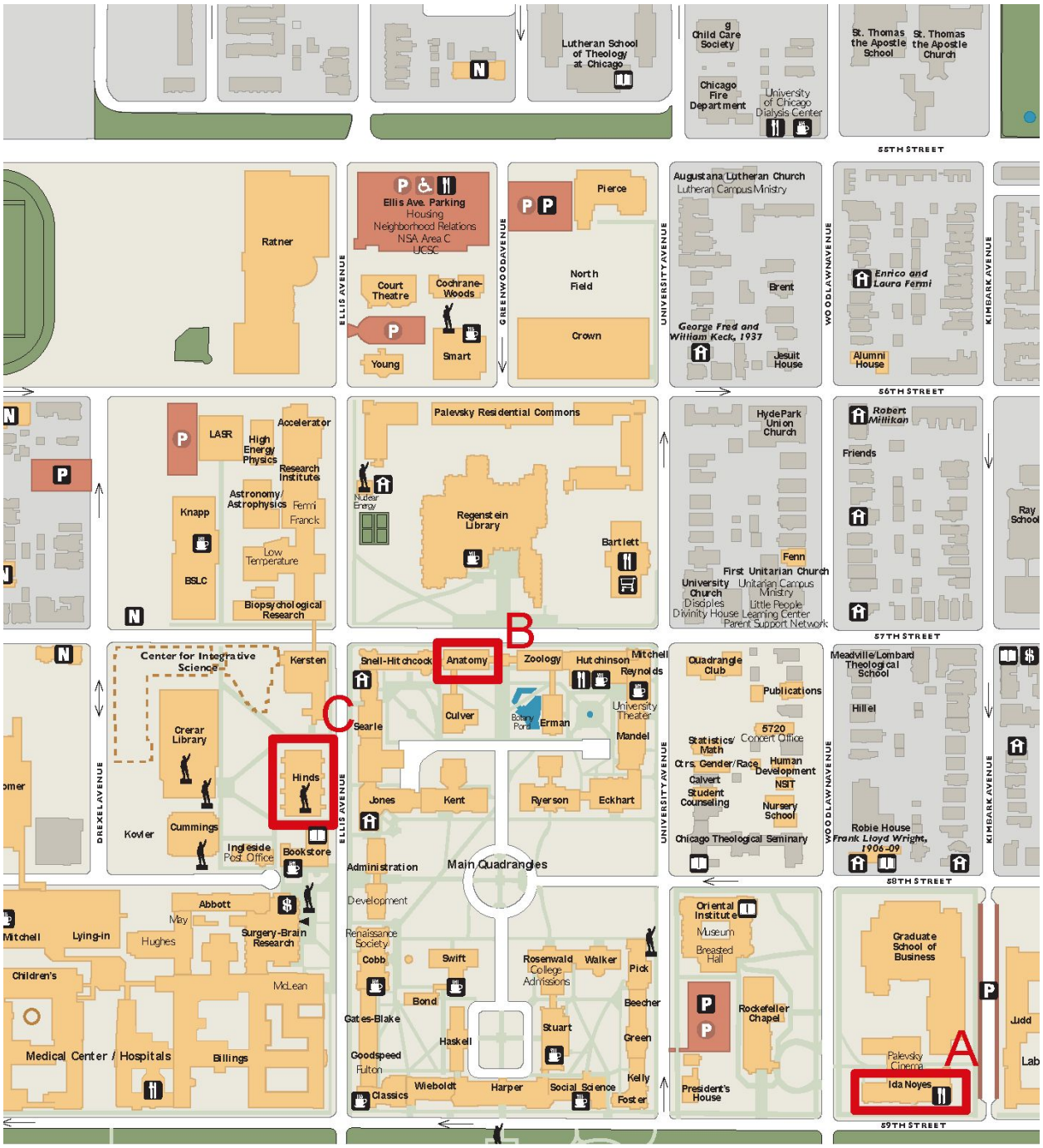
The Second Annual
Great Lakes Student Paleoconference

Nov. 9-11 2018 Chicago, IL

Program and Abstract Book

Special thanks to The Paleosociety and The UC Darwin Cluster for funding this event

The University of Chicago Campus



Welcome!

Welcome to the Second Annual Great Lakes Student Paleoconference! Last year, UChicago students, postdocs, and faculty traveled to The University of Michigan in Ann Arbor for an engaging series of talks and tours. It was a great success, and sparked what will hopefully be many more GLSPs to come. This year we are lucky enough to have students not only from The University of Chicago and The University of Michigan, but also Indiana University and Universidade do Estado do Rio de Janeiro. We hope you have an excellent time and feel welcome in this ever growing and strengthening student community.

We would like to especially thank Professor Zhe-Xi Luo and Professor Matthew Friedman for their encouragement and support. We couldn't have restarted this tradition without you. In addition, this years conference has been funded by the Paleontological Society, to whom we are grateful for the continuing support of building communities within paleontology.

The conference this year begins Friday night at The Jolly Pumpkin in Hyde Park. Saturday, eighteen talks will be presented in the historic Ida Noyes Hall. Rest assured, there will be breaks throughout the day, including lunch, exploration/tour time, and dinner in the (in)famous EvMorph room. Sunday, there will be a Post-Doc Q&A panel at The Field Museum, followed by collections tours.

We sincerely hope you enjoy your time here. If you have any questions, please email glsp.uchicago@gmail.com or contact one of the coordinators directly.

GLSP 2018 planning committee/coordinators:

Jacqueline Lungmus, *5th year*
Kelsey Stilson, *4th year*
Stephanie Baumgart, *4th year*
Vishruth Venkat, *2nd year*
Spencer Pevsner, *post-baccalaureate*

Schedule

Friday November 9th

7:00 pm - Drinks and Dinner at the Jolly Pumpkin in Hyde Park
Address: 5215 S Harper Ave, Chicago, IL 60615

Parking: Parking is available throughout Hyde Park and in the area surrounding Jolly Pumpkin. Some roads are pay-by-the-hour, while others are not. Be sure to check for signage where you park.

Saturday November 10th - Talks on the University of Chicago campus

Ida Noyes Hall - East Lounge
(Woodlawn and 59th; A on map)

9:30 am - Breakfast *from Einstein's Bagels*

Morning Talks
10:00 am - Benjamin Otoo
10:15 am - Alessio Capobianco
10:30 am - Rodrigo Tinoco Figueroa
10:45 am - Broc S. Kokesh
11:00 am - *{Coffee Break}*
11:15 am - Tariq A. Kareem
11:30 am - David Černý
11:45 am - Kierstin Rosenbach
12:00 pm - Danielle Goodvin

12:15 pm - Lunch *from Jimmy John's*

12:45 pm - Exploration time! People may explore campus or join one of three campus tour groups.

1) Jackie Lungmus will be leading a group to The Oriental Museum.
2) Spencer Pevsner will be leading a group to The Sereno Fossil Lab.
3) Kelsey Stilson will be leading a group to the X-Ray of Moving Morphology Facility (limit 8).

Afternoon Talks
2:00 pm - James Saulsbury
2:15 pm - Spencer Pevsner
2:30 pm - Kelsey T. Stilson
2:45 pm - Ethan Shirley
3:00 pm - Jordan Hood
3:15 pm - *{Coffee Break}*
3:30 pm - Ricardo Ely
3:45 pm - Katharine Loughney
4:00 pm - Zach Quirk
4:15 pm - Margaret Veitch
4:30 pm - Bian Wang
4:45 pm - wrap up

5:00 pm - Happy hour at the campus pub, located in the basement of Ida Noyes
There is a cash only cover to enter the bar, IDs are required

6:30 pm - Dinner *from Giordano's*
(in Hinds 176- aka "The EvMorph Room", C on map)

7:30 pm - Drinks in Hyde Park

Sunday November 11th - Panel and Collections Tours at the Field Museum

9:30 am - Breakfast *from Stan's Donuts*

10:00 am - Q&A Panel, topic: "Postdoctorals: How, When, and Where"
*in the **Bill Stanley Room**, 3rd Floor of the Field Museum, in the Bird Collections Wing*

Speakers: Tom Stewart, Dave Grossnickle, Eric Gorsack

11:00 am - Collection Tours, *Vertebrate Paleontology*

2:00 pm - Free time to explore the museum
You are welcome to stay in the museum as long as you want; the museum closes at 5pm

Abstracts

The sound of confusion: reappraising early tetrapod phylogeny

Benjamin Otoo
The University of Chicago Committee on Evolutionary Biology

Until the end of the 20th century the relationships of Paleozoic tetrapods to each other and modern groups were disputed, hampered by gaps in the Late Devonian-Early Carboniferous fossil record. Fruitful fossil collection, anatomical investigation, and phylogenetic study, assisted by technological advances such as computational cladistics and CT scanning, have greatly enhanced our understanding of the Devonian origin of tetrapods, the fin-limb transition, and enabled greater paleontological contributions to issues such those of lissamphibian origins. However, the age and membership of the tetrapod crown is disputed. Two contrasting hypotheses have emerged: a crown group originating at the Devonian/Carboniferous boundary and including multiple taxa traditionally considered stem tetrapods; and a more restricted mid-Carboniferous crown group preceded by a more diverse and disparate stem group. The two schemes use overlapping but non-identical taxon and character sets; the first includes new Early Carboniferous taxa and uses a more traditional mix of skeletal characters, whereas the second emphasizes braincase characters. This new ongoing work combines characters from multiple recent datasets as well as new characters in order to investigate early tetrapod phylogeny. Initial results are highly noisy, mainly due to the lability of the aistopods and fragmentary Late Devonian and Early Carboniferous taxa. The baphetids also move back and forth between the tetrapod stem and lissamphibian stem. This contrasts with the much more stable amniote stem. Experiments with taxon removal indicate that missing data is a persistent issue in generating both 'false' and challenging topologies. However, thus far a Late Devonian crown group is recovered more often than not, consistent with molecular divergence estimates, the presence of Devonian morphotypes in the Early Carboniferous, and trackways suggesting a Middle Devonian origin of the tetrapod total group.

Uncovering a post-K/Pg marine radiation of freshwater fishes: the unexplored diversity of early Paleogene marine osteoglossids (Teleostei; Osteoglossomorpha)

Alessio Capobianco[1,2]
[1]*The University of Michigan Department of Earth and Environmental Sciences*
[2]*The University of Michigan Museum of Paleontology*

Osteoglossomorphs are one of the earliest diverging lineages of modern teleost fishes. Extant species are strictly freshwater but geographically widespread in most continental landmasses, which makes them especially interesting for historical biogeography. Osteoglossomorphs have a relatively rich fossil record going back to Late Jurassic continental deposits. Surprisingly, fossil osteoglossomorphs belonging to the sub-clade Osteoglossidae are known from several Paleocene–middle Eocene marine deposits worldwide. Most of these fossils are fragmentary – representing isolated teeth or jaw elements – and they are usually referred to the genus *Brychaetus*, known from three-dimensionally preserved complete skulls from the early Eocene London Clay of England.

New articulated fossil specimens are starting to reveal a previously unrecognized diversity of marine osteoglossids, including some forms with elongated snouts, some with remarkably long and broad pectoral fins and others with specialized dentition. These findings suggest that fragmentary jaw elements cannot be confidently assigned to genus-level osteoglossid taxa. While the evolutionary relationships of these marine forms within the broader osteoglossomorph tree are still uncertain, new osteological data obtained with μCT scanning might indicate

a position within crown osteoglossids. This would imply a key role of marine dispersal in shaping the modern geographic distribution of osteoglossids.

Overall, these fossils hint at a scenario in which osteoglossids invaded the marine realm right after the K/Pg mass extinction and diversified in the span of 15 million years, achieving worldwide distribution. Further investigation of this poorly known marine radiation is needed to understand its role in early Paleogene marine ecosystems and its relationship with extant freshwater osteoglossids.

250 million years of puzzle pieces: Brazilian Paleozoic paleoichthyology and the scientific challenges of Brazilian paleontologists.

Rodrigo Tinoco Figueroa

Laboratório de sistemática e Biogeografia, Departamento de Zoologia, Universidade do Estado do Rio de Janeiro – UERJ, Brazil.

The study of Paleozoic fishes from Brazil continues as a neglected field within paleontology. Here I describe the history of Paleozoic paleoichthyology in Brazil, summarizing its known fossil fauna and highlighting its scientific relevance. The first tentative description of isolated fish remains date back to the first half of the twentieth century, yielding only superficial descriptions from researchers focused on other taxa (e.g. invertebrates, plants). The next decades were dominated by the work of Dr. Rubens da Silva-Santos, who described six Paleozoic fish species from several localities, as well as various new occurrences for South America, consolidating the field of paleoichthyology in Brazil. The works of Dr. Silva-Santos and other prominent paleoichthyologists lead to a considerably well know Permian fossil record, but the Devonian and Carboniferous remained understudied. The known Brazilian Paleozoic ichthyofauna extends from the earliest Devonian to the latest Permian and comprise placoderms, acanthodians, chondrichthyans and osteichthyans, mostly known by isolated remains, but also including exceptionally preserved specimens. The oldest fish fossils from Brazil are isolated but well preserved acanthodian and chondrichthyan elements from the Mancapuru Formation (Lochkovian, Amazon Basin), and has recently yielded the first record of articulated thelodont elements for South America. The Devonian record is more abundant in the Pimenteira Formation (Eifelian-Givetian, Parnaíba Basin), exhibiting a considerably diverse acanthodian and chondrichthyan fauna, as well as the only placoderm record from Brazil. The Carboniferous record is obscure, with just a few isolated fragments possibly related to actinopterygians and coelacanths. Finally, the Permian record is considerably abundant and diverse, with several actinopterygian and chondrichthyan species, from Paraná and Parnaíba basins, including articulated specimens and 3D preservation. Therefore, the Brazilian paleoichthyofauna demonstrates great potential for paleontological studies, especially concerning biogeographic patterns across time, but also taxonomic and evolutionary studies of the well-preserved Permian record.

Phenotypic Trajectory Analysis Reveals Temporal Divergence of Shell Shape in Bivalves from Adjacent Marine Lakes

Broc S. Kokesh

The University of Chicago Department of Geophysical Sciences

Patterns of shifting phenotypes within a population, be they based on genetic drift or plasticity, reflect potentially significant information regarding ongoing and past adaptation. For bivalves, shell morphology from time-averaged death assemblages may serve as a record of all phenotypic variability from the recent past, representing an expected range of variability by which the morphology of the living population can be tested. The goal of this study was to assess morphological variation of live and co-occurring dead specimens of *Ctena orbiculata* (Lucinidae, Bivalvia) to address 1) whether temporal morphological trajectories differ between

populations, and 2) whether morphological disparity differs between live and dead specimens. Specimens were collected from sieved sediments from Moon Rock Pond and Pain Pond, two adjacent marine lakes on San Salvador Island, Bahamas. Geometric morphometrics were used to quantify shape based on internal shell features and outline curves. Results demonstrate that mean shell shape varies among lakes, between live and dead specimens, and for the interaction between lake and life state. A principal component analysis reveals a common shift along PC2 shared by both populations, primarily as a reshaping of the shell margin. PC1 describes the relative length of the anterior adductor muscle scar, which strongly separates live populations from each lake, whereas dead specimens exhibit intermediate morphology in this regard. Thus, phenotypic change within these populations can be described as a series of shared and unique shifts that may be adaptive to the conditions associated with each lake. Surprisingly, dead specimens did not exhibit greater disparity than live specimens, countering the idea that dead specimens represent a time-averaged history of morphological changes. Rather, phenotypic shifts from dead to live appear to be dramatic departures from typical morphology.

STRUCTURE AND EVOLUTIONARY IMPLICATIONS OF TAIL CLUBS ATTRIBUTED TO THE SAUROPOD DINOSAUR *KOTASAURUS YAMANPALLIENSIS* FROM THE EARLY TO MIDDLE JURASSIC OF INDIA

Tariq A. Kareem[1,2] and Jeffrey A. Wilson[1,2]
[1]*The University of Michigan Department of Earth and Environmental Sciences*
[2]*The University of Michigan Museum of Paleontology*

Tail clubs evolved independently multiple times within amniotes, including at least twice within dinosaurs. The best known and most complex dinosaurian tail clubs evolved within ankylosaurids and consist of modified caudal vertebrae and osteoderms forming a 'knob' and 'handle.' Structurally simpler tail clubs have been reported for basal sauropods from the Jurassic of China (*Shunosaurus*, *Omeisaurus*, *Mamenchisaurus*). Of these, only those of *Shunosaurus* and *Mamenchisaurus* were found in association with definitive postcranial remains of those taxa. Tail clubs attributed to *Shunosaurus* and *Omeisaurus* are laterally expanded and rounded structures, and there are partially fused caudal elements that precede them. The *Mamenchisaurus* club is distinctive in its laterally compressed aspect. All three taxa possess 'forked' distal chevrons with anterior and posterior processes.

We report on tail club elements from the Kota Formation of India (Lower to Middle Jurassic), which has produced abundant but mostly disarticulated remains of the basal sauropods *Kotasaurus* and *Barapasaurus*. Five tail clubs were identified among the nearly 800 bones attributed to *Kotasaurus*. These elements are bilaterally symmetrical and roughly ovoid in dorsal outline. Their dimensions range from 140–308 mm (greatest length), 140–211 mm (greatest width), and 8–12 mm (greatest depth). 'Forked' chevrons and partially fused distal caudal vertebrae are present in one or both collections, suggesting that one of the two Indian basal sauropod taxa had a tail club and associated caudal structures. Conversely, presence of slender, elongated distal caudal vertebrae in both collections indicates that the other Indian taxon had a more gracile tail lacking a club. We provisionally attribute the tail clubs to *Kotasaurus*, but additional data are required to formalize this claim. The Kota Formation tail clubs are morphologically similar to those attributed to *Shunosaurus* and *Omeisaurus*, and share with them associated caudal vertebrae features—raising the question of whether tail clubs and associated structures evolved once, multiple times, or were gained and then lost within basal sauropods.

Inferring time trees and macroevolutionary patterns from fossil-only data: an example using bird-hipped dinosaurs (Archosauria: Ornithischia)

David Černý
The University of Chicago Department of Geophysical Sciences

A number of methods have recently become available to estimate divergence times from total-evidence datasets combining extant and extinct taxa. In principle, these methods can also be applied to datasets consisting exclusively of fossil tips; however, doing so poses several unique challenges, and as a consequence, relatively few studies have taken advantage of this possibility. To investigate the methodological issues associated with these approaches and their empirical performance, I inferred tip-dated phylogenies of bird-hipped dinosaurs (Archosauria: Ornithischia) using the two largest matrices published to date and the Sampled- Ancestor Fossilized Birth-Death (SA-FBD) model implemented in BEAST 2. The SA-FBD analyses failed to support many of the traditional relationships recovered by parsimony; however, a detailed examination showed that most of the conflicting nodes were poorly supported both in the BEAST 2 time trees and in parsimony cladograms, suggesting that ornithischian phylogeny is much less robust than generally assumed. Constraining the SA-FBD analysis to the highly asymmetrical topology favored by parsimony shifted the posterior mean age of the ornithischian root into the early Carboniferous, making it almost twice as old as the earliest known ornithischian fossils. Finally, I used summaries of BEAST 2 posteriors as a basis for diversification rate analyses performed using the recently released "fossil BAMM" (BAMM v2.6) package. Except for an analysis based on the spurious constrained-topology tree, no rate shifts were identified in ornithischian evolution. Given that the power to detect rate shifts is known to increase with the number of included tips, I urge caution when applying BAMM-type macroevolutionary analyses to wholly extinct clades. My results suggest that even the best datasets available for extensively studied clades may not be large enough to allow inferring diversification rate changes.

Pterosaur remains from the Late Cretaceous of Afro-Arabia provide insight into pterosaur diversity and flight capacity

Kierstin Rosenbach[1,2*], Iyad Zalmout[2], and Jeffrey Wilson[1,2]
[1]*The University of Michigan Department of Earth and Environmental Sciences*
[2]*The University of Michigan Museum of Paleontology*

Pterosaurs are an extinct clade of Mesozoic flying archosaurs, the largest of which appeared in the Late Cretaceous and reached wingspans of up to 12 meters. These large, late-appearing pterosaurs have been grouped together within Azhdarchidae, which has been regarded as the predominant pterosaur lineage during the Late Cretaceous. However, recent phylogenetic studies have not recovered a monophyletic Azhdarchidae, and recent reports identify other groups present in the latest Cretaceous (pteranodontids, nyctosaurids). This raises questions about patterns of pterosaur diversity at the end of the Mesozoic. Additionally, despite having a fossil record characterized by several exceptional fossil deposits (e.g., Solnhofen, Yixian, Crato, Niobrara), pterosaur fossils are rarely preserved in three dimensions. This aspect of their fossil record has limited insights into pterosaur flight mechanics.

Here we discuss Late Cretaceous pterosaur diversity and flight capability in light of new pterosaur remains recovered from Maastrichtian sediments of Jordan. This material represents the giant pterosaur *Arambourgiania* (ca. 10 m wingspan) and a new, smaller species (ca. 5 m wingspan). Both specimens consist of wing elements that preserve the original three-dimensional geometry of the bone as well as internal bone structure. We used high-resolution micro-computed tomography (μCT) to create three-dimensional models of these wing elements for the investigation of flight capacity using birds as a modern analog. Birds exhibit adaptive remodeling of internal wing bone structure in the form of struts and ridges; this response to the mechanical stresses of flight correlates with flight style. μCT scans reveal that similar structures are also present in the wing bones of these pterosaurs. The

humerus of *Arambourgiania* exhibits a series of helical ridges formed along the cortical bone, whereas the smaller species exhibits a denser pattern of hollow struts. These preliminary results suggest that the smaller species has internal morphology similar to that of flapping birds, whereas *Arambourgiania* has internal morphology similar to that of gliding or soaring birds.

Grant Information:
American Chemical Society Petroleum Research Fund (PRF 46006-E8 to JAW)

A new method of measuring Air Space Proportion in pneumatic skeletal tissue

Danielle Goodvin[1, 3], Kierstin Rosenbach[2, 3], Jeff Wilson[2, 3]
[1]*The University of Michigan Department of Ecology and Evolutionary Biology*
[2]*The University of Michigan Department of Earth and Environmental Sciences*
[3] *The University of Michigan Museum of Paleontology*

Pneumaticity refers to the hollow space within skeletal tissue caused by the invasion of the air sacs' diverticula of the respiratory system. This adaptation is hypothesized to function as body mass reduction and to improve metabolic efficiency. Pneumatic bones are present throughout Archosauria, and postcranial skeletal pneumaticity evolved independently in several archosaur groups: pterosaurs, sauropodamorphs, and theropods. The degree of pneumaticity is quantified by measuring the ratio of air space (that is represented in fossils by the infilling of matrix) to skeletal tissue, termed Air Space Proportion (ASP). Initially, ASP was measured solely where breaks in a specimen were already present, often relying on a single cross-section to represent the entire bone. A more recent method of measuring ASP used micro-computed tomography (m-CT) scanning to visualize the internal structure of a bone without destruction of the specimen. Applied to pterosaur fossils, this method provided a representative sample of slices, accounting for trabecular bone at the articulations and excluding struts in the shaft of the bone. We propose a complementary method of measuring ASP using high-resolution mCT scans and the program Mimics to reconstruct a three-dimensional (3D) model of pneumatized bones and fossils. These models provide a measure of the volumetric proportions of air and bone for a calculation of volumetric ASP (vASP). Here we report the application of this method to pterosaur wing bones, sauropod vertebrae, and avian wing bones. Preliminary results include vASPs over 95% for analyzed pterosaur humeri and an average of 62% for analyzed hummingbird humeri. The use of Mimics provides faster segmentation of fossil scans and rapid segmentation of modern bone via thresholding. This new method maximizes the amount of preserved skeletal tissue accounted for in ASP calculations and produces 3D models that will be used for further study of the biomechanical properties of pneumatic bones.

Niche breadth as a link between feeding morphology and extinction risk: an exploration with extant crinoids

James Saulsbury[1,2]
[1]*University of Michigan Department of Earth and Environmental Sciences*
[2] *University of Michigan Museum of Paleontology*

Niche breadth has frequently been invoked as a predictor of extinction risk: species that occupy a narrow range of habitats – stenotopes – are thought to be less resilient to environmental change and therefore tend to persist for shorter spans of geological time. Fossil crinoids in particular have yielded important insights into the link between stenotopy and extinction risk: geological duration has been shown to be lower in species that occupy fewer lithological facies and whose morphology is more atypical for a given taxonomic group. Furthermore, the "density" or fineness of the crinoid filtration fan delimits the range of currents in which they can feed efficiently, and has been implicated in extinction risk. Here we test the relationship between feeding morphology and ecological specialization for the most widespread and species-rich group of crinoids, the featherstars. Using a database of

11,045 modern occurrence records, we explore the relationships among geographic range, bathymetric range, and maximum inhabited depth. We test for relationships between these response variables and feeding morphology. Arm number, which varies from five to nearly 200, is used here as a proxy for fan density. Geographic range is weakly but positively correlated with bathymetric range. Featherstar occurences are recorded from 0-6000m, but many-armed (>45 arms) forms are restricted to shelf depths (<200m). Many-armed featherstars have relatively low geographic and bathymetric ranges. We discuss and attempt to sidestep statistical pitfalls relating to differences in sample size and phylogenetic autocorrelation. Our results support arm number as an important control on crinoid niche breadth, and experimental and computational approaches suggest that it does so by affecting the range of hydrodynamic regimes in which crinoids can efficiently feed. Stenotopy explains the putative link between crinoid feeding morphology and geologic duration in the fossil record, although the strength of this link remains unclear.

Analysis of Ecological Diversification in Marsupial Mammal Evolution by Multivariate Analyses of Their Limb Skeleton in Both Extant and Fossil Marsupials

Spencer Pevsner
The University of Chicago Department of Organismal Biology and Anatomy

Ecological diversification is an important feature of mammal evolution, and marsupials in particular show a wide variety of ecological and locomotor type adaptations (together, ecomorphotypes). I have conducted a quantitative analysis of fossil marsupials, studying their ecomorphotypes. I have built a multivariate model that predicts locomotor types based on a database of limb and skull measurements of extant marsupials with known locomotor functions. My pilot analysis showed my model can clearly distinguish between the arboreal and terrestrial locomotor types, and I am applying this model to fossil marsupials for thesis research. I recently expanded my database via greater taxonomic sampling, and am currently validating my analysis with CT scans, and applying my model to the study of mammalian evolution.

Mastication Fascination: Osteological Correlates of an Evolving Peripheral Sensory System

Kelsey Stilson, Callum Ross, and Zhe-Xi Luo
The University of Chicago Department of Organismal Biology and Anatomy

Teeth are some of the most well-studied structures in paleontology. They are the hardest bone in the body and, consequently, some of the most likely skeletal elements to fossilize. Teeth also preserve information about an animal's likely diet, health, and environment. Most research has been done on the occlusal surface, but the tooth root, surrounding periodontal ligament (PDL), and alveolar socket can reveal something which is not often fossilized: the evolution of a sensory system. To study the innervation of teeth and the PDL I am working with the Virginian Opossum (*Didelphis virginiana*). The opossum is omnivorous and, like most mammals, has one juvenile and one permanent set of teeth (diphyodonty) made up of incisors, canines, premolars, and molars. None of these teeth ever fuse to the alveolar socket. The dentition and mandible of the opossum are morphologically similar to early fossil Triassic pre-mammalian and mammalian taxa. Early Triassic Mammaliaformes and Mammalia show signs of endothermy and increased brain size, both of which require a higher and more efficient consumption of calories. With increased innervation in the PDL sensory system, these animals would have been able to quickly and safely break down food, "predigesting" it before it enters the stomach. Diphiodonty, precise occlusion, a retained PDL, a closed ventral tooth root, conical root structure, vascular structure, and distinctive ridges along the alveolar socket all point towards increased innervation. Tooth sensation through the PDL bridges the gap between fossil and neurological data with unique fossilizable osteological structures of mechanosensation.

The Story of a Peruvian elephant tooth: implications for paleontology and law

Ethan A. Shirley [1,2]
[1]*University of Michigan Department of Earth and Environmental Sciences*
[2] *University of Michigan Museum of Paleontology*

"Law" and "paleontology" are not words oft mentioned in the same breath, but new paleontological methods may stretch into the legal realm in unprecedented ways. New X-ray computed tomography (CT) technology permits imaging of specimens that was previously not possible. We have scanned one of the earliest-collected items in the University of Michigan Museum of Paleontology's vertebrate collections is a Peruvian gomphothere tooth. Gomphotheres are members of the order of elephants and their relatives, and they survived in South America until around ten-thousand years ago—when mammoths and mastodons went extinct in North America. Although late-Pleistocene gomphothere teeth and tusks are numerous in South American collections, few have been analyzed for life-history information. Life-history information can be used to test hypotheses of causes of extinction, but has only been explored in fairly well-preserved specimens and laws in South American countries have prevented destructive analysis. Because there is some debate about the degree to which humans caused megafaunal extinctions at the end of the Pleistocene, additional information from South American megafauna is important for understanding the extinction on a global scale. The Peruvian tooth was collected by U-M law school graduate Joseph Beal Steere in 1872 and allows us to test whether tropical specimens can be analyzed using the same techniques as better-preserved mid- and high-latitude specimens. Beal-Steere probably did not foresee that positive ground-truthing using this tooth would permit, but we have taken advantage of the opportunity to do both destructive and non-destructive sampling of the tooth to show how CT scanning can be used to open up new specimens to life-history analyses previously not thought possible. Digital renditions of teeth from CT scans create new legal issues with ownership of specimens that are considered national heritage in many countries. At the same time, these renditions permit more population-level life-history analyses on specimens that have never been examined in this way. Population-level analyses of species at the brink of extinction at the end of the Pleistocene could help us better model extinctions today, informing the creation of laws and policies to improve the protection of species.

The Yukagir mammoth: correlation of annual increments in tusk dentin using attenuation profiles acquired by X-ray computed microtomography

Hood, J.M.[1,2*], Fisher, D.C.[1,2], and Beld, S.G.[2]
[1]*University of Michigan Department of Earth and Environmental Sciences*
[2] *The University of Michigan Museum of Paleontology*

The Yukagir mammoth was an adult male woolly mammoth (*Mammuthus primigenius*) found in northern Yakutia (central Siberia) in 2002, and like all proboscideans (elephants and their relatives), his tusks contain layers of dentin. The length and density of increments within the dentin can provide insights into his life history, and variation in the appearance of annual increments is critical for correlating years between samples taken from a tusk. Transverse cores taken at regular intervals along the tusk axis collectively capture each annual layer of dentin present in the whole tusk, but each core only represents a small, yet overlapping, subset of those years. Annual increments in a series of tusk cores are analogous to strata represented in multiple outcrops, and, as in stratigraphy, we seek to correlate layers from one section to the next. In microscopic analysis of tusk dentin in thin section, annual and sub-annual layers present as bands of lighter and darker color, with the thicknesses varying seasonally. In 3D analysis of X-ray computed microtomography (microCT) scans, annual features are characterized by a typical pattern of variation in which attenuation gradually increases and then suddenly decreases near the boundary of the chronologically younger increment. However, the precise relationship between the location of an annual feature in thin section and the location of the same annual feature in microCT is not yet known. Previous microscopic

evaluation of sub-annual increments in thin section has yielded a provisional correlation of years between cores. This new method aims to correlate annual increments using variations in dentin density that present as different values of attenuation which will be registered using X-ray computed microtomography, and the results will be compared to those based on thin section analysis.

Dietary ecological niche dispersion in an ecomorphospace of platyrrhine primates and its association with cranial integration

Ricardo Ely
The Department of Earth and Atmospheric Sciences Indiana University

Morphological integration and modularity are concepts describing the degree of interdependence between traits in an organism. Integration describes a high degree of interdependence, while modularity describes relative independence of traits. A greater magnitude of interdependence (integration) among traits hampers evolutionary response, while trait independence (modularity) facilitates evolutionary flexibility, suggesting that modularity facilitates the evolution of ecological specializations and the ability for modular clades to occupy a wider array of niches. I tested this in platyrrhine primates by constructing a three-dimensional ecomorphospace based on dental topographic measures using principal component analysis (PCA). The breadth of dietary niche occupation in this ecomorphospace was measured using the Euclidean distance between each platyrrhine genus and a 'generalist' condition of the average dental shape of all genera. Indices measuring the degree of modularity (r2 , ICV) were collected from the literature for each genus. Linear regression and correlation was used to assess the relationship between modularity and niche dispersion. No significant correlations between PCA Euclidean distance and each integration index was detected. This indicates modularity may not have a strong influence on dietary niche dispersion (at least not in platyrrhines). Alternatively, the potential for modularity to allow clades to exploit ecological opportunities occurs at broader phylogenetic and ecological scales than those considered here. This hypothesis can be tested by broadening the taxonomic scope of the analysis presented here.

Preservation and faunal change of mammals in the Barstow Formation, southern California, and their implications for turnover at the Hemingfordian-Barstovian boundary

Katharine Loughney
Museum of Paleontology and Department of Earth and Environmental Sciences, University of Michigan, 1105 N. University Ave, Ann Arbor, MI 48109

The Barstow Formation of southeastern California preserves rich middle Miocene mammalian assemblages that form the basis of the Barstovian North American Mammal Age. In the Barstow Formation, the Hemingfordian-Barstovian boundary is characterized by an increase in large-mammal (>1 kg) diversity and the lowest stratigraphic occurrences of several taxa. This increase in diversity coincides with a change in facies and depositional environments, indicating that specific facies may have higher potential to preserve vertebrate remains than others. I examined the effects of facies and depositional environment on the preservation of large-mammal fossils in the Barstow Formation. Depositional environments in the Barstow Formation changed through time in relation to the tectonic and climatic history of the basin. I identified six major facies associations in the formation that represent the dominant environments at the time of deposition. Over time, environments transitioned from playa lakes and alluvial fans to floodplain settings with wooded grasslands and wetlands.

In order to characterize changes in faunal composition and turnover through the formation, I compiled species abundance and occurrence information from 148 vertebrate localities. I used abundance data to calculate evenness for faunal assemblages and presence-absence data to calculate turnover and 80% confidence intervals on

the stratigraphic ranges of 54 large-mammal species. From confidence intervals, I calculated inferred turnover of large mammals through the formation. Species body size and facies were important determinants of preservation potential; these features contribute to observed patterns in richness and evenness among facies associations, as well as species ranges through the formation. Observed lowest and highest occurrences clustered at specific stratigraphic intervals and correspond with facies transitions, including high observed turnover at the Hemingfordian-Barstovian boundary. Spikes in observed turnover lie in stratigraphic intervals that have produced significant amounts of fossil material. In contrast, patterns of inferred turnover based on confidence intervals differ from the observed pattern and are stratigraphically dispersed. High turnover that marks the Hemingfordian-Barstovian boundary in the Barstow Formation is a product of favorable preservation in proximal-channel settings, and the increase in diversity is more likely due to a shift in depositional environments than to an influx of immigrant taxa.

Neogene *Corylopsis* Seeds from eastern Tennessee

Zack Quirk[1*], Elizabeth J. Hermsen[2]
[1] *The University of Michigan Department of Earth and Environmental Sciences*
[2] *Paleontological Research Institution*

Fossil seeds of *Corylopsis* Siebold & Zucc. (Hamamelidaceae) have been identified from the Pliocene-aged Gray Fossil Site (GFS) in eastern Tennessee. The assignment of the seeds to Hamamelidaceae is based on the smooth testa and presence of a scar in the hilar region. The assignment to the genus *Corylopsis* specifically is based on the presence of a hilar facet in addition to the hilar scar, diagnostic characteristics for the genus *Corylopsis*. The GFS seeds have been assigned to a new fossil species based on differences of their hilar scar and facet characters as compared to other fossil species. The fossil distribution shows that *Corylopsis* was more widespread across the Northern Hemisphere continents in the past, although it persists only in East Asia today. Gray Fossil Site may have acted as a climate refugium during the late Miocene to early Pliocene, providing a suitable environment for warm temperate plants during a time of global cooling.

Time heals all wounds: what regeneration reveals about assessing predation intensity in crinoids

Veitch, M.A.[1*], Messing, C. G.[2], and Baumiller, T.K.[3]
[1] *The University of Michigan Museum of Paleontology,*
[2] *Nova Southeastern University Halmos College of Natural Sciences and Oceanography*
[3] *The University of Michigan Museum of Paleontology*

Stalked crinoids disappearance from shallow water in the late Mesozoic has long been attributed to increased predation during the Mesozoic Marine Revolution (MMR). In tests of this hypothesis using extant taxa, Oji (1996) and Baumiller (2013) found lower frequencies of predation-related injuries in deep water than in shallow-water crinoids. All extant stalked crinoids are restricted to depths >100m, whereas only featherstars - taxa that lose the stalk as juveniles - remain in shallow systems. Numerous studies have relied on injury prevalence (IP), the proportion of individuals with arm injuries in a population, as a measure of predation, with high IP interpreted as reflecting intense predation. However, due to the ephemeral nature of crinoid injuries, IP is influenced by two processes: directly by the rate at which injuries are incurred (injuries/time) and inversely by the rate at which injuries regenerate, leading to their "disappearance" (growth/time). In the context of the MMR hypothesis and the bathymetric predation gradient, reliance on IP without considering both processes can result in misleading interpretations regarding predation intensity.

We examined the relationships of these two processes via submersible in a large population of the stalked crinoid *Democrinus* cf. *brevis* off Isla Roatán, Honduras. Sites at 240 and 260 m have been monitored since 2015 to investigate arm loss, regeneration rates, and biotic interactions. We observed little evidence of abiotic disturbances

(excluding occasional falling debris) or self-*autotomization*. As *D. brevis* has only five unbranched arms and does not autotomize to increase arm number, predation is likely the main cause of arm loss. We obtained IP from video transects, and rate of arm regeneration by revisiting injured individuals over two 6-month periods and one 12-month period to measure regrowth. The high observed IP in *D.* cf. *brevis* (12-18%) is comparable to some shallow-water crinoids but is due to low regeneration rates rather than a high injury rate. Our results predict that individual crinoids will experience an injury every 3 years on average, lower than recorded for shallow-water crinoids and consistent with the hypothesis that the deep sea represents a refuge from predation for stalked crinoids.

Stable isotope paleoecology of *Teleoceras* (Mammalia: Rhinocerotidae) in the late Neogene of the Great Plains, North America

Bian Wang[1] and Ross Secord[2]

[1] The University of Michigan Department of Earth and Environmental Sciences

[2]The University of Nebraska Department of Earth and Atmospheric Sciences

The Rhinocerotidae have a long evolutionary history in the Cenozoic of North America and were some of the most widespread and ecologically diverse large herbivores on the continent. *Teleoceras* was one of the last two genera of rhinos that lived in North America and was a common component of fossil sites from the late early Miocene to the early Pliocene (~17.5–4.9 Ma). *Teleoceras* possesses a mixture of characteristics and adaptations that make it one of the most interesting North American rhinos. The short-limbed, barrel-bodied *Teleoceras* was long thought to be a semi-aquatic mammal due to its morphological resemblance to modern hippopotamus. Other similarities in herd structure and locomotion have also been identified between modern hippos and *Teleoceras* fossil assemblages. This interpretation remained popular for over a hundred years and made *Teleoceras* widely known as the "hippo-rhino". However, the hippo analogy runs counter to recent demographic studies of fossil assemblages. An arguably more rigorous approach is stable oxygen isotope analysis. The tooth enamel $\delta^{18}O$ values of fossil hippo-ecomorphs are expected to be significantly lower than those of the contemporaneous terrestrial ungulate fauna, due to differences in body water loss through feces and urine. To test if *Teleoceras* had a semiaquatic lifestyle, we collected bulk samples of tooth enamel from 39 specimens of *Teleoceras* and 22 specimens of the sympatric rhino, *Aphelops*. All samples were from the Great Plains localities spanning 9 Ma to 4.9 Ma. Additional isotope data were collected from the literature. Our data show no significant difference between *Teleoceras* and the associated terrestrial faunas. This result is consistent with previous oxygen isotope data from the middle-late Miocene of Florida and western North America. In addition, carbon isotope data generated in our study show that *Teleoceras* remained primarily a C_3 feeder during the expansion of C_4 grasslands in the Great Plains (~6.5 Ma), which may have contributed to their demise in the early Pliocene.