIOCENE GAP IN ODONTOCETE HISTORY: NEW DOLPHIN FROM KAIKOURA, NEW ZEALAND, HELPS RESOLVE RELATIONSHIPS FOR *PAPAHU*

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The phylogenetic position of *Papahu taitapu* (early Miocene, Nelson Province, New Zealand) is problematic. The original account placed *Papahu* high in the stem Odontoceti, while later studies have placed it in crown Odontoceti, above the Platanistoidea. Phylogenetic uncertainty reflects limited sampling of comparable structural grades and, especially, the lack of earbones, some basicranial features, and mandible with the holotype. Now, relationships have been reassessed using an undescribed *Papahu*-like dolphin (ZMT 73; including partial skull and tympanoperiotics) from Kaikoura, New Zealand. The early Miocene ZMT 73 provides details of the squamosal, tympanoperiotic and dentition (homodont single-rooted teeth) not preserved in *P. taitapu*. Cladistically, ZMT 73 plots within the crown Odontoceti as a sister species to *P. taitapu*, or (in implied weights analysis) in a two-species clade with *P. taitapu*. This enlarged *Papahu* clade lies between the more-basal Platanistoidea and more-crownward odontocetes including Physeteroidea, Ziphiidae and Delphinida. ZMT 73 is too incomplete to warrant naming as a new species, but it adds structural details for the *Papahu* clade and in turn for the poorly known early Miocene Odontoceti.

Grant Information
Fordyce's initial studies of ZMT 73 in the later 1970s were supported by a University Grants Committee PhD Scholarship.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

NEW INSIGHTS INTO THE DIVERSITY OF DINOSAURS FROM THE LOWER CRETACEOUS KANMON GROUP, SOUTHWESTERN JAPAN

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Vertebrate fossils including freshwater fishes, turtles, crocodiles, and dinosaurs have been collected from the Lower Cretaceous Kanmon Group in Fukuoka Prefecture, southwestern Japan since the 1950s. In marked contrast to the rich paleoichthyofaunas, a theropod tooth is the only dinosaur specimen from the Wakino Subgroup, the lower part of the Kanmon Group, which has been described in the last century. Although mostly fragmentary, the specimens from the subgroup potentially represent diverse dinosaur taxa. These specimens were examined in this study to clarify their taxonomic affinities. The largest specimen from the group is a fragmentary pneumatic bone fossil which is 35 cm in length and 20 cm in height as preserved. In lateral view, it only has one pneumatic fossa and neural centrum dorsally in contact with the fossa. The lenticular pneumatic fossa is craniocaudally long and the length of its major axis is one fifth of the specimen length. Internally, it has both large and small chambers. It was identified as a cervical vertebra of a basal titanosauriform. Another specimen is a partial maxillary or dentary tooth whose crown measures 8.7 mm in mesiodistal length and 6.4 mm in apicobasal height. Its wide and prominent primary ridge, shallow indentation to the right of the primary ridge in non-occlusal view, and horizontally oriented cingulum at the base of the crown suggest that it pertains to basal Neoceratopsia. It is large compared to the teeth of most known basal neoceratopsians in the Early Cretaceous, but the teeth of *Auroraceratops* are comparable in size. The occurrence of sauropod and ceratopsian specimens in addition to the previously discovered theropod specimen demonstrates the diversity of dinosaurs from the group to be higher than previously thought.

Technical Session XIX (Saturday, October 17, 2015, 3:45 PM)

PHYLOGENETIC CLUSTERING AND GEOGRAPHIC DISPERSAL AMONG PERMO–TRIASSIC TETRAPODS

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The recovery interval that followed the end-Permian mass extinction is generally regarded as a period of instability in terrestrial ecosystems, and previous workers have suggested that it saw greater levels of endemism in Gondwanan ecosystems than were seen before the mass extinction. This study utilized phylogenetic methods such as phylogenetic clustering in order to estimate frequencies of geographic dispersal among major tetrapod clades across the Permian–Triassic (P–T) boundary at multiple phylogenetic and spatial scales. These analyses reveal a complex biogeographical pattern in which major differences in dispersal frequency are seen not only between clades but also at different geographical scales. Most clades show a dramatic increase in phylogenetic clustering across the P–T boundary, with the few exceptions being clades that were highly successful during the recovery period, such as eureptiles and temnospondyls. These differences may be attributable to differential capacity for dispersal across regions of Pangea during the Early Triassic. Nearly all clades that experienced an increase in clustering across the boundary had recovered to pre-extinction levels by the Anisian. This study also found differences in dispersal frequency between regional, continental, and supercontinental scales for some clades, and this is potentially informative about the dispersal barriers that existed for different tetrapod clades on either side of the P–T boundary.

Colbert Prize (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

UNEARTHING PATTERNS OF NICHE VARIABILITY AND DIET FLEXIBILITY IN GREAT BASIN SMALL MAMMALS THROUGH THE HOLOCENE

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Climate exerts a strong control on mammalian community composition across many ecosystems via bottom-up influence on plant communities. This is especially apparent in the Great Basin (GB) of the American west, where changes in small mammal assemblages closely track trends in climate. However, species have responded individualistically to climate driven habitat change through the Holocene into the Anthropocene. We tested the degree to which diet variability for GB small mammals was tied to climate driven habitat changes. We evaluated both inter- and intraspecific variability in the isotopic niche breadth of five small mammal species through the Holocene to the present using stable isotope analysis. We then used Bayesian mixing models to estimate the relative contribution of multiple dietary sources to species' isotopic niches.

We expected intraspecific niche breadth and diet variability to increase during periods of increased climate variability and frequency of drought. Instead, we found that intraspecific variation in $\delta^{13}C$ and $\delta^{15}N$ signals for two heteromyids, *Perognathus longimembris* and *Dipodomys microps*, decreased during a period of the Holocene characterized by frequent, severe, and persistent droughts as compared to earlier periods. The heteromyid *Chaetodipus* spp., however, showed persistent low and decreasing variability in $\delta^{13}C$ through the Holocene to the present, and an alternating pattern of decreasing and increasing variation in the $\delta^{15}N$ signal, with greatest isotopic variation associated with the period characterized by the highest magnitude wet/dry oscillations.

Notably, patterns of niche breadth variability do not appear to track dietary functional group or body size, as interspecific concordance of niche breadth variability is observed between the large herbivore *D. microps* and the small granivore *P. longimembris*. Furthermore, two members of the family Cricetidae, *Reithrodontomys megalotis* and *Peromyscus maniculatus*, showed interspecific differences in isotopic niche breadth trends. Specifically, the omnivore *P. maniculatus* is characterized by low $\delta^{13}C$ variation through the Holocene, which increases eight fold from the end-Holocene to the present, indicating increased utilization of C_4 plants.

Small mammals are sensitive indicators of climate and habitat change. Teasing out why individual species have responded in certain ways to changes in drought may be key to predicting the impacts of chronic and accelerating environmental change on future biodiversity.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

STABLE ISOTOPE EVIDENCE FOR DINOSAUR ECOLOGY FROM CAMPANIAN EGGSHELL AT THE EGG MOUNTAIN LOCALITY, WESTERN MONTANA, USA

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Egg Mountain is a late Campanian (~75 Ma) fossil-bearing locality from the Two Medicine Formation of Montana. Abundant, and in some cases exceptionally well preserved dinosaur nests and mammal remains occur within a sequence of blue-grey, strongly carbonate-cemented mudstone. Egg Mountain uniquely preserves more than six different ootaxa. Two of these have associated embryos and can be taxonomically assigned. The carbonates of the Egg Mountain sediments and eggshell present the unprecedented opportunity to assess the trophic ecology and climate of a dinosaur-dominated vertebrate ecosystem from a single site. To this end, carbon and oxygen isotope ratios were measured from 19 samples of the Egg Mountain sediments and from 51 samples of 6 different ootaxa both from Egg Mountain and from more distant parts of the Two Medicine Formation.

The carbon and oxygen isotope ratios of the sampled eggshell cluster strongly by taxon and not by area of origin. Additionally, they differ from those of the encasing carbonate, suggesting that diagenesis has not completely overprinted the original isotopic signatures of the eggshell. The average $\delta^{18}O$ for the Egg Mountain eggshell is surprisingly low: -12.3‰, with a range from -14.5‰ to -8.06‰. If consistent with $\delta^{18}O$ measured from enamel phosphate, this suggests that the Egg Mountain taxa acquired their water from an unusual, isotopically light source.

The differences in eggshell carbon isotope ratios reflect dietary enrichment with trophic level, allowing the partial reconstruction of the Egg Mountain food web. The eggs of the theropod, *Troodon*, show the heaviest $\delta^{13}C$ values, indicating that it holds the highest position in the Egg Mountain trophic web. One unidentified ootaxon plots with *Troodon*, indicating the presence of another medium-sized carnivore in the Egg Mountain ecosystem. The eggs of the hadrosaur, *Maiasaura*, and another unidentified ootaxon have the lowest $\delta^{13}C$ values, suggesting herbivorous diets. The common, yet unidentified ootaxon, *Continuoolithus*, shows a wide range of moderate $\delta^{13}C$ values, indicative of a more diverse diet.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

ENVIRONMENTAL DRIVERS OF CROCODYLIFORM DIVERSITY AND EXTINCTION THROUGH THE JURASSIC/CRETACEOUS BOUNDARY

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Crocodyliforms are an extant group of highly successful pseudosuchian archosaurs. However, their macroevolutionary history remains poorly understood, partly as a result of heterogeneous sampling of their fossil record, which obscures genuine biological patterns. Here, we focus on their diversity dynamics through the Late Jurassic and Early Cretaceous, a relatively neglected period in crocodyliform history that witnessed the demise (e.g., the marine Thalattosuchia) and apparent radiation (e.g., the terrestrial Notosuchia) of major lineages. We take a combined approach to reconstructing their diversity via application of shareholder quorum subsampling (SQS) on a newly compiled and comprehensive fossil occurrence dataset (919 occurrences of 228 genera), as well as producing a phylogenetic diversity estimate (PDE) using a newly constructed and well-sampled (270 species) informal supertree. There is strong evidence for a substantial decline in total crocodyliform diversity through the Jurassic/Cretaceous (J/K) boundary, with terrestrial forms (including semi-aquatic taxa) suffering a more severe extinction than marine taxa. Marine genera show either a diversity decline through the J/K boundary (PDE), or a slight increase (SQS), although much of the Early Cretaceous is too poorly sampled for SQS to produce reliable diversity estimates. Extinction rates were highest in the latest Jurassic, and origination rates remained depressed through the Early Cretaceous. The responses of marine and terrestrial crocodyliforms to this extinction are decoupled; whereas marine taxa did not recover to pre-Cretaceous levels of diversity, terrestrial taxa rapidly recovered and exceeded pre-Cretaceous diversity. After accounting for serial autocorrelation in a range of environmental time series data, we fitted maximum-likelihood models to identify factors that might have driven our recovered diversity and extinction patterns. A combination of eustatic sea-level changes and perturbations to the marine sulphur cycle are primarily responsible for crocodyliform macroevolutionary dynamics through the Jurassic to Cretaceous interval. It is likely that these two factors are related, with a sea-level lowstand through the J/K boundary responsible for increasing sulphur toxicity, although we cannot rule out that climatic variability (e.g., a broad aridity belt covering the low latitudes of the Southern Hemisphere), or increasing volcanic activity (e.g., emplacement of the Paraná-Etendeka flood basalts), might also have played a role.

Grant Information
NERC PhD studentship to JPT

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

PALEOENVIRONMENTAL CONDITIONS IN EARLY PLEISTOCENE ROMANIA: IMPLICATIONS FOR HOMININ DISPERSALS

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Present evidence suggests that neither intrinsic (characteristics of the organism) nor extrinsic (external factors) hypotheses can fully explain the initial dispersal of hominins out of Africa in the early Pleistocene. Though the earliest hominins appear at Dmanisi, Georgia at ~1.85 Ma, other well dated European hominins have not been recovered before 1.4 Ma (Orce Basin, Spain). Current paleoenvironmental data suggest that hominin dispersals through Europe may have been facilitated by climatic changes, but few data describing the paleoenvironmental conditions in Eastern Europe, a region through which hominins presumably dispersed, are available for the early Pleistocene.

Here we present preliminary paleoecological data from two early Pleistocene localities in Romania. The earlier of these two sites, Graunceanu, is best attributed to the Late Villafranchian (MN17/MNQ1), making this site ~1.8 Ma. Copaceni, a slightly younger, smaller locality that is still actively producing fossils, has been preliminarily dated to ~1.2 Ma based on biostratigraphy. Together, these two sites bracket the interval during which hominins are thought to have first dispersed into Europe, and may therefore provide important clues regarding paleoenvironmental changes during this time. We examined mesowear and isotopic compositions for a sample of cervids (*Eucladoceros*, *Megaloceros*, indeterminate Cervidae) and bovids (*Leptobos*) from both of these sites. Mesowear analyses indicate that most of the specimens examined were browsers. *Megaloceros* and *Leptobos* have mesowear patterns consistent with leaf browsing, while Cervidae (gen. + sp. unknown) and *Eucladoceros* sp. are more variable, and overlap somewhat with mixed feeders. Most specimens analyzed have relatively low $\delta^{13}C$ values, consistent with foraging in forested to closed environments. These results are particularly interesting since ecomorphological analyses for *Eucladoceros* from Graunceanu indicate open-habitat adaptations; a mosaic morphological pattern for this taxon that has also been noted at other paleontological localities. Coupled with a continued re-inventory and analysis of the Graunceanu remains and continued recovery and identification of fossil remains from Copaceni, these data have the potential to shed further light on paleoenvironmental conditions during this critical time period in hominin evolution.

Grant Information
NSF BCS-0824607; Josiah Charles Trent Memorial Foundation; University of Arkansas

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

PARTITIONING CHANGE IN BODY SIZE AMONG HERBIVORES DURING THE MIDDLE MIOCENE CLIMATIC OPTIMUM

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During climatic shifts, we expect changes in the overall limits and distribution of mammalian herbivore body size within clades as a consequence of metabolic demands and shifts in vegetation structure and distribution. The middle Miocene Climatic Optimum is well-established as an interval with exceptionally high taxonomic diversity of browsing ungulates in North America, with considerably higher taxonomic diversity than is seen in any modern fauna. Following the onset of cooling, species richness of low-crowned (browsing) ungulates declined rapidly, while richness of higher-crowned (open-area feeding) taxa did not. These changes in richness reflect the loss of smaller-bodied hindgut fermenting herbivores, but are not indicative of the shifts in size distributions among guilds.

Analysis of a high-resolution data set of Cenozoic North American herbivore body size identified a four-fold increase in the maximum size of perissodactyls, and a concomitant increase in minimum size for perissodactyls, while the size minimum for artiodactyls did not change.

Statistical moments have been used to characterize the body size distribution at localities for the Pleistocene. Applying these measures to guilds from the Middle Miocene allows more finely detailed partitioning of changes in body size distribution among herbivores. The large herbivores increased in median size, which can be attributed to increasing median size among brachydont taxa, while higher-crowned taxa show little change in median size. Partitioning the taxa using a phylogenetic bracket for gut fermentation strategy shows a decline in median size among hindgut fermenters during the Barstovian. This is accompanied by subtler shifts in the skewness of the distribution of brachydont taxa at sites, and in the kurtosis of the distribution of foregut fermenting taxa. These trends in body size distribution across North America provide a more nuanced understanding of the changes among herbivorous guilds.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

CONCRETIONARY DINOSAUR TRACKS FROM THE UPPER CRETACEOUS BELLY RIVER GROUP OF ALBERTA, CANADA: NEW MODE OF FOOTPRINT PRESERVATION IMPLIES WIDESPREAD OCCURRENCE OF UNRECOGNIZED TRACKS

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A novel type of preservation for dinosaur tracks is recognized based on ichnofossils found in the Upper Cretaceous Belly River Group of southern Alberta. These tracks are preserved as conspicuous sideritic or calcareous concretions protruding out of fine-grained deposits, and may have largely gone unrecognized as tracks due to the unusual nature of their preservation. All tracks display similar internal structures (microscopic convoluted laminations) and are preserved in strata with pedogenic and sedimentary features (e.g., soft-sediment deformation, redoximorphic features, gley) indicative of wet paleoenvironments where the ground was soft and water-saturated. Such features suggest that formation of these concretionary tracks was initiated when waters rich in dissolved carbonates flooded footprints left in the soft substrate. As ponded water evaporated, minerals precipitated and mixed with clastic and organic material that washed into the footprints, settling to form fine laminations. Cementation of the infilled tracks into concretionary casts occurred relatively soon after burial (<100 years), probably in response to microbial activity related to decomposition of organics and to chemical saturation by mineral-rich groundwater. The composition of the mineral precipitate (calcium carbonate versus siderite) would have been dependent on the prevalent groundwater conditions (e.g., pH, dissolved carbonate and sulfate concentrations). Our recognition of this novel type of ichnofossil suggests that dinosaur tracks could be more

widespread than previously thought, particularly in strata that represent poorly-drained paleoenvironments. Concretionary tracks are transient ichnofossils that tend to disintegrate rapidly once fully exposed, which may explain why they are rarely recognized.

Grant Information
Royal Tyrrell Museum, Killam Postdoctoral Fellowship, and Natural Sciences and Engineering Research Council Discovery grant

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

"STUDENTS DISCOVER" SHARK TOOTH FORENSICS: A CITIZEN SCIENCE INITIATIVE BRIDGING MIDDLE SCHOOL STUDENTS, TEACHERS, AND PALEONTOLOGISTS

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In K-12 classrooms across the USA there is a clear imperative to enhance STEM education by engaging students with authentic, rather than prescriptive scientific experiences. In 2014, public school teachers from across North Carolina teamed up with paleontologists at NC State University and the NC Museum of Natural Sciences to participate in "Students Discover"–a National Science Foundation funded program in which middle school students and teachers conduct exploratory science at the museum, and then design and implement public science curriculum for classrooms based on these experiences. These curriculum-based lesson plans are modeled on NC Science Standards, Next Generation Standards, Social Studies Standards, and Common Core ELA and Math to encourage scaling in other classrooms across the USA and around the world.

The first paleontology effort developed as part of Students Discover was Shark Tooth Forensics – a public (citizen) science project – to advance our understanding of ecological and taphonomic biases within late Cenozoic marine deposits on the eastern seaboard using fossilized sharks teeth. Teeth derive primarily from the Miocene-age Pungo River and the Pliocene-age Yorktown Formations of the PCS Phosphate mine (Lee Creek) in Aurora, NC. North Carolina students sorted sediment to isolate fossil teeth, then measured and recorded specimen data and returned specimens with the remaining sediment to the museum for accessioning. Students analyzed the newly collected data as part of the curriculum. Histograms produced by each of 15 classes consistently recovered a normally distributed population of tooth sizes ranging from 1-22 mm (mean 5-6 mm). Reproduction of the results by paleontologists revealed that students found the majority of teeth, including the smallest specimens without magnification. This test demonstrates that middle school students can provide reliable data for citizen science projects involving the sorting of fossil material under these conditions. We noted that students with reserved demeanors in typical class settings became more active during open discussion and instruction. We also find that students display an increased interest in science that is likely attributable to the authentic, data-oriented approach taken in "Students Discover", whereby students can ask and answer questions for which there is no known answer and therefore contribute meaningfully to scientific knowledge and exploration. This interpretation is supported by self-reported data collected in the student's post-project assessment.

Technical Session XI (Friday, October 16, 2015, 11:00 AM)

EXPLORING RODENT HEAD-SPACE: GEOMETRIC MORPHOMETRICS APPLIED TO HETEROMYID CRANIA (RODENTIA: HETEROMYIDAE)

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Heteromyidae is an ecologically and morphologically diverse clade of rodents endemic to North America with a fossil record that extends from the recent to the Late Oligocene (ca. 32 Ma) and a well-resolved phylogeny for extant species based on mitochondrial genes. This clade is an ideal case for analyzing the evolution of cranial shape in relation to long term patterns of climatic and environmental change. Here we use 3D landmark-based geometric morphometrics to investigate cranial shape variation in a phylogenetically-broad sample of extant heteromyids to establish a framework for analyses that include extinct species.

High-resolution (3–34 µm) µCT scans of 24 extant species of heteromyids and one sciurid were isosurfaced and downsampled to 10 million polyfaces to minimize file size and resolution biases. We placed 74 homologous landmarks on each of the 25 cranial models to create the initial dataset. To examine observer error in landmark placement, we replicated placement of all landmarks 10 times on each of four specimens over several months and calculated standard deviations for each landmark. The observed errors on replicates of the same individuals were small relative to the differences between specimens.

After generalized Procrustes alignment of the 25 landmark configurations, we used principal component analysis to explore variation in cranial shape among the sampled heteromyids. All specimens clustered with congenerics on the first and second principal components, with sister clades *Perognathus* and *Chaetodipus* located somewhat apart from the rest. Interestingly, though genetic evidence has shown *Liomys* and *Heteromys* to be sister taxa, they do not group together in this low-dimensional summary of shape space. Thin-plate splines identified shape changes in the auditory and parietal regions of the skull as the important differences between genera, and landmarks in these regions also loaded more heavily on principal components one and two.

Our geometric morphometric approach, paired with the existing molecular phylogeny, provides a framework in which we can further explore cranial shape change in heteromyids, both extant and extinct. Continuing work is focused on increasing the taxon sampling and overall sample size in Heteromyidae and using more focused analyses to explore the relationship between phylogeny and morphology. Future work will apply these methods to the heteromyid sister taxon, Geomyidae, allowing us to explore cranial shape change across a broader spectrum of habitats, diets, and body sizes.

Grant Information
NSF EAR-1338262 and University of Minnesota Grant-in-Aid

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

THE UPPER CRETACEOUS THEROPOD RECORD OF THE IBERIAN PENINSULA

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Europe was an archipelago of islands at the end of the Cretaceous. Its continental Upper Cretaceous fossil record has been identified from several countries. Among them, the Iberian Peninsula record is one of the most informative. It can give us relevant information of the diversity and evolution of European dinosaur faunas at the end of the Cretaceous. The Iberian theropod record, however, is particularly scarce. Complete or partial theropod skeletons are rare and postcranial material is not abundant either, so our main knowledge comes from isolated teeth.

The Spanish sites of Laño (Condado de Treviño) and Lo Hueco (Cuenca) are identified as the richest and most diverse sites for theropod remains in all of Europe. Nearly three hundred teeth have been recovered from these two sites. Other outcrops, such as those from the South Pyrenees Basin (Lleida and Huesca), Quintanilla del Coco (Burgos), Chera (Valencia), Armuña (Segovia) and the Portuguese sites of Taveiro, Aveiro, and Viso, provided some remains, which also improve the information on the diversity and evolution of the theropod faunas at the end of the Iberian Cretaceous.

In the late Campanian, some sites from the South Pyrenees Basin (Vicari 4, Suterranya, and Figuerola 2) show the presence of four theropod taxa: Coelurosauria indet., *Richardoestesia*-like, cf. *Richardoestesia* sp. and an indeterminate form of large size. In the late Campanian and the early Maastrichtian interval, we find the highest diversity. In the sites of Montrebei (Lleida), Laño, Lo Hueco, Quintanilla del Coco, Chera and Armuña, seven theropod taxa are identified: Coelurosauria indet., cf. *Richardoestesia* sp., cf. Dromeosauridae indet., cf. Velociraptorinae indet., cf. *Pyroraptor olympius*, Ornithomimosauria indet. and Theropoda indet. In the late Maastrichtian record, from the sites of Blasi 1, 2B and 3 (Huesca), and from the Portuguese sites of Aveiro, Taveiro, and Viso, six theropod taxa are recognized: Coelurosauria indet., cf. *Paronychodon,* cf. *Richardoestesia* sp., cf. Dromeosauridae indet., cf. Troodontidae and Theropoda indet.

The strict stratigraphic control of these sites allows us to evaluate the evolution and the diversity of these faunas. We observe an increase of the diversity from the late Campanian to the early Maastrichtian, followed by a small decrease in the late Maastrichtian. As occurs in other European dinosaurian groups, the results suggest that in the Iberian Peninsula the non-avian theropod extinction was quick in geological terms.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

R.O.C.K.S.: REAL OPPORTUNITIES TO CONNECT KIDS WITH SCIENTISTS- A COLLABORATIVE OUTREACH PROGRAM BETWEEN SCIENTISTS, EDUCATORS, AND DIGITAL MEDIA TO BRING PALEONTOLOGY INTO THE CLASSROOM

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Through both its educational programming and partnerships with other highly regarded institutions, like the Grand-Staircase Escalante National Monument (GSENM), the Natural History Museum of Utah (NHMU) has a statewide reach that extends to every school district in Utah. Nonetheless, despite NHMU's extensive programming, many of Utah's schools remain underserved due to the lack of financial resources for field trips to the Museum or field sites. In response, the R.O.C.K.S. Program, or Real Opportunities to Connect Kids with Scientists, was developed to bring paleontology to life by taking students and teachers from a selected school into the field and behind the scenes at the Museum through digital and hands-on experiences.

The ROCKS Program has five components: (1) A suite of three videos showcasing paleontologists in the field at GSENM, fossil prep lab, and collections, each of which highlights the scientific process throughout the study of paleontology; (2) Teacher training and classroom outreach to emphasize critical thinking through hands-on exploration of paleontological specimens; (3) Skype session with the Curator of Paleontology in which students and teachers have the opportunity to reflect on research they completed during the outreach program and participate in scientific inquiry alongside an expert in the field; (4) Students and teachers visit NHMU to tour the areas featured in the videos, meet paleontologists, and engage with Museum exhibits; (5) Teachers and students complete an evaluation regarding their experiences with Museum scientists and educators.

The 4th grade classes chosen to participate in ROCKS were from a Title I Elementary School where only 19% of the students were deemed "proficient" in science after completion of their annual state-wide Core Curriculum exam. Additionally, 75% of the student body is OF low socio-economic status, with over half of all students being English Language Learners. Upon completion, the ROCKS Program reached 110 fourth grade students, four teachers, 17 chaperones, and 11 young children (ages 3-infant). While it is difficult to quantify the results, student and teacher evaluation responses indicated that ROCKS provided multiple opportunities that would have otherwise been unavailable to them. By allowing students to participate in scientific investigations alongside Museum staff, the ROCKS Program was able to break down the perception of the exclusivity of science and allow the student to see her/himself as not only a learner, but a paleontologist, too.

Grant Information
Support for this program was provided by the 2014 Paleontological Society Outreach and Education Grant

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

PALEOECOLOGICAL IMPLICATIONS OF A NEW SPECIMEN OF THE ANKYLOSAUR *MYMOORAPELTA MAYSI* FROM THE HANKSVILLE-BURPEE QUARRY, LATEST JURASSIC (TITHONIAN) MORRISON FORMATION (BRUSHY BASIN MEMBER)

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The Hanksville-Burpee Quarry, located on public lands administered by the Bureau of Land Management near Hanksville, Utah, represents a sauropod-dominated bonebed within the Brushy Basin Member of the Morrison Formation and is being excavated by Burpee Museum of Natural History and Stony Brook University. The site has been interpreted as a braided-river deposit and contains specimens of *Camarasaurus*, *Diplodocus*, *Apatosaurus*, and possible *Barosaurus*, as well as *Allosaurus* and a small ornithopod. A new specimen of *Mymoorapelta maysi* was discovered in the summer of 2014. Whereas other specimens of *Mymoorapelta* have been found spread over larger distances, the current specimen is spread over less than three cubic meters. The preservation and close association of the new specimen suggests that transport was limited and that this individual lived relatively far from the coast before being buried in this braided stream deposit. At present, the associated *Mymoorapelta* material appears to be that of one individual, as no duplicate elements have been found and element size is consistent. This specimen currently consists of approximately 24 osteoderms, three ribs, one vertebra, and a femur, with more likely to be uncovered in the coming season. Recent phylogenetic work has recovered *Mymoorapelta* as a nodosaurid or basally branching ankylosaurian, but little consensus exists as to its phylogenetic relationships. Studies of Cretaceous paleoecological dinosaur preferences suggest that nodosaurids may have lived closer to the coast than did ankylosaurids. However, the environmental preferences of the early members of the group are less understood due to their rarity in Jurassic deposits. This new occurrence of *Mymoorapelta* is notable not only because it increases the known number of specimens from 7 to 8, but also because it is a fourth co-occurrence in a locality dominated by sauropods.

Colbert Prize (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

BODY TEMPERATURE VARIATION OF MOSASAURS (SQUAMATA: MOSASAURIDAE) FROM THE WESTERN INTERIOR SEAWAY OF KANSAS, USA

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Mosasaurs (Squamata: Mosasauridae) were secondarily aquatic reptiles that evolved from varanid-like ancestors and spread into marine niches 98-65 Ma, during the last half of the Cretaceous. Within the Late Cretaceous strata of the Western Interior Basin of North America, over 3000 specimens have been described, allowing for a better understanding of mosasaur distribution, relationships, and diversity. Although these studies continue to add to the growing body of work, other important questions regarding the ecology of this family remain unanswered. The metabolic status of mosasaurs is paramount in understanding their daily energy needs, feeding methods, and the ability to take advantage of colder environments. Recent stable isotope studies comparing oxygen values of phosphate from the teeth of marine reptiles to those of coeval fish estimated mosasaur body temperature to be in the range of 35° ± 2°C to 39° ± 2°C. Additionally, other researchers recently analyzed the oxygen isotope composition from phosphate of coeval turtle and fish fossils from Kansas and Mississippi, demonstrating that previously observed paleoenvironmental zones of the Western Interior Seaway were latitudinal and likely a result of both temperature and salinity variation during the Late Cretaceous. Presented here are the results of an isotopic analysis of oxygen from phosphate preserved in the skeletal elements of core (cervical and dorsal vertebrae) and extremities (limbs, cervical and caudal vertebrae) of the North American mosasaurs, *Platecarpus*, *Tylosaurus*, *Clidastes*, and *Ectenosaurus* from western Kansas. The temperature estimates resulting from this study demonstrate that the core body temperature of mosasaurs were substantially higher than that of the surrounding ocean water and indicate that they were employing a form of endothermy as a source of internal heat.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

A U-PB ZIRCON AGE FOR REED'S QUARRY 9, UPPER JURASSIC MORRISON FORMATION, ALBANY COUNTY, WY

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Reed's Quarry 9 at Como Bluff in Albany County, Wyoming has yielded the most diverse, well-studied microvertebrate fauna from the Upper Jurassic Morrison Formation. Discovered in 1879 by W. H. Reed during his time prospecting and collecting fossils for O. C. Marsh, it was worked by Reed and others for nearly 10 years before it seemed to be exhausted. It was re-opened in 1897 by the AMNH, but yielded only one mammalian jaw at that time. Additional work was undertaken by the Field Museum in the 1960s, and then by a joint expedition from the AMNH and Yale during the summers of 1968–1970.

The result is a collection of many thousands of specimens, representing 30 taxa of bony fishes, lepidosaurs, amphibians, crocodylians, turtles, pterosaurs, and dinosaurs. Quarry 9 also yielded a diverse mammalian fauna, with more than 250 individual specimens representing 6 families.

The original, most productive fossil-bearing horizon was a gray-green silty mudstone with isolated mud clasts. This horizon was bulldozed during the excavations in the late 1960s and can no longer be observed today. Luckily, many of the fossils collected by Reed were removed with their surrounding matrix, and remained unprepared in the collections of the USNM. We recently removed and radiometrically dated this matrix; thus, the age we report here is that of the fossils collected from the original Reed excavations.

We processed the mudstone matrix using manual and ultrasonic disaggregation techniques as well as standard heavy liquid and magnetic separation methods. The resulting heavymineral separation was hand-picked under a binocular microscope to choose crystals with specific morphologies typical of ash-fall zircons such as elongate tips, longitudinal bubble trails, and transverse channels. Selected single zircons were analyzed using the CA-TIMS method. Based on these analyses, an age of 152.51 ± 0.47 Ma is proposed for Quarry 9. This age is the weighted mean of six $^{206}Pb/^{238}U$ dates with uncertainty at a 95% confidence interval.

This latest Kimmeridgian age for Reed's Quarry 9 has several important implications. First, it provides a radiometric age for a geographic area lacking in such data (most ages for the Morrison Formation are from the Colorado Plateau). Second, it allows direct correlation with other dated horizons in the Morrison Fm across the depositional area and helps in deciphering the complex stratigraphy of the formation. Finally, this new age allows comparisons with coeval vertebrate faunas worldwide including those from England, Portugal, Africa, and China.

Romer Prize Session (Thursday, October 15, 2015, 11:45 AM)

THE HIP JOINT FUNCTIONAL MODULE AND ITS SIGNIFICANCE IN THE EVOLUTION OF AVIAN LOCOMOTOR POSTURE

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Birds walk using a habitually flexed hip posture and a locomotor cycle proximally driven by knee flexion and femoral long axis rotation. This unique locomotor repertoire originated in a diverse assemblage of theropod dinosaurs. Theropods are characterized by wide disparities in body size, locomotor posture, and hip joint morphology. However, the origin of the modern avian hip joint is poorly understood. This study reconstructs the articular anatomy of theropod hip joints using osteological correlates, infers major trends in character transitions, and tests the integration between femoral and acetabular soft tissue anatomy. Femora and pelves of 96 theropods and outgroup taxa were digitized using 3D imaging techniques. Key phylogenetic transitions in ligament and cartilage were estimated using maximum likelihood ancestral state reconstruction on the osteological correlates. The femora of basal theropods possessed expanded fibrocartilage sleeves on the metaphysis, which surrounded the epiphyseal hyaline cartilage cores. The acetabulae of basal theropods permitted mostly parasagittal femoral movements, due to bony constraints imposed by the rostrolaterally ossified joint capsule. In contrast, avian-like articular cartilage, which consists of a composite fibro-hyaline structure, originated within Maniraptora. Reduction of rostrolateral joint capsule in Avetheropoda allowed the femur to undergo axial rotation and coupled protraction-abduction. Multiple maniraptoran lineages independently expanded the bony antitrochanter, suggesting bird-like acetabulae evolved independently in Therizinosauria, Oviraptorosauria, Deinonychosauria, and Avialae. These findings indicate that the avian-like flexed hip posture independently evolved in the four maniraptoran clades, and that the theropod hip joint underwent mosaic evolution within the avian stem-lineage. In particular, the femoral and the acetabular cartilages evolved as distinct modules, likely associated with the correlated evolution of epiphyseal cartilage with joint loading, growth strategies, and body size.

Grant Information
Jurassic Foundation Research Grant, Welles Research Fund, and University of Missouri Life Science Travel Grant

Poster Symposia (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

INTRODUCTION TO THE 3-D CARNIVORAMORPHAN POSTER SYMPOSIUM: TOOLS OF THE TRADE IN 3-D IMAGING BASED ANALYSES OF VERTEBRATE STRUCTURES

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Computed tomography (CT) and laser scanning provide ways to visualize and study organismal structure in silico and non-destructively. Despite 3-D approaches in systematic and functional morphological studies involving fossil and extant vertebrates becoming more common in the scientific literature, the software programs chosen by researchers have not been a focus of comparative study to clarify their suitability for different analytical approaches. A good demonstration of this point can be seen with the collection of research posters associated with this poster symposium. Here we provide an overview of the most commonly used commercial and open-source software programs for processing CT and laser 3D data. Three commercial programs (Mimics, Avizo, VG Studio) are commonly used to extract anatomical regions of interest from CT data, both for anatomical study or downstream analyses; however, the most comparable open-source option (3D Slicer) for 3-D feature extraction from CT is very much still under development, and the user interface more technical than in the commercial options. Next, several commercial mesh-improving programs (Geomagic Studio, Rhinoceros, Maya) are commonly used by vertebrate paleontologists and morphologists to clean up 3-D representations of the anatomical regions of interest from CT and laser scanning, or to generate suitable surface mesh models for output to downstream analysis programs, 3-D printers, etc. The open-source option (Blender) for conducting similar operations on 3-D representations presents a much steeper learning curve because of, again, its all-purpose, highly technical user interface, when compared to commercial programs. Lastly, we provide examples of commercial and open-source specialized software programs for conducting additional analyses (e.g., geometric morphometrics, finite element analysis, musculoskeletal reconstructions) or 3-D printing. This review of different software tools for 3-D imaging based analyses highlights the variety in the programs used to generate 3-

D representations and models, and suggests a need for software-based sensitivity tests of the same 3-D analysis protocol conducted using different programs. Before a baseline comparability measure can be established for data generated from different programs and protocols, direct comparisons of results arising from such analyses should be considered with caution.

Grant Information
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Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

A LARGE AND PRIMITIVE HIPPO-LIKE LOWER MOLAR FROM THE LOWER MIOCENE OF KENYA

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The origin of the Hippopotamidae (Mammalia, Cetartiodactyla) is currently hotly debated by several researchers. The undoubtedly oldest record of the family has come from the middle Miocene of Kenya, which has yielded a kenyapotamine hippopotamid, *Palaeopotamus ternani* (=*Kenyapotamus ternani*). *Morotochoerus* from the lower Miocene of Uganda and *Kulutherium* from the lower Miocene of Kenya are recently suggested to be representatives of primitive hippopotamids and are tentatively assigned to the Kenyapotaminae, although this phyletic relationship is still debated. The fossil material of these two Early Miocene genera is very limited.

Here, we report a lower molar trigonid of a large and primitive hippopotamus discovered from the upper lower Miocene Rusinga Group of Mfwangano (= Mfangano) Island (ca. 20–18 Ma) in Lake Victoria, southwestern Kenya. The present molar trigonid is similar in size to that of a living hippopotamus, and is comparable in morphology to that of the kenyapotamine hippopotamids in having a brachyodont crown, bunodont cusps, an M-like structure on the distal trigonid wall, a single-ridged premetacristid, and a buccolingually-bifurcate mesial root, and in lacking a paraconid. On the basis of its size and morphology, the present specimen appears to be assignable to *Kulutherium*, which is a putative kenyapotamine previously known from the upper lower Miocene Kulu Formation (ca. 17–15.5 Ma) of Kenya and is represented only by the upper dentition. The present specimen provides additional evidence that a living hippopotamus-sized, large hippopotamid had already existed during the early Miocene. If this specimen is definitively assigned to *Kulutherium*, it would also provide additional evidence to support the assignment of *Kulutherium* to the Kenyapotaminae.

Grant Information
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Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

A NEW SPECIMEN OF *SHARTEGOSUCHUS* (ARCHOSAURIA: CROCODYLIFORMES) FROM THE UPPER JURASSIC IN SHAR TEG, WESTERN GOBI DESERT, MONGOLIA

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The basal crocodyliform *Shartegosuchus asperopalatum* was originally described based on the holotype consisting of the skull and lower jaws. We report a new specimen of this taxon found by the Japanese-Mongolian Joint Expedition from the Upper Jurassic of the type locality, Shar Teg, in the western Gobi Desert of Mongolia. It is an articulated skeleton consisting of the skull and lower jaws, precaudal vertebral column, pelvic girdle, forelimb missing the manus, femur, tibia and fibula. The skull is 37 mm in length. CT scan data revealed that the sculptured secondary palate consists of both the palatine and pterygoid, with the part just anterior to the secondary choana likely comprised of the pterygoid. Unlike in the holotype skull, the right and left pterygoids and palatines do not meet ventrally, leaving the choanal groove open, suggesting that the opening or closure of this groove is an ontogenetically or individually variable characteristic. The presacral vertebral column is approximately 2.2 times as long as the skull. The neural arch and centrum of each dorsal vertebra are apparently fused together, suggesting that this is an individual close to maturity, despite the open choanal groove. As in *Fruitachampsa*, the preserved limb bones are all slender: the length/diameter ratio is 12.8 in the humerus, 16.8 in the ulna, and 14.3 in the femur, respectively. In addition, relative to the stylopodial elements, the zeugopodium is elongated in both the fore- and hind limbs: the ulna is 97% of the humerus in length whereas the preserved part of the tibia missing the distal part is 90% of the femur in length. In addition, the ulnare is also elongated, approximately 36% of the humerus in length. A cladistic analysis including postcranial characters confirmed a previously-proposed close relationship between *Shartegosuchus* and *Fruitachampsa* outside of Mesoeucrocodylia, supporting the hypothesis that the clade of these small-bodied crocodyliforms was widespread in Asia and North America.

Technical Session III (Wednesday, October 14, 2015, 8:15 AM)

THE PERMIAN AND TRIASSIC PARAREPTILES OF TANZANIA AND ZAMBIA: REVIEW OF DIVERSITY AND NEW LIFE HISTORY INSIGHTS PROVIDED BY OSTEOHISTOLOGY

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Parareptiles are prominent members of the Permo-Triassic faunas of Tanzania and Zambia, and recently renewed fieldwork in the Ruhuhu Basin of Tanzania and the Luangwa Basin of Zambia has recovered important new material. A critical review of historic and recently collected fossils fosters a deeper understanding of parareptile evolution and biogeography, and an osteohistological analysis provides important information about the life history of these animals.

Reexamination of Tanzanian fossils first described in the 1930s has revealed a pareiasaur with unique osteoderm morphology that likely represents a new taxon. The remainder of the pareiasaur material can be assigned to one of three genera also known from South Africa: *Pareiasuchus* and *Anthodon* from the upper Madumabisa Mudstone Formation of Zambia, and *Pareiasaurus* and *Anthodon* from the Usili Formation of Tanzania. These pareiasaurs support a *Cistecephalus* Assemblage Zone equivalent age for these two formations. Review of the Triassic material has led to the identification of a new procolophonoid, *Ruhuharia*, as well as a new procolophonid, both from the Middle Triassic Manda beds of Tanzania. By contrast, the Triassic Ntawere Formation of Zambia has yet to yield procolophonoid fossils. Although not as diverse as the contemporaneous South African or Russian faunas, the Permian rocks of Tanzania and Zambia have produced primarily cosmopolitan taxa shared with coeval rocks in the Karoo Basin of South Africa, whereas the Triassic parareptiles of Tanzania and Zambia consist of endemic taxa. Increased endemism during the Middle Triassic when compared to the Late Permian is consistent with the general pattern seen in southern Pangea.

In order to test hypotheses of growth and lifestyle in pareiasaurs, a histological analysis was conducted on a tibial cross-section from a subadult *Pareiasuchus nasicornis* from Zambia. The microstructure of the tibia is largely trabecular bone, with relatively thin compact bone composed of avascular parallel-fibered tissue, indicating a slow appositional rate. Growth marks are recognized in the cortex as annuli only (not as Lines of Arrested Growth), suggesting the periodic slowing (but not stopping) of growth. The circumference of these growth marks increases linearly towards the periphery, suggesting the individual was still growing at the time of its death. A linear discriminant analysis of the compactness of the tibia suggests a terrestrial lifestyle, in contrast with previous inferences of an amphibious lifestyle for a specimen of *Pareiasaurus*.

Grant Information
National Science Foundation EAR-1337569 and EAR-1337291 and Deutsche Forschungsgemeinschaft Mu 1760/2-3

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

CLARENDONIAN–BLANCAN VERTEBRATE BIOSTRATIGRAPHY AT THE EASTERN EDGE OF THE GREAT PLAINS, EAST-CENTRAL NEBRASKA, USA

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Pre-Rancholabrean Late Cenozoic vertebrate fossils from the North Loup Valley of east-central Nebraska, summarized herein for the first time, form an important link with previously documented faunas in the valleys of the Niobrara and Republican rivers and elsewhere. Six localities in Greeley, Howard, Nance, Sherman, and Valley counties span more than 8 million years of mammal and grassland evolution near the limit of the present Great Plains.

Remains of the barrel-bodied rhinoceros (*Teleoceras major*) and of the equid *Pseudhipparion gratum* restrict the Blasing and Fullerton Rhino localities to the Clarendonian North American Land Mammal Age (NALMA). Definitive Hemphillian taxa are identified from the Rockville and Happy Jack Mine localities. The Rockville fauna includes remains from two rhinocerotids (*Teleoceras fossiger* and *Aphelops mutilus*), the lion-sized felid *Machairodus* cf. *M. coloradensis*, the Kodiak-sized ursid *Agriotherium*, and the palaeomerycid *Pediomeryx hemphillensis*, an assemblage that clearly indicates a late Hemphillian (Hh3) age. Teeth of the geomyid *Pliogeomys* and an indeterminate sciurid were retrieved from the sediment fills of fossil rodent burrows at the Happy Jack Mine. The co-occurrence of two species of *Geomys*, the skunk *Buisnictis breviramus*, and *Canis lepophagus* restrict the Scotia Siphon locality to the Blancan (subdivision IV or V) NALMA. The newly discovered Davis Creek Reservoir site yields skeletal elements from the advanced gomphothere *Stegomastodon mirificus* and from the giant camelid *Titanotylopus*, which indicate a Blancan or early Irvingtonian age.

Geologic data suggest that no fossils older than the Clarendonian NALMA should exist in east-central Nebraska, but a geological reconnaissance indicates potential for the discovery of additional Clarendonian-Hemphillian fossil localities, and perhaps for new Blancan and Irvingtonian ones as well.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

REMOVING ASSUMPTIONS OF ANATOMICAL ORIENTATION FROM CLADISTIC CHARACTERS: AN EXAMPLE FROM PAREIASAURS

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The importance of standardizing anatomical nomenclature has been a point of debate over the past few decades. For the most part, paleontologists have managed to mesh terminology from the four major systems of classification (Nomina Anatomica, Nomina Anatomica Avia, Nomina Anatomica Vetinaria, and the unstandardized Romerian 'reptilian' terminology) into informative and multi-faceted descriptions of the anatomy observed in fossil species. Despite contention over the standardization of specific terms (e.g., names applied to certain bones) and cranio–caudal orientational terminology, limb orientational terminology (e.g., anterior, dorsal, etc.) is generally used without detailed consideration when anatomical character states are developed for phylogenetic analysis.

Pareiasaurs, a group of broadly distributed terrestrial herbivorous reptiles that lived during the middle to late Permian (~265–252 Ma), have been inferred to possess a sprawling forelimb and semi-upright hind limb. Hence, many characters and character states describing limb anatomy reflect the inferred posture, using the assumption of element orientation as part of the description itself. Our recent work on the appendicular skeleton of *Bunostegos akokanensis* (Amniota, Parareptilia), a morphologically unique pareiasaur with inferred non-sprawling posture, revealed a suite of characters that could not be scored given the assumption of sprawling orientation. In particular, the descriptors of orientation used on limb elements reveal a fundamental flaw: currently utilized terminology weaves both element anatomy and inferred posture into a single description.

In order to accurately compare and score the same morphologies with varying inferred posture across a clade, the anatomy and inferred orientation must be separated.

Here we present the most up-to-date revision of cladistic characters used to examine pareiasaur phylogeny that we have rigorously rewritten using a neutral vocabulary more universally applicable across taxa with a high degree of anatomical and postural variability. We advocate using within-element landmarks (e.g., flexor and extensor surfaces) as the primary orientational descriptor when describing the anatomy of bony elements (e.g., limbs) in which orientation is variable. This small shift has the potential to standardize appendicular orientational nomenclature across tetrapods and to encourage the distinction between element description and inferred element function.

Grant Information
This research supported by National Science Foundation EAR-0617718.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

EVALUATING THE INFLUENCE OF BODY SIZE ON APPENDICULAR ANATOMY OF TITANOSAURIAN SAUROPODS

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The postcranial anatomies of giant titanosaurians remain poorly known because of a combination of preservational and putative collection biases. This has hindered our understanding of whether specializations of wide-gauge posture may have evolved among the largest titanosauriforms in support of or as a consequence of extreme body size. *Dreadnoughtus schrani*, a recently described, giant titanosaur from the Campanian–Maastrichtian Cerro Fortaleza Formation of southern Argentina, offers the first opportunity for detailed study of the appendicular anatomy of a truly giant titanosaurian. The entire appendicular skeleton of *Dreadnoughtus* is represented, except the manus and portions of the pes. Comparison of *Dreadnoughtus* to related taxa reveals that though considerable variation exists among the appendicular skeletons of titanosauriforms, anatomical variations rarely correlate with body size. In particular, appendicular similarities are evident between *Dreadnoughtus* and taxa ranging from the large *Elaltitan* to the dwarf taxon *Magyarosaurus*. Cross-referencing body size against appendicular phylogenetic character states for titanosauriforms quantitatively confirms that appendicular apomorphies are broadly distributed among titanosauriforms of all body sizes. This suggests that distribution of appendicular similarities among titanosauriforms is controlled by phylogeny, not body size. Surprisingly, we found only a single feature to be shared exclusively by a suite of the largest titanosauriforms: an accessory ventrolateral process on the preacetabular lobe of the ilium. This process appears to have arisen in response to greater stress applied by hind limb adductor musculature in these giant sauropods. Continued investigation of titanosaurian anatomy, myology, and biomechanics is needed to gain greater understanding of the functional nature of wide-gauge posture and how it may or may not have varied among titanosaurs of differing body sizes.

Grant Information
National Science Foundation Graduate Research Fellowship (DGE Award #1002809)

Technical Session VI (Thursday, October 15, 2015, 11:30 AM)

TOOTH-LIKE STRUCTURES ON THE ROSTRUM OF THE CRETACEOUS BATOID *SCHIZORHIZA*

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Chondrichthyans possess both true teeth within their mouth and tooth-like denticles on their skin, both outside and inside the mouth. Understanding the relationships between teeth and denticles is fundamental to the interpretation of the origins of teeth within the gnathostomes. Superficially tooth-like structures on the body surface of sharks and rays typically comprise body-covering denticles and various structures that appear to be derived from them (such as dermal thorns in many rays and tail spines in stingrays). In addition, elongate 'teeth' are present on lateral edges of the rostrum of several clades; pristiophorids (sawsharks), pristids (sawfishes) and sclerorhynchids (extinct sawfish-like rays). Despite their highly derived form, these appear to represent convergent evolution of modified dermal denticles, either growing continuously (pristids) or added to/replaced through life (pristiophorids, sclerorhynchids).

Rostral 'teeth' of the Cretaceous batoid *Schizorhiza* differ from those of other chondrichthyans, and challenge the idea that all rostral 'teeth' are derived from dermal denticles and do not represent 'teeth outside the mouth', as they show a series of characters otherwise only present within oral teeth. Several partial to near complete articulated rostra were obtained from the Maastrichtian of Morocco. These were studied by surface observation, thin sectioning and micro CT scanning. Individual 'teeth' have a unique morphology with a short crown and deeply divided root. 'Teeth' do not reach the tip of the rostrum, and become progressively smaller as the rostral tip is approached. These 'teeth' form an alternating pattern along the edges of the rostrum, a pattern otherwise seen in oral teeth of chondrichthyans. In addition, replacement 'teeth' being present within the root cavity of the preceding 'tooth', with replacement occurring from below, a replacement pattern otherwise unknown in chondrichthyans but present in teeth of osteichthyans. Below the well and partially developed rostral 'teeth', developing crowns are seen to form parallel with the edge of the rostral cartilage before undergoing two rotations sets of before moving into replacement position. Rotation into position is present in modified denticles of some chondrchthyans (such as rostral 'teeth' of pristiophorids) and the oral teeth of some osteichthyans. We will discuss the significance of these characters and propose a likely model for genetic control of the development of these unique structures.

Grant Information
NERC

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

TWO MORPHOLOGICAL TYPES IN LOWER 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, eastern part of Hokkaido, Japan. Among 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 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 with each other considerably in crown size. In addition, the layer containing these molars could be a transgressive lag deposition, possibly including secondary fossils, 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, size difference in molars could not provide a feature to identify species.

Romer Prize Session (Thursday, October 15, 2015, 12:00 PM)

MECHANISMS BEHIND THE EVOLUTION OF THE DEFINITIVE MAMMALIAN MIDDLE EAR: INSIGHTS FROM DEVELOPMENT AND PALEONTOLOGY

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During synapsid evolution, postdentary elements in the reptilian jaw transitioned into the middle ear of early mammals. Separation from the dentary allowed unconstrained evolution of the middle ear ossicles, resulting in increased hearing sensitivity and amplified frequency range. This astounding transition is well documented in the fossil record. However, questions regarding the developmental sequence that drove the ossicular transition still remain. Given the importance of such an innovation, it is essential to understand the evolutionary pathway that led to the current phenotype, as this has implications for understanding the development of all mammals.

Modern marsupials are born exceptionally prematurely, prior to the development of the standard mammalian dentary-squamosal jaw joint. At birth, they 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. *Monodelphis* were collected at intervals throughout development and scanned with a micro-CT. Resulting scans were used to reconstruct three-dimensional images of the developing middle ear structures as they progressed. Specimens were also cryosectioned and immunohistochemically stained to identify the cellular processes underlying the gross morphological changes. Additionally, tissues were collected via laser capture microscopy and processed for RNA sequencing to identify differential gene expression.

Our findings are as follows: decreasing size and rearward movement of ossicles are false illusions created by continued growth and expansion of the surrounding skull elements, separation of Meckel's cartilage from the malleus occurs at postnatal day 20 and is facilitated by apoptosis, and separation and breakdown of the connecting Meckel's cartilage are facilitated by an upregulation of cartilage resorption genes paired with simultaneous downregulation of osteoblasts. Finally, marsupial developmental stages were compared with the known fossil record of early mammals exhibiting transitional forms of the definitive mammalian middle ear in order to resolve the question, in this instance, of whether ontogeny is truly recapitulating phylogeny.

Grant Information
Supported by NSF Graduate Research Fellowship and Doctoral Dissertation Improvement Grant.

Technical Session X (Friday, October 16, 2015, 9:30 AM)

A NEW SPECIMEN OF ORNITHOMIMID (THEROPODA) FROM DINOSAUR PROVINCIAL PARK PROVIDES UNPRECEDENTED DETAILS OF DINOSAUR PLUMAGE AND FEATHER EVOLUTION

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A newly discovered articulated partial skeleton of cf. *Ornithomimus* preserves body outlines, skin (preserved as thin carbonaceous film), and feathers. The skin represents an anterior femoral web similar to skin webs in extant birds; however, this is the first report for non-avian theropods. The specimen also shows signs of a body outline around the left leg preserved by differentiation in matrix. The new specimen is the first of this taxon to preserve a relatively complete tail that possesses feathers. Visible plumage indicates plumaceous feathers along the dorsal surface of the tail are longer than those on the remainder of the body. Plumage is absent on the ventrum of the tail. Feathers are also found on the proximal half of the femur, indicating the remainder of the leg was also devoid of plumage. This plumage pattern is similar to the pattern in *Struthio camelus* (ostrich), indicating that the plumage may have served a similar thermoregulatory function.

Feather macro-structure and micro-structure are preserved in extraordinary detail, allowing unprecedented understanding of the evolution of feathers. The feathers are simple branching structures composed of a fully developed rachis and ramus, with no indication of barbules. Using electron microscopy the internal structure of the feathers was compared to that of several extant birds. Internal structural components, such as the

pith, cortex, and melanosomes are identifiable. These components indicate that primitive feathers (prior to the development of barbules, and thus flight) were light and durable, and flight feathers were exapted based on these properties. This discovery pushes back the origin of organized interior feather structures to Maniraptoriformes. Both macro- and micro structure indicate that feathers were functioning similarly those found on *Dromaius novaehollandiae* (Emu) and *Rhea pennata* (Darwin's Rhea).

Technical Session I (Wednesday, October 14, 2015, 9:00 AM)

PRE- AND POSTNATAL GROWTH RATES OF INSULAR DWARFED HIPPOPOTAMI FROM THE PLEISTOCENE OF CYPRUS

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Fossil insular mammalian dwarfs have variably been reported to show rapid ontogenetic development, slow development, as well as truncation of growth. These three modes of dwarfing have different implications for the life history of the animals under consideration and their morphological plasticity. The three modes of dwarfing have been recognized in different species, on different islands, using different methodologies. It may, thus, be hypothesized that different taxa show different responses to island environments, or that environmental differences are the cause for the different dwarfing modes. Alternatively, the difference may even be a methodological artefact.

Cyprus, in the Pleistocene, was extremely isolated from a geological and biogeographical point of view. Only two macromammals successfully colonised the island before the Holocene: *Elephas cypriotes*, approximately 1.4 metres at the withers, and *Phanourios minor*. The latter is the smallest dwarfed hippo ever found; it stood 70 centimetres at the withers and weighed an estimated 200 kilograms, approximately 10% of its mainland ancestor's weight.

The main objective of this study was to determine the mode of dwarfing in insular hippopotami using bone histology. Bones of Pleistocene dwarfed hippopotami from Cyprus, and their normal-sized relatives (*Hippopotamus amphibius*), were thin-sectioned and studied under a polarizing microscope. Type of bone matrix, bone lacunae densities and counts of lines of arrested growth (LAGs) served as proxies for developmental rate and time.

Preliminary histological analyses on the radius suggest that both prenatal and postnatal bone growth in Cypriot dwarfed hippos is different from the normal mammalian pattern. Cypriot dwarfed hippos appear to have had slower growth rates than their normal-sized relatives both pre- and postnatally. Normal prenatal mammalian bone histology is typical for fast growth. The prenatal bone of the dwarfs, however, is indicative of much slower growth, exemplified by much lower vascularity. The observed prenatal growth pattern in the Cypriot dwarf has never been reported in any other mammal and could represent a previously unrecognized strategy to cope with changing environments, particularly when dealing with food stress during pregnancy.

Grant Information
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Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

FIRST EUROPEAN *PHENACOMYS* (ARVICOLINAE, RODENTIA) AND AN INTEGRATED HIGH-LATITUDE HOLARCTIC BIOTA IN THE EARLY PLEISTOCENE

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The Beringian Land Bridge is a well-documented dispersal corridor between the Eurasian continent and North America. Episodic sub-aerial exposure of a land bridge during the Late Cenozoic resulted from climatic oscillations and concomitant lowering of sea level. For much of the Pleistocene, dispersal was predominantly west-to-east (e.g., from Eurasia to North America), but a new discovery of the North American rodent *Phenacomys* from deeply buried sediments in The Netherlands documents an Early Pleistocene east-to-west invasion. The discovery reinforces earlier suggestive hints of an integrated Holarctic mammal fauna in the Early Pleistocene and provides a unique opportunity to establish a direct correlation of the classic mammal zonations of Europe and North America. *Phenacomys* is traditionally conceptualized as an endemic North American radiation of voles, and all extant taxa are exclusively North American. The first European remains of *Phenacomys* were recently recovered as part of the Zuurland Drilling Project from earliest Pleistocene strata (approximately 2.3–2.1 Ma). The specimens were found in stratigraphic association with species that are well-known from more southern European assemblages of Early Pleistocene age (Late Villanyian European Land Mammal Age, MN17), but also with contemporaneous taxa traditionally associated with more northern latitudes. The material represents a new form of the genus intermediate in hypsodonty between the Late Blancan and Early Irvingtonian records of *Phenacomys* in Alaska. The recognition of *Phenacomys* within the Zuurland assemblage demonstrates that the Bering land bridge served as a corridor for both eastward and westward dispersal of mammal species during the earliest Pleistocene, and served as a physiographic mechanism for the integration of a circumpolar biogeographic province at that time.

Grant Information
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Technical Session VIII (Thursday, October 15, 2015, 3:30 PM)

THE IMPACT OF LARGE TERRESTRIAL CARNIVORES ON PLEISTOCENE ECOSYSTEMS

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Large mammalian terrestrial herbivores, such as elephants, have dramatic effects on the ecosystems they inhabit, and at high population densities their environmental impacts can be devastating. Pleistocene terrestrial ecosystems included a much greater diversity of megaherbivores (e.g., mammoths, mastodons, giant ground sloths) and thus a greater potential for widespread habitat degradation if population sizes were not limited. Nevertheless, based on modern observations, it is generally believed that populations of megaherbivores (>800 kg), are largely immune to the effects of predation and this perception has been extended into the Pleistocene. However, as shown here, the species richness of big carnivores was greater in the Pleistocene and many of them were significantly larger than their modern counterparts. Fossil evidence suggests that interspecific competition among carnivores was relatively intense, and reveals that some individuals specialized on consuming megaherbivores. To estimate the potential impact of Pleistocene large carnivores, we use both historic and modern data on predator-prey body mass relationships to predict size ranges of their typical and maximum prey when hunting as individuals and in groups. These prey size ranges are then compared with estimates of juvenile and sub-adult proboscidean body sizes derived from extant elephant growth data. Young proboscideans at their most vulnerable age fall within the predicted prey size ranges of many of the Pleistocene carnivores. Predation on juveniles can have a greater impact on megaherbivores because of their long interbirth intervals, and consequently, we argue that Pleistocene carnivores had the capacity to, and likely did, limit megaherbivore population sizes.

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Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

PHYLOGENETIC REASSESSMENT AND PALEOECOLOGY OF THE MOSASAUR *TYLOSAURUS KANSASENSIS*

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During the Late Cretaceous (Coniacian, 87 – 82.5 Ma), when the Western Interior Seaway (WIS) was in full flooding stage from the Gulf of Mexico to Arctic Circle, a remarkable global event occurred which produced multiple effects that influenced the biodiversity of the Interior Seaway. This global event set forth multiple physical drivers that led to the radiation of the various subfamilies within Mosasauroidea and the parafamily Russellosaurina. Interpretation of one subfamily in particular has interesting implications for taxonomic placement, the tylosaurines. Three taxa and associated species are included in the subfamily Tylosaurinae. These taxa all occur in Upper Cretaceous strata; they are *Tylosaurus*, *Taniwhasaurus*, and *Hainosaurus*. Based on new morphological evidence from a well preserved specimen of *Tylosaurus kansasensis*, which was recovered from between marker units 2–5 in the Niobrara Formation, central Kansas, a unique combination of characters allows for differential diagnosis of the described taxon. Interpretations built on cranial and post cranial characters from this specimen can assist in maintaining taxonomic stability in Tylosaurinae when compared to co-occurring and younger taxa. The specimen on which this study focuses allows a differential diagnosis and information on the paleoecological role of *Tylosaurus*, based on comparative anatomy and current studies of WIS paleoecology and advancements in mosasaur research.

Technical Session XIV (Friday, October 16, 2015, 3:15 PM)

THE EVOLUTION AND FUNCTION OF FUSED CERVICAL VERTEBRAE IN MARINE AMNIOTES

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Marine amniotes exhibit many convergent adaptations linked to their aquatic lifestyle, including, among many others, a fusion of the anterior cervical vertebrae, or syncervicals, which independently evolved in plesiosaurs and ichthyosaurs, formed by the first two vertebrae, and cetaceans, in which it varies in its composition. While these syncervicals are anatomically similar, they likely serve(d) different functions given the disparity of body form, swimming style, and feeding ecology of these three groups. In order to test their potential functional links and associated evolutionary timing, I reconstructed the presence of a syncervical onto recently published phylogenies of plesiosaurs, ichthyosaurs, and cetaceans along with behavioral and ecological data.

Based on a maximum-likelihood analysis, the syncervical evolved a minimum of four independent times in cetaceans. In Physteroidea, the evolution of cervical fusion progressed from the posterior region, as shown in *Physeter*, which has cervicals 2–7 fused. Other odontocetes fused cervicals in the anterior region, and the syncervical seems correlated with fast swimming pelagic forms. Conversely, fusion in balaenids is correlated with slow, constant filter feeding behavior. However, the syncervical may also contribute to hydrodynamic efficiency in balaenids, as previous studies have demonstrated other features (e.g., curvature of baleen) increase hydrodynamic properties to improve feeding efficiency.

In ichthyosaurs, previous studies found increased swimming speed when the syncervical evolved, supporting a comparison between ichthyosaurs and non-physeteroid odontocetes. Despite missing data on the atlas-axis region in many early taxa, it is clear that the plesiosaur syncervical evolved as early as *Bobosaurus*. The syncervical of plesiosaurs is more similar to that of archosaurs than it is to ichthyosaurs and cetaceans, suggesting that its function may be unique among marine amniotes, but more studies on craniocervical function at the base of the clade are required. I conclude that syncervicals function to increase hydrodynamic efficiency but that future studies should be cautious when assuming that this increase is always linked to increased swimming speed, especially in extinct taxa.

Grant Information
Gates Cambridge Trust

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

DENTAL MICROWEAR IN *PACHYCEPHALOSAURUS* AND *STEGOCERAS* SUPPORTS ORTHAL MASTICATION IN PACHYCEPHALOSAURIA (ORNITHISCHIA)

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Previous models of mastication in pachycephalosaurs have supported an orthal power stroke with no propalinal motion. Given this model, dental microwear striations should be oriented parallel to sub-parallel to the apicobasal axis of the tooth. To test this hypothesis, dental microwear was examined on in situ teeth of *Pachycephalosaurus wyomingensis* (n = 1) and *Stegoceras validum* (n = 1) as well as isolated teeth referred to the latter (n = 6).

Discriminant function analysis of microwear striation orientation recovered three distinct modes. One of these modes displayed significantly ($p < 0.01$) longer striations and a greater length of the mean vector (parallelism) than the other two. These features indicate this mode was formed under the guidance of habitual jaw action and identify it as the power stroke. Striations of the inferred power stroke are oriented parallel to sub-parallel with the apicobasal axis and consistent with the predictions of orthal mastication. Furthermore, >70% of all microwear striations lie within an arc ± 20° from the apicobasal axis, supporting orthal motion as the preferred action.

A cluster analysis was performed on average angle, length, width, and mean vector lengths using Ward's algorithm. Data from pachycephalosaurs were combined with those collected from other marginocephalians to explore potential phylogenetic signal. Distinct pachycephalosaur, psittacosaurid, basal neoceratopsian, and leptoceratopsid clusters were recovered, but ceratopsids are dispersed across the other groups. The pachycephalosaur cluster is not separated from all ceratopsians, but groups most closely with psittacosaurids and early neoceratopsians. The pattern of groupings indicates that an orthal power stroke without propalinal motion, as well as broadly similar diets, may have been the ancestral condition for Marginocephalia.

Technical Session IX (Thursday, October 15, 2015, 3:00 PM)

RETURN TO EGG MOUNTAIN: AN EXCEPTIONAL RECORD OF LATE CRETACEOUS TERRESTRIAL PALEOECOLOGY FROM THE TWO MEDICINE FORMATION OF MONTANA, USA

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Egg Mountain represents a small outcrop of the Upper Cretaceous Two Medicine Formation in Teton County, Montana dating to just under 75.5 Ma. Early excavations produced the first dinosaur eggs and nesting grounds from North America. Interpretations of the thick, calcareous sequence included either deposition within or along the margins of a shallow, alkaline lake or as the product of pedogenesis. Recent excavation (2010-2014) of a large (10 x 7 x 1 m) quarry by the jackhammer removal of successive, 10 cm-thick, bedding-parallel intervals from the site has exposed specimens in plan view and led to revised understanding of the locality. Taphonomic, sedimentologic, and isotopic data favors deposition of floodplain overbank fines heavily modified by bioturbation, pedogenesis under subaerial conditions, and subsequent diagenetic overprinting. In contrast to earlier interpretations, carbonates likely formed at shallow depth from ground-water activity. The diversity and condition of body fossils further supports largely subaerial conditions. Nearly 70 m^3 of quarrying has produced only one very small turtle fragment. Otherwise, the assemblage consists of terrestrial taxa: dinosaurs, mammals, and iguanomorph lizards, as well as planispiral terrestrial gastropods. Individual elements of one large associated hadrosaur are in a state of disintegration, whereas tyrannosaur teeth are often preserved as splint-like shards. Nearly ubiquitous trace fossil evidence in the form of abundant insect pupae cases, dinosaur and non-dinosaurian egg assemblages representing minimally five ootaxa, coprolites, and emetolites (regurgitates) also indicate in situ terrestrial biotic activity. Palynological data from the area further suggests a relatively dry paleoclimate. Mammal and squamate remains occur in one of four modes: (i) isolated elements, (ii) closely associated to articulated skeletons, (iii) multi-individual aggregations of predominantly cranial elements, and (iv) concentrations of highly fragmented and small bony debris indicating a range of taphonomic histories. Overall, data show that Egg Mountain represents an exceptional record of Late Cretaceous terrestrial paleoecology.

Grant Information
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Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

NEWLY REPORTED LISSAMPHIBIAN AND SQUAMATE TAXA FROM THE WILLIAMS FORK FORMATION (UPPER CRETACEOUS: CAMPANIAN), COLORADO: CLOSING THE GAP

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The Upper Cretaceous (Campanian) Williams Fork Formation of northwestern Colorado contains a relatively diverse vertebrate paleofauna containing a number of theropod taxa (represented mostly by teeth), indeterminate hadrosaurs and ceratopsians, and more than a dozen species of mammals, plus aquatic and semi-aquatic taxa. Despite abundant representation in screen-washed and hand quarried samples, microvertebrates in the formation contain few named taxa, with most lizards and amphibians identified only to order. Study of previously undescribed specimens collected by screen-washing of ant hills in the formation allows some lower-level identifications. Here we report two specimens from the Dinomunge locality south of Rangely, Colorado, representing the first genus-level identifications among squamates and amphibians in the formation.

The first specimen is a right dentary fragment with four teeth belonging to the lissamphibian *Albanerpeton*. The other specimen is a right(?) dentary fragment with one tooth belonging to the teiid lizard family Chamopsiidae (cf. *Leptochamops*). Amphibians and lizards have been listed in the limited previous publications on the Williams Fork, but few have been described or illustrated and none has been identified to family or genus, so these identifications add to the known paleofauna of the formation.

Albanerpeton has been identified from Campanian rocks from Texas to Alberta, including in the Aguja, Fruitland-Kirtland, Kaiparowits, Milk River, Oldman, and Dinosaur Park formations. *Leptochamops* also appears to be a cosmopolitan genus, with specimens occurring in both northern and southern provinces during the Campanian, from southern Utah (and possibly New Mexico) to Alberta. The occurrences of these two taxa in northwestern Colorado, however, do fill a paleobiogeographical gap during the Campanian, as no *Albanerpeton* specimens have been previously reported between extreme southern Utah and northern Montana, and a similar absence of *Leptochamops* existed between southern Utah and southern Montana until now. These specimens confirm the ranges of both taxa throughout the latitudinal extent represented by the northern and southern paleobiogeographic provinces.

Technical Session XII (Friday, October 16, 2015, 8:30 AM)

PALEOARCTIC TURTLES FROM THE WAPITI FORMATION (GRANDE PRAIRIE, ALBERTA, CANADA) AND THEIR IMPLICATIONS FOR LATE CRETACEOUS BIOGEOGRAPHY

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The fossil record of turtles from the late Campanian Wapiti Formation of west-central Alberta consists of a very restricted number of isolated plastron fragments (n=3), none of which has been properly described or figured. Therefore, their contribution to our understanding of turtle diversity and abundance in this region is very limited. As Wapiti deposits represent paleoarctic ecosystems (approximate paleolatitude of 65°N) the occurrence of turtles has critical implications for our understanding of their paleogeographic distributions and, in particular, interpretations of biological and environmental factors during this time. Here, we report on new material of at least three types of turtles collected from multiple localities within the Wapiti Formation, including isolated elements ascribed to trionychids, chelydrids and baenids from two new microvertebrate localities, and portions of plastron, carapace, vertebrae, and a partial skull of a possible baenid turtle, as well as fragmentary chelydrids and trionychids from a new rich multitaxic bonebed dominated by exquisitely preserved meso-scale elements. These localities are representative of different stratigraphic levels, and are penecontemporaneous with the well-known deposits and faunas from both the Dinosaur Park and Bearpaw formations of central and southern Alberta. These occurrences represent the most northern record of each of these groups during the Campanian. Preliminary sedimentological analyses indicate that turtle-bearing deposits represent warm conditions and environments dominated by high water tables, low-energy fluvial transportation, and dense vegetation. These conditions most likely reflect inland shifting of coastal, distal alluvial plain and swampy environments triggered by the Bearpaw transgressive event. As such, the discovery of several high-latitude turtles may reflect a more northern limit to their distribution than was previously suspected. The relative diversity and abundance of turtles at a number of sites in the Wapiti Formation suggests that turtle distributions may not have been as biologically constrained by latitudinal temperature gradients as has been previously suggested, or that latitudinal gradients in temperature at these paleolatitudes during the Campanian were less severe than proposed. These new northernmost records from the Wapiti Formation further enrich evidence for a diverse high-latitude ecosystem in the Wapiti Formation during the late Campanian.

Technical Session IV (Wednesday, October 14, 2015, 3:15 PM)

SIMOCETID DIVERSITY IN THE OLIGOCENE OF THE EASTERN PACIFIC REGION

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Soon after their appearance in the early Oligocene odontocetes show a near worldwide distribution; however, little is still known of their early diversity. Recent phylogenetic analyses show that some of the European and most of the Western Atlantic (WA) taxa form a monophyletic group called Xenorophidae, which is usually considered as the sister group to all other odontocetes. Some of the more derived xenorophids show features associated with echolocation and telescoping of the skull, indicating that some form of echolocation evolved relatively early in odontocetes. In contrast a second WA group, the Agorophidae, usually occupies a more crownward position despite their overall more plesiomorphic appearance. A third group of early odontocetes, the Simocetidae, which come from Oligocene deposits in the Northeastern Pacific (NEP), share some similarities with agorophids. Although a number of other NEP specimens identified as agorophids have been informally described or mentioned in the literature, *Simocetus rayi* is currently the only simocetid described so far. Hence, the presence of agorophids in the Pacific region or additional simocetids remains to be evaluated in a phylogenetic context. Doing so would allow for a better assessment of early odontocete relationships and diversity.

Here I present the results of a phylogenetic analysis that includes five new Oligocene odontocetes from the NEP region. The results reveal that agorophids are absent in the NEP, and instead, all the newly added specimens are part of a monophyletic Simocetidae. This clade is nearly entirely formed of northern Pacific taxa; the only exception being *Ashleycetus planicapitis* from the early Oligocene of South Carolina, which had previously been placed in its own family.

In addition, preliminary observations of rostrum length to width ratios in simocetids and xenorophids, indicate that the latter have relatively long rostra (ratio > 2), similar to extant raptorial feeding odontocetes (e.g., *Inia*, *Delphinus*). Among simocetids, some species had rostra convergent with extant species that acquire their prey by suction feeding (e.g., *Kogia*) (length/width ratio < 2), while others are convergent with raptorial feeding taxa. These results confirm previously proposed hypotheses that simocetids are the earliest clade to show suction feeding adaptations, in addition to raptorial feeding. Furthermore, simocetids also show a range of estimated body sizes that coupled with the differences in feeding modes, which would have facilitated niche partitioning among coeval taxa.

Technical Session XII (Friday, October 16, 2015, 9:15 AM)

THE GHOST OF CLIMATE PAST: HISTORIC PRECIPITATION EXPLAINS CONTEMPORARY SPECIES RICHNESS IN NORTH AMERICAN TURTLES

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Climate is one of the most important factors explaining the tendency for species richness to increase with decreasing latitudes. However, the timeframe of climate influence is unclear, and it is disputed whether contemporary or historical climates have had a larger effect on modern species distributions. If species are in perfect equilibrium with their current climate, then the expectation is that contemporary climate gradients will be more explanatory of patterns of species richness than historical climate gradients. Here, we test our prediction that historical climate gradients have a greater influence on modern North American turtle species richness than contemporary climate gradients. Our results indicate that historical precipitation is a better predictor of current species richness than are contemporary climate gradients (McFadden's pseudo-R^2= 0.12 for MIROC-ESM last glacial maximum precipitation versus 0.009 for contemporary temperature and 0.08 for contemporary precipitation), implying that current North American turtle distributions are lagging behind the changing climate. This finding suggests that rapid climate change could have serious implications on North American turtle persistence due to their inability to track contemporary climate change.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

UNCOVERING PATTERNS OF THE EARLY DIVERSIFICATION AND BIOGEOGRAPHY OF THE CLUPEOMORPHA: A NEW BASAL CLUPEOMORPH FROM THE NORTHWEST TERRITORIES, CANADA

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The extant members of the superorder Clupeomorpha (herrings and allies) are among the most diverse and abundant fish species, but little is known about their early evolutionary history.The earliest fossil record of the Clupeomorpha in North America dates back to Albian deposits of Mexico and Canada. In 1975, an enigmatic clupeomorph fish, *Erichalcis arcta*, was described from the early/middle Albian Loon River Formation at Hay River (Northwest Territories, Canada). Because of the perplexing combination of characteristics, the new taxon was designated Clupeiformes incertae sedis. Since then, *E. arcta* has proven to be a composite taxon. The non-clupeomorph part of it was redescribed as a Euteleostei incertae sedis and retained the species name (*E. arcta*) while the clupeomorph part was left unstudied for decades.

Described herein is the fossil clupeomorph specimen previously assigned to *Erichalcis arcta*. As in other members of the superorder Clupeomorpha, the ventral margin of the body in the specimen is covered with spiny scutes and the supratemporal commissural sensory canal passes through the parietals. Along with these diagnostic characters, the new taxon also shows primitive traits of the basal members of the group, including a mediopariетal skull roof, unfused halves of the neural spines, and no evidence of presence of the recessus lateralis.

When included in a phylogenetic analysis, the new taxon forms a well-supported clade with two Early Cretaceous clupeomorphs reported from Mexico and Brazil, *Ranulfoichthys dorsonudum* and *Scutatuspinosus itapagipensis* respectively. These species are some of the oldest clupeomorphs known to date and represent the most basal members of the group showing an intermediate condition between extinct ellimmichthyiforms and extant clupeiforms. This is the first time this new clade of basal clupeomorphs has been reported. Together with other Aptian/Albian clupeomorphs from Europe, South America and Asia, these early North American species suggest that the Clupeomorpha underwent significant diversification by the Early Cretaceous, and already occurred in a wide variety of habitats (freshwater, estuarine, and marine environments). Paleoecology and biogeography of the early members of the Clupeomorpha also help address questions related to the origin and diadromous behavior within the group.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

OVERVIEW AND SIGNIFICANCE OF THE UNIVERSITY OF WYOMING VERTEBRATE FOSSIL COLLECTION

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Wyoming has a rich paleontological record due to several highly fossiliferous formations outcropping within the region's Laramide basins. As such, the University of Wyoming (UW) Vertebrate Fossil Collection has been and continues to be an excellent resource for studying the geological and biological history of the Rocky Mountain region, particularly for the Cenozoic Era. Here we summarize the key features of the UW Vertebrate Fossil Collection, emphasize the significance of the fossils housed therein, and encourage researchers to visit.

The UW Vertebrate Fossil Collection contains around 43,500 fossil vertebrate specimens originating from 1,700 site localities representing more than 75 geologic formations. The collection is specialized towards Cenozoic aged vertebrates (79%), but also includes specimens from the Mesozoic (20%) and the Paleozoic (< 1%). The Paleozoic specimens are mostly Devonian in age and primarily belong to the jawless vertebrate Heterostraci (56%, n = 63). Mesozoic specimens are largely from the Cretaceous (94.5%), but material from the Jurassic (5%) and Triassic (0.5%) are also available. Over half of the Mesozoic vertebrate collection is composed of Cretaceous mammal specimens (51%) but we also house several famous holotypes including: *Megalneusaurus rex*, *Platypterygius americanus*, *Platypterygius petersoni*, *Stegosaurus longispinus*, *Alphadon altaragos,* and *Meniscoessus seminoensi*.

Most of the Cenozoic specimens in the collection originate from Eocene and Paleocene aged rock units (41% and 37%, respectively) including the Fort Union Fm (19%), the Willwood Fm (17%), and the Hanna Fm (10%). In terms of taxonomic diversity, the Condylarthra (15%), Rodentia (11%), Primates (11%), and Multituberculata (10%) are the most well represented orders. The most common genera found within the UW Cenozoic Fossil Collection are *Hyopsodus* (n = 1,453), *Hyracotherium* (n = 1,057), *Ptilodus* (n = 1,026), and *Plesiadapis* (n = 459).

Although other institutions house larger Cenozoic vertebrate collections, the UW Vertebrate Fossil Collection is remarkable because it includes a significant portion of Paleocene vertebrate fossils. Furthermore, the collection houses over 40 mammalian holotypes and includes localities covering important climate transitions such as the Paleocene/Eocene Thermal Maximum. The collection additionally offers high-fidelity snapshots into past ecosystems like the Eocene Green River Lagerstätten or the Pleistocene Animal Trap Cave deposits. Research using the UW collection is encouraged.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

IS PLIOCENE HOMININ ABUNDANCE MEDIATED BY ECOLOGICAL FACTORS? A CASE STUDY FROM THE AFAR AND TURKANA BASINS, ETHIOPIA AND KENYA

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The abundance of animals is mediated by important ecological factors, such as the type of resources available and the competition for those resources. Thus, analyzing the abundance of a species across geographic space provides insight into the different selective pressures present at those different sites. In the Pliocene hominin fossil record, *Australopithecus afarensis* has been found to be relatively rare at Laetoli, Tanzania, which is thought to be the result of local ecological pressures. However, there is little information on how hominin abundance varies relative to fauna at other sites in eastern Africa, such as in Ethiopia and Kenya. To address this paucity of knowledge, we analyzed hominin abundance at the sites of Hadar and Omo-Shungura, Ethiopia, where only *A. afarensis* has been definitively recorded, and East and West Turkana, Kenya, where both *A. afarensis* and the synchronic hominin *Kenyanthropus platyops* is found. We also test the hypothesis that Hadar, Ethiopia will have greater numbers of hominins since it has been found in previous research to have ecological qualities that may support greater numbers of hominins. To test this hypothesis, while accounting for differences in collection methods and taphponomy between sites, we examined data from only a subset of the medium-sized mammals from the Hadar, Turkana, and Omo databases (n=361 in Hadar, n = 74 in East Turkana, n = 220 in West Turkana, n = 194 in the Omo). Using the minimum number of individuals for the tribes Hominini (which includes *Australopithecus* and *Kenyanthropus*), Papionini, Aepycerotini, and Antilopini, the relative abundance of medium-sized mammals within each site was calculated. Chi-square tests indicated significant differences in the proportion of medium-sized mammals across sites ($p > 0.001$), though chi-squared residuals showed that hominins were not driving these differences in distributions. Rather, ecological specialists, such as species within Antilopini and Papionini, were found to influence differences in mammalian distributions between sites where hominins were relatively more abundant in association with greater proportions of medium-sized mammals from more open environments.

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Technical Session XV (Saturday, October 17, 2015, 10:15 AM)

HUMANS, CLIMATE, AND VEGETATION CHANGE CAUSE MEGAFAUNAL EXTINCTIONS AT THE PLEISTOCENE-HOLOCENE TRANSITION IN THE ULTIMA ESPERANZA REGION (SOUTHERN PATAGONIA, CHILE)

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In the Late Quaternary Extinction, which occurred during the Pleistocene-Holocene transition, South America lost ~52 genera of megafauna, amounting to >80% of all mammals weighing >44 kg. Previous analysis of the megafaunal extinction chronology in relation to human arrival and major climate changes have revealed slightly different extinction patterns in different eco-regions of the continent, highlighting the importance of small scale analysis to understand how possible drivers of extinction operated. Here we present a detailed regional analysis in order to recognize extinction drivers in a biogeographically distinct region of southwestern Patagonia: Ultima Esperanza, Chile. We compiled a comprehensive dataset of 67 radiocarbon dates on megafauna and 25 on human occupation that allows constructing the chronology of megafaunal extinctions and early human occupation between 18,000–7,000 calendar years before present. We calculated confidence intervals to estimate the probable times of megafaunal extinctions and human arrival using the Gaussian-Resampled Inverse-Weighted McInerny method (GRWIM), and then compared inferred extinction timing with the timing of major

environmental changes in vegetation, climate, fire frequency and to the volcanic eruption of the Reclus volcano. Our results suggest that a combination of human impacts and climate-vegetation change drove megafaunal extinctions in the Ultima Esperanza area, and that the relative importance of the two factors varied according to taxon, but the volcanic eruption does not seem to have exacerbated extinctions. Interaction with humans seems to be the most plausible cause of mega-carnivore extinction. Coexistence of humans with extinct horses, camels and mylodonts for several thousand years rules out a scenario of rapid overkill of those megafauna by humans. On the other hand, the transition of vegetation from cold grasslands to *Nothofagus* forests corresponds with the disappearance of *Hippidion saldiasi* and *Lama* cf. *owenii*, and somewhat later the full establishment of *Nothofagus* forests and an increasing fire frequency coincides with the disappearance of mylodonts. These patterns suggest that a climate-driven reduction of open environments reduced the herbivore populations, making them susceptible to local extinction.

Grant Information
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Colbert Prize (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

VESTIBULAR SENSITIVITY IN EXTANT MONOTREMES AND IN MESOZOIC MAMMALIAMORPHS

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The semicircular canals (SCCs) of the vertebrate vestibular system detect head rotations and help to stabilize the eyes and head during locomotion. Various quantitative studies of mammalian SCCs have linked canal morphology with locomotion and 'agility'. Most mammalian comparative studies have been limited to therians, and most prior analyses of SCC morphology in fossil taxa have examined arc radius of curvature as a proxy for vestibular sensitivity. However, several analyses suggest that SCC orthogonality may be a better indicator of the angular head accelerations habitually generated during locomotion. Using high-resolution micro-CT scans, we measured SCC orthogonality in living monotremes and a variety of Mesozoic mammaliamorphs. Fossil taxa measured in our analysis include a tritylodontid (*Kayentatherium*), a morganucodontid (*Morganucodon*), an eutriconodont (*Astroconodon*), a multituberculate (*Kryptobaatar*), and an undescribed brasilodontid from Ischigualasto, Argentina. In each micro-CT scan, 100–140 landmarks were placed along the streamline length of each canal lumen. The landmarks were then used to generate the angles between ipsilateral canal pairs, and the angles were employed to determine variance of 90° (90var) and average deviation from 90° (90dev). These data were compared to existing measurements of SCC orthogonality in 74 living therian species. The values of 90var and 90dev for all fossil taxa and monotremes fall within the range of extant Theria (90dev = 1.3–18.5). In our fossil sample, the highest degrees of canal orthogonality were found in *Morganucodon* (90dev = 3.1) and *Kryptobaatar* (90dev = 3.4) and the lowest degree of canal orthogonality was found in *Kayentatherium* (90dev = 9.6). Extant monotremes and the remaining fossil taxa exhibit degrees of canal orthogonality in the mid-range of that exhibited by living therians. These results demonstrate that Mesozoic mammaliamorphs exhibit considerable diversity in their degrees of semicircular canal orthogonality. Some fossil taxa with highly orthogonal SCCs (e.g., *Morganucodon* and *Kryptobaatar*) appear to have been better adapted for detecting high angular head accelerations than other taxa with less orthogonal SCCs (e.g., *Kayentatherium*). These differences in canal orthogonality probably reflect differences in mode and/or speed of locomotion, but at present it is not possible to predict modes of locomotion from SCC morphology.

Symposium 3 (Saturday, October 17, 2015, 8:45 AM)

DIFFERENTIATING TOOTH SHAPE USING AUTOMATED THREE-DIMENSIONAL GEOMETRIC MORPHOMETRICS: TESTING ALIGNMENT SENSITIVITY AND UTILITY FOR ANALYSES OF SMALL MAMMALS ACROSS THE PALEOCENE-EOCENE THERMAL MAXIMUM

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Automated Three-Dimensional Geometric Morphometrics (auto3dgm) can quantify shape by generating a specified number of evenly spaced 3D correspondence points per surface (CPT) without requiring homologous features and is an advancement for the study of phenotype. However, when characterizing the shape space occupied by subtly varying morphotypes, results produced at low point sampling densities (128–256 CPT) are sensitive to alignment error that swamps biological signal. To determine at what, if any, settings auto3dgm is suitable for studying small amounts of variation we compared replicates of datasets that varied by morphotype similarity, surface subsampling in terms of faces per surface (FPS), and CPT. We used two datasets of lower molars of small mammals (~9–125g) from the Paleocene–Eocene Thermal Maximum (~56 Ma) of the Bighorn Basin, WY. The first dataset contained two marsupial species differentiable by size (*Peradectes protinnominatus* n=15, *Mimoperadectes labrus* n=15). The second set consisted of problematic "erinaceomorphs" that may be two species (n=46). Digitized occlusal surfaces of each tooth were subsampled to one of five levels ranging from high (no subsampling) to low (5,000 FPS). For each of those subsampling levels, copies of each dataset were aligned at one of four CPT settings: 128, 156, 512, and 1024. All 40 datasets were replicated. Replicates were compared via principal components analysis (PCA). In both datasets higher FPS and CPT improved alignment precision as measured by similarity between the replicates' correlation coefficient (r) of PC1. At no setting did replicate alignments consistently produce identical results. At 10,000 FPS and 256 CPT or higher, alignments of the marsupial data produced species clusters separated along PC1. In contrast, the "erinaceomorphs" did not show consistent separation of morphotype below 512 CPT. At the highest settings (no subsampling, 1024 CPT), shape variation along replicate PCs was qualitatively similar and replicate PC plots produced nearly identical results. In those replicates, PC1 was most strongly associated with wear and worn molars of potentially different morphotypes overlapped along PC1, though morphotypes could be discriminated using subsequent PCs. When wear was taken into account, specimens could be differentiated into two morphotypes, likely representing *Macrocranion junnei* and cf. *Colpocherus* sp. We conclude that at high FPS and CPT, auto3dgm is a useful tool for studying variation within and between species.

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Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

PRELIMINARY REPORT OF A HADROSAUR GRAVEYARD FROM THE CERRO DEL PUEBLO FORMATION (UPPER CRETACEOUS, CAMPANIAN), COAHUILA, MEXICO

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In the locality of Cañada Ancha, the geology is composed of clastic sedimentary rocks, the accumulation of material transported by water into a sedimentary basin. There are three members of detrital rocks: Member A-shale-is the basis; Member B-limolite; and Member Q-covering edges of sandstone on the surface. The thickness of the members varies from centimeters to meters. The stratigraphic column at this point shows Member A composed of shale at the base with a thickness of approximately 20 meters. There is no continuity of thickness. Its depth is uncertain, but we observed that this member is much thicker than in other locations, as there were different levels of depth. Above this member, Member B is composed of limolite with a thickness of approximately 10 meters, which contains fossils. This member increases the thickness significantly. And jutting out of this is Member Q, covering edges of sandstone distributed superficially. We observed that the edges are smaller in size and semi-rounded.

The remains of four hadrosauroids were found in Member B. These constitute cranial and postcranial elements found throughout the member. One of the individuals corresponds to a lambeosaurinae hadrosaur with bite marks in the proximal part of the tibia which probably correspond to a tyrannosaurid. Due to the position of the tooth marks found in this bone and its absence in the other collected elements of the sample, it is assumed that the animal was already dead when it was consumed by the theropod; however no teeth or other remains of this or any other type of carnivorous dinosaurs have been found there. The presence and abundance of remains of hadrosauroids in this member probably indicate an event in which these animals ended up drowning as a result of the flooding of a river, which dragged the bodies and deposited them on a sandbar.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

THE MICROVERTEBRATE ASSEMBLAGE OF THE DOWN'S QUARRY, UPPER TRIASSIC (ADAMANIAN), ST. JOHNS, ARIZONA

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The Downs' quarry is an Upper Triassic fossil-bearing horizon tentatively identified as low in the Blue Mesa Member of the Petrified Forest Formation near St. Johns, Arizona. The horizon yields numerous macro- and microvertebrate fossils from two distinct fossil bearing horizons, the lower of which is interpreted as correlating with (stratigraphically equivalent to) the adjacent *Placerias* quarry. Recently published ages of detrital zircons from the *Placerias* quarry yield a maximum age of 219.39 ± 0.16 Ma, placing the Downs' quarry within the Norian stage. Tetrapod biostratigraphy assigns it an Adamanian age, based principally on the occurrence of the index fossils *Calyptosuchus*, *Acaenasuchus*, and *Crosbysaurus*. The most common macrovertebrate specimens from both levels of the Downs' quarry include phytosaurs, aetosaurs (including *Desmatosuchus*, *Calyptosuchus*, and *Acaenasuchus*), and numerous other archosauromorphs. Microvertebrate collections and sediment from the Field Museum of Natural History (FMNH; collected by J. Bolt) and the North Carolina Museum of Natural Sciences (NCSM) collected in collaboration with Appalachian State University, provide additional insight into the diversity of the Downs' quarry assemblage. Sediment from the Downs' quarry was washed with mesh sieves ranging in size from 0.5 mm to 2.0 mm and picked for various body and trace fossils including bone fragments, teeth and tooth fragments, and coprolites. Small limb bones, vertebrae, and osteoderms are more common than at many contemporaneous assemblages. Microvertebrate fossils recovered include abundant osteichthyans, temnospondyls, lepidosauromorphs (represented by pleurodont and acrodont jaw fragments), and other archosauriforms (including *Protecovasaurus*, *Crosbysaurus*, *Uatchitodon*, and other indeterminate teeth of diverse morphotypes). Actinopterygian osteichthyans are represented primarily by scales (principally indeterminate but including palaeoniscoids), but also by centra. There are no chondrichthyans and fish are more rare than at the *Placerias* quarry, so we interpret the upper Downs' quarry as sampling a more terrestrial environment. The lower Downs' quarry microvertebrates come principally from a basal conglomeratic lag composed of intraformational clasts that hosts the primary bonebed. Coprolites are especially abundant

in the upper horizons, and many larger coprolites preserve bone and teeth fragments in larger matrix whereas fish scales are most commonly found within smaller specimens.

Grant Information
Supported by the Department of Geology and the Office of Student Research at Appalachian State University

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

DESCRIPTION AND GEOCHEMICAL ANALYSIS OF A BASAL NEOCERATOPSIAN ASSEMBLAGE FROM THE UPPER CRETACEOUS OF MONGOLIA

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The fossil record of Mesozoic dinosaur eggs is dominated by specimens assignable to Saurischia with two major clades of Ornithischia, Marginocephalia and Thyreophora, completely unrespresented by eggs or eggshell. Three previous assignments of ceratopsian eggs have proven to be either misidentified or lack clear skeletal associations. Here we describe and geochemically analyze a new specimen from the Late Cretaceous of central Mongolia, IGM 100/1021, that may have implications for the lack of ceratopsian and ornithischian eggs. The specimen consists of 11 tightly arranged and largely articulated basal neoceratopsian young (femur length = 24 mm). Most of these skeletons sit anatomically right side up with some individual skeletons more stretched out and others more curled. An irregular mineral layer surrounding some of the more curled individuals appears as a very thin cement, binding grains possibly into a continuous layer. Potentially, this mineral layer could represent the altered remains of either a rigid-shelled, parchment or pliable eggshell or simply a decay product from the carcass of the young. In order to test these alternate hypotheses, we undertook investigation of this mineral layer through ultra-violet (UV) photography, petrographic microscopy and SEM. Photographs under ultraviolet light showed a thin layer reacting to shortwave (254 nm) light, while elemental mapping through SEM revealed large amounts of calcium, oxygen, and phosphorous. The presence of phosphorous suggests that this mineral layer is either the remains of a soft-shelled egg or a product of decay. Petrographic thin-sections confirm the apparent mineral layer to be of uniform thickness and distinct from the surrounding matrix. Further discernment of the nature of this enigmatic layer will require more detailed examination high resolution imaging via light microscopy and SEM.

Grant Information
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Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

CHANGES IN UNITED STATES MAMMAL DIVERSITY OVER THE 20TH CENTURY: IMPLICATIONS FOR FUTURE RESPONSE TO CLIMATE CHANGE

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Biodiversity loss is recognized as a global crisis. Current research strives to quantify and predict the change in biodiversity throughout the world, focusing on a wide range of taxa. However, current predictive models of mammal diversity in the United States suffer from low precision. They are not scaled with adequate spatial or temporal resolution because richness has not been evaluated at a broad spatiotemporal scale. The prediction of changes in mammal diversity are important to land management and conservation efforts, and, without adequate information, the existing biodiversity in the United States may not be fully protected. Our research takes conservation paleobiology in a new direction by using paleobiological methods to analyze a high-resolution record of the changes in mammal diversity in the continental United States through the last 110 years. We collected mammal occurrence data from the online database VertNet and individual museum collections, divided it into ten year increments, and used scripts in ArcGIS 10.2 to produce sampling-standardized patterns of mammal diversity in each decade. We then analyzed the geographic distribution of diversity change over the 20th century. Mammal diversity in the last century increased in two regions: one northern horizontal strip between 43° and 47° latitude and one southeast strip from Texas to North Carolina. Diversity decreased throughout the rest of the United States. Our study describes regions in the United States that are experiencing the most severe biodiversity changes, which suggests that those regions should be focal areas for conservation efforts. Further directions include testing hypotheses about the role of climate and human population change to influence these patterns of mammal diversity shifts.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

PALEOGEOGRAPHY AND BODY SIZE CHANGE IN RHINOCEROSES (RHINOCEROTIDAE) THROUGH THE LATE MIOCENE OF NORTH AMERICA

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The Neogene is characterized by extensive cooling following the Mid-Miocene Climatic Optimum (MMCO) and a global expansion of C_4 grassland in the Pliocene. North American rhinoceroses (Family Rhinocerotidae), one of the most abundant mammal groups of the Neogene, disappeared in the Pliocene along with many other large land-mammals. Despite their good fossil record, no studies have focused on possible causes of their extinction. Today rhinos are represented by only five endangered species in Africa and Asia. In this study we examine patterns and potential causes of the extinction of North American rhinoceroses by studying several aspects of their ecology, namely: distribution, body size, and diet. The study time period is from the MMCO (late Hemingfordian to early Barstovian, ~17–15 Ma) to their last unquestionable appearance at the beginning of the Pliocene (latest Hemphillian, 4.5 Ma), during which three rhinoceros genera lived in North America: *Peraceras* (extinct by the Clarendonian), *Aphelops*, and *Teleoceras*. Previous work suggests that the body sizes of *Teleoceras* and *Peraceras* generally stayed the same in the late Miocene while *Aphelops* exhibited size increase in the Hemphillian, but a quantitative analysis is lacking. For this study, geographic data were compiled from online databases (MioMap, Fossilworks) and literature. Body size was approximated using M/1 and cheek tooth row length. Preliminary GIS-generated maps of high temporal resolution show the distributions of these taxa from California, across the Great Plains, to the East Coast, and suggest that the distribution of *Peraceras* shrank from the Barstovian to Clarendonian, while *Aphelops* and *Teleoceras* remained widespread across the continent until the late Hemphillian. The extinctions of *Aphelops* and *Teleoceras* were approximately geographically synchronous, suggesting a single cause. Preliminary results from measurements of teeth in the University of Nebraska State Museum are generally consistent with previous work, suggesting size increase in *Aphelops* but not the other taxa. Future work will include carbon isotope analysis of tooth enamel in *Teleoceras* and *Aphelops* from the Great Plains to test if either shows a shift to a C_4 dietary component in the Clarendonian or Hemphillian, as does *Teleoceras* in Florida in the Hemphillian. The results provide insight into how North American rhinoceroses responded to climatic and environmental change in the late Miocene and yield data useful for modeling how future climate and environmental change may affect large herbivores.

Grant Information
Yatkola-Edwards Research Grant, Nebraska Geological Society

Technical Session II (Wednesday, October 14, 2015, 9:00 AM)

THE OLDEST RECORD OF ORNITHUROMORPHA WITH IMPLICATIONS FOR EVOLUTIONARY RATE OF EARLY CRETACEOUS BIRDS

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Ornithuromorpha is the most derived avian clade in the Early Cretaceous, advanced members of which contain all living birds but not Enantiornithes. Previously, the oldest record of Ornithuromorpha is from the Yixian Formation (125 Ma) in the Jehol Biota. Here, we report a new ornithuromorph bird from the Huajiying Formation in the Jehol Biota. $^{40}Ar/^{39}Ar$ dating produced an age of 130.7 Ma for this horizon. Therefore, the Huajiying Formation is the second oldest avian bearing deposit in the world, only younger than the Upper Jurassic Solnhofen Limestones that preserve *Archaeopteryx*. The new specimen is referable to the Hongshanornithidae and constitutes the oldest record of the Ornithuromorpha. However, phylogenetic analysis reveals that hongshanornithids are deeply nested within Ornithuromorpha, which itself is resolved in a more derived phylogenetic position than some taxa known entirely from younger deposits. These inconsistencies between stratigraphy and phylogeny require the presence of ghost lineages and a much earlier origination date for the Ornithuromorpha, which in turn pushes back the divergence time with enantiornithines. We estimate evolutionary rates for Early Cretaceous birds, and the results predict that divergences between major basal avian clades had occurred by the Jurassic-Cretaceous boundary and reveal that rates of morphological change were highly heterogeneous between different Early Cretaceous avian lineages.

Grant Information
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Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

ORNITHURINE BIRD FROM THE EARLY CRETACEOUS OF CHINA PROVIDE NEW EVIDENCE FOR THE TIMING AND PATTERN OF THE EVOLUTION OF AVIAN SKULL

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Despite the increasing number of exceptional feathered fossils discovered in the Late Jurassic and Cretaceous of northeastern China, representatives of Ornithurae, a clade that includes comparatively close relatives of crown clade Aves (extant birds) and that clade, are still rare. Low ecological disparity was reported in Early Cretaceous birds. Here, we report a new ornithurine species from the Early Cretaceous of China, Jiufotang Formation. The new species shows an extremely elongate rostrum so far unknown in basal ornithurines and change our understanding of the evolution of aspects of extant avian ecology. Most of this elongate rostrum in the new species consists of maxilla, a characteristic not present in the avian crown clade in which most of the rostrum and nearly the entire facial margin is made up by the premaxilla. We find that, consistent with a proposed developmental shift in cranial ontogeny late in avialan evolution, that this elongate rostrum is achieved through elongation of the maxilla while the premaxilla remains only a small part of rostral length. Thus, only in Late Cretaceous ornithurine taxa does the premaxilla begin to play a larger role. The rostral proportions of the new species suggest an elongate rostrum may have facilitated the diversification of Ornithurae by making new food sources available.

Grant Information
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Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

ELUCIDATE THE ABSTRUSE: FIRST RECORD OF A BASAL EURASIAN FOSSIL BEAR (*PROTARCTOS*) FROM THE PLIOCENE CANADIAN HIGH ARCTIC

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In 1970, Philip Bjork described a small fossil bear from the Pliocene Glenn's Ferry Formation of southwestern Idaho. Based on a jaw fragment with a single m1 as the holotype, he was understandably perplexed and named it *Ursus abstrusus*. Additional material has not been forthcoming since its initial description and this species has remained an enigma. Hence the discovery in the 1990s of this bear from more complete fossils in the Pliocene Beaver Pond site of the Canadian High Arctic (>3.4 +0.6/-0.4 Ma), approximately contemporaneous to the Idaho holotype (3.48–3.75 Ma), threw much needed light on the mystery. Paleoenvironment of the Beaver Pond site was within a boreal larch (*Larix groenlandii*)-dominated forest near regional tree line and evidences from insects, oxygen isotope, tree ring width, and bacterial tetraether composition in the peat suggest a paleotemperature 15°C to 19°C warmer than present. With a moderately complete skull and lower jaws with associated postcranials, the new material from the Arctic represent a remarkably primitive basal ursine most comparable to the genus *Protarctos* previously known in the Pliocene of Europe and Asia. Dental characters consistent with such assignment include a P4 with a small, distinct protoconid located at carnassial notch, a M2 talon not very elongated, no pre-metaconid on m1, smooth posterior surface of m1 trigonid without zigzag pattern, presence of a distinct pre-entoconid, and m2 shorter than m1. Our phylogenetic analysis suggests that *Protarctos abstrusus*, along with a closely related species, *P. yinanensis*, from a Pliocene cave deposit in Yinan County, Shandong Province and an early Pleistocene loess deposit in Linxia Basin, Gansu Province in North China, is close to the base of the Ursini clade that gave rise to all living bears. The North American black bear (*Ursus americanus*) represents a separate line of immigration from Eurasia at a later time in the Pleistocene. With our identification of a high latitude North American bear that is closely related to its North China relatives, we reconfirm the idea that the Pliocene Canadian Arctic assumes a striking faunal similarity to that of East Asia as first recognized by Tedford and Harington. Such Eurasiatic zoogeographic and phyletic affinities are consistent with an active period of faunal interchange between Asia and North America, and offer a rare example of the presence of a fauna of Chinese Yushean characteristics within the High Arctic of North America.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

THE MYTH, MEDICINAL USES, AND MODERN SCIENCE OF "DRAGON BONES": THE PAST AND PRESENT IMPACT OF TRADITIONAL PRACTICES ON VERTEBRATE PALEONTOLOGY IN CHINA

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The first extensive scientific study of Chinese vertebrate fossils was based on "dragon bones" (long gu) and "dragon teeth" (long chi) purchased from apothecaries by the German naturalist Karl Haberer near the start of the 20th century. Myths about dragons extend back to the dawn of Chinese civilization, and the use of dragon bones and teeth (DBT) in traditional Chinese medicine (TCM) has its basis in a book called the Shennong Bencao Jing from the Han Dynasty (207 BC–220 AD) or earlier. DBT were originally classified among medicines derived from beasts (shou), then as being from scaly animals (lin chong) by the early Ming Dynasty (1368–1644), and later as minerals (jin shi) in the late Qing Dynasty (1644–1911). Most modern TCM sources acknowledge that DBT are vertebrate fossils (mostly of late Cenozoic mammals). In powdered form, they are used for applications ranging from treating insomnia to covering wounds, and feature in recently patented TCM products.

Many TCM books through history have mentioned DBT without describing them or explicitly discussing their origins. Nevertheless, a survey of references to DBT in historical TCM literature indicates that these terms often were applied to vertebrate fossils, which were widely believed to literally represent the bones and teeth of dragons. However, some scholars in the Tang (617–907 AD) and Qing Dynasties regarded them as derived from fish or the action of the Earth's qi (a mystical force). Though debate about the origins of DBT continued, the Kangxi and Qianlong Emperors (Qing Dynasty) appear to have been among the first people to understand the formation of fossils in the modern sense. Scientific progress and international collaboration were stimulated at the end of the Qing Dynasty, and allowed paleontology to break free of traditional views of fossils and emerge in China as an academic discipline. This change, driven by both foreign and homegrown scientists, ultimately led to the flourishing of Chinese vertebrate paleontology.

The DBT trade has had both positive and negative effects on science. From the end of the 19th century onwards, contacts with dealers resulted in the discoveries of many localities, including the Zhoukoudian and *Gigantopithecus* paleoanthropological sites. The trade continues to produce scientifically valuable specimens. However, numerous fossils are destroyed every year for their supposed medicinal value. TCM laws do not regulate the collection or use of DBT, but TCM practitioners are exploring substitutes to comply with Chinese fossil protection laws.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

REVISITING THE PHYLOGENETIC RELATIONSHIPS OF SHUOTHERIIDAE (SHUOTHERIDIA, MAMMALIAFORMES)

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The family Shuotheriidae containing *Shuotherium*, representing the legion Yinotheria and order Shuotheridia, were proposed on the basis of a single left dentary fragment collected from the Upper Shaximiao Formation, Sichuan, China. The most striking dental feature of this animal is the talonid-like structure (designated the pseudo-talonid by the original authors) anterior to the trigonid on lower molars, forming a pseudo-tribosphenic occlusal pattern with its upper molars. Shuotheriidae was first referred to the Trechnotheria and considered the sister group to other trechnotherians. However, the phylogenetic relationships of Shuotheriidae were differently argued as related to Docodonta, the sister-taxon to Cladotheria, and the sister-taxon to Australosphenida. Recently, most analyses related to Mesozoic mammals grouped Shuotheriidae together with Australosphenida in one clade, but detailed examination of these analyses revealed no apomorphic character diagnoses for this clade. Reexamination of the type specimens of *Shuotherium dongi* and *S. shilongae* requires a different interpretation for some characters from that used in the data matrix of the recent phylogenetic analysis, e.g., the dental formula of cheek teeth and the postdentary trough, etc. Phylogenetic analysis using a revised dataset with changes based on the new interpretation of characters provide a result that Shuotheriidae nests inside the typical symmetrodonts, similar to that proposed before. Such a result suggests that the relationships between Shuotheriidae and Australosphenida need to be reconsidered.

Technical Session XI (Friday, October 16, 2015, 9:45 AM)

DIETARY BEHAVIOR, MORPHOLOGY AND THE ORIGIN OF *AUSTRALOPITHECUS*

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Ever since the discovery of *Australopithecus* in 1925, the ability to process a diverse array of foods has been considered a hallmark of the origins of the *Australopithecus*-human clade. The ability to fall back on hard or tough foods is thought to have afforded early hominins the ability to exploit a variety of habitats, especially the expanding open woodlands and grasslands in East Africa during the early Pliocene, underlying the success of the australopith radiation.

The earliest *Australopithecus* species is *A. anamensis*, known from 4.2–3.8 Ma. It is generally thought of as representing the early part of an anagenic lineage leading to *A. afarensis*, known from 3.7–2.9 Ma. *Australopithecus anamensis* and *A. afarensis* are broadly similar morphologically, have similar patterns of molar microwear, and so were originally thought to have shared a similar set of dietary adaptations. However, recent stable carbon isotope data reveal a significant difference in foods ingested, with *A. anamensis* consuming an almost pure C_3 diet, whereas *A. afarensis* consumed a range of C_3 and C_4 foods.

This paper compares the dentognathic morphology of *A. anamensis* and *A. afarensis* in light of these new data on their dietary behaviors and an expanded fossil record of the earliest *Australopithecus* sample from Kanapoi, Kenya. These species display significant morphological differences associated with an increasing ability to process harder and/or tougher foods in *A. afarensis*, and perhaps changes in ingestive behaviors. Compared with *A. anamensis, A. afarensis* exhibits a reduction in basal dimensions of the anterior dentition, relatively larger postcanine teeth, more posteriorly divergent toothrows and vertical mandibular symphysis, and thicker molar enamel and an apparent slower rate of occlusal toothwear on the anterior dentition. These data suggest that *A. anamensis* may not have exhibited a typical australopith diet, and raises questions about the role of diet in australopith origins and the relationships among diet, morphology and paleoecology.

Grant Information

National Science Foundation BCS 1231749, Wenner Gren Foundation, University of Missouri Research Board, University of Missouri Research Council, West Turkana Paleo Project

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

STRATIGRAPHIC CONTEXT AND DATING OF THE MIDDLE AND LATE EOCENE VERTEBRATE LOCALITIES OF THE FAYUM, EGYPT

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The Fayum Oasis and surrounding areas in Egypt include a number of exceptionally rich and important fossil vertebrate sites. These include the Wadi Al-Hitan World Heritage Site, made famous by the abundance of archaeocete whale remains, and the site BQ-2 with its diverse terrestrial mammals, including primates. Despite the importance of this area, the stratigraphy is poorly understood and there has be little agreement in the dating of the fossiliferous units. This is in large part due to the extreme diachroneity of some of the rock units and paucity of biostratigraphically useful fossils within the shallow water facies.

Platform carbonates are overlain by condensed open marine mudstones of the Gehannam Formation. These span the Bartonian–Priabonian boundary, with a diverse offshore marine fauna being present throughout, including marine mammals. Four units of shoreface sandstone of the Birket Qarun Formation overlie and partly pass into the Gehannam Formation. The lowest of these sandstone units is dated to nannofossil zone NP19/20, and hence 'mid' Priabonian, and contains the oldest archaeocetes described from the region. Diverse fossils, including abundant whales, are present throughout the Birket Qarun Formation, but these are especially concentrated at the top of the lowest sandstone (lowstand systems tract) and in the transgressive lower part of the third sandstone and its lateral equivalent within the Gehannam Formation (transgressive systems tract).

The overlying Qasr el Sagha Formation is a very rapidly deposited deltaic/lagoonal complex. Tidal channels from two to over 40 metres deep are present throughout. The lower part of this formation is still in nannofossil zone NP19/20. Interchannel deposits contain a fully marine, but probably shallow water, assemblage. Larger channels also include deeper water elements near the base, with transported terrestrial and quasimarine elements being present within the uppermost part of a small channel fill at quarry BQ-2. The transition to the non-marine units above is sharp but conformable and coincides with the base of the Oligocene.

The clastic succession indicates the initiation of Nile-type drainage and coincides with the uplift of East Africa, preventing drainage to the east. It is likely that clastic

successions in the Qattara Depression and Libya can be related to the same sedimentological episodes. This is largely based on, and dedicated to, the work of Chris King, who passed away earlier this year.

Symposium 3 (Saturday, October 17, 2015, 8:00 AM)

HOW MANY LANDMARKS ARE ENOUGH? IDENTIFYING ADEQUATE SAMPLING OF LANDMARKS FOR CAPTURING THE SHAPE OF SPECIMENS

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Accurate morphological characterizations are critical for generating reliable results and formulating credible conclusions on the evolution, function, development, and taxonomy of organisms. A seldom addressed but key issue in geometric morphometrics is whether sufficient numbers of landmarks have been sampled to characterize biological variation in shape. If important finer details or local shape differences are not represented by the shape data collected, this may lead to erroneous conclusions biased by landmark choice. Conversely, oversampling of landmarks may be limiting because the computational load necessary for data analysis increases. Indeed, an important corollary to this point is that many multivariate statistical tests assume that the number of specimens exceed the number of shape variables. An appropriate assessment of landmark sampling, therefore, requires the knowledge of minimum number of landmarks needed to capture the full shape variation exhibited by the system under study. Here, I present a new R script that helps determine whether: (1) a given data set has reached an asymptote in shape information and (2) a subset of landmarks are able to capture the same degree of shape information as a parent data set. Furthermore, it identifies key landmarks in the original data that particularly enhance the fit of pruned data sets to the full data set. This approach allows a systematic removal of landmarks with minimal impact to the signal present in the original shape data. Performing the analysis on empirical data sets suggests that many published data sets with less than 30 landmarks do not capture enough shape variation, potentially producing spurious results. Notably, other data sets with a dense sampling of semilandmarks demonstrate equivalent shape information with much smaller number of landmarks, implying that many landmarks can be removed inconsequentially. Thus, evaluating an optimal set of landmarks for potentially incomplete specimens, as is typical with fossil data sets, may be critical to preventing spurious analyses as well as promoting statistically rigorous ones. Given the robustness of the analysis to a varying number of specimens, I recommend performing the analysis on pilot data comprising a comprehensive landmark sampling on a preliminary sampling of specimens to determine the number of landmarks needed for the entire study. Broadly, this script enables evaluation of previous geometric morphometric studies and facilitates pursuit of accurate and efficient understanding of biological processes.

Grant Information

Richard Gilder Graduate School; Division of Paleontology, American Museum of Natural History; NSF GRFP; Sigma-Xi Grants-In-Aid of Research (Grant No. G20110315156273)

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

NEW CROCODYLOMORPH FOSSILS FROM THE LATEST TRIASSIC OF EASTERN NEW MEXICO

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Large-bodied crocodylomorph archosaurs are very rare components of Late Triassic terrestrial faunas, represented by single partial skeletons referred to the genera *Carnufex*, *Redondavenator*, and a third unnamed taxon (CM 73332). These Late Triassic basal crocodylomorphs replaced more basal loricatans as apex predators in the terrestrial realm. Here, we report several isolated elements of large basal crocodylomorphs recently recovered from the Redonda Formation (uppermost Triassic) of eastern New Mexico. A right ilium is unusual in possessing an extremely elongate and strongly mediolaterally compressed preacetabular process that extends well beyond the pubic process, and a distinct supraacetabular buttress with ridges that extend onto both the preacetabular and postacetabular processes. The ilium is most similar to the same element from a mostly complete, articulated basal crocodylomorph skeleton from the Ghost Ranch Quarry in New Mexico (CM 73332). However, the supraacetabular buttress does not possess the deep ridges and striations found on the ilia of *Hesperosuchus* and CM 73372. The anterior part of a dentary is expanded dorsoventrally as in *Hesperosuchus* and *Postosuchus*, but differs in possessing a narrow straight symphyseal suture on just the anteromedial surface of the tip of the bone and a medial bulge to accommodate the enlarged second and third alveoli. A left calcaneum corresponds well with other paracrocodylomorphs, but possesses a distinct hook-like tuber, similar to crocodylomorphs such as *Saltoposuchus* and poposauroids like *Shuvosaurus*. The body of the calcaneum differs from those taxa in being transversely expanded. These elements may represent a cranial element and postcrania of the large putative stem-crocodylomorph *Redondavenator*, known from a snout fragment from the same formation. The increasing evidence of large, basal crocodylomorphs indicates that large basal crocodylomorphs are more diverse than previously recognized and become more common in strata towards the end of the Triassic.

Technical Session IV (Wednesday, October 14, 2015, 1:45 PM)

WHAT IS A LARGE BRAIN GOOD FOR? BRAIN SIZE AND BEHAVIORAL COMPLEXITY DO NOT ASSOCIATE IN MARSUPIALS

WEISBECKER, Vera, University of Queensland, Brisbane, Australia; BLOMBERG, Simon, University of Queensland, Brisbane, Australia; GOLDIZEN, Anne, University of Queensland, Brisbane, Australia; BROWN, Meredeth, South Australian Government, Adelaide, Australia; FISHER, Diana, University of Queensland, Brisbane, Australia

The overall large brains of mammals, and the tendency of many mammalian lineages to evolve tremendous brain sizes relative to body size (here termed 'large brains'), represent a high cost. Large brains require intense maternal investment during growth-a constraint that is well-catered for by the efficient mammalian reproduction-and also correlate with low-seasonality habitats that offer consistent food supply. The evolutionary drivers of such costly brain size increases are thought to be cognitively complex behaviors, including either interactions with the environment (e.g., locomotion or diurnal rhythm) or complex social behaviors (e.g., pair-bonding or biparental care). However, nearly all work on this issue is based on placental mammals, whose broad variability of reproductive traits is known to confound patterns of behavioral evolution. Here, we provide a less confounded analysis by testing the explanatory power and relative importance of constraints vs. selection hypotheses of brain size evolution in the reproductively homogenous marsupial mammals (n=178). Based on a wide range of reproductive, geographical, and ecological variables, we use phylogenetic partial least squares (pgls) modeling to provide the first side-by side evaluation of energetic constraints models (including variables of maternal investment and seasonality) and behavioral models (including variables of social complexity and environmental interactions). Akaike Information Criterion (AIC) comparisons show that behavioral models are highly unlikely compared to the maternal investment model. The only clear associates of brain size are the constraints variables of litter size and seasonality, the latter manifesting in significantly larger brains of New Guinean vs. Australian marsupials. Finer-grained pgls models of sociality traits in kangaroos, dasyurids, and possums also revealed no links between brain size and behavior. We conclude that energetic constraints represent the main determinants of mammalian brain size, in contrast to a probably negligible contribution of behavioral variables. This supports the tenets of the more generalized 'cognitive buffer hypothesis' that larger brain sizes confer a global, unspecific advantage, and specifically cautions against the extrapolation of results on the reproductively complex placentals to the origins of the mammalian brain.

Grant Information

ARC DECRA(DE120102034), ARC Discovery Project (DP140102656) to VW; Future Fellowship (FT110100191) and Australian Research Fellowship (DP0773920) to DOF.

Technical Session V (Wednesday, October 14, 2015, 2:00 PM)

WHEN MICROSTRUCTURE ISN'T ENOUGH: ADDITIONAL DIAGNOSTIC CRITERIA TO TEST AMONG HYPOTHESES OF BONE TISSUE IDENTITY

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Histologists describe pathological and other tissues using many anatomical, compositional, and developmental characteristics. Paleohistologists use these characters to infer the identity, function, and evolution of fossilized bone tissues. However, they lack consensus on which characters are most useful for diagnosis, and often only a few microstructural features are examined. This makes comparisons difficult and leads to misidentification, calling the resultant functional and evolutionary inferences into question. These problems worsen when fossil tissues share some but not all characteristics of living forms, the range of extant variation is unknown, or etiologies cannot be linked unambiguously to bony features.

We identify nine types of diagnostic criteria that should be used to test among hypotheses of tissue identity: gross morphology, location (both skeletal distribution and extent), stimulus, timing in context of life history, development, chemical composition, duration, and microstructure (using explicit aspects of fibrillar, vascular and osteocyte density, arrangement, and shape). All but stimulus can be evaluated in archeological/subfossil bone, and most can be evaluated in fossils. We demonstrate the need for a more comprehensive set of criteria using the examples of avian osteopetrosis (AOP; pathology) and medullary bone (MB; reproductive marker), common alternative hypotheses for endosteally-derived tissues in fossil birds, nonavian dinosaurs, and pterosaurs. Their correct identification informs questions of disease and life history evolution in Ornithodira. We examined MB in eight extant bird species, described the range of extant microstructural variation, and compared its histological features to that of genetically-diagnosed AOP. We then re-evaluated every reported case of MB and AOP outside crown birds using the above criteria. When only some microstructural features are considered, they are indeed difficult to distinguish. However, if a broader suite of anatomical, microstructural, positional, compositional, and developmental data is used, the tissues are quite distinct. AOP can be rejected in nearly every case using broader criteria.

Adopting a common set of criteria and reporting more microstructural features provides greater diagnostic power and enables comparison among histological studies. Additionally, clarifying definitions and diagnoses eliminates tautology by positing a test of an etiological hypothesis (definition) by independent lines of empirical evidence (diagnosis).

Grant Information

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Technical Session XV (Saturday, October 17, 2015, 9:15 AM)

CHRONOLOGIC CALIBRATION AND CROSS-CONTINENTAL CORRELATION OF THE SOUTH AMERICAN LAND MAMMAL 'AGES': UPDATE 2015

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In the 20 years since the last major synthetic compilation of time-calibration data for the roughly 20 South American Land Mammal 'Ages' (SALMAs) then recognized, there have been significant advances in constraining SALMA ordination, numerical age ranges, and even the validity of some SALMAs. New SALMAs have also been proposed, some of which are formulated as formal stage-age units rather than the more traditional informal biochronologic units. Development of extremely high-precision isotope geochronology, in particular $^{40}Ar/^{39}Ar$ and U-Pb (uranium-thorium-lead) systems, represents a key advance in calibrating biochronologies. Within this framework, new high-precision dates and magnetostratigraphic data are integrated in a large scale,

continent-wide calibration of Cenozoic South American biochronologic data and an updated SALMA geochronology. We detail advances in calibrating the ages of sedimentary sequences and faunas representing particular SALMAs, emphasizing marked revisions from prior understanding, as well as substantial new data from Andean and other sequences where fossils occur within volcaniclastic units or associated with volcanic-rich sediments that can be reliably dated using high-precision methods.

Our results show that the most substantial changes in temporal calibration are in the Paleogene SALMAs. The Itaboraian, Riochican, Casamayoran, and Mustersan are significantly younger than formerly recognized; the Mustersan has shifted ~10 Myr from prior estimates, from early mid-Eocene to latest Eocene. Conversely, the Paleocene Tiupampan and Peligran each are ~2 Myr older than previously recognized.

Land mammal 'ages' historically were presumed to be applicable across an entire continent, but it is now clear that many classically-recognized SALMAs have more restricted geographic applicability, particularly between the tropics and high latitudes. This study examines how this apparent limitation of the SALMA timescale actually allows for enhanced understanding of spatial variation in faunal distribution and rates of turnover throughout the Cenozoic. Temporal correlations of fossiliferous units across broad geographic areas and inferences of synchrony or temporal offsets of biotic and physical environmental changes rely on correlation to a more finely calibrated timescale, such as represented in our updated SALMA synthesis.

Grant Information
A.R.W. was supported by the NSF GRFP while conducting this research.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

TRENDS IN VERTEBRATE AND CEPHALOPOD DIVERSITY IN THE 'AGE OF FISHES'

WHALEN, Christopher D., Yale University, New Haven, CT, United States of America, 06520-8109

The Devonian saw a rapid diversification of active, pelagic predators in what has been termed the Devonian Nekton Revolution. Although gnathostomes, or jawed-vertebrates, appeared in the Ordovician, they only rose to ecological prominence in the Devonian when oceans began to resemble modern ecosystems. Most studies attempting to understand this radiation have compared genus-level trends among the five classes of Gnathostomata (Placodermi, Acanthodii, Chondrichthyes, Actinopterygii, and Sarcopterygii) and the jawless 'ostracoderms'. However, the extinct placoderms and acanthodians are widely considered paraphyletic relative to the extant taxa, questioning the value of distinctions among these Paleozoic groups. Furthermore, Devonian gnathostomes did not radiate in a vacuum – cephalopods are in many ways the ecological counterparts of vertebrates in the marine realm. The Devonian saw the initial proliferation of the extremely successful ammonoids, a monophyletic lineage on the stem of modern coleoid cephalopods, in addition to the radiation of the gnathostomes. Rather than compare the various taxa of gnathostomes to each other, I compare Gnathostomata to the vertebrate total-group (including the conodonts), the cephalopod total-group, and Ammonoidea. In the absence of a phylogenetic framework confirming the monophyly and composition of the various genera included, I present a species-level diversity curve. Species are binned to stages from the Silurian (Pridoli, ~423 Ma) to the Mississippian (Tournaisian, ~347 Ma). Given the significant gaps in the coverage of these lineages in the Paleobiology Database, I supplement that information with records from the *Treatise on Invertebrate Paleontology*, GONIAT (an online database of Paleozoic Ammonoids), the Yale Peabody Museum collections, and the primary literature.

Technical Session XIII (Friday, October 16, 2015, 3:30 PM)

ANATOMICAL AND POSTURAL ADAPTATIONS TO LARGE SIZE IN DINOSAURS

WHITE, Dominic E., The George Washington University, Washington, DC, United States of America, 20052

Large size evolved numerous times in dinosaurs, and support of the body would have become a significant biomechanical challenge as size increased. Postural and anatomical changes allowed dinosaurs to counteract these demands: for example, many large ornithischian and sauropodomorph dinosaurs reverted back to obligate quadrupedality as they increased in size. However, it is unclear why other large dinosaurs were facultative quadrupeds (e.g., hadrosaurs), or were able to retain a bipedal stance at large size (e.g., theropods). I used an integrative approach that considers both the axial and appendicular skeleton to study how different dinosaur clades were able to alter both posture and anatomy to allow the evolution of large size.

The evolution of quadrupedality has been difficult to trace in transitional taxa due to the lack of definitive osteological indicators. To investigate how quadrupedality evolved in these different clades, I used a new metric based on relative fore- and hind limb dimensions to estimate the degree of quadrupedality in dinosaurs. Under this proxy, thyreophorans, ceratopsians, and sauropodomorphs show the progressive evolution of obligate quadrupedality, while hadrosaurs evolve a stance intermediate between bipedality and quadrupedality. These postural trends are consistent with those estimated by previous studies. The evolution of a more quadrupedal stance is correlated with increasing size in these clades.

To investigate how the axial skeleton co-evolved with the limbs, I used photogrammetry to build 3D models of the dorsal vertebrae and ribs of 24 taxa of different sizes and postures from each of the main dinosaur families. 3D geometric morphometric analyses indicate significant differences between the dorsal axial skeletons of bipeds and quadrupeds. Much of this shape difference appears in features with direct relevance to posture and support, such as elongated neural arches (increasing the epaxial muscle moment arm), larger centra (to bear increasing stresses), and varying amounts of serial differentiation in the axial skeleton (reflecting more even loading scenarios in quadrupedal dinosaurs). These results not only reveal how dinosaurs were able to adapt to large size, but also suggest novel osteological correlates of quadrupedality in both the appendicular and axial skeleton.

Grant Information
Cosmos Foundation Scholarship, William Warren Graduate Fellowship

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

NAVIGATING THE SCIENCE OF GLOBAL CHANGE: INTERACTIVE TOOLS TO ENHANCE STUDENT UNDERSTANDING

WHITE, Lisa D., University of California, Berkeley, CA, United States of America, 94720-4780; BEAN, Jessica R., University of California, Berkeley, CA, United States of America; THANUKOS, Anna, University of California, Berkeley, CA, United States of America; FRANKEL, Josh, University of California, Berkeley, CA, United States of America

Understanding Global Change is a new web resource under development by the University of California Museum of Paleontology that will support teaching and learning about the science of global change through rich and varied content, vetted teaching resources, and effective strategies for enhancing K–16 science literacy. In order to make complex systems more readily teachable, we made clear distinctions among drivers of global change (e.g., burning of fossil fuels, volcanism), ongoing Earth system processes (e.g., albedo, the greenhouse effect), and the state of Earth's physical and biological systems (e.g., temperature, productivity), while creating conceptual links that reveal the interdependency and feedbacks among these categories. This basic scheme underlies the central conceptual framework for the site, which will be embodied in a visualization tool that shows the multiple connections among drivers and changes in the Earth system. These illustrations will be clickable images linked to narrative site content. With this tool, users can navigate the site and site illustrations to support teaching and assessment activities that reinforce key concepts within storylines. Users can explore multiples lines of scientific evidence for modern anthropogenic global change and global changes that occurred deep in Earth's history. Instructional use of the website and framework will be enhanced by a robust teaching resources database. The site content is aligned with core ideas and cross-cutting concepts within the Next Generation Science Standards and the Common Core. We expect the site to provide new avenues and opportunities for greater public and student engagement with the complex topic of global change.

Grant Information
Understanding Global Change is supported by a grant from the Gordon and Betty Moore Foundation (#3416) to C.R. Marshall.

Colbert Prize (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

PALEOCLIMATE RECONSTRUCTION USING THE VERTEBRATE FOSSIL RECORD: CONSTRAINING TEMPERATURE AND PRECIPITATION HISTORIES OF THE NEOGENE CENTRAL GREAT PLAINS BASED ON THE FOSSIL RECORD OF *ALLIGATOR*

WHITING, Evan, University of Nebraska-Lincoln, Lincoln, NE, United States of America, 68588; HEAD, Jason, University of Nebraska-Lincoln, Lincoln, NE, United States of America

Geographic distributions of poikilothermic vertebrates are strongly dependent upon ambient climate, and the physiological and environmental limits to distributions in extant taxa can be used to estimate paleoclimates for the ranges of closely related and ecologically similar fossil taxa. *Alligator* is a potentially useful paleoclimatic proxy datum, because it is an anatomically distinct taxon with a dense fossil record starting in the late Paleogene of North America. Critical minimal values for environmental temperature and precipitation are known for the genus, but the impact of climate on *Alligator* distributions and the relative roles of temperature and precipitation are unknown, limiting the ability to hindcast climate in deep time.

To constrain climatic parameters for the distribution of *Alligator*, we constructed Species Distribution Models (SDMs) based on the current range of extant *A. mississippiensis*. We compared geographic presence data to 19 climatic variables using the Maximum Entropy algorithm to predict both fundamental ranges and to determine the relative contributions of individual climate parameters to distributions. Our results indicate that the actual range of *Alligator* approximates its potential distribution, and that minimum precipitation followed by Mean Annual Temperature (MAT) are the primary drivers of distribution. The relative contributions of precipitation and MAT in our analysis contradict previous studies that used coldest month mean temperature as the primary constraint on *Alligator* ranges. The close overlap between actual and potential ranges indicate that faunal interactions are not limiting factors in distributions, and the close relationship between climate and distribution makes *Alligator* a useful climate proxy.

The fossil record of *Alligator* reveals a history of occurrence and extirpation in the Central Great Plains through the late Paleogene and into the Neogene. *Alligator* first occurred in the late Eocene and disappeared from the region during the Oligocene. The taxon reappeared in the early Miocene (Hemingfordian) and last occurred in early late Miocene (Clarendonian) at the latitudes of modern Nebraska, with continued Southward shifts in distribution through the Pliocene. Distribution shifts in the *Alligator* fossil record suggest that the primary environmental changes through the Great Plains Neogene were patterns of fluctuating and increasing aridification as opposed to primarily changes in temperature.

Grant Information
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Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

RE-DESCRIPTION OF *'MOROSAURUS' AGILIS*, A CURIOUS JUVENILE SAUROPOD FROM THE MORRISON FORMATION OF NORTH AMERICA, WITH APPLICATION OF PHOTOGRAMMETRIC VISUALIZATION METHODS

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The type material of *Morosaurus agilis*–United States National Museum (USNM) 5384, a partial skull and the first three cervical vertebrae–has been a taxonomic mystery since its initial description by O. C. Marsh in 1889. Following the relegation of *Morosaurus* to a junior synonym of *Camarasaurus*, this material has been without a proper taxonomic assignment despite previous suggestions that it belongs to

Haplocanthosaurus. Here, USNM 5384 is re-described and compared to material from *Apatosaurus*, *Camarasaurus*, *Demandasaurus*, *Dicraeosaurus*, *Diplodocus*, *Galeamopus*, *Giraffatitan*, *Haplocanthosaurus*, *Kaatedocus, Limaysaurus*, *Nigersaurus*, and *Suuwassea* in an effort to discover its taxonomic affinities. USNM 5384 is assigned to Diplodocoidea based upon the presence of a scarf-like contact between postorbital and frontal (a feature convergently seen in some derived titanosauriforms) and a hook-like posterior process of the frontal. It can be further placed into the clade Flagellicaudata based on the exclusion of the parietal from the margin of the post-temporal fenestra, and into Diplodocidae based upon a supratemporal fenestra without contribution from the frontal and a subvertical axial neural spine. Although USNM 5384 can be further distinguished from *Apatosaurus* based on the lack of a robust supraoccipital crest and from *Galeamopus* by the absence of the laterally projecting spur on the atlantal neural arch, the early ontogenetic age of the specimen combined with a lack of lower-level synapomorphies or autapomorphies precludes more specific assignment at this time.

'*M.* ' *agilis*, like many other contemporary specimens, is heavily infiltrated with iron which makes it both very dark and very dense. This in turn makes it hard to photograph and also difficult to image using radiographic techniques (x-ray, CT scan). To alleviate some of the difficulty visualizing this specimen, we have utilized high resolution photogrammetry to create surface renderings of the specimen. These renderings will make sharing of morphological data easier, and permit users from all over the world to study this enigmatic specimen.

Technical Session III (Wednesday, October 14, 2015, 10:45 AM)

MAMMAL-LIKE THECODONTY IN HERBIVOROUS MIDDLE PERMIAN TAPINOCEPHALIDS (THERAPSIDA, DINOCEPHALIA)

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Thecodonty has traditionally combined two components of anatomy: the geometry of tooth emplacement in the jaw with deep sockets and presence of a soft tissue (i.e., periodontal ligament) anchoring the tooth to the jaw. However, these characters are logically distinct and vertebrates use a diversity of attachment geometries and tissues. Mammals employ three attachment tissues (cementum, a periodontal ligament, and alveolar bone) in forming a gomphosis between the teeth and jaw. Among synapsids, gomphosis is thought to be a derived state restricted to mammaliaforms and some derived, non-mammalian cynodonts. By contrast, most other fossil synapsids appear to employ reptile-like ankylosis, where the tooth is fused to the jaw.

Here we report on the presence of thecodonty and gomphosis in a recently discovered assemblage of middle Permian tapinocephalid dinocephalians from Zambia. Jaws preserved with true tooth sockets and devoid of functional teeth, as well as numerous isolated teeth with intact roots, indicate that tapinocephalids had thecodont implantation. To assess the homology of tapinocephalid thecodonty with that of mammals, we conducted the first histological examination of tapinocephalid dental and jaw material. Isolated teeth with intact roots and jaws of tapinocephalids were sectioned and revealed the presence of the three tissue types associated with gomphosis. Isolated teeth contain a tissue layer surrounding the root of the tooth that is distinct from the enamel layer of the crown. This layer appears to be mostly acellular with a possible outer cellular sub-layer that includes frequent Sharpey's fibers running parallel to the longitudinal surface of the tooth, which taken together suggests a cementum composition. Jaw sections in multiple anatomical planes display the presence of a bone tissue lining the socket distinct from the surrounding jawbone suggesting alveolar bone. Additionally, the presence of Sharpey's fibers along the surrounding edge of the socket and in cementum layers would indicate a periodontal ligament was present in life. The geometry associated with tapinocephalid tooth implantation provides evidence for thecodonty and the tissues indicate gomphosis, bringing the first appearance of mammal-like tooth implantation back to at least the middle Permian (> 260 MA). Because tapinocephalids were herbivorous and had precise, tooth-to-tooth occlusion, our findings suggest that the evolution of tooth implantation in synapsids was more strongly influenced by diet than previously considered.

Grant Information
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Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

MAGNETOSTRATIGRAPHY OF THE CRETACEOUS GALULA FORMATION FROM THE RUKWA RIFT BASIN, TANZANIA

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The Cretaceous period is poorly represented in the fossil record of sub-Saharan Africa when compared to other Gondwanan landmasses, presenting a gap in our understanding of biotic evolution following the breakup of the supercontinent. Recent work in the Rukwa Rift Basin of southwestern Tanzania has revealed exposures of the Cretaceous-age Galula Formation, which is made up of sandstones, conglomerates, and mudstones, and is interpreted to represent a broad fluvial environment with associated floodplain deposits. It also preserves an important Cretaceous vertebrate fauna, including titanosaurian sauropods, gondwanatherians, and mammal-like notosuchians. A significant shift from tropical semi-arid to tropical humid conditions is recorded moving upsection through the Galula Fm, which is thought to correspond to regional tectonic reorganization during the Mesozoic. Precise age constraints for the Galula Fm are necessary to understand the timing of these changes and to understand African vertebrate evolution during this time; however, this is hindered by a lack of appropriate material in the Galula Fm for radioisotopic dating. Detrital zircon analyses suggest a maximum depositional age for the Galula Fm in the Upper Jurassic, while the fauna suggests a middle–Upper Cretaceous age. Possible correlation to the mid-Cretaceous Dinosaur Beds of Malawi has been proposed based on similar lithology and faunal assemblages; however, more precise dating is required to test this.

We have collected paleomagnetic hand samples from 46 levels in four stratigraphic sections of the Galula Fm to create a new magnetostratigraphic framework for the unit. Paleomagnetic samples are being stepwise thermally demagnetized to determine their characteristic remanent magnetization and preliminary results show that the Galula Fm preserves a stable characteristic remanent magnetization carried by hematite. Two polarities are preserved within the unit, which is highly significant, as the middle Cretaceous is characterized by the Cretaceous long normal, and in this case even a single reversal is likely to be highly informative. This new magnetostratigraphy for the Galula Fm will help constrain the timing of deposition and may be used to provide further temporal constraint for biological, environmental, and tectonic changes in eastern Africa during the Cretaceous. Moreover, this will allow more confident correlation between exposures of the Galula Fm within the basin and to other potentially correlative sequences elsewhere in eastern and central Africa

Grant Information
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Technical Session X (Friday, October 16, 2015, 11:15 AM)

THE COLORFUL EGGS OF DINOSAURS: HOW FOSSIL METABOLITES REVEAL NESTING BEHAVIOR

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Since dinosaur nesting behavior is a popular but controversial research topic, reliable indicators for behavioral reconstructions are required. In extant birds, eggshell coloration based on the metabolites protoporphyrin IX (PP, reddish pigment) and biliverdin (BV, blue-greenish pigment) reflects the nesting environment and brooding behavior. The physiological pathways producing colored eggshell were generally seen as synapomorphies of modern birds. However, maniraptoran dinosaur eggs have never been tested for the presence of eggshell pigments. Here we present the phylogenetically most basal evidence, based on ESI (+) Q-TOF mass spectrometry, of endogenous BV and PP which are preserved in 66 million year-old oviraptorid eggshells of *Heyuannia huangi* from Henan, Jiangxi and Guangdong provinces, China.

Semi-quantitative estimations of the actual amounts of color pigments suggest that the eggs of *Heyuannia huangi* contained originally more BV than PP. Unlike BV being incorporated over almost the entire thickness of the eggshell, PP is stored mainly in the outer eggshell cuticle. Consequently, the discovery of PP suggests cuticle preservation and two-tone egg coloration. Based on the present-day pigment ratio the original color impression cannot be accurately reconstructed, but it likely would have been olive green in immaculate eggs or speckled brown on a bluish background if the eggs were maculated.

Such a coloration results in efficient crypsis of eggs in open nests covered with plant material. Eggshell coloration, serving mainly for egg crypsis, became positively selected for when parent animals started building open nests. Thus the pigment preservation in the eggs of *Heyuannia* indicates open or partially open nesting, for which there is also evidence through porosity measurements. In extant birds, blue-greenish egg pigmentation involves complex social adaptions, for instance, intensive parental care and increased paternal investment, suggesting similar behavior in oviraptorid dinosaurs. Furthermore eggshell coloration physiologically hints at a bird-like oviduct which enzymatically provides a membrane transfer and eggshell-pigment incorporation mechanism. This discovery offers a new biochemical perspective on eggshell paleobiology and elucidates the potential of fossil metabolites to reconstruct dinosaur behavior and physiology.

Technical Session IX (Thursday, October 15, 2015, 3:30 PM)

A NEW TERRESTRIAL VERTEBRATE FAUNA FROM THE LATE CRETACEOUS FERRON SANDSTONE OF NORTH AMERICA

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The Late Cretaceous was characterized by exceptionally high global sea levels with frequent reduction or absence of terrestrial deposition, severely limiting our understanding of terrestrial ecosystems from that time. An especially underrepresented time in the terrestrial fossil record is the Turonian, for which only a few terrestrial body and trace fossil localities exist across North America. Here we report a new terrestrial fauna from multiple localities in the Ferron Sandstone Member of the Mancos Shale Formation of Utah. Bentonites at the base and top of the Ferron Sandstone have been radiometrically dated as middle–upper Turonian (91.25 ± 0.77 - 90.64 ± 0.25 Ma). The Ferron Sandstone was deposited as part of a fluvial-deltaic complex that encroached on the then-extensive Western Interior Seaway. The new fauna is known from both body- and ichnofossils and contains evidence of sharks, turtles, crocodilians, pterosaurs, ornithopod, sauropod, and theropod dinosaurs. Body fossils are found primarily at the base of fluvial and distributary channels deposited within a fresh-to-brackish-water lower delta-plain environment. Trackways include sauropod, theropod, and ornithopod tracks. The most extensive example occurs on a single very extensive (hundreds of square meters) bedding plane. At the present state of excavation, sauropods are by far the most common trackmakers at the site, with a large size range of preserved tracks, from inferred very young juveniles to adults. The presence of sauropods at the site is unexpected, as the only other Late Cretaceous North American occurrences of the clade are approximately 10 and 20 million years older and younger, respectively. Sauropods were not extirpated from North America near the Early–Late Cretaceous boundary as previously suggested; instead, the presence of sauropods in just one among many better-sampled coastal Late Cretaceous North American faunas suggests their genuine rarity at the time. Because these tracks were made within 10 km of the coast, Late Cretaceous North American

sauropod rarity is not fully explainable by their inhabiting poorly represented 'inland' environments, as previously suggested.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

UN-CONVENTIONAL SCIENTIFIC OUTREACH: USING SCIENCE FICTION AND MEDIA CONVENTIONS TO PROMOTE PALEONTOLOGY AND NATURAL HISTORY MUSEUMS

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Natural history museums and paleontology face challenging times. Attendance at many natural history museums has declined due several factors: perceptions of unchanging exhibits, state and local school budget cuts, and overall increase in visual media use. Many view these museums as a home for 'dead things'. Additionally, paleontology has struggled to remain relevant to the general public, who increasingly view it as 'digging in the dirt' with little practicality in the modern world. One method to help counteract these misconceptions is to utilize well attended media conventions for museum outreach and exhibition. One rapidly growing type of conventions are comic cons. Often weekend events, these multimedia, multi-interest events bring thousands to tens of thousands of people to one location for one weekend. The general demographic for these convention goers include comic book collectors, superhero and Sci-Fi fans, fans of popular TV shows (Walking Dead) and, most importantly, families! In 2014, the four day Wizard World Chicago Comic Con exceeded 90 000 attendees and attendance is expected to increase yearly. In February 2015, the Burpee Museum exhibited at the Wizard World Comic Con at Madison, Wisconsin. Although only the first such Comic Con held in Madison, attendance was a surprising 10 000 for three days. Burpee's booth showcased collection material including dinosaur skull casts, real fossils, touchable displays and free items to pass out: temporary tattoos, museum pens, brochures, and general information. Madison is only 74 miles (119 km) from Rockford, and thus within the area that Burpee serves, but most people Burpee interacted with had no idea there was a museum in Rockford. Tallies of 1543 interactions were kept, and feedback was overwhelmingly positive. Aside from exhibition, other convention tools include presentations and panel discussions. Some science fiction conventions have a 'science track' where scientists can present information about their research and field questions from the audience (which would include members of the general public, authors and artists). In some venues these are among the highest attended panels for the convention. Conventions thus present an opportunity for public outreach interaction similar to the 'Café Scientifique' approach but with audiences that can be orders of magnitude larger and within the context of a larger organized environment.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

A NEW TAENIOLABIDOID MULTITUBERCULATE FROM THE MIDDLE PUERCAN (PU2) OF THE NACIMIENTO FORMATION, NEW MEXICO, AND A REVISION OF TAENIOLABIDOID SYSTEMATICS AND PHYLOGENY

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Multituberculates were among the most abundant and taxonomically diverse mammals of the late Mesozoic and Paleocene, reaching their zenith in diversity and body size in the Paleocene. Taeniolabidoidea includes the largest known multituberculates that possess highly complex cheek teeth adapted for herbivory. A new specimen from the early Paleocene (middle Puercan; biochron Pu2) of the Nacimiento Formation, New Mexico, comprised of a partial skull with a nearly complete upper dentition, represents a new large-bodied taeniolabidoid genus and species. It possesses diagnostic taeniolabidoid characters and is most similar to *Taeniolabis*, but differs in being smaller and having fewer M1 cusps and a relatively larger P4 compared to M1.

We performed a phylogenetic analysis to examine the relationships within Taeniolabidoidea that included new information from the new Pu2 taxon and from new specimens of *Catopsalis fissidens*, and data from all other described North American and Asian taeniolabidoids. Results indicate that *Catopsalis* is non-monophyletic. The new Pu2 taxon and *Taeniolabis* form a clade (Taeniolabididae), as do the Asian *Lambdopsalis*, *Sphenopsalis*, and possibly also *Prionessus* (Lambdopsalidae).

The latest Cretaceous North American taxon *Bubodens magnus* was the largest Mesozoic multituberculate and the largest late Cretaceous mammal. It may represent the oldest and only known Cretaceous taeniolabidoid. Taeniolabidoids underwent a modest taxonomic radiation during the early Paleocene of North America and underwent a dramatic increase in body size with *Taeniolabis taoensis* possibly exceeding 100 kg. Taeniolabidoids appear to have gone extinct in North America by the late Paleocene, but the appearance of lambdopsalids in the late Paleocene of Asia suggests that they dispersed from North America in the early to middle Paleocene.

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Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

ISOLATED DROMAEOSAURID TEETH FROM THE BATHONIAN (MIDDLE JURASSIC) OF DORSET, UNITED KINGDOM

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Small bodied theropod taxa are known from isolated teeth and fragmentary remains occurring throughout the British Bathonian. The exception is the tyrannosaurid *Proceratosaurus bradleyi* which comprises a partial skull, mandibles, hyoid and cervical rib fragments. Small isolated teeth occur at a number of microsites in southern England. The sites usually represent small ponds, channel fills or swamps formed on low-lying exposed limestone platforms. Some 200 kg of sediment from the Forest Marble Formation (Middle Jurassic, Bathonian) microsite of Watton Cliff, Dorset was analysed for microvertebrate remains. The microsite is a channel deposit cutting through a nearshore bioclastic limestone. Sixteen small theropod teeth, including four complete crowns, were recovered during this process. The majority of the teeth are fragmentary and show evidence of extensive abrasion. In addition to the theropod teeth, the microvertebrate fauna comprises a mixture of both terrestrial and non-terrestrial taxa including mammals, ornithischian dinosaurs, amphibians, crocodiles, sharks and fish. The teeth were scanned using a micro-CT. Each stack of CT data was processed to produce 3D models representing individual teeth. Standard measurements (crown width and height, basal width and denticle counts) were taken directly from the 3D models and added to a database containing > 3500 tooth measurements obtained from the published literature. The dataset is dominated by small bodied North American theropod taxa (dromaeosaurs and troodontids) with the addition of some data from non coleurosaurian theropods. Principle component analysis and discriminant function analysis were used to test the similarity of the Watton teeth with known clades, allowing the referral of the Watton teeth to the Dromaeosauridae. This pushes back the origin of dromaeosaurids from the Kimmeridgian to the Bathonian, supporting previous suggestions that the clade was present in the Middle Jurassic, and adding to the hypothesis that the coelurosaur radiation occurred earlier than the current body fossil record supports.

Technical Session XVII (Saturday, October 17, 2015, 3:45 PM)

THE SKULL OF *TAPUIASAURUS MACEDOI* (DINOSAURIA: SAUROPODA), A BASAL TITANOSAUR FROM THE EARLY CRETACEOUS OF BRAZIL

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The recent discovery of a partial skeleton of the sauropod dinosaur *Tapuiasaurus macedoi* offers the first glimpse of the skull of a titanosaur from South America, where the greatest diversity of that group has been recorded since the late 19th Century. Surprisingly, cranial elements are known for just over 20 of the ca. 70 titanosaur genera-the vast majority of which are fairly fragmentary and restricted to the Late Cretaceous. Only three complete titanosaur skulls have been described to date; two of these are from the latest Cretaceous (*Nemegtosaurus*, *Rapetosaurus*), and the third, *Tapuiasaurus*, is from the Early Cretaceous (Aptian). Initial analyses recovered the three taxa with complete skulls as a monophyletic group, an arrangement that implies two ghost lineages that exceed 50 million years. Here, we provide a complete description of the cranial elements with the benefit of additional preparation and CT imaging. We were able to identify six additional autapomorphies of *Tapuiasaurus macedoi*, including a jugal with an elongate dorsal process that forms much of the posteroventral border of the antorbital fenestra, lateral temporal fenestra divided by a second squamosal-postorbital contact, and upper jaw teeth with labial wear facets.

We direct the new morphological data from *Tapuiasaurus* towards a re-assessment of its phylogenetic position within Titanosauria. Although initial analyses recovering a monophyletic Nemegtosauridae had moderate support, they depend in part on a configuration of missing data wherein a subset of taxa (nemegtosaurids) could be scored for a substantial number of cranial features but many fewer postcranial features and another subset of taxa (other titanosaurs) had the converse pattern. That is, monophyly of nemegtosaurids relied predominantly on cranial features, few of which could be scored in other titanosaurs. Under these conditions, even small changes to the cranial data scored can strongly impact results. Rescoring *Tapuiasaurus* for all characters and scoring the Late Cretaceous *Isisaurus* for 10 cranial characters not previously scored produced a marked topological rearrangement. *Tapuiasaurus* was recovered as a basal titanosaur adjacent the Early Cretaceous *Malawisaurus* and *Tangvayosaurus*, and the *Nemegtosaurus* + *Rapetosaurus* clade was disrupted. Although support for this result is relatively weak, it implies a substantial reduction in the implied stratigraphic debt. Some suboptimal trees (plus 2–5 steps) and a few random topologies offer still further congruence with the stratigraphic record.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

A REASSESSMENT OF CRANIAL ONTOGENY IN *EINIOSAURUS PROCURVICORNIS* AND *ACHELOUSAURUS HORNERI*: IMPLICATIONS FOR CENTROSAURINE TAXONOMY AND EVOLUTION

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Einiosaurus procurvicornis and *Achelousaurus horneri* are the two most represented centrosaurine dinosaurs from the late Cretaceous Two Medicine Formation of northwest Montana. The holotype specimen of *Einiosaurus* is characterized by its large, strongly procurved nasal horn, rounded supraorbital ornamentation, and posteriorly projecting P3 parietal process. Twenty meters higher in the formation, *Achelousaurus* features highly rugose nasal and supraorbital bosses and posterolaterally curved P3 parietal processes. Juveniles of both taxa exhibit short supraorbital horn cores and posteriorly curving nasal horns. *Einiosaurus* is primarily represented by two multi-individual sites, the holotype having been recovered from the Canyon Bonebed (CB). A large, articulated skull (Museum of the Rockies [MOR] specimen 456-1) with adult surface texture from CB exhibits rugose and ridged boss-like supraorbital ornamentation, a posterolaterally curved P3 process, and an anteroventrally compressed nasal horn with a rugose dorsal surface and partially anteriorly excavated tip. These features approach morphologies observed in the holotype of *A. horneri*. An additional specimen of *E. procurvicornis* (MOR 456-8-13-7-5) exhibits a similarly anteroventrally compressed nasal horn. The nasal horn morphology of large specimens of *E. procurvicornis* is consistent with the transformation of this element into a rugose and anteriorly excavated nasal boss, present in *A. horneri*.

Further, an additional *Einiosaurus* parietal (MOR 456-8-27-87-2) exhibits posterolaterally inclined P3 processes which are nearly identical to those of a referred specimen of *Achelousaurus* (MOR 571), and a disarticulated postorbital (MOR 681) from the *A. horneri* holotype locality is morphologically similar to *Einiosaurus* but features shallow, incipient boss-like ridges. Clear distinctions between specimens of *E. procurvicornis* and *A. horneri* may be obscured by ontogenetic changes in cranial morphology. These species were initially suggested to represent intermediate members of an anagenetic (transformational) lineage of centrosaurines, lacking autapomorphies. This survey suggests that features currently considered autapomorphic for these taxa may need to be reassessed in light of ontogenetic transformations. Our findings are consistent with the evolutionary transformation of *E. procurvicornis* into the more derived *A. horneri*.

Technical Session II (Wednesday, October 14, 2015, 11:45 AM)

OSTEOHISTOLOGICAL INSIGHT INTO *PTERANODON* ONTOGENY

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The number of *Pteranodon* specimens collected from the Smoky Hill Member of the Niobrara Chalk in western Kansas allows for analysis of bone microstructure across a range of body sizes. Here, descriptions of femoral microstructure patterns provide the beginning of an ontogenetic framework for studying *Pteranodon* bone histology. Although some histologic features such as vascular canal density, osteocyte density, and osteocyte shape are broadly consistent among sampled specimens, bone tissue type differs. The largest femur sampled has a cortex dominated by parallel-fibered to lamellar bone, indicating slow bone deposition rates. The presence of an outer circumferential layer signals that the individual was skeletally mature at the time of death. In contrast, a mid-sized femur reveals a cortex of woven bone, associated with higher bone deposition rates. Microstructure suggests a sub-adult ontogenetic stage. The smallest femur sampled has slow-growing parallel-fibered bone more similar to the largest adult specimen. These results indicate that there may be a large amount of adult body size variation in *Pteranodon*, which is in agreement with previous studies on *Pteranodon* ontogeny. However, it may be that the smallest specimen sampled is from a large *Nyctosaurus* specimen. Continued osteohistological analysis of additional *Pteranodon* and *Nyctosaurus* specimens should shed light on intraspecific variation, sexual dimorphism, and taxonomic uncertainties.

Symposium 3 (Saturday, October 17, 2015, 10:30 AM)

EVOLUTION OF OPERCLE BONE SHAPE IN CICHLID FISHES FROM LAKE TANGANYIKA – UNCOVERING ADAPTIVE TRAIT INTERACTIONS IN EXTANT AND EXTINCT SPECIES FLOCKS

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Phenotype-environment correlations and the evolution of trait interactions in adaptive radiations have been widely studied to gain insight into the dynamics underpinning rapid species diversification. Among the morphological traits examined in adaptive radiations, most comprise combinations of linear measurement or scored character data and few traits are directly amenable to comparison with other species flocks. Uncovering commonalities in trait complex evolution in phylogenetically, morphologically and ecologically distinct species flocks would be highly desirable in assessing key questions underpinning how adaptive radiation progresses. We here explore use of the operculum bone as a trait that can be compared in extant and extinct fish taxa. In this study we explore the phenotype-environment correlation and evolution of operculum shape in cichlid fishes, which collectively represent an unparalleled example of adaptive radiation in vertebrates, using an outline-based geometric morphometric approach combined with stable isotope indicators of macrohabitat and trophic niche. We then apply our method to a sample of extinct saurichthyid fishes, a highly diverse and near globally distributed group of actinopterygians occurring throughout the Triassic, to assess the utility of extant data to inform our understanding of ecomorphological evolution in extinct species flocks. A series of comparative methods were used to analyze shape data for 54 extant species of cichlids (N = 416), and 6 extinct species of saurichthyids (N = 44). Results provide evidence for a relationship between operculum shape and feeding ecology, a concentration in shape evolution towards present along with evidence for convergence in form, and significant correlation between the major axes of shape change and measures of gut length and body elongation. The major axes of shape change reflected a broadening of the anterior-posterior axis of the operculum coupled with a narrowing of the dorsal-ventral axis. Geometric morphometric methods provide a powerful approach for enabling reconstruction of phenotype-environment interactions and modes of evolutionary diversification in deep time.

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Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

STABLE ISOTOPE ANALYSIS OF THE EARLY HEMPHILLIAN *TELEOCERAS FOSSIGER* (PERISSODACTYLA: RHINOCEROTIDAE) FROM THE HIGH PLAINS OF KANSAS: PALEODIET AND PALEOCLIMATIC RECONSTRUCTION

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Teleoceras fossiger is an Early Hemphillian rhinoceros from the High Plains of North America. The *T. fossiger* specimens used in this study are from the Ash Hollow Formation of Minium Quarry in Graham County, Kansas and a second quarry in Ellis County, Kansas. The teeth are housed at the Sternberg Museum of Natural History (FHSM). This study uses the structural carbonate in the tooth enamel of *T. fossiger* to determine if C4 plants comprised part of the animals' diets, and uses the $\delta^{18}O$ values to reconstruct the paleoenvironmental conditions (including precipitation and paleotemperature). The methodology used for this project to isolate the structural carbonate uses sodium hypochlorite (NaOCl) to dissolve organic matter and 1M acetic acid to remove the non-structural carbonate. Once structural carbonate of the tooth enamel is isolated, it is analyzed using a continuous flow Finnigan MAT Delta Plus XP stable isotope ratio mass spectrometer. The data will be compared to the average $\delta^{13}C$ values of C3 and C4 plants to determine if C4 plants were consumed during the Early Hemphillian when C3 plants were dominant. The most noticeable change in the plant biomass occurs during the Late Hemphillian, which is the Miocene to Pliocene transition. If *T. fossiger* shows C4 biomass in its diet. It means the change over from C3 plants to C4 plants at this latitude began sooner than previously thought. If *T. fossiger* was consuming a water-stressed C3 plant diet it would indicate a more aquatic diet, which is significant for the overall understanding of rhinoceros diets in the High Plains of Kansas during the Late Miocene.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

CHANGES IN SMALL TETRAPOD FAUNAS DURING THE EARLY TO LATE CRETACEOUS TRANSITION IN NORTH CENTRAL TEXAS

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The geographic proximity of late Early Cretaceous and early Late Cretaceous vertebrate faunas in north central Texas provides tests for evolutionary as well as environmental change associated with the opening of the Western Interior Seaway and the rise to dominance of angiosperms in the flora. Intercalated marine units provide excellent chronological constraints for small tetrapods from the late Aptian–early Albian Trinity Group (~113 Ma) and those from the middle Cenomanian Woodbine Formation (~96 Ma).

These two vertebrate faunas both occur in near coastal environments, and at higher taxonomic levels, the small tetrapods share similarities. However, in detail faunal change is apparent because of new appearances, turnover at lower taxonomic levels and differences in relative abundances. Making their first appearances in the Woodbine fauna are snakes and metatherian mammals, which were not present in the Trinity Group. Crocodyliform specimens are dominant in abundance in both faunas, even among very small tetrapods. Amphibians and lizards, as well as mammals are less common, but show diversity in each of the faunas. Multituberculates are most common among the Trinity Group mammals, followed closely by triconodonts in terms of number of specimens. This appears to change by the time of the Woodbine Formation fauna based on a smaller sample, with tricondonts and therians at least as abundant as multituberculates.

These changes in the small tetrapod faunas parallel the turnover in the largest members of the fauna (dinosaurs and crocodyliforms), as would be expected with over 15+ million years separating the faunas. Among the large tetrapods, nodosaurid, and hadrosauriform dinosaurs make their first appearance by or just before the Cenomanian, just as snakes and metatherian mammals appear in the small vertebrate fauna.

Technical Session XIV (Friday, October 16, 2015, 2:30 PM)

THE FIRST TRIASSIC PLESIOSAUR: A SKELETON FROM THE RHAETIAN OF GERMANY AND ITS IMPLICATIONS FOR THE EVOLUTION OF PLESIOSAUR LOCOMOTION

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Previously known from the earliest Jurassic to the end of the Cretaceous, plesiosaurs are among the most common and best studied Mesozoic marine reptiles. Despite a history of research spanning nearly 200 years, the origin of their unique, barrel-shaped body and paraxial locomotion by underwater flight is poorly understood. The recent discovery of the first Triassic plesiosaur skeleton, from the Rhaetian of Westphalia (Germany), markedly improves this situation.

The new specimen preserves intermediate morphologies between non-plesiosaur pistosaurs and plesiosaurs, with phylogenetic analysis revealing it to be a new taxon and placing it basal to all other plesiosaurs. The skeleton is nearly complete and largely articulated, with an estimated total length of 1.6 m. Parts of the skull, the vertebral column, parts of the shoulder girdle and pelvic girdle, as well as the left humerus and femur, the complete left zeugopodials, and some phalanges are preserved. Open neurocentral sutures and unfinished neural spines identify the specimen as a subadult.

A conspicuous character, also seen in some Early Jurassic plesiosaurs but not in pistosaurids, is the V-shaped neurocentral suture of the cervical vertebrae, with the neural arch extending far ventrally on the side of the centrum. The resulting three-dimensionally folded suture surface gave the neurocentral suture strength while allowing continued growth. The limbs are developed as paddles with a straight-shafted humerus and femur and zeugopodials that are only slightly longer than wide. Together with the paddles, the reinforced, V-shaped cervical neurocentral suture may have evolved as an adaptation to underwater flight. The stiff neck would have compensated for the dorsoventral moments generated by paraxial paddle movement. Foreshortened zeugopodials are a plesiosaur synapomorphy which is not present in *Bobosaurus* from the Carnian of the Italian Alps, arguing against *Bobosaurus* representing the most basal plesiosaur.

To further constrain the ontogenetic stage of the new specimen, the humerus and femur and some ribs were sampled histologically. The long bones show radial fibrolamellar bone with abundant woven tissue, suggesting rapid growth. Growth marks indicate an age of less than two years. The new taxon thus suggests that the paraxial swimming style evolved in concert with a high metabolic rate in the most basal plesiosaurs in the latest Triassic, possibly enabling them to survive the Triassic/Jurassic extinctions and leading to their explosive radiation in the earliest Jurassic.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

A REVISED SCENARIO OF CO_2 ELIMINATION IN EARLY TETRAPODS-INFERENCES FROM OSTEOLOGICAL CORRELATES OF GILLS, SKIN, AND LUNG VENTILATION

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One of the most important physiological changes during the fish to tetrapod transition and the subsequent terrestrialization of vertebrates was the increasing reliance on lung breathing, with the concomitant decrease in importance of gill breathing. The main problem involved here was to cope with the excessive accumulation of CO_2 in the body and to avoid respiratory acidosis. In the past, several often mutually contradicting hypotheses of CO_2 elimination via skin, lungs, and gills in early tetrapods have been proposed, based on theoretical physiological considerations and comparison with extant air breathing fishes and amphibians. In more recent years, new osteological correlates of skin structure, mode of lung ventilation, and gills in early tetrapod fossils have been identified, allowing us to re-evaluate previous hypotheses in light of the now available fossil evidence and to present a revised scenario of CO_2 elimination in early tetrapods. The plesiomorphic situation for tetrapods, as shown by stem tetrapods of the Devonian and Carboniferous, was a decoupled O_2 uptake via the lungs by buccal pumping and CO_2 release via internal gills, whereas the rather gas-impermeable skin played a minor role in gaseous exchange. The two main lineages of crown group tetrapods, the amphibian (temnospondyls plus lissamphibians) and amniote lineage (stem amniotes plus amniotes), used different strategies of CO_2 elimination. Like in stem tetrapods, O_2 uptake and CO_2 release remained always largely decoupled in temnospondyls that ventilated their lungs via buccal pumping and relied mainly on their internal gills for CO_2 release. Temnospondyls were able to reduce their internal gills, but not before their skin became more permeable to gas and their body size was reduced, to shift from internal gills to the skin as the major site of CO_2 elimination, a pattern that is retained in most lissamphibians. In contrast, internal gills were lost very early in stem amniote evolution. This was associated with the evolution of the more effective aspiration pump that allowed the elimination of the bulk of CO_2 via the lungs, leading to a coupled O_2 uptake and CO_2 loss in stem amniotes and later in amniotes.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

INITIAL WORK ON THE CURSORIAL PATHOLOGY OF *TROODON FORMOSUS*

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Troodon formosus was a small (~ 50 kg) theropod common to the Upper Cretaceous (Campanian) Two Medicine Formation of western Montana. A review of specimens of *Troodon formosus* housed at the Museum of the Rockies revealed eleven abnormal vertebral and appendicular elements. This abstract consists of initial findings and some insight into the paleobiology of *Troodon*. In the axial skeleton, there are two abnormal cervical vertebrae, one of which (MOR 553S-7.28.91-236) exhibits arthritis and the other of which (MOR 553S 8.3.92-141) either has evidence of septic arthritis, diskospondylitis, or osteomyelitis. There is a dorsal vertebra (MOR 553S 7.20.91-120) with a depression on the centrum articular surface suggestive of degenerative disc disease or diskospondylitis. One caudal vertebral series (MOR unnumbered specimen) displays fusion of centra and soft tissue ossification suggestive of prior trauma. There is an abnormal forelimb element, a left second metacarpal (MOR 553S 8.13.92-237) with a small eminence on the extensor surface that may represent a tendon avulsion. In the hind limbs, a left femur (MOR 553S 7.16.0-61) is rippled along the cranial cortex on the upper midshaft of the diaphysis that may be consistent with premature physeal closure and continued growth of the diaphysis and metaphysis, although taphonomic factors cannot be excluded. In the metapodials of the hind limb, three abnormal metatarsals were found. A right first metatarsal MOR 748 has a cranio-medially oriented flange along the extensor cortex which may represent tendinous or ligamentous ossification. A right fourth metatarsal (MOR 553S 1.11.01-8) has a partially healed superficial bone injury with periosteal reactive response. A left fourth metatarsal (MOR 553S 8.17.92-260) has a small proliferation on the flexor cortex, which may also represent a tendon avulsion. The last abnormal element is a claw from the right pes phalanx II of (MOR 553L 7.25.89-313), which has a healed displaced angulated fracture with remodeling of the associated ligament pits. These abnormalities support the interpretation of *Troodon* as an active cursorial animal with injuries and degenerative bone pathology consistent with this lifestyle.

Technical Session XIV (Friday, October 16, 2015, 2:15 PM)

A NEW GENUS AND SPECIES OF ICHTHYOSAUR (REPTILIA, ICHTHYOPTERYGIA) FROM THE BLUE LIAS FORMATION (LOWER JURASSIC) OF THE UNITED KINGDOM

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The Blue Lias Formation (Lower Jurassic) of the United Kingdom documents the first diverse ichthyosaur fauna post-dating the end-Triassic extinction event. To date, four genera have been recognized, represented by as many as 10 species. Here, we report a new genus and species of ichthyosaur from the Blue Lias Formation, represented by two specimens: a partial skeleton from Lyme Regis, Dorset and a nearly complete, three-dimensionally preserved skull from Stockton, Warwickshire. The new taxon can be distinguished by the following characters: an overbite comprising 26% of the snout length*, a densely pitted surface of the maxilla*, a two-pronged anterior process of the jugal, a series of anteroposteriorly oriented striations located anteroventral to the posterior process of the jugal*, and the presence of a jugal process of the postorbital that forms a fork encompassing the posterodorsal part of the jugal* (asterisks denote autapomorphies). The significant overbite is an especially striking feature of the new ichthyosaur's anatomy because the snout and dentition of the new taxon are more robust than those of other ichthyosaur taxa known to possess overbites –*Excalibosaurus* and *Eurhinosaurus*. This suggests a markedly different ecology. The new Jurassic taxon also retains some plesiomorphic features previously recognized almost exclusively in Triassic taxa, including the presence of the anterior terrace of the supratemporal fenestra. This combination of primitive and derived characters is reflected in the phylogenetic analysis, which places the new taxon near the base of Neoichthyosauria.

Technical Session XV (Saturday, October 17, 2015, 9:30 AM)

THE NEW WORLD TROPICS AS A CRADLE OF MAMMALIAN BIODIVERSITY: A PRE-GABI RECORD

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The Great American Biotic Interchange (GABI) was a substantial perturbation of New World Tropics (NWT) ecological dynamics, potentially obscuring our ability to test process-based hypotheses concerning the origin of NWT biodiversity. Efforts of the Panama Canal Project have extensively added to our knowledge of the early Miocene Centenario Fauna, a pre-GABI mammalian paleofauna from the Panama Canal Basin that, combined with the rich mammalian record of North America, allows us to test hypotheses that invoke higher origination rates, lower extinction rates, and/or greater net emigration to explain the origin and maintenance of NWT mammalian biodiversity. In this study, early Miocene occurrence data from North and Central America, including new data from the Panama Canal, were analyzed to track the geographic distribution of first and last appearances in mammalian genera during the early Hemingfordian North American Land Mammal Age (He-1 NALMA subdivision, ~19–17.5 Ma). Cluster analysis of faunal similarity among regional collections of He-1 mammals reveals two distinct faunal provinces with a latitudinal boundary of 33°N, clearly defining a biologically-meaningful boundary between tropical and extra-tropical mammalian communities during the He-1 NALMA subdivision. After taking sampling intensity into account, our results show a statistically significant higher proportion of first appearances in the tropical faunal province relative to the extra-tropical province with no significant difference in last appearances, supporting the hypothesis that higher origination rates lead to greater mammalian biodiversity in the NWT. The Out of the Tropics model for the origin of latitudinal biodiversity gradient in multiple clades predicts that extra-tropical regions should disproportionately accumulate older taxa over geologic time due to relatively lower origination rates and high immigration sourced from tropical regions. In our dataset, the average longevity of range-through and last appearance He-1 mammalian genera in the two provinces are not statistically significantly different, failing to provide support for the Out of the Tropics model.

Grant Information

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Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

HOW DID THE OLDEST ARCHOSAURS OF NORTH AMERICA GROW?

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Archosauria originated in the Early Triassic, but bones of early members are rare and little is known of the paleobiology of these organisms. To investigate the growth of early archosaurs, we focused on the abundant archosaur remains from the early Middle Triassic Moenkopi Formation of New Mexico. Although the limb elements are found isolated, we attribute three distinct femora to two poposauroids; one likely pertains to *Arizonasaurus* (based on inferred morphology and other data), the others to a shuvosaurid-like poposauroid (distinct ridge on the anterior surface, lack of a fourth trochanter ridge). We conducted bone histology on femora from two differently sized (estimated length = 24-30 cm and 15-19 cm, respectively) shuvosaurids and *Arizonasaurus* (estimated length = 22-28 cm). The larger shuvosaurid shows one clear line of arrested growth (=LAG) and another at the innermost cortex. The cortical bone is comprised of woven bone, with slight increases in organization precluding the LAG; the outermost edge of the cortex is composed of lamellar bone. Vascular canals anastomose in all directions and there is a slight decrease in vascularity corresponding to the increase in organization preceding the LAG. The small shuvosaurid exhibits no LAGs. The bone is woven, but displays a higher degree of vascularity, with canals being primarily longitudinal. The outermost edge of the cortex is composed of lamellar bone and the interior edge is lined with endosteal bone. Both shuvosaurids have trabecular bone within their medullary cavities, with the small individual having proportionally more than the larger one. The *Arizonasaurus* individual also deposits woven, disorganized bone, with the disorganization following parallel bands. It exhibits one LAG, with the disorganized bone becoming more organized preceding it. Within the woven bone, the vascular canals bear frequent anastomoses, to a greater degree than the shuvosaurids. The abundance of vascularity declines greatly in the organized regions near the LAG. Erosion of the medullary cavity is evident and more uniform than that in either of the shuvosaurids, though there is no deposition of endosteal or trabecular bone. These two early archosaurs demonstrate that Archosauria were fast-growing when the clade originated; these tissue types were maintained through the Triassic among pseudosuchians and the faster growing tissue types are not found in the surviving pseudosuchians, extant crocodylians.

Grant Information

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Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

LATE PLEISTOCENE FLAT-HEADED PECCARIES (*PLATYGONUS COMPRESSUS*) FROM BAT CAVE, MISSOURI, WITH COMMENTS ON THEIR PALEOBIOLOGY

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Bat Cave, located in the central Ozarks of Pulaski County, Missouri, has been recognized for its late Pleistocene fauna since the 1950s, and portions of it were excavated throughout the 1960s under the direction of Dr. Oscar Hawksley. From these excavations, 6337 elements corresponding to 98 individual peccaries of the species *Platygonus compressus* were reported, making this species by far the most numerous vertebrate recovered from the cave. In spite of its abundance, the peccary remains were never analyzed in any great detail. Instead, Hawksley and co-authors noted that the fossils would be included in a comprehensive *P. compressus* paper by other researchers, which never occurred. In addition to the original collection, Schubert led a number of trips into the cave and collected more remains. Here we address the *P. compressus* fossils from the site, some 42 years after the original publication by Hawksley and others. Our assessment of the material indicates that many elements were misidentified, and that all *P. compressus* age groups are represented, from very young to old-aged individuals. Carnivore damage is common and indicates varying degrees of modification. Despite the abundance of the fauna, no other large or medium-size ungulates are known from the site, as would be expected from an ongoing carnivore den. The age profile, lack of other ungulates, and carnivore modification, leads us to suggest that the peccaries died in the cave. Thus, the carnivore damage may be the result of cave hunting or scavenging. The Bat Cave sample also preserves a number of canines that exhibit smooth wear surfaces that are perpendicular to the crown and root. These features, also known as gum-line notching, have been interpreted to represent either rooting behavior or browsing. Based on the orientation of the wear patterns, we concur with the browsing hypothesis. In addition to our paleobiological study of the peccaries, we also report radiocarbon dates on the site for the first time. Accelerator mass spectrometry analyses on *P. compressus* teeth date the species and deposit to the Last Glacial Maximum.

Technical Session XVII (Saturday, October 17, 2015, 2:30 PM)

THE SMALLEST KNOWN DIPLODOCID SKULL: NEW INSIGHTS INTO SAUROPOD CRANIAL DEVELOPMENT

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The Mother's Day Quarry in the Upper Jurassic Morrison Formation of south-central Montana preserves a monodominant assemblage of immature diplodocid sauropods. Included among the thousands of appendicular and axial elements are two small, partial skulls. The more complete specimen (Cincinnati Museum Center [CMC] VP14128) is deformed by anteroposterior and lateral crushing, but preserves details of braincase and posterolateral skull anatomy, including the orbit and laterotemporal and supratemporal fenestra. The right and left premaxillae, maxillae, and dentaries are also preserved, as are four anterior cervical vertebrae. A second braincase was found in close association and is morphologically indistinguishable from the more complete skull. The skull is estimated to have a total length of < 25 cm.

CMC VP14128 is assigned to Diplodocidae on the basis of the presence of an elongate prefrontal and paroccipital process with a rounded ventrolateral end, and the lack of squamosal-quadratojugal contact. The skull is delicate, with an elongated rostrum and narrow-crowned teeth restricted to the anterior portion of the jaws. The presence of a basipterygoid recess and basipterygoid processes that lack an anteroventral flare distinguish CMC VP14128 from *Apatosaurus,* while the basal tubera are robust, triangular, and protrude posteroventrally from the basicranium. The cervical vertebrae exhibit cervical ribs that do not project below and lateral of centrum, dorsoventally elongate postzygapophyses, centrum length proportionally greater than cotyle width, posteriorly orientated diapophyses, a steep angle between prezygapophyses and neural spine, cotyle angled to the centrum, and a less convex ventral surface of centrum; all of which are observed in *Diplodocus*.

The combination of vertebral and cranial characters supports the assignment of the Mother's Day Quarry sauropods to *Diplodocus* sp. These small skulls highlight significant cranial modifications throughout ontogeny and are in agreement with other interpretations of changing diplodocid cranial shape that may relate to niche partitioning and food acquisition in immature animals.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

AN ONTOGENETIC HISTOANALYSIS OF POLAR DINOSAURS FROM VICTORIA, AUSTRALIA

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High-latitude paleofaunas are of particular interest to dinosaur paleontologists because of the unique conditions under which dinosaurs survived and flourished, including months of twilight or polar darkness. Basal ornithopods ('hypsilophodontids') and small theropods are common in the Early Cretaceous (Aptian–Albian) high latitude non-avian dinosaur fossil record of Victoria, Australia. A previous histologic analysis suggested Victorian polar dinosaurs had physiologies similar to their lower-latitude relatives, due to similar tissue organization and presence of cyclical growth marks (CGMs). For the current study, hypsilophodontid and theropod tibiae and femora were histologically examined to better understand Australian polar dinosaur ontogenetic life histories, which have remained largely unexplored. In general, hypsilophodontid elements with three or fewer CGMs consist of fibro-lamellar to loosely parallel-fibered tissue with longitudinal vascularity. Tissue becomes predominately parallel-fibered in the mid to outer cortex if more than 3 CGMs are present. The Aptian sample consists of eleven hypsilophodontids with CGM counts between zero and seven, and a plot of CGM versus tibia length reveals a weak asymptotic trend with considerable individual variation in body size versus age. The outer cortex of two hypsilophodontids (with 6 and 7 CGMs respectively) consists of an external fundamental system (EFS), signaling skeletal maturity. No asymptotic trend emerges for the Albian sample, possibly due to the smaller sample size of six, individual variation in body size, and/or unrecognized different species. However, three of the six Albian hypsilophodontids contain an EFS, and these three individuals have CGM counts between 3 and 4. The two Aptian theropod samples include a femur of 19.3 cm and a tibia of 17.8 cm, with zero and 8 CGMs respectively, and no EFS. The innermost cortex of the femur is fibro-lamellar but changes to loosely parallel-fibered tissue in the mid to outer cortex. The theropod tibia is predominately parallel-fibered. This initial ontogenetic study suggests high individual variation in hypsilophodontid body size, and confirms a small asymptotic adult size for Victorian hypsilophodontids. With additional sampling, separation between ontogenetic, individual, and species variation within Victorian hypsilophodontids and theropods will become more evident.

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Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

TITANOSAURIAN AND OTHER VERTEBRATE REMAINS FROM THE CRETACEOUS GOKWE FORMATION, CENTRAL ZIMBABWE

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Fossil vertebrates from the Gokwe Formation (Fm) of central Zimbabwe have been known for over 50 years, yet remain poorly understood due in part to their poor preservation and the uncertainty surrounding their age, previously constrained to Upper Jurassic-Cretaceous. Collections from the Gokwe Fm include a diverse array of vertebrate fossils that both expand the scope of African faunal distributions and permit a more complete assessment of the age of the Gokwe Fm itself. Generally, the Gokwe Fm preserves isolated and mostly fragmentary remains of theropod and sauropod dinosaurs, mesoeucrocodylian crocodyliforms, pleurodire turtles, and lepisosteid fish. Theropod remains, consisting primarily of isolated teeth and vertebrae, suggest the presence of at least one taxon of medium-bodied abelisauroid. Sauropods are known from isolated caudal vertebrae, teeth, and one osteoderm. Though fragmentary, these remains likely correspond to at least one taxon of titanosaurian on the basis of caudal vertebral morphology. One proximal caudal vertebra possesses a highly procoelous centrum and a flat posterior articular surface that differs from the morphology of potentially contemporaneous basal African titanosaurs such as *Malawisaurus dixeyi, Rukwatitan bisepultus,* and *Karongasaurus gittlemani*. A second morphology is represented by a single distal caudal vertebra with a procoelous centrum and pronounced chevron processes that differ from distal caudal vertebrae associated with *M. dixeyi, R. bisepultus and K. gittlemani*. Isolated teeth are rod-like and preserve well-developed high-angle wear facets, as observed in other titanosaurians such as *M. dixeyi* and *K. gittlemani*. Additionally, a large (310 mm diameter) osteoderm demonstrates the presence of lithostrotian titanosaurs in the Gokwe Fm assemblage. The preserved fossil assemblage may indicate that the Goke Fm is Cretaceous in age, and highlights the potential of the Gokwe Fm to enhance our understanding of vertebrate evolution, diversity, and geographic distribution in Africa during the Cretaceous.

Colbert Prize (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

ONTOGENETIC LONG BONE HISTOLOGY OF *EDMONTOSAURUS ANNECTENS* (ORNITHISCHIA: HADROSAURIDAE) FROM A MONODOMINANT BONEBED

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Comparative histological analyses of polar and temperate populations of the hadrosaurid *Edmontosaurus* from the Maastrichtian of North America have supported suggestions polar populations were not migratory. Long bones from *Edmontosaurus* sp. from Alaska, which are derived from small individuals, show numerous textural shifts between reticular and laminar (circumferential) fibrolamellar bone (FLB), but this pattern was inconsistently observed in a sample of larger *E. regalis* individuals from Alberta. The differently sized individuals, of potentially different ontogenetic stages, complicate the interpretation of histological differences. In order to better understand the ontogenetic histological changes of *Edmontosaurus*, we conducted the first detailed histological analysis of *E. annectens,* using a population from the Ruth Mason Dinosaur Quarry (RMDQ), a monodominant bonebed in the Hell Creek Formation of South Dakota. Multiple long bone elements (five tibiae 56-88 cm, four femora 68-106 cm, two humeri 45-65 cm) were thin-sectioned. Categorization of bones followed published ontogenetic growth stages ranging from late juvenile to adult, recognized on the basis of relative size and patterns of histological changes at each growth stage/size class.

Late juvenile bones are all composed of primary bone tissues exhibiting a large medullary cavity surrounded by highly vascularized woven-fibered bone within the inner cortex. The vascularity of the outer cortex largely consists of reticular bone transitioning into pronounced laminar bone extending to the periosteum. Subadults preserve this highly vascularized woven-fibered inner cortex but begin to reduce the relative area of the medullary cavity. Prominent lines of arrested growth (LAGs) appear in the outer cortex, while the first growth mark shows a sharp gradational shift from laminar to reticular bone. Adults have well developed secondary osteons and the outermost cortex comprised

solely of laminar bone preserves stacking of LAGs indicating the individuals were approaching asymptotic body size.

Juveniles and subadults exhibit a stronger zonation of bone with consistent shifts between reticular and laminar FLB than adults in the same population (RMDQ). This study reveals some of the putative differences between the polar and temperate samples may instead reflect the growth stages of individuals in each sample. Further studies should focus on comparing material over a range of size and age classes in order to test for latitudinal differences in dinosaurian growth strategies.

Technical Session VIII (Thursday, October 15, 2015, 3:00 PM)

THE RELATIONSHIP BETWEEN PREY SIZE AND CRANIAL STRESS IN TERRESTRIAL MAMMALIAN CARNIVORES

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Terrestrial mammalian carnivores, both eutherian and metatherian, show considerable variation in facial morphology. Diet, similarly, is known to span from almost entirely carnivorous to almost entirely herbivorous. It has been suggested that a capacity to generate higher bite forces may correlate with a preference for relatively larger prey. Here, in the largest and most inclusive such study attempted to date, we apply 3D Finite Element Analysis using models representing the skulls of 50 species of 'carnivorous' terrestrial mammals to test the hypothesis that species that regularly take relative large prey are adapted to resist higher bite forces. Digital models of carnivore crania were constructed, and simulated forces were then applied to each model, with the level of force applied scaled to body mass. Differences in stress distribution along the rostrum were recorded for each species and compared using a geometric morphometric approach. Consistent with the proposed hypothesis, we found a significant relationship between higher relative prey size and lower cranial stress. However, while overall results suggest that the ability of crania to withstand stress is a good general indicator of preferred prey size in terrestrial mammalian carnivores, and hence useful in the prediction of diet in fossil taxa, other factors must also be considered.

Grant Information
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Technical Session X (Friday, October 16, 2015, 11:45 AM)

A BIZARRE NEW THEROPOD FROM THE JURASSIC OF HEBEI, CHINA, AND THE DIVERSIFICATION OF THE SCANSORIOPTERYGIDAE

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The Scansoriopterygidae is a recently discovered endemic clade of basal paravian theropods only known previously from the Middle-Upper Jurassic of the Daohugou Locality, Ningcheng County, Inner Mongolia, China. Here we report a new scansoriopterygid based on a specimen collected from the Tiaojishan Formation of the Mutoudeng Locality, Qinglong County, Hebei Province. The fossiliferous strata at Mutoudeng are similar in age to those at Daohugou, and their fossil content forms part of the Yanliao (or Daohugou) Biota of northeast China.

The new taxon is distinguishable from other scansoriopterygids in a number of features across the skeleton. The most surprising and distinctive such feature is a long rod-like bone that extends from the carpus. The rod-like bone is probably analogous to the styliform cartilage of petauristine flying squirrels, which arises from the wrist and helps to support the flight membrane. More broadly, elongate, unjointed skeletal elements are associated with various distal limb joints in pterosaurs and in several mammal groups, including bats, and invariably are part of the supporting apparatus of an aerodynamic membrane. We suggest a similar function for the rod-like element in the new theropod, which is probably neomorphic in origin. Corroborating evidence for this functional inference is provided by patches of sheet-like soft tissue, likely representing remnants of the flight membrane, associated with the rod-like bone and the manual digits. Preserved feathers are also present, but are filamentous rather than pennaceous. This new find thus suggests the presence in a basal paravian of an aerodynamic apparatus totally different from the archetypal wings of all other known volant theropods but similar to the membranous wings of various other tetrapods, evidently the product of a remarkable evolutionary experiment along the line to birds. The new find highlights numerous unusual skeletal and integumentary features of scansoriopterygids, and demonstrates that this group represents a case of extreme morphological divergence near the origin of birds.

Grant Information
National Natural Science Foundation of China (41372014, 41472023, 41120124002 and 41125008)

Technical Session I (Wednesday, October 14, 2015, 10:45 AM)

TOOTH ENAMEL SURFACE TEXTURE ANALYSIS FOR THE EXTANT DEER POPULATIONS WITH KNOWN DIET

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Identifying the diet of fossil herbivores remains a long-standing and important question for researchers. Herbivores that exists today show that the great diversity in their diets corresponds to their habitats. The empirical data drawn from extant herbivores provide a robust background from which to assume the paleoecology of fossil specimens. Although recent dietary reconstruction methods are significantly improving our understanding of the paleodiet of fossil herbivores at the species level, the resolution of these methods is not sufficient for detecting dietary changes at the intraspecific level that are linked to local habitat. In order to explore the dietary variation induced by ecological diversity, we analyzed enamel surface texture of the lower second molar of extant deer populations (*Cervus nippon*) with known diet and habitat. The deer have been conventionally classified as intermediate feeders; however, recent ecological studies revealed that their dietary contents showed broad diversity from grazing to browsing that correlated to their local habitat or seasons. We analyzed six deer populations in Japan. Their tooth enamel surface texture data were collected by confocal laser microscope at a vertical sampling interval of 0.1 μm and examined using 3D surface texture analysis based on industrial parameters (ISO 21578). Using ISO parameters to measure surface texture characteristics enables more reliable comparative dietary reconstruction than conventional microwear studies by reducing inter-observer errors and providing numerical data compatible with multivariate statistics.

Here we show that ISO parameters can quantitatively distinguish various levels of intermediate feeding within the same species. One-way analysis of variance showed that height, functional volume, and feature parameters were significantly different among populations. Some of the parameters were correlated to proportion of grass in mean annual diet. The results suggest that enamel surface texture have the potential to reveal geographic or seasonal differences in diet at the intraspecific level. However, there was no significant difference in isotropy of surface texture direction, which implied chewing stroke movement was almost the same irrespective of their dietary difference. These data have important implications for establishing a method for high-resolution paleodiet reconstruction that can detect differences at the intraspecific level and for paleoenvironmental reconstruction based on herbivore diet in local areas.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

UTILITY OF SCLEROTIC RINGS IN MOSASAUR PHYLOGENY AND BEYOND: NEW INSIGHTS FROM THE SUBFAMILY MOSASAURINAE

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Mosasaurs (Squamata: Mosasauridae) were a highly successful group of Late Cretaceous (ca. 98–66 Ma) aquatic lizards that exhibited a high degree of adaptation to life in water. Like many modern lizards and birds, a sclerotic ring composed of scleral ossicles was present within mosasaur eyes. Despite their rich fossil record, however, mosasaur sclerotic rings are seldom preserved intact. Consequently, our understanding of this structure in mosasaurs has been limited because no direct comparisons of sclerotic rings have been made between different members of the Mosasauridae, and those of the order Squamata. The phylogenetic utility of the mosasaur sclerotic ring, both within Mosasauridae and within Squamata, has thus remained uninvestigated to date. Here we describe the sclerotic rings in four hydropedal mosasaur genera, ranging in age from the Coniacian to the Maastrichtian: *Clidastes*, *Tylosaurus*, *Platecarpus*, and *Mosasaurus*. The subfamily Mosasaurinae is represented by *Clidastes* and *Mosasaurus*, whereas *Tylosaurus* and *Platecarpus* belong to a distinct clade called Russellosaurina. Specimens of *Clidastes* sp., cf. *C. liodontus* (FMNH PR 495, previously identified as *C. propython*) and *Mosasaurus* sp., cf. *M. hoffmannii* (NHMM 2013001) exhibit an identical scleral ossicle count and arrangement, despite their temporal separation of about 20 million years. At the same time, the ossicle count and arrangement exhibited by these two mosasaurine genera are distinct from those of russellosaurine *Tylosaurus proriger* and *Platecarpus tympaniticus*, which share their attributes with numerous extant terrestrial lizard taxa within Iguania and Scleroglossa. In stark contrast, no living squamate taxa share the mosasaurine condition of the sclerotic ring construction, which hints at a phylogenetic distinctiveness of mosasaurines within Mosasauridae specifically, and Squamata broadly. Furthermore, our discovery of the presence of a 'mosasaurine-type' sclerotic ring in a specimen referable to *Clidastes liodontus*, currently the basal-most member of hydropedal mosasaurine mosasaurs, renders further support for the notion that hydropedality-the flipper derivation from limbs-within mosasaurs likely arose independently in mosasaurines and russellosaurines. Finally, the apparent evolutionary decoupling between the scleral ossicle arrangement and secondary aquatic adaptation within the mosasaurine lineage makes these attributes of sclerotic rings informative phylogenetically, both within Mosasauridae and Squamata.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

DIETARY VARIABILITY IN PLIO-PLEISTOCENE CAMELIDS

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Stable carbon ($\delta^{13}C$) isotope values from tooth enamel can be used to reconstruct dietary variability and determine the feeding strategies of extinct camelids. Using new and previously published data from fossil sites in North and South America, we aim to clarify the degree to which Plio-Pleistocene camelids varied their diet at specific sites and across their range, as inferred from stable carbon isotopes. We compiled previously published $\delta^{13}C$ values of the dietary generalist, *Hemiauchenia* (n = 122), the opportunistic browser, *Camelops* (n=80), and the specialized forest browser, *Palaeolama* (n = 44). Specifically, we quantified the total isotopic range of each taxon and the degree

to which camelids from a given site reflect their total isotopic range, to test the following hypothesis: dietary generalists consistently demonstrate more variable $\delta^{13}C$ values at a given site than specialists.

The mean $\delta^{13}C$ value for *Camelops* (-6.5‰) was significantly greater than both *Hemiauchenia* (-7.6‰) and *Palaeolama* (-11.7‰), and *Hemiauchenia* had a significantly greater mean $\delta^{13}C$ value than *Palaeolama*. *Hemiauchenia* had the largest range in $\delta^{13}C$ values of 16.8‰, followed by *Camelops* (13.0‰), and *Palaeolama* (7.1‰). These means and ranges are consistent with prior dietary interpretations noted above, including the suggestion that *Camelops* may have consumed C_4 shrubs. A bootstrap analysis without replacement was used to generate and compare equal numbers of samples per taxon (n=44). In all iterations, *Camelops* and *Hemiauchenia* both had significantly greater variances than *Palaeolama*. In contrast, variances were indistinguishable between *Hemiauchenia* and *Camelops* in 76% of the iterations. *Hemiauchenia* had the greatest spread in site-specific $\delta^{13}C$ ranges (0.9‰ to 15.4‰, mean site range of 6.1‰), followed by *Camelops* (1.3‰ to 13.0‰, mean = 4.5‰), and *Palaeolama* (1.5‰ to 5.5‰, mean = 3.1‰). At sites with five or more individuals per taxon, *Palaeolama* used an average of 34.9% of its known isotopic range, followed by *Camelops* (40.4%) and *Hemiauchenia* (44.2%). On average, camelids use ~35-44% of their known isotopic range at a given site; however, the most generalized camelids are consistently more variable in $\delta^{13}C$ values. Thus, *Hemiauchenia* and *Camelops* were not just opportunistic feeders that altered their diets when present at different sites; instead, these camelids had a broader range of $\delta^{13}C$ values at a given site as compared to the more specialized forest browser *Palaeolama.*

Preparators' Session (Thursday, October 15, 2015, 11:45 AM)

MULTI-PART STORAGE JACKET FOR LARGE VERTEBRATE FOSSILS

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Very large bones, such as sauropod limb bones, may be in several heavy pieces. This can make it difficult to maneuver the specimen. By following the Yale Peabody Museum Vertebrate Paleontology Lab's previously published protocol for making storage jackets using Hydrocal and Hydrocal FGR plasters, fiberglass, and medium density fiberboard (MDF) and adding a few new steps, a multipart jacket is made that lines up exactly. Large bones supported in the jacket can be studied as if they were in one unbroken piece.

Separations in the jacket are placed along pre-existing breaks in the element. Before anything else, the bone sections are lined up exactly in the sand box. A piece of ¾ in MDF cut to the size of the bone in the assumed single piece is then cut again at the separation points. 'Feet' are added per our usual method. The cut MDF pieces are laid on a large flat surface and 2 X 4s running the full length of the entire base are attached onto the 'feet' of the MDF base, joining it together as if the base is one solid piece.

The exact break is offset slightly so that the bone overhangs the jacket and the base by approximately ? in. A piece of cardboard fit closely to the plastic and clay covered bone acts as a separator between the parts and creates this space. The cardboard wall is coated with petroleum jelly to ensure the plaster from one section does not attach to another section.

The jacket is then made using our usual method. Once the jacket is completed, the sections are removed, and each is treated as an individual base. All the completed bases will line up exactly. Aside from enabling easier and more accurate measurements, the individual bases can help when moving and storing the specimen.

Grant Information
Save America's Treasures, National Park Service, U.S. Department of the Interior

Symposium 3 (Saturday, October 17, 2015, 10:45 AM)

LANDMARKS IN THE BONY LABYRINTH: SHAPE OF THE INNER EAR PREDICTS PALEOECOLOGY OF LIMB-REDUCED FOSSIL REPTILES

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The bony labyrinth varies in shape among amniotes of different habits. Our previous work on modern squamates found significant differences in vestibular shape among terrestrial burrowers, terrestrial generalists, and marine swimmers. Principal component analysis of squamate vestibules showed clustering of habitat groups in the morphospace. Here we predict habitat preference of two fossil squamates: *Platecarpus coryphaeus*, a mosasaur from the Cretaceous of North America, and *Dinilysia patagonica*, a snake from the Cretaceous of South America. Both taxa have modified appendages, with *Platecarpus coryphaeus* having flipper-like limbs and *Dinilysia patagonica* being limbless. Their highly specialized or incomplete postcranial skeletons hinder habit comparison with modern squamates, using conventional ecomorphic traits such as trunk-tail ratio. We therefore examined the bony labyrinth of both taxa using high-resolution X-ray computed tomography. Virtual models of the bony labyrinth show that *Platecarpus coryphaeus* had a small vestibule surrounded by long semicircular canals. In contrast, *Dinilysia patagonica* has an expanded vestibule occupying most of the space defined by the semicircular canals. We represented the shape of the fossil bony labyrinths using six type-2 landmarks and 22 semilandmarks placed on the lateral surface of the vestibule and the lateral semicircular canal. Principal component analysis, including the fossils and 42 modern squamates, show that *Platecarpus coryphaeus* clustered with marine snakes, whereas *Dinilysia patagonica* clustered with terrestrial burrowing snakes and lizards. Linear discriminant function analysis predicted *Platecarpus coryphaeus* as a swimmer with a probability of 85.7%, and *Dinilysia patagonica* as a terrestrial burrower with a probability of 93.4%. Although *Dinilysia patagonica* was much larger than modern burrowing snakes, our new data indicates that its inner ear was highly modified for living underground. Our results provide a case study of using geometric morphometric approaches to predict ecological traits in fossils.

Grant Information
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Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

FIRST RECORD OF A SOMPHOSPONDYLAN SAUROPOD FROM UTAH, AND PALEOECOLOGY OF SAUROPODS IN UTAH DURING THE ALBIAN

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The Mussentuchit Member (Albian) of the Cedar Mountain Formation of Utah, USA, has produced a number of dinosaur remains (ankylosaurs, ornithopods, theropods, and sauropods). Price River 2 Quarry (PR2) is a bonebed, stratigraphically positioned at the base of the member, and has yielded turtles, crocodiles, pterosaurs, and dinosaurs (including the ankylosaur *Cederpelta* and *Peroloplites*). Previously, sauropod material from PR2 was identified as a brachiosaurid, but this study suggests that it is composed of at least two clades of sauropods (Brachiosauridae and Somphospondyli).

Somphospondylan material includes cervical and dorsal vertebrae, scapulae, and fibulae, having somphospondylan synapomorphies: presacral vertebrae with subcentimeter-scale pneumatic chambers in the entire vertebra, single spinopostzygapophyseal lamina in middle and posterior dorsal vertebrae, scapula with medially facing glenoid, reduced fourth trochanter of femur, well-developed anterior crest at fibular proximal end, and gently expanding fibular distal end. This is the first record of a somphospondylan from Utah and suggests the co-occurrence of somphospondylans and brachiosaurids in Utah during Albian.

Sauropods from PR2 range from medium to large in body size. Medium-sized sauropods include a brachiosaurid. Two humeri of the brachiosaurid are approximately 120 cm long, and histological sections show no LAGs but abundant secondary osteons distributed in the outer cortex, representing histological ontogenetic stage ~12-13 (adult). *Paluxysaurus* and *Petrobrasaurus* have humeri similar in length, and body masses are estimated as 12 to 15 t for these genera. On the other hand, the largest sauropod of PR2 is represented by a cervical vertebra (126.5 cm long), which is similar in size to those of one of the largest sauropods, *Sauroposeidon* (body mass of 56 t). This suggests that a gigantic sauropod was present at higher paleolatitudes (Utah) in the Albian, and that variable sized sauropods co-existed in the Albian of Utah.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

DINOSAUR FAUNAL TURNOVERS IN THE EARLY CRETACEOUS OF NORTHERN CHINA

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Understanding the Cretaceous Terrestrial Revolution cannot be complete without knowledge of what happened in the Early Cretaceous of China. Three dinosaur faunas have been recognized in the Early Cretaceous of northern China: the Hekou Dinosaur Fauna, the Jehol Dinosaur Fauna, and the Mazongshan Dinosaur Fauna. The Hekou Dinosaur Fauna is recovered from the pre-Barremian Early Cretaceous of north-central China, and is characterized by the presence of abundant titanosauriform sauropods, a polacanthid ankylosaur, and a non-hadrosauriform styracosternan iguanodont. The Jehol Dinosaur Fauna is recovered from the Barremian – early Aptian Yixian and Jiufotang formations of northeastern China, and is characterized by the presence of abundant psittacosaurs and feathered theropods, and basalmost representatives of neoceratopsians and hadrosauroids. The Mazongshan Dinosaur Fauna comes from the middle Aptian – middle Albian Zhonggou Formation in the Mazongshan area of northwestern China, and is characterized by the presence of abundant basal neoceratopsians and basal hadrosauroids, a large-bodied ornithomimosaur and therizinosaur, and the absence of psittacosaurs.

The Hekou Dinosaur Fauna is similar to those in the pre-Aptian of both Europe and North America. In these faunas, polacanthid ankylosaurs and non-hadrosauroid styracosternans were widely distributed, indicating connections among Asia, Europe, and North America during this period. Our isotopic data indicates the Hekou Dinosaur Fauna lived in a seasonal cool and dry intermontane climate with terrestrial paleotemperatures of 18-19°C. These conditions continued into the Barremian, and evidence suggests that the Jehol Biota existed in a cold highland climate. The Jehol Dinosaur Fauna is unique in yielding the first neoceratopsian and hadrosauroid, and is probably the cradle for these clades. Our lacustrine carbonate analysis in northwestern China recovered very warm paleotemperatures (averaging 31°C) during the Early Aptian. This transition from cool and dry to warm and wet environments in the Aptian played an important role at the beginning of the Cretaceous Terrestrial Revolution, and the Mazongshan Dinosaur Fauna probably marks the beginning of the Late Cretaceous Asian and North American dinosaur faunas. Faunal interchange proceeded when connections between northern China and North American were established during the Aptian-Albian. Our preliminary work also indicates a radiation of angiosperms associated with the development of the Mazongshan Dinosaur Fauna.

Grant Information
Hundred Talents Project of the Chinese Academy of Sciences; National Natural Science Foundation of China (41472020)

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

ADDITIONAL MATERIALS OF THE PLIOCENE PENGUIN *'PYGOSCELIS' GRANDIS* (AVES, SPHENISCIFORMES), AND THE GENERIC STATUS OF THE SPECIES

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'*Pygoscelis*' *grandis* is an extinct species of the crown group Spheniscidae, originally described based on a partial post cranial skeleton from the Bahía Inglesa Formation (BIF, middle Miocene – Pliocene). Its remains have only been recovered from the upper levels of the formation, from the "Los Negros" locality (Pliocene). Its main characteristics are is its large size, similar to the largest extant species of the family, unusual for the genus *Pygoscelis*, and also its distribution at a latitude of 27° S: today, the entire genus has a sub Antarctic distribution. Aside from the original phylogenetic analysis of the holotype,

more recent analyses fail to recover the species inside the genus, but its relationships with the group of Antarctic penguins (*Pygoscelis* + *Aptenodytes*) are still supported. Field work in the BIF has provided additional material, described here. All fossils are currently housed in the Museo Nacional de Historia Natural, Santiago de Chile. The new material includes a complete humerus and a complete tibiotarsus, previously unknown in the holotype. Together with fossils identified as juvenile remains, this species has been proposed to have been breeding in the area. The new material allows us to perform histological thin sections of the long bones (humeri, femora and tibiotarsi) showing high rates of growth and massive bone remodeling. These additional fossils complement the phylogenetic information available for this enigmatic species. To date, the Sphenisciformes (penguin) fauna in the BIF was exclusively represented by extinct species of extant genera in the crown group. Extinct genera of penguins basal to the crown group, such as *Palaeospheniscus*, have not yet been reported, but are abundant in the Neogene levels of Argentinian coastal Patagonia. If '*Pygoscelis*' *grandis* fails to be recovered as an extant genus of penguin, then the diversity of the BIF penguins will be represented by three different genera, including *Spheniscus* and *Pygoscelis*, the latter being exclusively represented by *Pygoscelis calderensis*. These data show that extant diversity was not established before the Pliocene – Pleistocene boundary, and prior to the Pleistocene, extinct penguin genera were still present on the Southeastern Pacific coast.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

UJAYFA QUARRY IN THE SHUMAYSI FORMATION OF SAUDI ARABIA YIELDING *SAADANIUS HIJAZENSIS* AND OTHER MID-OLIGOCENE VERTEBRATES

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The early catarrhine primate *Saadanius hijazensis* was first found in fluvial red beds of the Shumaysi Formation of late early or early late Oligocene age (29–28 Ma). The Shumaysi Formation is a complex of mature but poorly-sorted, fine- to coarse-clastic sediments shed during rifting and initial opening of the Red Sea that now separates Arabia from Africa. The type locality is on the western slope of the Harrat Al Ujayfa basalt plateau near Jeddah in the western part of Saudi Arabia. In order to recover more of the fauna of this locality, a large quarry was developed on the western side of the Harrat about 40 meters south of the original discovery site. Some five meters of sediment were removed to reach the bone bed, and a meter-square grid was laid out above the bone bed covering an area of 170 square meters. Quarrying has exposed a 30–50 cm thick stratigraphic interval yielding partial crania, dentaries, teeth, and postcranial bones of mammals and other vertebrates above a distinctive thin leached layer of paleosoil. Careful excavation of this bone bed at the northern edge of the quarry has produced new vertebrate material with valuable information about taphonomy, deposition, preservation, distribution, and diversity of the mammalian fauna. Many bones were broken before burial, but the quarry also preserves some small and delicate remains.

The Ujayfa Quarry fauna includes turtles, crocodilians, an anthracothere artiodactyl, proboscideans, at least two species of hyracoids, an embrithopod, and at least three primate taxa (including male and female *Saadanius*, and dentaries of two smaller primates). Additional specimens must be prepared before they can be identified. The Ujayfa fauna recovered to date is intermediate between those of surrounding early Oligocene sites in Oman and Egypt, and late Oligocene sites in Ethiopia and Kenya.

Grant Information
Research project was funded by the Saudi Geological Survey and the University of Michigan.

Symposium 1 (Wednesday, October 14, 2015, 1:45 PM)

BODY MASS TRANSFORMATIONS IN THE MID-CRETACEOUS OF NORTH AMERICA: HOW EUSTASY, RANGE RESTRICTIONS, AND CLADE SORTING SHAPED THE EVOLUTION OF DINOSAUR SIZE

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Terrestrial ecosystems of western North America (NA) underwent a prolonged, poorly documented faunal reorganization between the late Early Cretaceous and early Late Cretaceous–a time span informally dubbed the mid-Cretaceous. The need to characterize this transformation prompted three decades of intense, targeted, multi-institutional fieldwork, an initiative that has added substantially to the diversity of Cretaceous assemblages. Yet, to date, progress parsing out biotic and abiotic drivers has occurred largely on the margins of this interval. Such advances include characterizing a parabolic Cretaceous dinosaur diversity curve that peaks in the Campanian and linking this to range restrictions associated with the development of the Western Interior Seaway (WIS), as well as disentangling the impact of intercontinental faunal exchange on ecosystem composition, beginning with the initiation of the Early Cretaceous Laurasian Interchange Event (EKLInE) in the Albian. Newly emerging data on Cenomanian dinosaurs from the Cedar Mountain Formation further decreases the mid-Cretaceous biodiversity gap and provides new fodder for macroevolutionary questions. In particular, recently discovered species include some of the largest theropods yet known from the continent, prompting us to explore how a changing landscape associated with the formation of the WIS shaped patterns of NA dinosaurian size.

We documented and/or estimated femur length (FL) for NA taxa of multiple dinosaurian clades with preliminary preference for those with Late Jurassic through Late Cretaceous records, and total available land area (TLA) across this interval. We find bimodal distributions of FL and TLA, with peaks in both variables between the Aptian-Cenomanian and again in the Maastrichtian for several dinosaur clades. Outside of a phylogenetic context, our results suggest shrinking body size in concordance with maximum sea-level rise and reduction in TLA (from >20 to <6 million km^2) between the Turonian and Campanian; however, we find multifarious possible explanations for this pattern in our samples. For some clades (e.g., Ankylosauria, Theropoda), apparent body size reductions can be attributed to clade sorting as a result of differential extinction throughout the mid-Cretaceous. Other phylogenetically contextualized clades exhibit dichotomous patterns: Ornithopoda demonstrates a relatively continuous size increase over time, whereas the caenagnathid record supports body size reduction in associated with reduced TLA in post-Cenomanian landscapes.

Technical Session I (Wednesday, October 14, 2015, 8:30 AM)

ANCIENT DNA AND RADIOCARBON DATES RESOLVE PLEISTOCENE *CAMELOPS* (FAMILY CAMELIDAE) PHYLOGENY AND CHRONOLOGY IN EASTERN BERINGIA

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Species of *Camelops* are the most commonly recovered members of the Family Camelidae at late Blancan to late Rancholabrean fossil localities across western North America, from central Mexico to Alaska. *Camelops* and all other camelids in North America suffered complete extinction along with several other megafauna around 13 k cal. yr BP. *Camelops* fossils are relatively rare in the unglaciated areas of Alaska and Yukon (Eastern Beringia). Despite being present in far northwest North America, *Camelops* failed to disperse across the Bering isthmus into Eurasia, unlike the lineage which includes extant camels (*Camelus)* and their presumed ancestor *Paracamelus*. Paleogenomic data obtained from three postcranial fossils attributed to *Camelops* cf. *hesternus* recovered from Yukon reveal they are sister taxa to African and Asian bactrian and dromedary camels, to the exclusion of the South American camelids (llamas, guanacos, alpacas, and vicuñas). These results contradict previous morphology-based phylogenetic models for *Camelops*, which instead suggest a closer relationship between *Camelops* and the South American camelids. The molecular data imply a Late Miocene divergence of the *Camelops* clade from lineages that separately gave rise to the extant camels of Eurasia.

To establish a chronology for *Camelops* cf. *hesternus* in Eastern Beringia, we obtained 24 new radiocarbon dates on ultrafiltered collagen and single amino acids (hydroxyproline) from 22 fossils. All of the new resulting ages are beyond or near the ~50 kyr BP limit of the ^{14}C dating method. These radiocarbon dates contradict previous reconstructions that suggested *Camelops* inhabited Arctic and Subarctic latitudes during the late Wisconsinan glacial interval. Instead, *Camelops* only dispersed northward into and inhabited Eastern Beringia prior to ~50 kyr BP, and likely only during the relatively warm last interglacial (Sangamonian: ~125–75 kyr) interval, similar to that of American mastodon (*Mammut americanum*) and Jefferson's ground sloth (*Megalonyx jeffersonii*). The failure of *Camelops* to disperse to Eurasia can be attributed to having occupied Eastern Beringia only during interglacial times when the Bering isthmus was flooded. This interglacial megafauna community likely suffered local extirpation with return to glacial conditions around ~75 kyr and was replaced by the typical Holarctic *Mammuthus-Equus-Bison* dominated fauna.

Technical Session X (Friday, October 16, 2015, 11:00 AM)

BABY LOUIE: A THEROPOD PERINATE FROM THE CRETACEOUS OF CHINA REVEALS AFFINITY OF THE LARGEST KNOWN DINOSAUR EGGS

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Baby Louie, a theropod perinate skeleton associated with the largest known type of dinosaur eggs, was repatriated to China in 2014. The specimen was originally collected from the Upper Cretaceous Xixia Basin, Henan Province, and was illegally exported to the USA in 1993. Although the specimen was recognized to be key to the taxonomic affinity of the giant eggs/nests known as *Macroelongatoolithus*, it was not possible to do a detailed scientific study of the specimen until it was repatriated.

The specimen is a small (snout-vent length of 38 cm), semi-articulated skeleton lying on its side on a partial clutch of 6-8 large eggs. The edentulous dentary and other bones readily identify the skeleton as an oviraptorosaur. The lack of fused skull bones, underdeveloped processes of long bones, and the highly vascularised bone textures reveal the skeleton is from a perinate. The size of the animal relative to that of the egg reveals that it is more likely a late term embryo rather than a hatchling.

The elongate, approximately 40 cm long eggs have elongatoolithid ornamentation and eggshell histology. They are similar to those previously reported for other oviraptorids, although much larger. The eggs are subhorizontal, lie subparallel to one another, and occur in two separate layers beneath the skeleton. Their morphology and arrangement compared to complete *Macroelongatoolithus* nests indicate that they were probably part of a giant ring-shaped clutch, some 2-3 meters in diameter. Bones found within one or two other eggs in the specimen may indicate the entire nest was in the latter

stages of incubation when it was buried. Similarities between the morphology of these large nests and those known for small oviraptorids suggest a similar style of incubation where the adult sat in the clutch center.

Based on the size of the *Macroelongatoolithus* eggs and features of the embryo, the egg-layer was a large oviraptorosaur, estimated to be over 1500 kg. Until the discovery of *Gigantoraptor* in 2007, an affinity of these eggs with giant oviraptorosaurs was considered questionable because previously known species were much smaller. Although only one partial skeleton of a giant oviraptorosaur is known, *Macroelongatoolithus* eggs are known from China, Mongolia, South Korea, and the USA, implying that these dinosaurs were geographically widespread and that their skeletal remains have yet to be identified in many regions.

Technical Session V (Wednesday, October 14, 2015, 3:30 PM)

WHAT ARE CHARACTERS, CHARACTER STEPS, AND PARSIMONY?

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Maximum parsimony remains the most common tool for reconstructing phylogenies using morphological characters. However, there are some drawbacks in the current implementation of maximum parsimony, not least of which is that for the same morphological trait, when the variables are divided differently, the possible steps for this specific character will change accordingly. Because of the conflicting phylogenetic signals among different morphological traits, the shortest tree is only an artifact of the subjective character state delimitations.

During the last few decades, different methods were attempted in order to solve this problem. These include different approaches to group variables, and different weighting schemes, including the traditional "unweighting" scheme, to manipulate the effect of different characters. But none of the methods has been shown to be successful. The fundamental question is how a step in one character can be compared to that in another. Here, I present a standardized character step weighting approach. In this approach, the variable range of character steps in each different character is set to the same scale. In practice, it is simply achieved by adding a coefficient of 1 / (maximum possible steps – minimum possible steps) to each character. It can be equally achieved by finding the best tree that maximizes the averaged retention index.

In the parsimony approach, each character is viewed as independent before it is used in an analysis. Therefore, before adding the steps from different characters, the different dimensions among steps from different characters have to be distinguished. I propose a novel approach in which the variable ranges of the steps among different characters are adjusted to be equal. Through this approach, each character, regardless of whether it has binary or infinite states, carries the same weight, and thus the most balanced phylogenetic signal is found in the final best tree. This scheme also allows us to maximally delimit character states and thus to achieve maximum accuracy. For the measurement of homoplasy, the averaged retention index, rather than the traditionally reported C or R (the consistency index or the retention index of the whole tree), should be used to reflect the self-compatibility of the data matrix.

This approach is tested on empirical studies. The results show the superiority of this method compared to the traditional method in eliminating character state delimitation problem, finding the most balanced phylogenetic signals among conflicts, and not losing any evidence.

Poster Session II (Thursday, October 15, 2015, 4:15 - 6:15)

ALLOMETRIC SCALING OF MERYCODONT ANTILOCAPRID HORN CORES

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The evolutionary trajectory of horn morphology in the basal antilocaprids of Miocene North America is poorly understood because phylogenetic relationships are unresolved; taxonomic diagnoses rely on limited horn core or dental characters that are rarely applicable across assemblages. In the wastebasket taxa *Merycodus* and *Cosoryx*-a compilation of basal merycodont antilocaprids, horn core shape appears conserved, maintaining the straight-shafted, anteroposteriorly bifurcating bony architecture. However, horn cores exhibit size gradation across assemblages even though horn core growth ceases after the first postnatal year, suggesting that, as in other horned ruminants, interspecific differences in the allometric scaling of horn cores could explain the observed variation. Here, I investigate patterns of scaling in merycodont horn cores relative to body size using prolific Hemingfordian–Clarendonian attritional, fluviatile deposits in coastal California, the Basin and Range, and the Great Plains. I reduced confounding signals from assemblages with more than one antilocaprid species by limiting analysis to assemblages with a unimodal size distribution of astragalus volume, herein used to approximate body size, after accounting for intraspecific sexual differences in size. For each assemblage, I limited scaling analysis to skeletal adults, which were determined using the chronology of dental eruption, and presence of burr(s) on horn cores. I performed landmark-based geometric morphometrics to determine variations in horn core shape. Principle Component Analysis suggests that size differences explain the majority of variation. I estimated body size using the crown area of the lower first molar on articulated jaws. To control for differential crown wear, I standardized my measurements using assemblage-specific indices of crown area to maximum molar length derived from unworn adult lower first molars. I determined the scaling ratios for each fossil assemblage using mean body size and mean values for each of five sets of horn core measurements: shaft length from burr to point of bifurcation, maximum shaft diameter, maximum shaft volume, maximum anterior tine diameter, and maximum posterior tine diameter. Results were visualized on bivariate plots. My analysis suggests that assemblage-specific mean scaling ratios of shaft length to body size cluster into two cohorts that do not conform to *Merycodus* and *Cosoryx*, indicating the need for taxonomic reexaminations.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

FORELIMB DIMORPHISM IN MIXOSAURIDS FROM THE ANISIAN GUANLING FORMATION OF PANXIAN, GUIZHOU

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Mixosauridae is a clade of middle-sized ichthyosaurs characterized by a well-developed long sagittal crest and large anterior terrace of the upper temporal fenestra on the skull. They were well diversified and widely distributed in both Panthalassa and Tethys of the Middle Triassic. They show rather unique features in the forelimb compared with other Triassic ichthyosaurs, such as the humerus being as wide as long with an obvious anterior flange, the kidney-shaped ulna and more than seven phalanges with rather reduced shafts in one row. During the past decade, plenty of mixosaurid specimens have been discovered from the Middle Triassic of South China but the species diversity that they represent remains unclear because the degree of inter- versus intraspecific variation is unknown. We therefore quantitatively examined morphological variation in the most abundant species, *Mixosaurus panxianensis*. Detailed study reveals significant discrepancies in forelimb morphology in this species, which has not previously been described. Two types can be recognized based on our observations and measurements of the eight specimens which can be assigned to Mixosauridae. Type I forelimbs possesses the following features: the angle between the two distal articular facets of the humerus being less than 130°, the anterior margin of the radius bearing two deep notches, the contiguous shaft of ulna being reduced, with the smallest specimen bearing a small notch, the proximal margin of the intermedium being emarginated. Type II exhibits different morphological features: the angle between the distal humeral facets greater than 135°, the notches on the anterior margin of the radius not conspicuous, especially the proximal one, the contiguous shaft of ulna not being totally reduced but showing a deep notch on the posterior margin, the proximal margin of the intermedium bearing a deep notch. Allometric relationships are found between the ulnar length and the antero-posterior length of the intermedium, and the two types appear in separate regression lines in the double-logarithmic plot, as in *Chaohusaurus*. Further investigation of other skeletal features are necessary before concluding if the two morphological types represent sexual dimorphism or taxonomic differences.

Technical Session VI (Thursday, October 15, 2015, 8:30 AM)

A NEW SILURIAN PLACODERM PROVIDES INSIGHT INTO EARLY EVOLUTION OF EYES IN JAWED VERTEBRATES

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The Xiaoxiang Vertebrate Fauna from the Ludlow (Silurian) of Yunnan, China has provided key fossil evidences for the understanding of early evolution of jawed vertebrates. Notably, *Entelognathus primordialis* shows a mosaic character combination of features typical for stem-group and crown-group gnathostomes. However, *Entelognathus primordialis* lacks the preservation of detailed endoskeletal information on the morphology of brain cavity and canals for nerves and blood vessels. Here we report a new Silurian placoderm from the Xiaoxiang Fauna with a perfectly preserved anterior portion of the neurocranium. The new form resembles *Entelognathus primordialis* in the general bone pattern of the skull roof, the presence of premaxillary bones, and the oblong sclerotic bones that are fused to the skull roof, all potential apomorphies that may denote a close relationship between these two taxa. The eyes are positioned close to the nasal capsules, evoking the condition in jawless fishes such as *Sacabambaspis*. The high-resolution computed tomography of the new form reveals the exquisite preservation of the neurocranium, the optic capsules in particular. Similar preservation of optic capsules has previously been observed in two Early Devonian placoderms, namely *Murrindalaspis* and a buchanosteid arthrodire. The investigation on the morphology of the optic capsules and neurocranium in the new form will shed light on the evolution of eyes in the transition from stem-group to crown-group gnathostomes.

Technical Session IV (Wednesday, October 14, 2015, 2:45 PM)

A NEW BARTONIAN LATE MIDDLE EOCENE ARCHAEOCETE FAUNA (CETACEA) FROM THE ARIDAL FORMATION AT GUERAN IN SOUTHWESTERN MOROCCO

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Lutetian early middle Eocene archaeocete faunas are well known from Pakistan and Egypt, where they are dominated by semiaquatic Protocetidae that were foot-powered swimmers. Priabonian late Eocene archaeocete faunas are well known in Egypt and the southern United States, where they are dominated by fully aquatic Basilosauridae that were tail-powered swimmers. Transitional faunas of Bartonian late middle Eocene age are critical for understanding the evolutionary transition from foot-powered to tail-powered swimming. Here we review the five whales known to date from the first good Bartonian archaeocete fauna. This comes from the Aridal Formation at Gueran (or Guerran), a remote uninhabited area in the western Sahara Desert of southwestern Morocco.

The Aridal Formation is variously considered to represent middle and late Eocene time or sometimes all of the Paleocene and Eocene. We focused on a single meter-thick sandstone unit of the formation that is now being exploited commercially. During a 2014 expedition were were able to identify five archaeocetes, two protocetids and three basilosaurids: (1) a medium-sized protocetid represented by teeth, vertebrae, a partial innominate, and a proximal femur; (2) a very large protocetid-probably *Pappocetus*-represented by teeth, a partial innominate, and a femoral head; (3) a medium-sized basilosaurid most similar to *Chrysocetus* represented by crania, dentaries, teeth, and many vertebrae; (4) a large basilosaurid most similar to *Platyosphys* represented by a partial braincase, teeth, and many vertebrae; and (5) a large *Basilosaurus* most similar to *B. drazindai* represented by lumbar vertebrae. The best evidence for the age of the sandstone studied at Gueran comes from the fossil whales themselves: a fauna that

includes both protocetids and basilosaurids is almost certainly Bartonian because basilosaurids are not known from the Lutetian and a single protocetid is known to have ranged into the earliest Priabonian. The Gueran fauna is definitely older than that at Dakhla farther south in Morocco, which yields only basilosaurids.

The importance of the Gueran fauna will not be fully realized until more complete specimens of each taxon can be collected. Of greatest interest will be crania, limbs, and vertebral series to facilitate comparison with known protocetid and basilosaurid species, and to enable assessment of the degree to which each species was aquatic. There is at present no place with greater potential for study of the transition from foot-powered to tail-powered swimming in archaeocetes.

Grant Information
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Colbert Prize (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

FUNCTIONAL OCCLUSION IN A RODENT KNOCKOUT MODEL AND IMPLICATIONS FOR MAMMALIAN TOOTH EVOLUTION

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Tooth morphology is key in the study of mammalian evolution. Differences in cusp shape, number, size and orientation provide evidence of phylogeny, as well as alterations in feeding strategy and amount of intraoral processing. Tooth morphology is the result of many complex developmental interactions within the tissues that make up the developing tooth. After eruption, the only alterations to tooth morphology are through food processing and occlusion, creating complex wear facets on the teeth. Changes in tooth morphology presumably lead to changes in occlusion of the teeth, and consequently in the function of the toothrow. Determining the effect of changes in tooth morphology on occlusion has implications for understanding the underlying mechanisms that drove the degree of dental diversity we see in both extinct and extant mammals. We tested the hypothesis that a change in tooth morphology would lead to a change in the occlusion in mice using a neural crest specific knockout of the first coding region, exon 1, of bone morphogenetic protein 7 (BMP7). These BMP7 mutant specimens have a distinctive craniofacial morphology, which includes noticeably altered tooth morphology. Mutant teeth have extra cusps, mostly on the first upper and lower molars, along with differences in cusp morphology. The functional occlusion of 3D models of the right upper and lower toothrows of mice of different ages were found to exhibit different wear facets in the mutant and control specimens, indicating that a change occurred in occlusion due to changes in morphology. Variations in the wear facets within the control and mutant groups were minimal compared to the variation between groups. Using different age sets of mice to test our hypothesis provided a view of occlusion shortly after tooth eruption, and later once wear facets have developed. This research suggests that developmental changes can cause changes in occlusion and cumulatively may lead to dental adaptations that are observed in extinct and extant mammals.

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