3RD ANNUAL GREAT LAKES STUDENT PALEOCONFERENCE

(NOV. 8–10, ANN ARBOR, MI)

Welcome everybody to the Third Annual Great Lakes Student Paleoconference (GLSP)! We are thrilled to host this edition in Ann Arbor, MI, two years after the very first GLSP brought students, postdocs and researchers of the University of Chicago and Field Museum at the University of Michigan to spend a weekend talking together about paleontology and simply having fun. Many things changed at U of M in these two years, and probably none is more conspicuous than the completion of the brand-new Biological Sciences Building, a state-of-the-art research, teaching and scientific communication center that also hosts the new University of Michigan Museum of Natural History public exhibits.

Hence, we think that there couldn't have been a better time to welcome back (or welcome anew) everybody in Ann Arbor for this special occasion. This year's GLSP greatly expanded its scope and will feature over 50 participants, including 34 scientific presenters from seven different institutions of the Great Lakes macroarea, and a science communication panel. We cannot be happier to see this yearly gathering growing in numbers, and we wish that in the future it will become a staple for paleontology students across the Midwest– and beyond –that want to share their ideas and research.

We hope you will all have a great time during this weekend in Ann Arbor!

Sincerely,

The GLSP 2019 organizing committee

ABOUT THE LOGO

The logo of the 3rd GLSP was designed by Rodrigo T. Figueroa. It merges an iconic mammoth silhouette with the State of Michigan and the Great Lakes, using the traditional colors of the University of Michigan – maize and blue.

CONFERENCE SCHEDULE

	Friday 8th	Saturday 9th	Sunday 10th
Morning		**8:45 am – 9:20 am** Breakfast at BSB	**9:00 am – 9:30 am** Breakfast at BSB
		9:20 am - 12:00 pm Talk sessions	**9:30 am - 11:30 am** Scientific Communication Panel
Afternoon	Arrival and meeting with hosts	**12:00 pm - 1:00 pm** Catered lunch	**11:30 am -** Visit to UMMP exhibits
		1:00 pm - 5:30 pm Talk sessions and poster session	
Evening	**7:30 pm – onward** Welcome dinner and get-together	**6:30 pm - onward** Catered dinner (Wilson house)	

The talk sessions and faculty panel will be held in Room 1010 of the Biological Sciences Building (BSB), 1105 N University Ave, West Atrium entrance. Posters will be hanged out in the corridor just outside the same room. The catered dinner on Saturday will be held at Prof. Jeff Wilson's house (see next page).

WELCOME DINNER AND GET-TOGETHER – FRIDAY NOVEMBER 8TH, 7:30 PM

Upon arrival in the bucolic city of Ann Arbor and after checking in with their hosts (if hosted by somebody), all registrants are invited to join a welcome dinner at Grizzly Peak Brewing Co., a cozy but spacious brewpub set in downtown Ann Arbor (120 W Washington St).

SCIENCE COMMUNICATION PANEL – SUNDAY NOVEMBER 10TH, 9:30 – 11:30 AM

On Sunday, all attendees are invited to a science communication round table from 9:30 to 11:30 AM led by **Dr. Jennifer Bauer** (Invertebrate Paleontology Collection Manager at the University of Michigan Museum of Paleontology), **Ashley Hall** (Marketing Coordinator at the Nature Center at Shaker Lakes), and **Lee Hall** (Preparator of Vertebrate Paleontology at the Cleveland Museum of Natural History). The science

communication panel will introduce participants to various avenues of digital and in-person science communication, allow for ample discussion time in small and large groups to a museum educator, preparator, and collection staff, and showcase platforms currently used by paleontologists. Participants will leave with a better understanding of how and where to share their science. Breakfast and refreshments will be provided beforehand and during the event. After the panel, everyone is welcome to attend an informal tour of the new University of Michigan Museum of Natural History exhibits.

SCIENTIFIC PROGRAM
(NOVEMBER 9TH, 2019)

TIME	EVENT
08:45-09:20	**WELCOME PARTY (WITH COFFEE AND BREAKFAST)**
09:20-09:30	Welcome Address.
09:30-09:45	Exceptional preservation of fossils from the Silica Shale (Middle Devonian) of Ohio, Michigan, and Indiana revealed using X-ray computed tomography. *PRESCOTT VAYDA*
09:45-10:00	Patterns of evolutionary rates within two iconic lineages: are "living fossils" alike? *RAFAEL A. RIVERO-VEGA*
10:00-10:15	The evolution of dermal rays in tetrapodomorph paired fins. *THOMAS STEWART*
10:15-10:30	What's in a whatcheeriid: new synapomorphies, new family diagnosis, and new perspective on early tetrapod evolutionary history. *BEN OTOO*
10:30-10:35	Microfossils from a range of depositional environments across the Neoarchean Campbellrand-Malmani Carbonate Platform, Kaapvaal Craton, South Africa. *ANDREA CORPOLONGO*
10:35-11:00	**COFFEE BREAK**
11:00-11:15	The first Permian occurrence of Iniopterygia (Chondrichthyes, Holocephali). *RODRIGO T. FIGUEROA*
11:15-11:30	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*
11:30-11:45	A new method of measuring Air Space Proportion in pneumatic skeletal tissue. *DANIELLE GOODVIN*
11:45-12:00	Evaluating the performance of diversification rate estimation methods in extinct clades with empirical and simulated data. *DAVID ČERNÝ*
12:00-13:00	**LUNCH**
13:00-13:15	Reconciling conflicting testimonies on the origins of the marine biodiversity hotspot. *JAMES SAULSBURY*
13:15-13:30	Description and morphospace analysis of the oldest occurring crown squirrelfish (Teleostei: Holocentridae). *JAMES ANDREWS*
13:30-13:45	A long-snouted marine bonytongue (Teleostei: Osteoglossidae) from the early Eocene of Morocco: glimpse into the underappreciated diversity of an early Paleogene marine radiation of predatory fishes. *ALESSIO CAPOBIANCO*

13:45-14:00	New fossils of *Palaeoamasia kansui* (Mammalia, Embrithopoda): Implications for embrithopod evolution. *MELISSA WOOD*
14:00-14:15	Reading the leaves: developing a quantitative approach to improve interpretation of fossil monocot leaf systematics and ecology. *ZACK QUIRK*
14:15-14:20	Examination of torso morphology in extant terrestrial amniotes to infer the body morphology of quadrupedal non-avian dinosaurs. *MYLES MA WALSH*
14:20-14:45	**COFFEE BREAK**
14:45-15:00	Dental topographic change with macrowear and dietary inference in *Homunculus patagonicus*. *PEISHU LI*
15:00-15:15	Diagenetic heterogeneity of time-averaged vertebrate remains in marine settings: a test case of the Miocene Sharktooth Hill Bone Bed, California. *RACHEL LAKER*
15:15-15:30	Tectonic influences on species richness of mammals in the Middle Miocene Dove Spring Formation, California. *FABIAN HARDY*
15:30-15:45	Carbon isotopic values of the mammalian community of the Ngorora Formation, Kenya. *ELLIOT GREINER*
15:45-15:50	Functional and phenotypic modularity in the trophic bones of aquatic-foraging snakes. *DANIEL RHODA*
15:50-16:30	**COFFEE BREAK + POSTER SESSION (8 POSTERS)**
16:30-16:45	Phylogenetic effects dominate avian wing morphology over ecology. *STEPHANIE L. BAUMGART*
16:45-17:00	Dietary ecomorphological dispersion and phenotypic integration in Felidae and Mustelidae (Mammalia; Carnivora). *RICARDO ELY*
17:00-17:15	High-latitude benthic bivalve biomass and recent climate change: Testing the power of live-dead discordance in the Pacific Arctic. *CAITLIN MEADOWS*
17:15-17:30	Dead Men Still Tell Tales: Molluscan death assemblages record a boom-bust invasion and a changing community in Jamaica's Kingston Harbour. *BROC S. KOKESH*
18:30-	**DINNER (AT JEFF WILSON'S HOUSE)**

LIST OF POSTERS (POSTER SESSION; CORRIDOR IN FRONT OF BSB 1010; 3:50-4:30 PM)

Mysteries from the Missing Million: Investigating ecological change in the Southern Kenya Rift during the emergence of *Homo sapiens*. *MARA PAGE*

A marine bonebed of the Upper Cretaceous Niobrara Chalk, western Kansas. *JONATHAN G. ALLEN*

The first occurrence of an ichthyodectiform fish (Osteichthyes: Actinopterygii) from the Arlington Member (mid-Cenomanian) of the Upper Cretaceous Woodbine Formation in Texas. *RILEY J. HACKER*

Using the extant megamouth shark, *Megachasma pelagios*, to infer the dentition of the fossil megamouth shark, *Megachasma applegatei*. *ALEXANDRA KRAK*

Ray-finned fishes (Actinopterygii) from the Late Permian Minnekahta Limestone of South Dakota. *JACK STACK*

Skull mechanics and functional morphology of Brasilodontidae, the sister clade to mammals. *CHARLES J. SALCIDO*

Postcranial anatomy and functional forelimb morphologhy of the Luangwa Basin cistecephalid *Kembawacela kitchingi* (Therapsida: Anomodontia). *CAROLINE P. ABBOTT*

Double-scanning and Gaussian blurring improve quality of paleontological CT data: experiments with two mammoth tusks. *ETHAN A. SHIRLEY*

PRESENTATION ABSTRACTS

(IN PRESENTATION ORDER)

EXCEPTIONAL PRESERVATION OF FOSSILS FROM THE SILICA SHALE (MIDDLE DEVONIAN) OF OHIO, MICHIGAN, AND INDIANA REVEALED USING X-RAY COMPUTED TOMOGRAPHY

Prescott Vayda*[1], Loren Babcock[1], Emma Oti[1], Lawrence Wiedman[2]

[1] School of Earth Sciences, The Ohio State University, Columbus, OH

[2] Department of Biology, University of Saint Francis, Fort Wayne, IN

* Speaker

The Silica Shale of northwestern Ohio and adjacent areas of southern Michigan and northeastern Indiana contains a diverse assemblage of Middle Devonian fossils, many of which are preserved in part by pyrite. Body fossils have been collected from the Silica Shale for more than a century, and large collections have been amassed. Study of samples from the Silica Shale using X-ray Computed Tomography (XCT) reveals that internal nonbiomineralized or lightly biomineralized tissues of shelly taxa are commonly replicated by pyrite. Pyritized trace fossils also have been imaged in some layers. XCT scanning reveals the Silica Shale to be a remarkably rich Konservat-lagerstätte, and exceptional preservation by means of pyrite is present in localities stretching across the Silica Shale outcrop belt. Visualization of the internal soft tissues of some organisms has been aided further by 3D printing of digital models generated using XCT scans. Using XCT, the internal soft tissues of trilobites, brachiopods, and corals have been imaged, and fine details have emerged in many specimens. Pyrite replication seems to have begun quickly after the death of many organisms present in the Silica Shale. Many enrolled trilobites have preserved digestive systems, although preserved guts are rare in outstretched trilobites. This suggests that enrolled specimens were corpses, whereas most outstretched trilobites were probably molts. Many brachiopods show preserved brachidia and lophophores, and a few have pyritized muscles and organs. Rugose corals have pyritized structures resembling mesenteries. Results of XCT scanning on fossils from the Silica Formation open that possibility that other deposits rich in pyritized fossils also may yield similarly detailed preservation of nonbiomineralized anatomical structures.

COELACANTH DIVERSITY THROUGH TIME

Ethan D. France*[1], William E. Bemis[1]

[CANCELLED!]

[1] Department of Ecology and Evolutionary Biology, Cornell University, Ithaca, NY

* Speaker

Coelacanths are among the most famous “living fossils,” but their history is not one of stagnation. Over the last 410 million years they have survived four mass extinctions, occupied a variety of habitats, and fluctuated significantly in diversity. Perhaps most surprisingly, the group has produced disparate

morphological forms, some quite unlike the extant *Latimeria*. This talk will summarize ongoing research into the history of the coelacanths, with the goal of measuring two related trends: taxonomic diversity and morphological disparity. It will discuss the quality of the coelacanth fossil record and the challenges it poses. Finally, it will place our current knowledge into context, discussing potential drivers for patterns of coelacanth diversity.

PATTERNS OF EVOLUTIONARY RATES WITHIN TWO ICONIC LINEAGES: ARE "LIVING FOSSILS" ALIKE?

Rafael A. Rivero-Vega*[1,2], Matt Friedman[1,2]

[1] University of Michigan Museum of Paleontology, Ann Arbor, MI

[2] Department of Earth and Environmental Sciences, University of Michigan, Ann Arbor, MI

* Speaker

Differing patterns of morphological rates of change across the evolutionary history of groups are a well-known and well-studied facet of the Tree of Life. So-called "living fossil" lineages are a unique example of this disparity, remaining apparently unchanged over extremely long timescales while other, closely related lineages may diversify extensively in short periods of time. Two traditionally iconic "living fossils"—coelacanths and lungfishes—show comparable broad scale declines in evolutionary rates from the Devonian to the present. However, the precise patterns of morphological rates through time, and their correspondence to environmental shifts and lineage diversity, remain largely unexplored. To address this problem, the most recent and complete morphological matrices available for both clades were processed and used to infer Bayesian phylogenetic trees. However, rather than using a standard birth-death or tip-dating model, the Fossilized Birth-Death method, which jointly estimates branch divergence times and evolutionary rates, was used. In addition, paleoenvironmental data on all taxa were gathered from the literature and used to calculate shifts in the proportion of marine and freshwater taxa over the evolutionary history of each clade. Results indicate that although the consensus view of morphological rates declining over time is accurate, the intrinsic patterns making up those trends are considerably distinct. Coelacanths experienced high rates of morphological change in the Devonian and Permian to Triassic periods, with declining rates towards the present. Conversely, lungfishes showed very high rates of morphological change in the Devonian with lower, relatively stable rates afterwards. These rate peaks were tentatively associated with habitat shifts from freshwater to marine ecosystems, number of lineages through time, and mass extinctions. These results highlight how phylogenetic analyses of morphological trends informed by novel methods and rich fossil records can reveal previously unknown, finer-scale evolutionary variability. Further, this study represents a starting point for future, more comprehensive analyses incorporating traits such as body shape and jaw morphology or comparative analyses between other "living fossil" animal and plant lineages.

THE EVOLUTION OF DERMAL RAYS IN TETRAPODOMORPH PAIRED FINS

Thomas Stewart*[1], Neil Shubin[1]

[1] Department of Organismal Biology and Anatomy, University of Chicago, Chicago, IL

* Speaker

Paleontological studies of the fin-to-limb transition have focused almost exclusively on evolution of the endoskeleton. However, comparative analyses of dermal fin rays can also inform the behavior, ecology and developmental evolution of tetrapodomorph fishes. Here I use computed tomography to describe the dermal rays of the pectoral fins of three tetrapodomorph species: *Sauripterus taylori*, *Eusthenopteron foordi*, and *Tiktaalik roseae*. We find that in the lineage leading to crown group tetrapods, fin rays were simplified (segmentation and branching was lost), the fin web was reduced in size, and asymmetry evolved between dorsal and ventral hemitrichia. In tetrapodomorph pectoral fins, dorsal hemitrichia generally cover the endoskeleton to a greater degree than the ventral hemitrichia, indicative of dorsoventral asymmetries in the distribution of fin musculature. In *Tiktaalik*, dorsal hemitrichia cover the third and fourth mesomeres, while ventral hemitrichia are restricted distal to these elements, suggesting the presence of ventralized musculature at the fin tip, analogous to a fleshy palm. Dorsal and ventral hemitrichia also differ in cross sectional area. *Eusthenopteron* dorsal hemitrichia are slightly larger than ventral hemitrichia, and the magnitude of difference is consistent between individuals of different sizes; while *Tiktaalik* dorsal hemitrichia are several times larger than ventral hemitrichia, and magnitude of asymmetry is greater in larger individuals. This indicates a transition from isometric to allometric scaling between the dorsal and ventral hemitrichia in elpistostegids. Dermal fin ray evolution in tetrapodomorphs shows convergence with benthic actinopterygians and adaptation to substrate-based loading and prior to the origin of digits.

WHAT'S IN A WHATCHEERIID: NEW SYNAPOMORPHIES, NEW FAMILY DIAGNOSIS, AND NEW PERSPECTIVE ON EARLY TETRAPOD EVOLUTIONARY HISTORY

Ben K.A. Otoo*[1], John R. Bolt[2], Eric Lombard[1], Michael I. Coates[1], Kenneth D. Angielczyk[2]

[1] Department of Organismal Biology and Anatomy, University of Chicago, Chicago, IL

[2] The Field Museum of Natural History, Chicago, IL

* Speaker

Over 300 additional specimens of *Whatcheeria* have become available since its initial description in 1995. These, as well as phylogenetic and analytic advances, have motivated an in-depth restudy of its postcranial skeleton. Comparative anatomical investigation has revealed new diagnostic features for *Whatcheeria*, as well as synapomorphies for *Whatcheeria* and *Pederpes*. These include a single ankle ossification associated with pedal digit I, a flat-topped fourth trochanter, and the absence of an internal trochanter. Further synapomorphies come from a recently published study of the palate of *Whatcheeria*. These new data are included within an emended, more precise diagnosis for the family Whatcheeriidae. Phylogenetic analyses support a monophyletic Whatcheeriidae including *Whatcheeria* and *Pederpes*. *Ossinodus*, occasionally referred to as a whatcheeriid, is usually recovered stemward among Devonian taxa such as *Ventastega* and *Ichthyostega*, but its position is unstable. Reexamination of attributed whatcheeriid material suggests that the clade represents a distinct Mississippian Euramerican radiation with a possible Late Devonian origin. The age, distribution, and abundance of *Ossinodus*-like material suggests that it, too, is a late-surviving member of a distinct Devonian clade. This reassessment increases the number of Devonian limbed tetrapod morphotypes and putative Devonian/Carboniferous boundary crossers by a minimum of two. These findings imply that early tetrapod faunas included members of both pre- and post-Hangenberg Event lineages at least through the middle Mississippian, and that they not only survived the extinction event but also participated in subsequent diversification events.

MICROFOSSILS FROM A RANGE OF DEPOSITIONAL ENVIRONMENTS ACROSS THE NEOARCHEAN CAMPBELLRAND-MALMANI CARBONATE PLATFORM, KAAPVAAL CRATON, SOUTH AFRICA

Andrea Corpolongo*[1], Andrew Czaja[1], Nicolas Beukes[2]

[1] Department of Geology, University of Cincinnati, Cincinnati, OH

[2] Department of Geology, University of Johannesburg, Johannesburg, South Africa

* Speaker

The Archean fossil record holds valuable information regarding life's emergence and early evolution on Earth, but it has not been fully described. The 2.68 to 2.5 Ga Campbellrand-Malmani carbonate platform on the Kaapvaal Craton warrants the attention of Precambrian paleontologists because it is a well-preserved representation of marine basinal to supratidal microbial ecosystems as they existed during the late Archean era, just before the Great Oxygenation Event (2.44 – 2.3 Ga). We explored seven localities along the Campbellrand-Malmani Carbonate Platform that contain exposed microbialite lithofacies for the presence of black chert layers, lenses, and nodules and collected samples where black cherts were found. Black cherts within microbialite carbonates represent silicified, organic-rich regions of preserved microbially mediated sedimentary structures, and can contain well-preserved fossils of the microorganisms that lived when those sedimentary structures formed. Here I will present interpretations of unique and unusually large organic microstructures that I have observed during the early phase of examination of the samples we collected. I will also discuss the ultimate goal of this project, which is to describe and compare the microbial ecosystems that existed across different near-shore marine environments in this pivotal time in Earth's history.

THE FIRST PERMIAN OCCURRENCE OF INIOPTERYGIA (CHONDRICHTHYES, HOLOCEPHALI)

Rodrigo T. Figueroa*[1,2], Matt Friedman[1,2]

[1] University of Michigan Museum of Paleontology, Ann Arbor, MI

[2] Department of Earth and Environmental Sciences, University of Michigan, Ann Arbor, MI

* Speaker

Iniopterygians are a group of stem holocephalans (Gnathostomata: Chondrichthyes) characterized by the presence of enlarged pectoral fins positioned posterodorsally to the head, and sometimes bearing hook-shaped denticles on the first enlarged radial. These animals were, until now, only known for Carboniferous deposits from North America and Scotland, comprising two families (Iniopterygidae and Sibyrhynchidae). Here we report the first iniopterygian occurrence from South America, extending the range of this group into the Cisuralian. We analyzed 10 specimens from the Lontras Shale deposit of the Campo Mourão Formation of the Paraná Basin, Brazil. The specimens are preserved within siderite concretions and show skull, pectoral fins, and vertebral elements, in both lateral and dorsal view. Unfortunately, most of the material is flattened, due to the original cartilaginous composition of their skeleton. The μCT results indicate that the braincase of these iniopterygians was completely unmineralized, but the shoulder girdle and fins show at least some degree of mineralization. The large basipterygium, articulated to the distal portion of the scapulocoracoid bears a large condyle for articulation with the first distal radial of the pectoral fin. This feature seems to be also present in *Sibyrhynchus* and *Iniopera*, but is absent in *Iniopteryx* and *Promexyele*, indicating that it might be a synapomorphy of the family Sibyrhynchidae, to which the

Brazilian specimens are tentatively associated. This novel occurrence indicates that iniopterygians survived until later than previously thought, and also with a much wider distribution, reaching high latitudes into the southern hemisphere.

THE ROOT OF THE MATTER

Kelsey Stilson*[1], Callum F. Ross[1], Zhe-Xi Luo[1], Melvin Bonilla[1], David A. Reed[2]

[CANCELLED!]

[1] Department of Organismal Biology and Anatomy, University of Chicago, Chicago, IL

[2] University of Illinois at Chicago College of Dentistry, Chicago, IL

* Speaker

Teeth are an essential component of the mammalian mouth, a multimodal system that communicates sensations of taste, touch, smell, pain, and temperature to the brain. Teeth are also a sensory feedback system. Information is constantly sent to the brain about food and tongue position, food hardness and temperature through neurons in the pulp, dentine, and the periodontal ligament (PDL). The PDL connects each tooth to its respective socket through a network of unmineralized collagen fibers, blood vessels, nerves, and support cells. Teeth are the ideal sensory system to study because they are found in most animals both alive and extinct, and are preferentially preserved in the fossil record. Triassic Mammaliaformes are the outgroup to true Mammalia and show a suite of adaptations unique to the Mammalian line. These include complex occlusion, a reduced and limited number of tooth generations, fur, increasing relative brain size, and a multi-root tooth system. This multi-root tooth system expanded the surface area available to the periodontal ligament, an area called the radicular surface. To examine this multi-root system, we focused on the marsupial *Didelphis virginiana* (the opossum). Opossums are a great study system because of their larger size compared to most available marsupials, as well as the morphological similarity of their teeth and tooth roots to Triassic Mammaliaformes. We used immunohistochemistry and FIJI to identify and map individual nerve locations and types in mandibular M1 and M2 of the opossum. Innervation was found to be most dense in the lingual and inter-radicular regions of the PDL in our preliminary studies. There were more nerves toward the crown of the tooth (rather than the apex), but this may be a function of PDL area and must be investigated further. The inter-radicular space showed a unique groove-like morphology that needs to be compared with fossil material. The alveolus itself also shows dorsoventrally orientated grooves. Collagen fibers were oriented radially, with a cross-hatching pattern within radicular areas or areas where the tooth root ran parallel to the cortical mandibular bone. The greatest vascularization was in the inter-radicular portion of the alveolus. These results show that the evolutionarily newer radicular area is different from rest of the PDL and warrants further study and comparison with early Mammaliaformes.

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], Jeffrey A. Wilson[1,2]

[1] University of Michigan Museum of Paleontology, Ann Arbor, MI

[2] Department of Earth and Environmental Sciences, University of Michigan, Ann Arbor, MI

* Speaker

Tail clubs evolved independently multiple times within vertebrates, including at least twice within dinosaurs. The best known and most complex dinosaurian tail clubs evolved within ankylosaurs. Ankylosaur tail clubs were formed by the distal caudal vertebrae interlocking to form a stiff "handle" which was enveloped by osteoderms forming a "knob". Structurally simpler tail clubs have been reported for sauropods from the Jurassic of China (*Shunosaurus*, *Omeisaurus*, and *Mamenchisaurus*). Tail clubs attributed to *Shunosaurus* and *Omeisaurus* are laterally expanded, rounded structures with signs of segmentation ventrally, and there are partially fused caudal vertebrae that precede them. The *Mamenchisaurus* tail club is simpler, formed by four fused distal caudal vertebrae. In this study we report on tail clubs from the Kota Formation of India (Lower to Middle Jurassic), which has produced abundant but mostly disarticulated remains of the basal sauropods *Kotasaurus yamanpalliensis* and *Barapasaurus tagorei*. These remains were collected from geographically adjacent sets of localities but housed in distinct collections. Four tail clubs were recovered among the nearly 400 bones attributed to *Kotasaurus*. Computed Tomography (CT) scans of the Kota tail clubs are presented to explain the internal structures. We provisionally attribute the tail clubs to *Kotasaurus*, but additional data are required to formalize this claim—of particular interest is the possibility that the tail clubs could belong to *Barapasaurus*, which was recovered near *Kotasaurus* and in a mostly disarticulated state. The Kota tail clubs are similar in shape to those attributed to *Shunosaurus* and *Omeisaurus* and share with them ventral segmentation and a distinct posterodorsal depression. Associated characters of the distal caudal vertebrae, such as fused vertebrae, are shared between *Barapasaurus*, *Kotasaurus*, *Shunosaurus*, *Omeisaurus*, and *Mamenchisaurus*. So far, tail clubs have been associated only with basal sauropods—raising the question of whether tail clubs and associated structures evolved once, multiple times, or were gained and then lost within basal sauropods.

A NEW METHOD OF MEASURING AIR SPACE PROPORTION IN PNEUMATIC SKELETAL TISSUE

Danielle Goodvin*[1,2], Kierstin Rosenbach[1,3], Jeffrey A. Wilson[1,3]

[1] University of Michigan Museum of Paleontology, Ann Arbor, MI

[2] Department of Ecology and Evolutionary Biology, University of Michigan, Ann Arbor, MI

[3] Department of Earth and Environmental Sciences, University of Michigan, Ann Arbor, MI

* Speaker

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, sauropodomorphs, 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 (μ-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 μCT 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.

EVALUATING THE PERFORMANCE OF DIVERSIFICATION RATE ESTIMATION METHODS IN EXTINCT CLADES WITH EMPIRICAL AND SIMULATED DATA

David Černý*[1], Daniel Madzia[2], Graham J. Slater[1]

[1] Department of Geophysical Sciences, University of Chicago, Chicago, IL, USA

[2] Institute of Paleobiology, Polish Academy of Sciences, Warsaw, Poland

* Speaker

Differing rates of diversification represent one of the most promising explanations for the uneven distribution of species richness across the tree of life, but the estimation of these rates has proved difficult. Recent mathematical and simulation-based studies suggested that macroevolutionary rates – whether estimated from time-calibrated phylogenies of extant taxa or non-phylogenetic data for fossils – may, in general, not be identifiable. However, commonly used Bayesian methods for diversification rate estimation such as PyRate and BAMM may be able to mitigate this problem by the use of informative priors. To investigate whether this is the case, we applied both methods to the 'bird-hipped' dinosaurs (Archosauria: Ornithischia), an extensively studied group of fossil vertebrates, as well as to simulated phylogenies and fossil records with paleontologically realistic properties. We obtained results suggestive of identifiability problems for PyRate and inconclusive results for BAMM, indicating that the method may not have enough power to detect diversification rate shifts in realistically sized fossil phylogenies. In agreement with other recent findings, we urge caution when applying both methods to extinct clades, and note that the use of neither fossil data nor phylogenetic information may be sufficient to overcome the problems in question.

RECONCILING CONFLICTING TESTIMONIES ON THE ORIGINS OF THE MARINE BIODIVERSITY HOTSPOT

James Saulsbury*[1,2]

[1] University of Michigan Museum of Paleontology, Ann Arbor, MI

[2] Department of Earth and Environmental Sciences, University of Michigan, Ann Arbor, MI

* Speaker

The processes that shape global gradients in species richness are an issue of recent contention. Most explanations emphasize geographical differences in diversification, but richness and diversification have been found to be decoupled in several major clades, suggesting a role for processes like asymmetric dispersal in generating richness patterns. Many major marine lineages have their greatest richness in the

Indo-West Pacific (IWP), but this has not always been the case: the marine richness hotspot is thought to have moved east from the West Tethys over the Cenozoic. Whether this occurred through 1) a shift in the center of diversification or 2) through elevated dispersal into the IWP is not understood. Here, I investigate the history of the richness hotspot among featherstar crinoids, a group of echinoderms that are diverse and abundant on tropical reefs, especially in the IWP. Using ancestral range reconstruction with a new time-scaled phylogeny of 152 living species, I show that neontological data support an IWP origin for most major featherstar lineages. However, featherstar fossils are restricted to the West Tethys and Atlantic from the group's origin in the Jurassic, only appearing in Asia in the Cenozoic. Living and fossil datasets are beset by formidable temporal and spatial biases, respectively, but I lay out a cautious approach to adjudicating between the two. First, I use simulations to demonstrate that, given a scenario of changing dispersal rates between regions through time, we should expect to be misled by ancestral range reconstructions from neontological data. Next, I explore taphonomic controls: the existence of stalked crinoids and other echinoderms in moderate abundance from the Jurassic of Asia supports the assertion that featherstars were not there, at least until the Cretaceous. Finally, I infer the phylogenetic affinities of some Mesozoic featherstars and recover several Jurassic forms deep within the crown group, supporting scenario 2 in which major featherstar clades originated in the West Tethys and then dispersed into the IWP. This scenario might be general, and points toward unresolved questions in macroevolution – for example, whether the aspects of a region that promote elevated in situ diversification are different from those that promote elevated immigration.

DESCRIPTION AND MORPHOSPACE ANALYSIS OF THE OLDEST OCCURRING CROWN SQUIRRELFISH (TELEOSTEI: HOLOCENTRIDAE)

James Andrews*[1,2], Matt Friedman[1,2]

[1] University of Michigan Museum of Paleontology, Ann Arbor, MI

[2] Department of Earth and Environmental Sciences, University of Michigan, Ann Arbor, MI

* Speaker

Squirrelfishes (Holocentridae) are marine, reef-dwelling, and primarily nocturnal fishes including approximately 90 living species. Holocentrids occupy a critical phylogenetic position as a close outgroup to the hyperdiverse percomorphs. The earliest fossils associated with squirrelfishes are early Late Cretaceous (ca. 100-80 Ma) in age and are loosely tethered to the holocentrid stem lineage. There is a stratigraphic gap between these and the earliest well-known Cenozoic holocentrids, which are early Eocene in age (ca. 49 Ma) and clearly belong to the crown radiation. We used micro-computed tomography to examine three-dimensionally preserved holocentrid remains from near the Cretaceous-Paleogene boundary (66 Ma) of the Hornerstown Formation of New Jersey that punctuates this stratigraphic gap. A posterior lateral expansion of the parasphenoid, imperforate ceratohyal, and strong notchings on the ventral border of the ceratohyal indicate that it is crownward of known Cretaceous forms. Presence of an edentulous dorsomedially-upturned process at the symphysis of the premaxillae, and an alveolar process of the premaxillae bearing an antero-lateral expansion overhanging the dentary are derived features suggesting placement as sister to Myripristinae within the crown group. This identification is contrasted by an otolith morphology common to the holocentrine subgroup, though this may be consistent with placement deep on the myripristine stem. Divergence time estimates suggest an origin of ca. 70 Ma, in contrast with past

estimates of ca 53 Ma. We then use geometric morphometrics to analyze the skull of this specimen within the morphospace of extant forms.

A LONG-SNOUTED MARINE BONYTONGUE (TELEOSTEI: OSTEOGLOSSIDAE) FROM THE EARLY EOCENE OF MOROCCO: GLIMPSE INTO THE UNDERAPPRECIATED DIVERSITY OF AN EARLY PALEOGENE MARINE RADIATION OF PREDATORY FISHES

Alessio Capobianco*[1,2], Matt Friedman[1,2]

[1] University of Michigan Museum of Paleontology, Ann Arbor, MI

[2] Department of Earth and Environmental Sciences, University of Michigan, Ann Arbor, MI

* Speaker

The fossil record of osteoglossid fishes (commonly known as bonytongues) includes several marine taxa found in early Paleogene deposits worldwide. This is particularly remarkable as extant bonytongues are strictly freshwater and are nested within a larger clade (Osteoglossomorpha) of freshwater fishes. Whether marine osteoglossids represent a clade descended from a single colonization of marine environments or a polyphyletic assemblage resulting from multiple independent marine invasions remains unclear. Here we describe a new species of osteoglossid from marine early Eocene (Ypresian) deposits of Morocco, represented by an articulated and three-dimensionally preserved skull with pectoral girdle. Besides displaying unique anatomical features such as an elongated preorbital region – likely reflecting a feeding ecology that is peculiar among bonytongues, this specimen exhibits a tantalizing combination of characters shared with different extant osteoglossid subclades. Phylogenetic analyses including the new taxon as well as other previously described marine bonytongues reveal that these form a clade nested within crown osteoglossids, hence supporting a single marine invasion from a freshwater ancestor. Moreover, some freshwater taxa are recovered within the marine clade, suggesting that reverse transitions from the sea to riverine and lacustrine environments might have occurred multiple times during the early Paleogene. Overall, the bonytongue fossil record hints at a diverse marine radiation of these predatory fishes after the K–Pg mass extinction and at a complex biogeographical and ecological history –including intercontinental dispersal and several major environmental transitions– during the first 20 million years of the Cenozoic.

NEW FOSSILS OF *PALAEOAMASIA KANSUI* (MAMMALIA, EMBRITHOPODA): IMPLICATIONS FOR EMBRITHOPOD EVOLUTION

Melissa Wood*[1], K. Christopher Beard[2], William J. Sanders[1]

[1] University of Michigan Museum of Paleontology, Ann Arbor, MI

[2] Department of Ecology and Evolutionary Biology, University of Kansas, Lawrence, KS

* Speaker

Embrithopods are an enigmatic order of Afrotheria (Mammalia) represented since the early 1900s only by late Paleogene African arsinoitheres. In 1979, however, Sen and Heintz attributed the western Asian mid Paleogene genus *Palaeoamasia* to Embrithopoda. This genus was known only by a handful of dental specimens and the dental formula and complete morphology is unknown. This project focuses on new Lutetian (43 Ma) dental material from the Uzunçarşıdere Formation of Central Turkey, including a nearly

complete maxilla of *Palaeoamasia kansui*. Through comparison with other specimens of *Palaeoamasia kansui* and geologically older and younger embrithopod species from Africa, as well as penecontemporaneous species from Turkey and eastern Europe, it can be determined that *Palaeoamasia kansui* contains an unexpected mix of ancestral and derived features, in that cheek tooth crown morphology resembles the ancestral condition, but the presence of a marked diastema between the anterior and posterior dentition is derived with respect to the earliest known embrithopods. This project sheds light on embrithopod relationships, demonstrating that there are two distinct evolutionary trajectories in the order Embrithopoda: one in Africa that produced massive body size and specialized cheek tooth crown morphology while retaining a primitive anterior dental battery, and a separate one in Eurasia that produced a unique dental formula and apparently more derived anterior dental morphology while conserving small body size and primitive cheek tooth crown morphology. This project was supported by NSF grants EAR-1543684 and EAR-1923294.

READING THE LEAVES: DEVELOPING A QUANTITATIVE APPROACH TO IMPROVE INTERPRETATION OF FOSSIL MONOCOT LEAF SYSTEMATICS AND ECOLOGY

Zack Quirk*[1], Selena Smith[1,2]

[1] Department of Earth and Environmental Sciences, University of Michigan, Ann Arbor, MI

[2] University of Michigan Museum of Paleontology, Ann Arbor, MI

* Speaker

Monocots, a group of flowering plants that includes grasses (Poaceae) and palms (Arecaceae), are the foundation of trophic levels of many terrestrial ecosystems. In this project, we aim to study how leaf morphology in living monocots, specifically vein length per area (VLA), varies among groups and how this trait relates to systematics with the goal of better identifying fragmentary monocot leaf fossils. We examined VLA in 389 monocot species of 10 orders and 37 families. VLA ranges on the ordinal level from 0.28 to 16.6 mm mm-2, while dicot VLA from other studies ranges from 0.4 to 24.4 mm mm-2. We used one-way ANOVA and Tukey's honest significant difference (HSD) to test for significant differences in mean VLA between orders and families and found both were statistically significant ($p<2x10-16$). There were significant differences in VLA means between orders for Poales, Arecales, and Zingiberales as the most different compared to other orders (Tukey's HSD test $p<0.01$). At the family level, Tukey's HSD test revealed significant differences in VLA means for Asparagaceae/Orchidaceae (Asparagales); Commelinaceae (Commelinales); Dioscoreaceae (Dioscoreales); Alstroemeriaceae/Liliaceae/Colchiaceae (Lilales); Poaceae (Poales); and Zingiberaceae/Musaceae (Zingiberales) compared to other families ($p<0.01$). For our largest sampled order, Zingiberales, we compared measurements of leaf length, width, and area with VLA (total, parallel, cross) and found family-specific relationships although there was no ordinal level relationship between VLA and leaf shape. We also used the same measurements in fossil Zingiberales as an additional comparison. While further sampling across monocots will be necessary, these results suggest that VLA is distinct enough to use in future studies to aid in the identification of fossil monocots, which is critical for downstream analyses such as determining how monocots responded to past climate changes and examining monocot leaf trait evolution.

EXAMINATION OF TORSO MORPHOLOGY IN EXTANT TERRESTRIAL AMNIOTES TO INFER THE BODY MORPHOLOGY OF QUADRUPEDAL NON-AVIAN DINOSAURS

Myles M.A. Walsh*[1], Kenshu Shimada[1]

[1] Department of Biological Sciences, DePaul University, Chicago, IL

* Speaker

Body mass and body size estimates of extinct vertebrates typically involve a range of techniques and often depend on measurements of extant taxa. Such estimates of extinct vertebrates are often determined using quantitative relationships between the size of certain skeletal elements and body mass or body size. The size, including the girth, of amniote torsos which house the viscera comprises a substantial portion of the total body mass. Variations of torso morphology among diverse vertebrate taxa appears to be poorly investigated throughout the literature. This study examines torso morphology of diverse extant, terrestrial, quadrupedal amniote taxa (i.e., small to large reptiles and mammals) based on mounted skeletal and preserved specimens in museums with the goal of collecting comparative data to apply to quadrupedal, terrestrial non-avian dinosaurs. Complex torso morphology is conceptually simplified to represent a cylindrical shape defined by the following three variables: the maximum anteroposterior thoracolumbar length, the maximum lateral rib cage width, and the maximum dorsoventral rib cage depth. Assumptions associated with skeletal data include: 1) the degree of curvature within vertebral columns which potentially affects the extrapolation of torso volumes; and 2) the volume of each attained 'cylinder' representing a slightly overestimated value as the anterior and posterior ends of the vertebrate torso generally taper. Nevertheless, resulting 'cylinder' volumes are considered adequate representations of approximate positions of the pectoral and pelvic girdle, respectively. Based on body weight data of the examined taxa gathered from literature, the plan is to examine the relationship of the body weight to each of the three torso morphology variables in addition to a combination of those variables. If there exist quantitative patterns, this study is anticipated to provide important comparative data for reconstructing the body form of non-avian quadrupedal dinosaurs, that in turn would improve the estimations related to body mass and body size of such extinct species.

DENTAL TOPOGRAPHIC CHANGE WITH MACROWEAR AND DIETARY INFERENCE IN *HOMUNCULUS PATAGONICUS*

Peishu Li*[1,2,3], Paul E. Morse[4,5], Richard F. Kay[3,5]

[1] Department of Organismal Biology and Anatomy, University of Chicago, Chicago, IL

[2] Department of Biology, Duke University, Durham, NC

[3] Division of Earth and Ocean Sciences, Nicholas School of the Environment, Duke University, Durham, NC

[4] Florida Museum of Natural History, University of Florida, Gainesville, FL

[5] Department of Evolutionary Anthropology, Duke University, Durham, NC

* Speaker

Homunculus patagonicus is a stem platyrrhine from the late Early Miocene, high-latitude Santa Cruz Formation, Argentina. Its distribution lies farther south than any extant platyrrhine species. Prior studies of the dietary specialization of *Homunculus* suggest either a mixed diet of fruit and leaves, or a more dominantly leaf-eating diet like that of *Alouatta* or *Brachyteles*. To gain further insight into the diet of *Homunculus*, we examined macrowear-induced changes on the occlusal surfaces of the first and second lower molars of *Homunculus* with three homology-free dental topographic measures: Dirichlet normal energy (DNE), orientation patch count rotated (OPCR), and relief index (RFI). We compared these data with wear series of two previously published extant platyrrhine taxa, the folivorous *Alouatta* and the frugivorous *Ateles*, which exhibit distinctive patterns of change in occlusal sharpness with macrowear. Given the folivore-like dental morphology of unworn *Homunculus* molars, we predicted that changes in dental topographic metrics with wear in *Homunculus* would follow a pattern more similar to *Alouatta* than to *Ateles*. However, wear-induced changes in *Homunculus* crown sharpness (DNE) and complexity (OPCR) are more similar to the pattern observed in the frugivorous *Ateles*. The pattern of lower molar occlusal morphology change with macrowear observed in *Homunculus* lower molars suggests a primarily frugivorous diet with leaves as a fallback resource, consistent with probable fluctuation in seasonal fruiting abundance in the high-latitude extratropical environment in late Early Miocene Patagonia.

DIAGENETIC HETEROGENEITY OF TIME-AVERAGED VERTEBRATE REMAINS IN MARINE SETTINGS: A TEST CASE OF THE MIOCENE SHARKTOOTH HILL BONE BED, CALIFORNIA

Rachel Laker*[1]

[1] Department of Geophysical Sciences, University of Chicago, Chicago, IL

* Speaker

Skeletal remains associated with unconformities and other stratigraphically important surfaces have the potential to be strongly time-averaged, leading to the potential for diagenetic heterogeneity. Diagenetic infillings, alteration, and replacement should, in principle, reflect the burial rate (sedimentation or lack thereof), environmental energy, burial-exhumation cycles, and duration of residence within the most taphonomically active part of the sedimentary column. Diagenetic heterogeneity should thus provide evidence of non-depositional as well as depositional conditions, including cryptic stratigraphic boundaries not evident from sediments alone. To test these ideas, thin-sections of cetacean rib and shark tooth fragments are being examined from the Sharktooth Hill Bonebed (SHBB), a 10-50 cm interval within the Round Mountain Silt that has been intensely studied owing to its wide diversity of vertebrate taxa, from sharks to gomphotheres. The SHBB is thought to mark a surface of maximum transgression and represent 700,000 years of condensation by the starvation or bypassing of siliciclastics during the Middle Miocene Climatic Optimum (15.9-15.2 Mya; Pyenson et al. 2009, Geology). Pyenson et al. reported macroscopic taphonomic damage, including extensive fragmentation, some rounding, and bone cracking akin to subaerial weathering, despite no known occurrence of subaerial exposure. My new petrographic and SEM analysis reveal the way in which cracks propagated and whether cracking was due to water absorption or drying; the sequence of void infilling, apatite replacement, and surface coatings of skeletal elements; and variation among tissue types (cortical and cancellous bone, tooth dentin and enamel). Bone from a largely articulated cetacean from the overlying highstand system tract illuminates the understanding of late versus early diagenesis – if diagenesis is more influenced by residence time in the mixed layer than by pervasive,

deep burial conditions, then greater heterogeneity is expected within the SHBB, where the bones experienced up to 700,000 years of varied conditions.

TECTONIC INFLUENCES ON SPECIES RICHNESS OF MAMMALS IN THE MIDDLE MIOCENE DOVE SPRING FORMATION, CALIFORNIA

Fabian Hardy*[1,2], Catherine Badgley[1,2]

[1] University of Michigan Museum of Paleontology, Ann Arbor, MI

[2] Department of Earth and Environmental Sciences, University of Michigan, Ann Arbor, MI

* Speaker

Periods of tectonic activity often coincide with marked changes in the species richness of fossil mammals. Basin extension and uplift of the surrounding area generates new habitats and changes corridors for the dispersal of mammal species. We investigated the link between faunas and an increase in basin area through a study of changes in mammalian species richness from the Middle to Late Miocene (12.5 – 8.0 Ma) Dove Spring Formation of the El Paso Basin in the northwestern Mojave region of California. Two stages of tectonic activity occurred during deposition. Left-shear fault movement south of the basin led to counterclockwise rotation at approximately 10.0 Ma, and east-west extension contributed to subsidence beginning near 9.5 Ma. Increasing accommodation space accumulated sediments from sources south of the basin until the activation of a new source in the form of the Sierra Nevada near 8 Ma. We examined changes in the sediment accumulation rate and the frequency of fossil localities to assess the tectonic influence on preservation potential. These features display an inverse relationship in the El Paso Basin. The frequency of localities is greatest in the middle of the section, reaching a peak at 9.5 Ma after a long interval of declining sediment accumulation rate and coarsening lithology. A subsequent sharp decline in the frequency of localities coincides with a rapid but brief increase in sedimentation rate. The environmental conditions leading to this relationship were further examined in the field through stratigraphic analysis of depositional facies. Using a dataset compiled from fossils at the Natural History Museum of Los Angeles, we determined changes in mammalian species richness over time. We reconstructed stratigraphic ranges for 31 large-mammal taxa (>1 kg) and determined temporal ranges supported by 50% confidence intervals. The species richness of most mammalian families peaks at 10.0 Ma and is positively correlated with the number of fossil localities per time interval. A notable exception to this pattern is the disappearance of grazing horses (Anchitheriinae and Equinae) from the basin by 9.0 Ma, prior to any other group, which may indicate a shift in habitat or a dearth of grazing resources. We will use soil organic matter and plant biomarkers to examine this potential change in vegetation in a future study.

CARBON ISOTOPIC VALUES OF THE MAMMALIAN COMMUNITY OF THE NGORORA FORMATION, KENYA

Elliot Greiner*[1], John Kingston[1]

[1] Department of Anthropology, University of Michigan, Ann Arbor, MI

* Speaker

In East Africa, the late Miocene signaled a gradual shift from more archaic mammals to the ancestors of more modern mammalian taxa that came to coexist with later hominoids and hominins, and has also been characterized as a time of environmental change. As such, a key question relating to this period is how paleoecological fluctuations, particularly the spread of C4 grasslands in East Africa, influenced or mediated hominoid evolution during the late Miocene. The large-scale floral shifts that occurred with C4 expansion affected mammalian communities through a changing resource base, and the dynamics of the associated competition to procure them. These effects, in addition to the expanse of C4-dominated biomes during the late Miocene, would have had important consequences for hominin evolution, especially as they could relate to the earliest evidence for potential potential early (6-7 ma) hominins. Different emergence dates for the rise of C4 vegetation in East Africa have been proposed, however little is still known regarding C4 related environmental change during the 12-8 ma interval in Kenya. Investigating the ecological conditions associated with mammalian taxa in the Ngorora Formation of the Baringo Basin of Kenya (12-8 ma) through use of enamel isotopes will be used to document and characterize an important and generally undersampled interval in hominoid evolution by studying vegetation profiles associated with site-specific instances of faunal turnover and succession. Furthermore, it can be used to explore the specific ecological conditions of hominoid-bearing localities from the Ngorora Formation that spans this period of environmental and faunal turnover.

FUNCTIONAL AND PHENOTYPIC MODULARITY IN THE TROPHIC BONES OF AQUATIC-FORAGING SNAKES

Daniel Rhoda*[1], Marion Segall[2]

[1] Department of Earth and Atmospheric Sciences, Indiana University, Bloomington, IN

[2] Department of Herpetology, The American Museum of Natural History, New York, NY

* Speaker

Snakes are predators that must detect, capture, manipulate, and ingest prey exclusively using their heads and anterior trunk. These different functions require the coordinated movements of different combinations of bones, forming functional modules. Bones within a functional module are expected to share selective pressures associated with its function and thus their morphologies may covary over evolutionary time (i.e., morphological integration and modularity). However, the same bone may contribute to the function of more than one functional module, and the relative importance of different functions varies across species. The trophic bones of snakes are therefore an intriguing model system to study patterns of morphological integration and modularity as well as the relative importance of extrinsic (e.g., function) versus intrinsic (e.g., developmental) factors in shaping these patterns. Here, using high-density 3D geometric morphometric methods and phylogenetically informed 2-block partial least squares analyses, we quantify the morphologies and patterns of evolutionary integration between 7 trophic bones of a dataset of 67 micro-CT scanned specimens of 31 species of aquatic-foraging snakes. We find strong integration between the trophic bones and no clear modular structure.

PHYLOGENETIC EFFECTS DOMINATE AVIAN WING MORPHOLOGY OVER ECOLOGY

Stephanie L. Baumgart*[1], Mark W. Westneat[1], Paul C. Sereno[1]

[1] Department of Organismal Biology and Anatomy, University of Chicago, Chicago, IL

* Speaker

High aspect ratio wings are typically attributed to large soaring birds, while low aspect ratio wings are attributed to birds which continually flap and are more agile in the air. Recent studies have shown a high phylogenetic signal in wing shape morphometrics but a low ecological signal. It is expected that evolutionary history would play a big part in the shape of a bird wing, but it seems surprising that ecology seems to play such a small role in predicting wing shape. Previous metrics for avian ecology have generally been limited to flight style (i.e., gliding, flapping). Here we test several ecological variables to determine whether any of these metrics is able to tease out more information regarding the correlation between ecology, phylogeny, and wing shape. We collected two-dimensional geometric morphometric data from a diverse group of 136 "water bird" wings. The wing and dorsal covert outlines were digitized using 13 homologous landmarks and 27 sliding semi-landmarks. We then used a principle component analysis (PCA) to visualize the data and a canonical variate analysis (CVA) to determine how well the data separates into groups by foraging behavior and then by clade. Some behaviors like stalkers and plunge divers have tight clusters, while other behaviors like surface diving and probing have a wide disparity of wing shape. Clades cluster out much more clearly. Charadriiformes, for example, have generally higher aspect ratio wings, though a few converge with lower aspect ratio wings. The CVA shows that bird wings can be accurately classified by clade 79.4% of the time, while classification accuracy of ecological variables ranges from 55.9-63.2%. Avian wing morphology is likely constrained by aerodynamic requirements put on the bird wings to allow them to be a functioning airfoil, but these results also suggest lessened ecomorphological constraints, perhaps due to the dynamic nature of a constantly morphing wing.

DIETARY ECOMORPHOLOGICAL DISPERSION AND PHENOTYPIC INTEGRATION IN FELIDAE AND MUSTELIDAE (MAMMALIA; CARNIVORA)

Ricardo Ely*[1]

[1] Department of Earth and Atmospheric Sciences, Indiana University, Bloomington, IN

* Speaker

Phenotypic integration describes the degree of trait correlation and the partitioning of morphological components into subsets of highly correlated traits. Little work has been performed on the relationship between phenotypic integration and ecological evolution in the context of the ecospace. Greater integration is suggested as limiting the ability for a group to occupy a broader range of ecological space compared to groups displaying less integration, which are less constrained phenotypically, evolving to greater ecospace occupation. This work utilizes cranial geometric morphometrics (GMM) on mustelids and felids to calculate overall levels of integration, and dietary indices from the lower first molar (carnassial) to construct a dietary ecomorphospace. Mustelids are a carnivoran family displaying a wide range of dietary ecomorphological disparity, while felids are constrained to hypercarnivorous diets. This work seeks to test

the hypothesis that greater dietary ecomorphological disparity in mustelids is achieved through lesser degrees of cranial phenotypic integration.

HIGH-LATITUDE BENTHIC BIVALVE BIOMASS AND RECENT CLIMATE CHANGE: TESTING THE POWER OF LIVE-DEAD DISCORDANCE IN THE PACIFIC ARCTIC

Caitlin Meadows*[1], Jacqueline Grebmeier[2], Susan Kidwell[1]

[1] Department of the Geophysical Sciences, The University of Chicago, Chicago, IL

[2] Chesapeake Biologic Laboratory, University of Maryland Center for Environmental Science, Solomons, MD

* Speaker

Time-averaged molluscan death assemblages sampled from tropical to temperate open continental shelves commonly disagree in species composition with local living communities only in areas that have changed in response to anthropogenic eutrophication and other locally intense human stresses, providing a means of recognizing shifted baselines. In contrast, the ability of live-dead discordance to resolve the spatially heterogeneous effects of human-induced climate change has not been tested in high-latitudes, where climate change entails substantial changes in nutrient cycling with consequences for benthic biomass and where cold waters are antagonistic to carbonate shell preservation. North Pacific Arctic and Subarctic seabeds offer ideal conditions for testing the resolving power of molluscan live-dead discordance, using well-documented ecologic changes in nutrient cycling and benthic biomass in response to reduced sea ice. Ecosystem monitoring since 1980 has established that the boundary between the Arctic and the Subarctic on the Bering Sea continental shelf, maintained by ice-influenced bottom water, shifted northward between 1998 and 2001. The benthic community in the transitioned area now experiences new pelagic predators, more variable quantity and quality of deposited food, and altered sediment grain size. We find that bivalve death assemblages agree closely with counterpart living communities in taxon and guild composition and are not subject to significant post-mortem bias where Subarctic or Arctic conditions have persisted. Significant live-dead discordance occurs only in areas with documented changes in carbon delivery, sediment grain size, and community composition over the last several decades; there, death assemblages are mixtures of shells from pre- and post-transition communities. This spatial pattern is robust to both numerical abundance- and biomass-based measures of community composition. In fact, biomass is especially powerful in revealing fine, station-level discordance at sites with known benthic transitions. Live-dead discordance can thus reliably differentiate between stable and rapidly changing habitats in high-latitude settings, relevant to evaluating climate change, and biomass-based currencies of community composition improve spatial resolution.

DEAD MEN STILL TELL TALES: MOLLUSCAN DEATH ASSEMBLAGES RECORD A BOOM-BUST INVASION AND A CHANGING COMMUNITY IN JAMAICA'S KINGSTON HARBOUR

Broc S. Kokesh*[1], Thomas A. Stemann[2]

[1] Department of the Geophysical Sciences, The University of Chicago, Chicago, IL

[2] Department of Geography and Geology, University of the West Indies, Kingston, Jamaica

* Speaker

The Indo-Pacific green-lipped mussel (*Perna viridis*) was first observed in the Kingston Harbour in 1998, likely introduced through contaminated ballast water. The species quickly overtook mangrove roots, wharf pilings, and pier walls as it outcompeted native species. However, the population has declined within the last decade, to the point of absence in some previously inundated areas. The full scope of the invasion, as well as potential impacts on native species, are therefore difficult to further elucidate with reference to only the living community. The goals for this study were to 1) compare dead shell abundances to densities reported during peak invasion, and 2) assess live-dead discordance for the entire bivalve community. We surveyed bivalves attached to mangrove prop roots and wharf pilings and collected death assemblages from bulk sediment samples surrounding Port Royal on the south side of the harbor. *Perna viridis* shells were present and abundant in most dead samples, reflecting the magnitude of this short-lived invasion. However, the proportions of the three most abundant native species (*Crassostrea rhizophorae*, *Isognomon alatus*, and *Brachidontes exustus*) always exceeded *P. viridis*, likely due to considerably longer accumulation and time averaging. These three species make up the bulk of the live community, although their relative abundances differ from those of the dead. Further, the previously undocumented charru mussel (*Mytella charruana*) appears to have invaded the harbor within the last decade, an opportunity possibly created by the decline of *P. viridis*. Although death assemblages are widely used for defining baselines that predate modern communities, these findings demonstrate their ability to also capture rapid ecological events that further contextualize community changes.

POSTER ABSTRACTS

MYSTERIES FROM THE MISSING MILLION: INVESTIGATING ECOLOGICAL CHANGE IN THE SOUTHERN KENYA RIFT DURING THE EMERGENCE OF *HOMO SAPIENS*

Mara Page*[1], Naomi Levin[1]

[1] Department of Earth and Environmental Sciences, University of Michigan, Ann Arbor, MI

* Speaker

Homo sapiens appeared in East Africa around 200ka, with archaeological evidence for human-like behavior as far back as 300ka with the transition to the Middle Stone Age (MSA). Southern Kenya is the site of a huge volume of hominin, faunal, and climate records, making it a critical region for understanding the ecosystem dynamics which link environmental change to human development. The Olorgesailie basin, in southern Kenya, also is the setting of an 85% faunal turnover event during the same period, wherein large-bodied grazing specialists were replaced with smaller-bodied, generalist relatives. These are important events in the development of modern humans and modern east African ecology, and the catalyst has been attributed to increasing aridity and variability in the vegetation present on the landscape. My project will explore the links between human evolution and ecological change by building records of aridity and dietary change in the last million years as preserved in the stable isotopes of fossil mammal teeth in southern Kenya. Within this broad question, I hope to investigate several specific questions about the ecological history of particular taxa, such as when elephants switched from grazing to browsing behavior, whether dietary changes predate extinctions and appearances of new species, and these large herbivores shared the available food resources. I also aim to understand how water sources and water availability changed through time at Olorgesailie. These tooth enamel isotope records can be compared directly to the archaeological and paleontological data from southern Kenya to understand the link between ecological and environmental change during this important time in human evolution.

A MARINE BONEBED OF THE UPPER CRETACEOUS NIOBRARA CHALK, WESTERN KANSAS

Jonathan G. Allen*[1], Kenshu Shimada[1]

[1] Department of Biological Sciences, DePaul University, Chicago, IL

* Speaker

The Niobrara Chalk exposed in western Kansas is a rock formation formed between 87 and 82 million years ago in the Late Cretaceous that was deposited in the Western Interior Seaway that split the North American continent into two landmasses. The Niobrara Chalk is well known for diverse fossil marine vertebrates, such as sharks, bony fishes, and marine reptiles, as well as a variety of fossil invertebrates. However, fossil remains, particularly vertebrate fossils, in the stratigraphic unit are generally sparse. FHSM VP-644 is a calcareous rock specimen collected from the Niobrara Chalk in Gove County, Kansas, and housed in the Sternberg Museum of Natural History in Hays, Kansas. Although its exact stratigraphic horizon within the Niobrara Chalk is uncertain, the occurrence in Gove County suggests that it must be of late Coniacian or early-middle Santonian in age. The rock specimen is unique because it is packed with numerous, small,

disarticulated bones and teeth of fossil marine vertebrates with very little matrix that can be characterized as a 'bonebed.' The rock matrix was dissolved in acetic acid to extract skeletal and dental elements, and although the examination of the taxonomic composition of the bonebed is ongoing, the paleofauna is found to be taxonomically diverse, consisting of at least 17 vertebrate taxa. They include chondrichthyan taxa such as *Squalicorax*, *Cretoxyrhina*, and *Rhinobatos*, and osteichthyan fishes like *Palaeobalistum*, *Ichthyodectes*, Plethodidae, *Pachyrhizodus*, *Cimolichthys*, and *Enchodus*. The bonebed also includes some mosasaur (marine lizard) teeth. Although the bonebed likely represents a time-averaged rock unit possibly formed due to a period of a regressive event that led the concentration of vertebrate elements, it is significant because it offers insights into the composition of small vertebrate taxa that are generally not well represented in the Niobrara fossil record. In fact, if the bonebed represents a time-averaged unit, and if those fossils represent randomly accumulated remains over a certain period of time, the relative proportions of represented taxa may reflect their relative abundances in the Western Interior Sea in the area during the Niobrara time. If so, *Enchodus* spp. were the most abundant vertebrate taxa in the Niobrara sea.

THE FIRST OCCURRENCE OF AN ICHTHYODECTIFORM FISH (OSTEICHTHYES: ACTINOPTERYGII) FROM THE ARLINGTON MEMBER (MID-CENOMANIAN) OF THE UPPER CRETACEOUS WOODBINE FORMATION IN TEXAS

Riley J. Hacker*[1], Kenshu Shimada[1]

[1] Department of Biological Sciences, DePaul University, Chicago, IL

* Speaker

DMNH 20149 is a 96 million-year-old, nearly complete skeleton of an actinopterygian bony fish housed in the Perot Museum of Nature and Science in Dallas, Texas, USA. It was collected in Denton County, Texas, from the Upper Cretaceous Woodbine Formation (mid-Cenomanian) within the Arlington Member representing a deltaic deposit formed along the Western Interior Seaway of North America. DMNH 20149 presently exposes the right lateral side and measures about 39 cm and 50 cm in standard length and total length, respectively. Based on preliminary observations, the body is laterally compressed and elongate (fusiform body plan) with the maximum body depth of about 11 cm. The overall skull morphology and body form of DMNH 20149 strongly suggest that it belongs to the order Ichthyodectiformes, a group of predatory, primitive teleosts that lived from the Middle Jurassic (Bathonian) to the Late Cretaceous (Maastrichtian). Ichthyodectiformes is known in the fossil record of every continent and is taxonomically diverse, consisting of three families, 22 genera, and 42 species. However, unlike previously described ichthyodectiforms, DMNH 20149 exhibits two notable features that make it distinct. The first feature is that DMNH 20149 is toothless. To date, all known Jurassic and Cretaceous ichthyodectiforms have teeth that range in size from minute teeth in *Gillicus* to large robust teeth in *Xiphactinus*. The second notable feature is that DMNH 20149 has a triangular dentary. Within Ichthyodectiformes, triangular dentaries are a characteristic found in Jurassic forms, whereas Cretaceous forms have a rectangular dentary. Therefore, these notable anatomical features suggest that DMNH 20149 is a new Late Cretaceous taxon that represents the last member of the ichthyodectiforms with the Jurassic jaw design.

USING THE EXTANT MEGAMOUTH SHARK, *MEGACHASMA PELAGIOS*, TO INFER THE DENTITION OF THE FOSSIL MEGAMOUTH SHARK, *MEGACHASMA APPLEGATEI*

Alexandra Krak*[1], Kenshu Shimada[2]

[1] Department of Biological Sciences, DePaul University, Chicago, IL

[2] Department of Environmental Science, DePaul University, Chicago, IL

* Speaker

Megachasma pelagios (Lamniformes: Megachasmidae) is a large filter-feeding fish with a dentition commonly characterized as 'homodont.' We used landmark-based geometric morphometrics to investigate whether or not sufficient variation in tooth morphology is present in *M. pelagios* that may aid in reconstructing the dentition of *M. applegatei*, a fossil (late Oligocene–early Miocene) megamouth shark known only from isolated teeth. We examined the upper right and lower right dental series of the holotype of *M. pelagios* (BPBM 22730: 4.5 m TL male). Each dental series was divided into the 'mesial half' (upper = tooth rows 1–24; lower = tooth rows 1–21) and 'distal half' (upper = tooth rows 25–47; lower = tooth rows 22–42) to determine if teeth of the four groups can be distinguished quantitatively. Whereas our tooth samples of *M. pelagios* consisted only of teeth from the right side of the jaw, photographs of these right teeth were flipped to mimic the teeth from the left side of the jaw. Although plots do overlap, our analysis shows that each positional catergoy of teeth occur at a different region of the morphospace. Our analysis also shows that lower teeth are morphologically less variable than upper teeth. Two-hundred and seven teeth of *M. applegatei* housed in the Natural History Museum of Los Angeles County, California, plotted with teeth of *M. pelagios* not only show that the two megachasmids are morphometrically distinct, but also that teeth of *M. applegatei* exhibit a wider morphological range than those of *M. pelagios*. More remarkably, the distribution pattern of plots for *M. applegatei* is very similar to that for *M. pelagios*, suggesting that some inferences about the original tooth arrangement in the mouth may be possible for *M. applegatei*.

RAY-FINNED FISHES (ACTINOPTERYGII) FROM THE LATE PERMIAN MINNEKAHTA LIMESTONE OF SOUTH DAKOTA

Jack Stack*[1], Michael Gottfried[1]

[1] Department of Earth and Environmental Sciences, Michigan State University, East Lansing, MI

* Speaker

We describe previously unexamined specimens of ray-finned fishes (Actinopterygii) from the Late Permian Minnekahta Limestone of South Dakota from the collections of the Yale Peabody Museum of Natural History (YPM) and the Field Museum of Natural History (FMNH). This material includes a partially articulated, well-preserved specimen (FMNH, PF 3721) of the head and anterior portion of the trunk of a ray-finned fish. The partially three-dimensionally preserved skull of this specimen exhibits several aspects of the cranial anatomy that are typically crushed in Paleozoic actinopterygian specimens, including the ventral portion of the skull and an impression of the skull roof. Also, a largely complete, laterally flattened specimen (PF 3712) of a small (approximately 6 cm in total length), elongate individual may represent a juvenile form of a larger species. However, the complete scale cover of this individual, including the base of the median fins, indicates that it is a small adult. This material also includes several partially complete

specimens that lack articulated skulls, along with isolated elements that appear to represent ray-finned fishes. These specimens are well enough preserved to form the basis for detailed morphological and taxonomic study, an uncommon opportunity in the sparse, generally poor Permian fossil record of ray-finned fishes. The Minnekahta assemblage may therefore offer broader insights into the taxonomy and systematics of Late Permian ray-finned fishes.

SKULL MECHANICS AND FUNCTIONAL MORPHOLOGY OF BRASILODONTIDAE, THE SISTER CLADE TO MAMMALS

Charles J. Salcido*[1,2], Pamela G. Gill[2,3], Agustin G. Martinelli[4], Ian J. Corfe[5], Marina B. Soares[6], Cesar L. Schultz[7], Emily J. Rayfield[2]

[1] Department of Earth and Atmospheric Sciences, Indiana University, Bloomington, IN

[2] School of Earth Sciences, University of Bristol, Bristol, UK

[3] Earth Sciences Department, The Natural History Museum, London, UK

[4] CONICET-Sección Paleontologia de Vertebrados, Museo Argentino de Ciencias Naturales "Bernardino Rivadavia", Buenos Aires, Argentina

[5] Developmental Biology Program, Institute of Biotechnology, University of Helsinki, Helsinki, Finland

[6] Departamento de Geologia e Paleontologia, Museu Nacional, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil

[7] Departamento de Paleontologia e Bioestratigrafia, Instituto de Geociências, Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil

* Speaker

Triassic vertebrate assemblages of the Santa Maria Supersequence in Brazil have yielded many specimens of cynodont therapsids including members of the clade Brasilodontidae. Recent phylogenetic analyses place this clade as the sister clade to Mammaliaformes. While these specimens have been described in detail, little work has been done to quantify the skull mechanics. The skulls of the brasilodontids *Brasilodon*, *Brasilitherium*, and *Minicynodon* are analyzed to compare their functional morphology and biomechanics to the Early Jurassic mammaliaforms *Morganucodon* and *Kuehneotherium*, and any similarities could be interpreted in light of the ontogenetic status of the comparable brasilodontids We here compare the results of biomechanical and finite element analysis (FEA) of the mandibles of *Minicynodon* and *Brasilodon*, both to each other and to those of *Morganucodon* and *Kuehneotherium* from a previous study. Specimens were μCT scanned, segmented in Avizo 9.4.0, meshed in Hypermesh to prepare for FEA, and then imported into Abaqus for testing. Biomechanical analysis includes beam analyses such as second moment of area, polar moment of inertia, and section modulus results that were obtained from Moment Macro in ImageJ. Although the overall trends are the similar in *Minicynodon* and *Brasilodon*, the latter has higher resistance to torsion and bending strength than *Minicynodon*. Also, for *Brasilodon*, the posterior end has a near constant resistance to torsion, with a sudden drop between pc4 and pc3. These differences may support an ontogenetic relationship and niche partitionin. The polar moment of inertia results also show that the mandibles of the brasilodontids are able to resist torsion in a similar manner to *Morganucodon* and may indicate a similar mode of feeding. During segmentation, the postdentary bones of *Brasilodon* and *Minicynodon* were found to be preserved and are more similar to those of *Morganucodon* (thin and rod-like) than other nonmammalian cynodonts (e.g., *Probainognathus jenseni* and *Riograndia guiabensis*). This

further supports the close connection between brasilodontids and mammaliaforms, displaying a transitional stage in the evolution of the mammalian jaw joint and middle ear right before the mammaliaform condition.

POSTCRANIAL ANATOMY AND FUNCTIONAL FORELIMB MORPHOLOGHY OF THE LUANGWA BASIN CISTECEPHALID *KEMBAWACELA KITCHINGI* (THERAPSIDA: ANOMODONTIA)

Caroline P. Abbott*[1], Kenneth D. Angielczyk[2], Jacqueline K. Lungmus[1], Katarina Keating[1]

[1] Darwinian Sciences Cluster, The University of Chicago, Chicago, IL

[2] The Field Museum of Natural History, Chicago, IL

* Speaker

Dicynodonts, the most diverse clade of synapsids aside from crown-group mammals, were among the most abundant terrestrial amniotes in the late Permian and Early Triassic. The dicynodont family Cistecephalidae was one of the first synapsid lineages to show a high degree of ecomorphological specialization. In particular, cistecephalid forelimbs present a suite of characters suggestive of a fossorial lifestyle, but nuances in their morphology allude to a higher degree of functional disparity within the family than previously recognized. *Kembawacela kitchingi*, a new genus of cistecephalid from the Luangwa Basin in Zambia represents the third genus known with well-preserved postcrania, particularly from one specimen (NHCC LB 820). In this study we 1) discuss the phylogenetic position of *Kembawacela* within Cistecephalidae, 2) describe the postcranial anatomy of NHCC LB 820, and 3) compare its functional adaptations with those of other anomodonts and extant fossorial taxa using comparative anatomy and forelimb functional indices. Within Cistecephalidae, we find that *Kembawacela* forms a sister group to *Sauroscaptor*, *Kawingasaurus*, and *Cistecephaloides*. In regards to its postcranial anatomy, *Kembawacela* presents a mosaic of characters similar to other cistecephalids, such as a robust humerus with broad condyles, proportionally large ulna with a tall olecranon process, and an elongate scapula with a curved posterior dorsal process. However, *Kembawacela* differs from other cistecephalids, by having a distinct process for the insertion of M. latissimus dorsi on the humerus, and a unique facet for the capitulum on the trochlear notch of the ulna. The results of the forelimb functional indices are consistent with digging specialization in all cistecephalids, but they also reveal a considerable degree of functional disparity within the clade. Our results suggest that variation in cistecephalid ecology has been underestimated, and thus requires further study. As one of the first synapsid groups to exhibit high ecomorphological specialization, cistecephalids represent a poorly-understood model of the origins of functional specialization in synapsid lineages.

DOUBLE-SCANNING AND GAUSSIAN BLURRING IMPROVE QUALITY OF PALEONTOLOGICAL CT DATA: EXPERIMENTS WITH TWO MAMMOTH TUSKS

Ethan A. Shirley*[1,2], Daniel C. Fisher[1,2], Adam N. Rountrey[1], Michael D. Cherney[1], Joseph J. El Adli[1,2,3], Albert Protopopov[4], Valerii Plotnikov[4], Semyon Grigoriev[5]

[1] University of Michigan Museum of Paleontology, Ann Arbor, MI

[2] Department of Earth and Environmental Sciences, University of Michigan, Ann Arbor, MI

[3] Statistical Research Inc., Redlands, CA
[4] Academy of Science of the Republic of Sakha (Yakutia), Yakutsk, Russia
[5] Mammoth Museum, North-Eastern Federal University, Yakutsk, Russia
* Speaker

High-resolution computed tomography (CT) provides paleontologists access to information about specimens that was unattainable until recently. Because fossils consist primarily of mineralized hard parts of ancient organisms, often in a rock matrix, paleontological scanning requires high X-ray energies, which tend to decrease contrast in the resulting scans. Therefore, reduction in noise and enhancement of features is critical for paleontological CT applications. The simplest means of reducing noise is by averaging data from consecutive slices in a CT image stack. More control of this type of combination is possible with a blur function in three dimensions, which permits different weighting of data averaged from nearby voxels in different dimensions, rather than an unweighted average between consecutive slices. Applying a Gaussian blur to our scans altered the original data, but permitted recovery of information on features that were otherwise easily misidentified, unidentifiable, or unmeasurable. We measured annual increments of tusk dentin on a mammoth from Maly Lyakhovsky Island, in the Siberian Arctic, using the modified data to recognize life history patterns that were indecipherable in the noisier raw data. We attempted a second method of feature enhancement in the tusk of Yuka, a juvenile mammoth from the northern coast of Yakutia. By scanning the same tusk twice and adding the scans together, we were able to suppress some noise and known artifacts of reconstruction without losing resolution or otherwise compromising the data, revealing measurable growth features within the tusk that were obscured by noise and artifacts in the unmodified data. This methodology may further enhance features by combining scans taken at different X-ray energies to distinguish nearly identically radiodense materials from one another based on differential absorption of radiation related to density and atomic number. Controlled 3-dimensional blurs and double-scanning have merit beyond the realm of Quaternary mammoth tusks, and may be instrumental in clarifying features of older fossils with more extensive diagenetic alteration.