

Neoceti Symposium, Saturday 8:45

BODY SIZE AND CRYPTIC TROPHIC SEPARATION OF GENERALIZED PIERCE-FEEDING CETACEANS: THE ROLE OF FEEDING DIVERSITY DURING THE RISE OF THE NEOCETI

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Marine mammals with homodont dentition and relatively little specialization of the feeding apparatus are often categorized as generalist eaters of squid and fish. However, analyses of many modern ecosystems reveal the importance of body size in determining trophic partitioning and diversity among predators. We established relationships between body sizes of extant cetaceans and their prey in order to infer prey size and potential trophic separation of generalized fossil cetaceans. Methods for predicting body size of fossil taxa from three occipital measures (bicondylar breadth; foramen magnum and occipital condyle areas) were also developed using allometric models determined from measurements made on >2500 skulls representing all extant species. Models for body size prediction were confirmed for numerous fossil taxa with well-preserved axial postcrania. Enhanced by inclusion of additional parameters describing the feeding apparatus (tooth density; tooth row length and position; rostrum length/breadth; tooth cross-sectional area and eccentricity as measured at the enamel-dentine juncture), body size was found to be a useful predictor of prey size in generalized cetaceans. We used body size and these other parameters to infer trophic roles for a large number of Oligocene and Miocene cetaceans with unspecialized feeding anatomy. Overall, trophic diversity of generalized cetaceans was low in the Oligocene, but increased dramatically in the Middle-Late Miocene and later. This transition marks the extinction of squalodontids and other pre-neocete lineages and rise and diversification of the Neoceti, and superficially suggests that the Neoceti competitively displaced its ancestors. However, major changes in oceanographic conditions (including latitudinal stratification of oceans and increased coastal upwelling) and changes in the prey base utilized by cetaceans were also occurring during this time, rendering simple competitive scenarios for this transition untenable. We suggest that numerous factors played a role in the rise and diversification of the Neoceti, but their adaptability to changing environmental conditions was a major factor accounting for their success.

Poster Session III

DYNAMICS OF ENVIRONMENTAL CHANGES DURING THE LATE PLEISTOCENE IN THE ALTAI MOUNTAINS (RUSSIA, WESTERN SIBERIA) BASED ON MAMMAL AND MOLLUSK DATA FROM PALEOLITHIC ARCHEOLOGICAL SITES

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Faunal studies aimed for the reconstruction of the paleoenvironment of the late Pleistocene and its dynamics during the time of prehistoric man were conducted through the analysis of extant biota and through the study of the fossil biota including mollusks, birds, and mammals from the deposits of the Paleolithic archeological sites. Nine major extant plant associations, each with its specific mammal and mollusk fauna, were identified. The most typical existing association in the northwestern Altai Mountains is the taiga with scattered alpine and steppe elements. Extinct communities of mammals, birds and mollusks in the Altai Mountains went through significant faunal changes during the late Pleistocene-Holocene. Most of the biotic changes were caused by climate, but some could have resulted from the influence of prehistoric man. Climatic changes caused abrupt decrease of the nival and steppe elements in the biota and increase in the number of taiga species. Despite these changes many species survived the Pleistocene/Holocene transition. Presence of Siberian species in both extinct and extant Altai faunas indicates that changes in the ecological composition of the paleocommunities occurred in otherwise zoogeographically stable environment. Changes in the composition of the biota of the studied region occurred through the "recruitment" of taxa from other regions of Altai Mountains and adjacent territories. Using a combined approach and including such groups as mollusks in the analysis allowed us to confirm and more precisely describe the dynamics of the paleoenvironmental changes in the late Pleistocene and Holocene. Number of bones of small and large mammals as well as the number of Paleolithic artifacts showed that prehistoric man had an important influence on the paleoenvironment of the ecosystems of the Altai Mountains. Previously conducted studies show that prehistoric man occupied the niche of a "large carnivore". It was documented that prehistoric man were eliminating part of the ungulate population and were competing with such carnivores as the cave bear and cave hyena.

Saturday 9:15

CT SCANNING THE NOSE OF EUSTHENOPTERON

AHLBERG, Per, Uppsala Univ., Uppsala, Sweden

Historically, the debate about the origin of the tetrapod choana has focused substantially on a single taxon, the osteolepiform lobe-finned fish *Eusthenopteron foordi* from the Late Devonian of Miguasha, Quebec. A three-dimensional skull of this fish was described exhaustively by Jarvik from a grinding series, arguably making it the best understood of all Devonian vertebrates. Nevertheless, Jarvik's description of a tetrapod-like choana in *Eusthenopteron* was challenged head-on in 1981 by Rosen et al., who claimed that Jarvik had exaggerated the size of the supposed internal nostril, and that this opening was really a fang pit receiving the tip of the anterior coronoid fang. More recently, evidence from the

acid-prepared osteolepiforms *Medoevia* and *Gogonasmus* has offered strong support for Jarvik's interpretation, but *Eusthenopteron* itself has not been reexamined in detail. Uncertainty has persisted about the relationship between the large endoskeletal "fenestra endochoanalis" and the apparently much smaller choana, and about the occlusion of upper and lower jaw fangs relative to the choana.

A CT scan investigation of a large skull of *Eusthenopteron*, carried out in collaboration with University of Texas and Parc de Miguasha, offers an opportunity to image and digitally "dissect" a complete three-dimensional snout region. We find that a choana is indeed present, somewhat narrower but otherwise similar to that described by Jarvik. It does not receive the anterior coronoid fang, which bites mesial to the edge of the dermopalatine and is received by a pit in that bone. The fenestra endochoanalis is partly floored by the vomer and the dermopalatine, restricting the choana to the lateral part of the fenestra. The nasal cavity is proportionately much shorter than in Jarvik's reconstruction, possibly because the latter was based on two specimens that were incorrectly aligned.

Poster Session III

THE DICROSTONYX PARADOX, NEW EVIDENCE FROM A 40,000 YBP MICRO-FAUNA, JAGUAR CAVE EASTERN IDAHO

AKERSTEN, William, Idaho State Univ., Pocatello, ID

All modern *Dicrostonyx* are well adapted to arctic tundra conditions; consequently, Pleistocene occurrences have been viewed as definitive evidence of past tundra conditions and disharmonious associations. A few have suggested that the evidence is more compatible with a change in the ecological requirements of *Dicrostonyx*. A very fossiliferous 160 cm section recently excavated in 20 cm increments from Jaguar Cave at the base of the Beaverhead Mountains dates from 39,120 BP to >48,400 BP. The matrix is comprised of small, interlocking siliceous limestone fragments weakly cemented by loess, very difficult to excavate, which would have all but eliminated mixing of levels. Small numbers of *Dicrostonyx groenlandicus* occur through most or all of the section (not all levels have yet been completely processed and studied) in disharmonious association with *Lemmiscus*, other small mammals, and as yet unidentified snakes and lizards. While the mammal association can readily be explained an example of a disharmonious association, the association of snakes and lizards with a supposed tundra form is extremely difficult to explain. The key taxon appears to be *Dicrostonyx*; its adaptations may be more related to deep snow, not necessarily to tundra conditions. I suggest that its present distribution, allopatric (except for a modest overlap) with the widespread and very adaptable *Microtus pennsylvanicus*, has resulted from its having been gradually outcompeted by the latter over much of its original range, remaining only in its present tundra refugia. One explanation for the co-occurrence of *Dicrostonyx* and small reptiles at Jaguar Cave 40,000 years ago is that the winters had fairly deep snows which favored the adaptations of *Dicrostonyx*, but the summers were relatively warm and long enough for small reptiles to reproduce and obtain adequate food for winter hibernation. My interpretation is that North American *Dicrostonyx* is an indicator of substantial snow depth but may or may not be an indicator for tundra conditions.

Marine Reptiles Symposium, Wednesday 2:00

AN UPDATE ON NEW MARINE REPTILES FROM THE TROPIC SHALE OF SOUTHERN UTAH

ALBRIGHT, L., Univ. of North Florida, Jacksonville, FL; GILLETTE, David, Museum of Northern Arizona, Flagstaff, AZ; TITUS, Alan, Grand Staircase-Escalante National Monument, Kanab, UT

Fieldwork conducted in the Tropic Shale of southern Utah, ongoing since 2000, has resulted in the recovery of several specimens of short-necked plesiosaurs representing both the Polycotyliidae and the Pliosauridae. Although these specimens have been reported in previous abstracts, completion of our studies has resulted in revised conclusions. Of three different polycotyliids recovered, it has been determined that two represent new taxa. In addition to the known *Trinacromerum bentonianum*, one of the new taxa appears to share a sister taxon relationship with the late Santonian/early Campanian *Polycotylus latipinnus*. The second new taxon, together with new unnamed taxa from the late Cenomanian of South Dakota and Japan, represents a new clade of polycotyliids based primarily on the distinctive morphology of certain paddle elements. Representing the Pliosauridae are two new specimens of *Brachauchenius lucasi*, both of which include skull material and one of which includes pectoral and pelvic elements previously unknown for this taxon. Although the Late Cretaceous Cenomanian/Turonian Stage boundary falls within the lower part of this unit, all but one of the specimens was found in lower Turonian strata based on molluscan assemblages found in direct association with the skeletal material. The Turonian plesiosaur fauna of the Tropic Shale, and consequently the large vertebrate fauna of the Cretaceous Western Interior Seaway, is considerably more diverse than previously realized. There is no indication that this fauna suffered any negative consequences as a result of global scale oceanographic events, including marine extinctions, that transpired during late Cenomanian-early Turonian time.

Romer Prize Session, Thursday 8:00

A NOVEL APPROACH TO RESOLVE BASAL CROCODYLOMORPH SYSTEMATICS

ALLEN, David, DeKalb, IL

Modern crocodylians are crurotarsan archosaurs called crocodylomorphs. The basal-most genera belonged to subgroups Sphenosuchia and Protosuchia. In contrast to extant semi-

aquatic sprawling crocodylians, sphenosuchians and protosuchians lived mainly in terrestrial settings and had more erect limbs. Over the past twenty years researchers have attempted to resolve phylogenetic relationships within and between these groups. Many analyses suffered from poor preservation of specimens and a bias towards the study of cranial compared to postcranial features. The monophyly of Sphenosuchia and Protosuchia is questioned because of weak support. New character-taxon matrices are often produced by adding a small number of novel characters to portions of pre-existing datasets, giving new and larger matrices. This study investigates the systematic relationships between Sphenosuchia and Protosuchia and within each of these groups. To achieve this goal, a supermatrix has been compiled containing sphenosuchian and protosuchian genera with both novel and published characters. One of the limitations of a supermatrix approach is the great quantity of missing data encountered as a result of inapplicable characters and incomplete specimens. To avoid this, a novel analytical method named the supermatrix-supertree method, is introduced. In this approach a supermatrix is subdivided into a series of submatrices based on which body region each character applies to. Genera only represented by skulls can still be included without requiring lots of missing data. Each submatrix is treated as a separate analysis and resultant most parsimonious trees form the basis of a supertree analysis to combine the partially overlapping trees into a single phylogeny. This novel approach emphasizes the positive aspects of fossil specimens by focusing on preserved bones, thereby reducing the negative effects of missing data and avoiding the exclusion of poorly represented genera. My analyses show that suites of regional cranial and postcranial characters are not bound to agree regarding the monophyly of these groups. However, any conflicting phylogenetic signals are reconciled by the supertree building process.

Saturday 2:00

A REVISED QUANTITATIVE TIME SCALE FOR NORTH AMERICAN CRETACEOUS AND CENOZOIC VERTEBRATES

ALROY, John, Univ. of California, Santa Barbara, CA

Many European mammal workers have adopted quantitative biochronological methods like appearance event ordination (AEO), which also have been widely used by invertebrate paleontologists and micropaleontologists for more than 40 years. Most North American mammal workers still use a time scale whose definitions, boundary ages, and faunal correlations are set by committee. A 2004 book on North American mammals with 34 authors devotes 20 pages to semantics and two sentences to a dismissal of quantitative methods. It prefers to equate age and subage boundaries with first appearances of immigrant genera (IFADs), even though generic appearances are unstable and diachronous, as shown in 1998. An event sequence generated by AEO using the latest species-level Cretaceous and Cenozoic North American Paleobiology Database data is highly accurate: the rank-order correlation (ρ) between concurrent range zones (CRZs) of collections and 73 Ar-Ar dates tied to them is 0.993. Taxonomy doesn't matter. Accuracy is just as high if an event sequence is computed using the original published identifications and ignoring reidentifications and synonymies ($\rho = 0.995$). Nearly half of collections don't include any immigrant genera, so in principle they can't be correlated using IFADs. Subages can be estimated for the others using the IFAD of the last-appearing genus each includes. After numbering the subages in order, these assignments have unacceptable correlations with the dates ($n = 47$, $\rho = 0.960$; $\rho = 0.988$ for CRZs compared with these dates only). Thus, the committees seem to have used diverse criteria instead of the IFAD definitions. Simply matching their age assignments with the dates yields a correlation similar to that seen for the AEO estimates ($\rho = 0.994$), despite the fact that the dates themselves were used to determine the assignments. So, assignments for all other collections can only be more discordant. Thus, the mammal age system is highly inaccurate if its definitions are taken seriously, and still inaccurate if they are ignored. Current numerical age estimates based on quantitative biochronology are available on the Paleobiology Database web site.

Poster Session III

ON THE OCCURRENCE OF *NOTELOPS* IN TLAYÚA QUARRY, TEPEXI DE RODRÍGUEZ, PUEBLA, MÉXICO

ALVARADO-ORTEGA, Jesús; MAYRINCK, Diogo de; BRITO, Paulo, Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil

Tlayúa Quarry is the most important fossil fish locality in México. A rich and diverse fish assemblage has been recovered from its limestone strata deposited under marine and freshwater influences. The occurrence of *Notelops* in this Early Cretaceous Mexican locality has been only vaguely reported. A review of some of these specimens confirms the original generic assignment and reveals that they represent a new species of *Notelops*, which until now has been formally recognized as a monotypic genus. The presence of a suite of characters such as two rows of teeth in the lower and upper jaws, dorsal fin located slightly behind the middle body, first uroneural reaching the second preural centrum, and the presence of about 50 to 55 preural centra supports this preliminary proposal. The occurrence of this new species increases the geographical range of *Notelops* from the Albian deposits of Santana Formation, Northeastern Brazil, to the Albian deposits of Tlayúa Quarry, Puebla, Central Mexico. A morphological review of *Notelops* is undertaken to attribute its phylogenetic position with respect to all known Pachyrhizodontoidei.

Poster Session II

NEWLY DISCOVERED PARTIAL CRANIUM OF *ACRITOPARAMYS FRANCESCOI* (RODENTIA: ISCHYROMYIDAE) FROM THE BIGHORN BASIN, WYOMING SUPPORTS A CHANGE IN CLASSIFICATION TO THE SUBFAMILY PARAMYIINAE

ANDERSON, Deborah, St. Norbert College, De Pere, WI

Acritoparamys francescoi is one of the earliest known members of the family Ischyromyidae, its fossil record beginning in the Early Eocene (55.5 MA). Originally classified in the subfamily Paramyinae, the genus was moved to the Reithroparamyinae based primarily on characteristics of the molar crown pattern and anterior position (level with middle of P4) of the posterior aspect of the anterior root of the zygoma. Recent discovery of a partial cranium of *Acritoparamys francescoi* from the Bighorn Basin, Wyoming is the basis for a more complete analysis of the evolutionary relationships and taxonomic status of the genus. The specimen includes a complete set of left molars (dp3-M3) associated with the partial cranium, and the right P4 and M1 on a maxillary fragment, as well as two nearly complete mandibles with all molars in situ. This is the first reported M3 known for the species. Qualitative features of the cranium were compared to other skulls known for the subfamily Reithroparamyinae and Paramyinae. The M3 was described in detail; other molars were similar to those found in previously described specimens. Cranial features found to be distinct from other members of the subfamily Reithroparamyinae include the curved maxilla-premaxilla, large angle of the anterior face of the zygoma, a rounded piece of maxilla separating premaxilla from the orbit, posterior aspect of orbit broad and rounded instead of angular, relatively large infraorbital foramen, and posterior margin of anterior part of the zygomatic arch in line with anteroloph of M1. In each case, the skull more closely resembles those known for the Subfamily Paramyinae, supporting reclassification to this taxon.

Saturday 11:30

ON THE SKULL OF *CACOPS ASPIDEPHORUS* WILLISTON (TETRAPODA; TEMNOSPONDYLII; DISSOROPHIDAE) FROM THE LOWER PERMIAN OF TEXAS

ANDERSON, Jason, Univ. of Calgary, Calgary, AB, Canada

One of the most frequently depicted amphibians from the Early Permian, the armored temnospondyl *Cacops aspidophorus*, is also among the most poorly known dissorophids in terms of cranial anatomy. Because the matrix tightly encrusts the bone, it is difficult to determine where matrix ends and bone begins. The type series was prepared in such a manner as to obliterate the external surface of the bone so that, although complete skulls of *Cacops* are known, no sutures have been described.

A partially prepared specimen on display at the University of Michigan Exhibits Museum was investigated as a part of my revision of dissorophoid temnospondyls. After cleaning it was discovered to have a full complement of sutures on the lower jaw, which prompted my present exploration of all unprepared cranial material from the *Cacops* Bone Bed held at the Field Museum of Natural History. This new material was supplemented by reexamination of the type series.

Sutures demarking all ossifications of the lower jaw save the articular can be made out with varying degrees of clarity. Sutures on the lateral skull, skull roof, and palate are also distinguishable. Most important features to note in the skull proper include the presence of alary processes on the premaxilla, a very thin maxilla, and an LEP that might have been prevented from participating in the ventral orbital margin. Rostrally the lower jaw of *Cacops* is very narrow and only the dentary can be seen except for a small exposure of the presplenial. The presplenial comes to a point at the symphysis but does not seem to contribute to it. An adsymphyseal ossification, the first described from a dissorophoid, bearing a fang and replacement pit pair forms the lingual half of the symphysis in a pattern similar to that in the colosteid *Greererpeton burkemorani*. These features allow *Cacops* to be coded in a matrix of lower tetrapod jaw characters, which will be explored in detail. With the recent description of an adsymphyseal in an amphibamid temnospondyl, it raises the possibility that the adsymphyseal of lower tetrapods may be homologous to the mentomeckelian ossification in modern amphibians. This character will be discussed at length.

Poster Session I

LOCOMOTOR STRATEGY AND MASS PREDICTION FOR THE NOTOUNGULATE *PROTYPTOTHERIUM* (EARLY MIOCENE, SANTA CRUZ, ARGENTINA)

ANDERSON, Leah, CROFT, Darin, Case Western Reserve Univ., Cleveland, OH

Mammal fossils are abundant, diverse, and well preserved in the early Miocene Santa Cruz Fauna of southern Argentina. Some of the most common remains are of notoungulates, the most speciose group of endemic South American ungulates. Despite the availability of excellent specimens, few studies have investigated notoungulate paleobiology. This partly stems from the lack of living descendants which presents challenges for reconstructing attributes such as body mass and locomotor strategy. We here present results of a study that uses a variety of extant mammals to infer these attributes for one Santa Cruz notoungulate, *Protypotherium* (Interatheriidae: Interatheriinae).

Postcranial measurements were taken from 45 species of modern rodents, lagomorphs, and ungulates of known body mass (< 10 kg) and locomotor habit (fossorial, occasionally fossorial, generalized, saltatory, cursorial, or arboreal). Some measurements were expressed as ratios to form ten indices related to limb function (e.g. humerus robustness index). Body mass of *Protypotherium* was inferred using 14 postcranial regression equa-

tions calculated from these extant taxa: estimates were averaged and results (6.92 kg and 6.55 kg) are similar to previously published values. Principal Components Analyses (PCA) and Discriminant Function Analyses (DFA) of both raw measurements and functional indices were used to assess locomotor habit. *Protypotherium* plots closest to fossorial taxa in the PCA of raw data but plots closest to a generalized mammal (*Proechimys*) in the PCA of indices. It is classified as arboreal in the DFA of raw data and as fossorial in the DFA of functional indices. These results indicate that the limbs of *Protypotherium* were adapted for force not speed. The relatively large mass of *Protypotherium* and the inferred fossorial habits of closely-related notoungulates suggest a fossorial lifestyle is more likely. The humerus, femur, and manus of *Protypotherium* most closely resemble the arboreal rodent *Erethizon* among extant taxa examined, however. A broader study of modern arboreal and fossorial taxa would likely help discriminate between the two alternatives.

Thursday 1:30

THE EARLIEST PTEROSAURS

ANDRES, Brian, Yale Dept. of Geology and Geophysics, New Haven, CT

The Triassic record of pterosaurs is limited to five species from central Europe, a species from Greenland, two wing metacarpals from Gloucester, and about 30 isolated tooth elements referred to the pterosaurs. The most complete of these isolated elements are two jaw fragments with in situ teeth from the Dockum Group of Texas. These specimens were found in sediments of Carnian Age, whereas, the oldest pterosaur specimens are from the Upper Norian. If these fragments belong to pterosaurs, they would be the oldest known members of this group and extend its range by about ten million years.

These jaw fragments and the other isolated teeth have been referred to the pterosaur *Eudimorphodon*. This taxon is unique among Triassic pterosaurs in having a widespread distribution, even without considering these teeth. *Eudimorphodon* is the only Triassic pterosaur taxon known from more than one described specimen, more than one locality, found on more than one modern continent, and present in both terrestrial and marine sediments of most pterosaurs. The teeth of *Eudimorphodon* are unique among pterosaurs in having a multicusped morphology of up to five large cusps. However, similar dentition is present in nonmammalian cynodonts of the same time. The isolated teeth are often identified as possibly belonging to one or the other. Study of the two more complete jaw fragments from Texas will help infer on whether these isolated teeth belong to pterosaurs and whether this group is older than previously known.

Analysis of the Texas jaw fragments using Microfocus CT scanning at the University of Amherst Digital Paleo Lab reveal features that allow the referral of one specimen to the pterosaur *Eudimorphodon*, and the other to the Cynodontia. These specimens highlight the unusual convergence and differences between these two groups. Possible reasons for this level of convergence are explored. Phylogenetic analyses by this and other authors do not recover *Eudimorphodon* as basal pterosaur taxon. This would imply an unrecorded radiation of pterosaurs in the Carnian or even earlier. A review of the referred isolated teeth reveals that most are cynodonts or other archosauriforms. Some teeth are similar to but lie outside the diversity of the Texas and other *Eudimorphodon* specimens.

Poster Session III

MAMMALS AND MARKER BEDS IN THE WASATCH AND GREEN RIVER FORMATIONS: EOCENE BIOSTRATIGRAPHY NEAR FREIGHTER GAP, GREAT DIVIDE BASIN, SOUTHWESTERN WYOMING

ANEMONE, Robert, Western Michigan Univ., Kalamazoo, MI; WATKINS, Ron, Curtin Univ. of Technology, Perth, Australia; MOORE, Bill, Southern Illinois Univ., Carbondale, IL; STROIK, Laura, Arizona State Univ., Tempe, AZ

Recent paleontological investigations in Paleocene and Eocene terrestrial deposits of the Great Divide Basin have greatly increased our knowledge of the evolution of early Tertiary mammals in a previously little-studied sedimentary basin along the continental divide in SW Wyoming. During the past ten summer field seasons we have collected and catalogued 7000 fossil mammals from nearly 80 localities in Clarkforkian and Wasatchian deposits across the Paleocene-Eocene boundary. These fossils have come from a number of different areas within this large (ca. 10,000 square kilometers) basin, including the vicinity of Steamboat Mountain and Freighter Gap in the northern part of the basin. In this paper we report new results concerning the presence of geological marker beds and their stratigraphic relationships to fossil mammal localities in the Steamboat Mountain-Freighter Gap region of the Great Divide Basin. The early Tertiary deposits of the Wasatch formation in this region are of fluvial origin, and comprise more than 3000 feet of essentially flat lying sandstones, siltstones, oil and clay shales, and coal beds. The first marker unit is a sandstone bed with bivalves and gastropods that closely resembles a unit figured by Pipiringos in 1961, and which he considered to be in the lower part of the Luman tongue of the Green River Formation. It occurs near the 7100 ft contour in T24N, R100W, approximately 5 miles east of Freighter Gap. The second marker bed comprises a sequence of stromatolites, oil paper shales, ostracod-bearing sandstone, and a gastropod and bivalve-bearing limestone. It is found less than a mile to the north of the first marker, at the 7500 foot contour, where it caps the fossiliferous sequence in this part of the Great Divide Basin. The fossil mammals recovered from approximately 20 different localities in the Freighter Gap area (ca. 2500 specimens) are clearly of Wasatchian age, and can be tied into a local stratigraphic column in relation to these marker beds and the general stratigraphy of the region.

Saturday 12:00

WERE END-PERMIAN TERRESTRIAL VERTEBRATE COMMUNITIES UNUSUALLY SUSCEPTIBLE TO EXTINCTION?

ANGIELCZYK, Kenneth, Univ. of Bristol, Bristol, United Kingdom; ROOPNARINE, Peter, California Academy of Sciences, San Francisco, CA; WANG, Steve, Swarthmore College, Swarthmore, PA

The end-Permian mass extinction was the largest extinction event of the Phanerozoic, with strong effects on marine and terrestrial communities, but its causes remain obscure. Part of this uncertainty stems from the fact that few unique mechanisms have been definitively associated with mass extinctions. Regardless of their ultimate causes, however, it is clear that mass extinctions represented times of severe ecological crisis, during which ecological community functions were altered or shifted into new states. Thus, many of the species that became extinct during intervals of mass extinction probably did not succumb to the direct effects of abiotic triggers, but instead were victims of the resultant ecological crises and failing communities. In particular, the trophic relationships that exist between different organisms in a community may make them vulnerable to cascades of secondary effects, in which the effects of a perturbation of some members of a community can spread throughout a food web, potentially causing its collapse. However, this raises the question of whether communities of differing trophic connections are equally susceptible to extinction.

To address this question, we constructed probabilistic models of trophic networks for eight terrestrial vertebrate communities, ranging in age from late Middle Permian to early Middle Triassic, from the Karoo Basin of South Africa, and subjected them to different types of perturbations. Our results indicate that the communities' extinction resistances are not uniform. For example, the earliest Triassic *Lystrosaurus* Assemblage Zone community is more resistant to a bottom-up trophic perturbation than any of the other communities. However, the latest Permian *Dicynodon* Assemblage Zone community is only marginally more vulnerable, indicating that a large disturbance would be necessary to account for observed levels of extinction. These results are significant because they help to focus our search for potential causes of the end-Permian extinction, and can provide insight into whether mass extinctions have acted over time to increase the extinction-resistance of communities.

Student Poster Session

SYSTEMATICS OF THE CHALICOTHERIINAE (PERISSODACTYLA) AND THE IMPORTANCE OF REVISING OLD COLLECTIONS

ANQUETIN, Jérémy, The Natural History Museum, London, United Kingdom

Chalicotheres are quite peculiar perissodactyls with large bifid claws instead of hooves and reduced hindlimbs. Members of the subfamily Chalicotheriinae present the most derived morphology among chalicotheres, with extremely reduced hindlimbs, quite elongate forelimbs and a knuckle-walking gait (all converging toward a gorilla-like posture). Miocene chalicotherines from France and Germany were also the first chalicotheres to be described at the beginning of the 1800s. During the main part of the 1900s, it was assumed that there was only one chalicotherine genus throughout the Miocene: *Chalicotherium*. Recently, a new taxon from Greece (*Anisodon macedonicus*) shed new light on chalicotherine phylogeny and it was proposed that middle and late Miocene taxa should be divided into two genera.

In order to test this hypothesis, I revised historic specimens of *Anisodon grande* from France (including the first known chalicotherid skull). Some of these remains have not been studied since 1890 and most have never been accurately described. In addition, new remains of *Chalicotherium goldfussi* from Saint-Gaudens, France are described, including the first known complete mandibular symphysis which indicates that *C. goldfussi* has three incisors. Based on these new data, a cladistic analysis was performed and its results are reported here. The division of middle and late Miocene taxa into two main clades (*Anisodon* and *Chalicotherium*) is strongly supported. Furthermore, this analysis proposes a novel pattern of relationships. *Nestoritherium sivalense*, *C. wuduensis* and '*C. goldfussi*' from Titov Veles (Macedonia) are no longer close relatives of *C. goldfussi* as previously thought, but rather belong to the genus *Anisodon* and become *A. sivalense*, *A. wuduensis* and *A. sp.*, respectively. Recently described *Kalimantsia* needs to be reviewed to properly assess its relationships and nomenclature.

Poster Session I

THE FIRST DINOSAUR REMAINS FROM THE SUSTUT BASIN, NORTH-CENTRAL BRITISH COLUMBIA, CANADA

ARBOUR, Victoria, Dalhousie Univ., Dartmouth, NS, Canada; GRAVES, Milton, Dalhousie Univ., Halifax, NS, Canada

Dinosaur bones discovered in 1971 represent the first dinosaur fossils reported from the Sustut Basin, and also the first dinosaur skeletal material discovered in British Columbia. The bones were discovered in a talus slope during thorium and uranium exploration near the intersection of Birdflat Creek and Sustut River (NTS map sheet 94D, McConnell Creek Area). Outcropping in the area are Late Cretaceous rocks of the Sustut Group, representing fluvial and lacustrine deposition in an intermontane successor basin. Information from the original field notes, as well as examination of the siltstone matrix surrounding the bones, suggests that the bones may have originated from the Brothers Peak Formation (Campanian to Maastrichtian). Elements recovered include the distal fragment of a tibia and fibula, seven pedal phalanges including two unguisals, the proximal fragment of a humerus, a complete radius, a poorly preserved ulna, and a possible fragment of the pelvic girdle. Although

the specimen is fragmentary, a new taxon closely related to the basal ornithopod *Thescelosaurus* may be represented by the Sustut material.

Poster Session III

EARLY DIVERSIFICATION OF ICTIOBIN FISHES IN NORTH AMERICA AND PATTERNS OF DISTRIBUTION

ARRATIA, Gloria, Univ. of Kansas, Lawrence, KS; ALVARADO-ORTEGA, Jesus, ALVARADO-ORTEGA, Jesus, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil

The order Cypriniformes with about 3,000 species is the largest clade among extant teleosts. Cypriniformes comprise six extant families: Balitoridae, Catostomidae, Cobitidae, Cyprinidae, Gyриноcheilidae, and Psilorhynchidae. Among them, the family Catostomidae is represented today by about 14 genera and 80 species occurring in China, northeastern Siberia, and North America. Two catostomid species occur in Asia (*Myxocyprinus asiaticus* and *Catostomus catostomus rostratus*), whereas all other species occur in North America. These include ictiobines (*Carpiodes* with 5 spp. and *Ictiobus* with 3 spp.), cycleptines (*Cycleptus*), and catostomines (e.g., *Catostomus*, *Moxostoma*). Concerning the catostomid fossil record, ictiobines are known from Eocene-to-Recent, cycleptines from Oligocene-to-Recent, and catostomines from Miocene-to-Recent localities. The fossil ictiobines have been assigned to the extant genera *Ictiobus* and *Carpiodes*. Important exceptions are the Asiatic genus *Vasnetzovia* and the genus *Amyzon* known from 7 extinct species that have been recovered in middle Eocene-early Oligocene localities in both Asia and North America. New ictiobin material recently recovered in the Pliocene of Mexico enlarges the morphological knowledge of the group, its content and also the range of geographical distribution of ictiobines in the past. The present contribution describes the early diversification of the ictiobines in comparison with the modern members of the group, and discuss evolutionary morphological trends of ictiobines. Past and present patterns of geographical distribution are revised and a possible explanation for the major changes is presented.

Poster Session III

THE FOSSIL RECORD OF ENDEMIC AFRICAN MAMMALS (AFROTHERIA)

ASHER, Robert, Museum fuer Naturkunde, Berlin, Germany

The fossil record of placental mammals in Africa does not yet adequately document the evolutionary history of several of its endemic clades. In particular, much of the novelty of the recently named order Afrotheria (tenrecs, golden moles, elephant shrews, aardvarks, hyraxes, elephants, sea cows) is due in part to the lack of well-known fossils that could be perceived as morphologically intermediate between its ungulate-grade (elephants, sea cows, hyraxes, aardvarks) and insectivoran-grade (tenrecs, golden moles, elephant-shrews) constituents. Yet fossil relatives of all of these living clades exist. Furthermore, current hypotheses of afrotherian interrelationships can form the basis of mutually exclusive predictions regarding what we might recover, eventually, from the African fossil record. In this presentation I examine the bearing of new data on afrotherian fossils and interrelationships in order to make predictions regarding the morphology of common ancestors within the afrotherian radiation.

Poster Session II

RECOGNITION OF INSECT TRACES ON MODERN AND FOSSIL BONES

BADER, Kenneth, Univ. of Kansas, Lawrence, KS

Subaerially exposed carcasses attract insects that rapidly consume flesh. During the final stage of decomposition, insects consume or modify the remaining dry skin, flesh, and bones. Modern examples of insects that damage bone include dermestid beetles, tineid moths, and termites. Dermestid beetle larvae consume bone after the flesh and skin is removed from desiccated carcasses. After feeding for approximately four weeks, *Dermestes* larvae produce pupation chambers with U-shaped cross sections in hard substrates such as bone. Tineid larvae feed on keratin and bore straight-walled pupation chambers into horn cores. *Tinea* and *Ceratophaga* also construct reinforced tubes composed of silk, earth, and keratin from the underside of horns into the soil. Termites protect themselves by encasing their galleries and food sources in stercoral, a mixture of soil, feces, and saliva. Laboratory experiments have proven that termites can scratch bone with their mandibles, although there is no evidence suggesting that termites consume bone.

Similar insect traces have been identified on dinosaur bones from the Upper Jurassic Morrison Formation of northeastern Wyoming. Examples of these traces are molded with silicone rubber before the application of consolidants and cast using Dyna-cast plastic. Casts studied and photographed under SEM can be compared to modern insect traces on bone and wood, as well as to modern root traces on bone. Unlike modern traces produced by tineid larvae and termites, a protective material does not cover the fossil traces. The most common trace is a shallow pit produced by a feeding insect or an insect anchoring its pupation chamber against the bone. U-shaped pits on the dorsal vertebrae of a *Camarasaurus* are identical to dermestid pupation chambers.

Wednesday 4:45

ARCHOSAUR SHOULDER MECHANICS AND THE EVOLUTION OF AVIAN FLIGHT

BAIER, David, Brown Univ., Providence, RI

Archosaurs share a common shoulder morphology—an elongate, ovoid humeral head articulates with a saddle-shaped glenoid cavity. Primitively, the open margins of the glenoid ori-

ent antero-posteriorly. However, extant flying birds exhibit a derived shoulder, in which the open margins of the glenoid saddle orient vertically. Force balance analyses of the avian shoulder joint show that the high loads imposed on the joint by the pectoralis muscle during flight requires the acroracohumeral ligament (AHL) to maintain stability. 3-D motion analysis reveals that the homologous ligament in the American alligator (CHL) is relatively unimportant during high walks and that antagonistic muscles are capable of balancing the pectoralis force. Thus, a major evolutionary shift in the mechanical system of the shoulder joint occurred within archosaurs, from a primarily muscle-based balance system to a ligament-based balance system in extant birds. Reconstruction of key morphological features of the shoulder girdles of Mesozoic birds and closely related theropod dinosaurs suggests that the evolution of flight preceded the acquisition of an AHL-based force balance system. *Confuciusornis* shows indications of a transitional stage where the AHL may play an increasingly important role in stabilizing the shoulder. A fully modern AHL force balance system was likely present in the common ancestor of Ornithorhynchidae. A mechanical approach to shoulder function will greatly enhance our ability to interpret scenarios of the evolution of flight.

Wednesday 5:30

EARLY EOCENE TERRESTRIAL MAMMALS FROM GUJARAT, WESTERN INDIA

BAJPAI, Sunil, KAPUR, Vivesh, DAS, Debasis, SHARMA, Ritu, Indian Institute of Technology, Roorkee, India; THEWISSEN, Johannes, Northeastern Ohio Universities College of Medicine, Rootstown 44272, OH

The early Paleogene terrestrial fossil record of India, particularly for the 50-55 Ma interval, is important in i) understanding the dispersal patterns of many of the modern mammalian orders and in ii) constraining the timing of contact between the Indian plate and the Asian block. Until last year, the early Eocene continental fossil record from India was almost completely lacking. The discovery of diverse terrestrial mammals from the Ypresian lignitic sediments at Vastan Lignite Mine, District Surat, Gujarat, western India, offers an excellent opportunity to fill this major gap in the Indian Paleogene fossil record. The Vastan mammals are approximately 52 million years old (or possibly slightly older) and presently include perissodactyls, artiodactyls, hyaenodontid creodonts, primates, insectivores, apatotherians, proteutherians, bats, rodents and at least one other placental group. In addition, marsupials have also been discovered for the first time from the Indian Eocene. Among the medium-sized mammals, perissodactyls are the most abundant and include a new family Cambaytheriidae, diagnosed on the basis of a single genus *Cambaytherium*, with three named species, and characterized by remarkably bunodont teeth without any loph development. In addition, a small tapiroid also represents perissodactyls at Vastan. Primates comprise at least four taxa, of which only two have been named so far.

Overall, the discovery of this remarkable fauna from Vastan raises several important questions as to their biogeographic origins, and is potentially important in testing current ideas involving “out of India” or “into India” dispersal following the initiation of India-Asia collision. Although much more needs to be done to uncover the diversity of the Vastan mammals, the initial study suggests that this fauna is dominantly holarctic, though endemic at family/genus level.

Poster Session II

A SKULL AND ASSOCIATED SKELETAL PARTS OF A PLEISTOCENE TAPIR FROM VIRGINIA

BAKER, Caroline, Washington, DC; GRADY, Frederick, Smithsonian Institution, Washington, DC

A nearly complete though somewhat crushed skull of a Pleistocene tapir was recovered from a cave in Bath County, Virginia. The skull was found with three cervical vertebrae, fragments of thoracic vertebrae, rib parts, a nearly complete scapula, a humerus, and a partial ulna. A second metatarsal was found about four meters away. The skull retains all the deciduous premolars and the first molars are fully erupted and unworn. The parietal bones come together to form a sagittal crest rather than a sagittal table in the only ontogenetically similar aged Pleistocene tapir skull known. Based on all available measurements, this tapir is identified as *Tapirus veroensis*. All previous finds of Pleistocene tapirs from Virginia have been isolated teeth.

Friday 9:45

EMBRYONIC ORNITHISCHIAN FROM THE UPPER CRETACEOUS OF MONGOLIA

BALANOFF, Amy, NORELL, Mark, American Museum of Natural History, New York, NY

The fossil record is unique in that it provides a direct window through which we can observe deep-time slices of broad and inclusive patterns that characterize morphological evolution. Because organisms can be thought of as the sum of their space-time slices, the ability to observe, in a fossil, multiple levels of the complex hierarchy through which anatomical variation is expressed (e.g., ontogenetic and phylogenetic) increases the potential for gaining important insights into the evolution of morphological diversity. Ontogenetic data, when clearly available, are directly applicable to important questions such as the evolution of growth rates, the acquisition and polarization of osteological characters, and paleobiological properties of organisms. Immature specimens, however, may be difficult to confidently place within a phylogenetic context because of a lack of recognized apomorphic characters and the difficulty of visualizing sometimes very small and obscured embryonic speci-

mens. High-resolution X-ray computed tomography (HRCT) provides a reasonable solution to at least the latter of these problems and is used in the present study to visualize and describe an embryonic specimen contained within a small egg (~ 4cm) from the upper Cretaceous of Mongolia. This specimen consists primarily of postcranial material, including the femur, tibia, fibula, humerus, ulna, and numerous vertebrae. The embryo is diagnosed to Ornithischia based on the placement of a fourth trochanter along the caudomedial diaphysis of the femur and is tentatively assigned as a protoceratopsian. This assignment is supported by the exclusive presence of protoceratopsians in surrounding sediments. If correctly allocated, this specimen provides another important stage in the life cycle for this clade. The use of HRCT and the large ontogenetic dataset available reveal novel insights into the nature and rate of growth as well as the lifestyle (i.e., precocial vs. altricial) of an immature specimen. This is an important contribution to the still small but ever growing sample of fossil vertebrate embryos.

Poster Session II

FEATURES OF POSTERIOR MANDIBLE SHAPE IN RHINOCEROIDEA USING DISTANCE AND LANDMARK MORPHOMETRIC METHODS

BALES, Gerald, Western Univ. of Health Sciences, Pomona, CA

The Rhinoceroidea (Perissodactyla: Ceratomorpha), a large mammalian group appearing early in the Tertiary, achieved wide geographic, ecologic, and taxonomic diversity. The rhino fossil record includes many partial (half) and complete mandibles of genera representing a significant temporal and spatial diversity. The half mandible (including body, angle, ramus, condyle, and coronoid process) is a relatively two-dimensional structure when viewed laterally. As such, it is amenable to 2-D landmark morphometric analyses (splines and outlines) as well as distance methods (bivariate and multivariate ordinations). The functional role of the mandible is dominated by its mechanical participation in supporting the lower grinding tooth row and providing the force and motion of the teeth in chewing. Mandible shape may be hypothesized to include aspects of these mechanical requirements as influenced by diet and type of chewing (in addition to historical constraints and accommodation of other evolutionary features like skull size). Fifty five fossil mandibles representing 15 extinct genera are analysed. Included are *Hyrachyus*, an early small rhinocerotid, and *Paraceratherium*, the largest rhinocerotid. Thirteen specimens of *Teleoceras* provide a glimpse of intragenetic variation. The four living genera provide a good correlation with known feeding ecology. Ten landmark distances were measured directly on the mandibles to capture aspects of shape included in the parts listed above. Twelve 2-D landmarks were digitized from photographs. The distance and 2-D landmarks sets overlap but are not identical. Preliminary analysis shows that few of the parts are highly intercorrelated, suggesting more "local" control of shape within the mandible. Among the more obvious shape features are the coronoid processes which seem to vary mostly with respect to three aspects (a) length, (b) forward angulation, and (c) the degree of backward curvature to a point by the upper half of the processes. The mechanical significance of these features has yet to be determined.

Poster Session I

ANURANS FROM THE LOWER CRETACEOUS CRATO FORMATION OF BRAZIL: A PRELIMINARY REPORT

BARBOSA DE MOURA, Geraldo, Universidad Federal de Pernambuco, Recife, Brazil; BAEZ, Ana, Universidad de Buenos Aires, Buenos Aires, Argentina

The Aptian Crato Formation, Araripe Basin, northeastern Brazil, has yielded one of the most significant Early Cretaceous fossil assemblages in the world, being well-known for its taxonomic diversity and remarkable preservation. Plant, invertebrate, and vertebrate remains have been discovered in beds interpreted as representing a lacustrine environment. Herein we describe several anuran specimens recently recovered from the upper limestone beds of the Crato sequence. These remains are mainly characterized by their articulated condition and relative completeness (notably the hindlimbs), suggestive of rapid burial, minimal transport, and absence of post-mortem scavenging. In addition to a pipimorph pipoid, at least two neobatrachian taxa are represented, which are the earliest records of Neobatrachia to date. The probable affinities of one of the neobatrachians indicate not only that basal splitting of this group had already occurred, but that the radiation of hylids were well underway. The anurans, with the possible exception of the aquatic pipimorphs, may have inhabited the paludal marginal areas of the Crato lake. The Crato anuran record contrasts with other known Early Cretaceous anurofaunas, such as that from the Barremian lithographic limestone locality of Las Hoyas in Spain, which include only "archaeobatrachians" but no neobatrachians.

Poster Session I

IMPLICATIONS OF THE PRESENCE OF THE MEGALOSAURIPUS-THERANGOSPODUS ICHNOASSOCIATION (THEROPODA) IN THE BERRIASIAN (EARLY CRETACEOUS) OF THE IBERIAN PENINSULA

BARCO, José, Zaragoza, Spain; CANUDO, José, Univ. of Zaragoza, Zaragoza, Spain; CUENCA-BESCÓS, Gloria, Univ. of Zaragoza, Zaragoza, Spain; RUIZ-OMENACA, José, MUJA, Colunga, Spain

The *Megalosauripus-Therangospodus* ichnoassociation (M-Ti) is characterized by the presence of these two ichnogenera. It is well documented in the Late Jurassic of North America and Asia, and has been considered a good biostratigraphic marker for this time interval. The presence of M-Ti in sediments of the Berriasian Huérteles Alloformation (Soria) suggests

that the deposit could be Late Jurassic. Our studies also recognize the M-Ti in the Villar del Arzobispo Fm (Teruel) dated with foraminifers as Early-Middle Berriasian. This does not detract from its biostratigraphical value but allows us to extend its upper limit as far as the Berriasian, at least in this region of the Iberian Plate. Since the theropod ichnological record at the base of the Cretaceous grows, it is possible that M-Ti's will be discovered in other parts of Laurasia. However, there is another possible interpretation for this presence within a new and interesting panorama. The break-up of Pangea at the end of the Late Jurassic brought the separation of the faunas of Laurasia and Gondwana, producing biogeographic isolation among them, as was the case with the Late Jurassic-earliest Cretaceous sauropods of northeast Iberia. The theropod skeletal record currently discovered is fragmentary and fails to shed light upon this issue. Tracks, by contrast, provide more information: the presence of the "jurassic" theropods of the M-Ti at the base of the Early Cretaceous might also be explained in terms of the presence of endemic faunas that survived through to the beginnings of the Cretaceous in some parts of the archipelago formed by the lands emerged at south Europe.

Poster Session II

REPTILIAN FAUNAS FROM THE MAASTRICHTIAN PHOSPHATES OF MOROCCO

BARDET, Nathalie, PARIS, France; PEREDA-SUBERBIOLA, Xabier, Universidad del País Vasco, Facultad de Ciencia y Tecnología, Departamento de Estratigrafía y Paleontología, Bilbao, Spain; JOUVE, Stéphane, JALIL, Nour-Eddine, Cadi Ayyad Univ., Faculty of Sciences Semailia, Dept. of Earth Sciences, Marrakech, Morocco; BOUYA, Baâdi, Office Chérifien des Phosphates, Khouribga, Morocco

The Upper Cretaceous-middle Eocene (Maastrichtian to Lutetian) phosphatic deposits of Morocco (i.e. Oulad Abdoun and Ganntour basins) are well known by very rich and diversified vertebrate faunas, including selachians, bony fishes, marine reptiles, dinosaurs, pterosaurs, mammals and marine birds. Since the pioneer work of Arambourg in the 1950's, only selachians have received scientific attention because of their biostratigraphical utility. Recently, an active collaboration between the Office Chérifien des Phosphates (Morocco), the Ministère de l'Énergie et des Mines (Morocco) and the Centre National de la Recherche Scientifique (France), has led to extensive field work and a very rich collection has been accumulated. A great number of well preserved and articulated specimens have been collected, contrasting with the isolated and fragmentary remains previously known.

The Maastrichtian phosphatic outcrops have yielded one of the most diverse mosasaurid fauna of the world. It consists of *Mosasaurus beaugei*, *Platecarpus ptychodon*, *Prognathodon currii*, *Globidens phosphaticus*, *Halisaurus arambourgi*, *Prognathodon* sp. (*Mosasaurus* cf. *Leiodon anceps* of Arambourg) and, tentatively, *Carinodens belgicus*. This assemblage is typical of the southern margin of the Mediterranean Tethys. Marine reptiles also include the varanoid squamate *Pachyvaranus crassispondylus*, a new elasmosaurid plesiosaur, both bothremydid and chelonoid turtles, and very scarce remains of dyrosaurid, gavialoid and eusuchian crocodyliformes. Continental reptiles are also found in this shallow marine environment. They consist of the azhdarchid pterosaur *Phosphatodraco mauritanicus* and saurischian dinosaurs, including a ceratosaurian theropod and a titanosauriforme sauropod.

Neoceti Symposium, Saturday 11:00

THE FAMILY AETIOMETIDAE AS A MODEL FOR EVOLUTION OF STEM MYSTICETI

BARNES, Lawrence, Natural History Museum of Los Angeles County, Los Angeles, CA; GOEDERT, James, Univ. of Washington, Wauna, WA

The tooth-bearing family of primitive mysticete whales, the Aetiometidae is, with many new discoveries, becoming recognized as increasingly diverse both morphologically and taxonomically. The family is limited to Oligocene occurrences, and all documented aetiometids are from the North Pacific realm. Four subfamilies can be recognized within the family, three named and one un-named. The subfamily Chonecetinae are stem aetiometids, with elongate skulls and the eutherian dental formula. The Morawanocetinae are divergent aetiometids with wide crania, elaborate cheek tooth crowns, and short necks. The Aetiometinae, the longest-surviving clade of aetiometids, are characterized by simplified cheek tooth crowns, and polydonta in some derived taxa. Character analyses indicate that Aetiometidae were derived from Archaeoceti, although there probably were as-yet unnamed, intermediate, family-level taxa. No known aetiometid can be demonstrated to have had baleen, and all taxa are younger geochronologically than the earliest-occurring baleen-bearing mysticetes. The Aetiometidae are, however, a model for the evolutionary stages between the Archaeoceti and the baleen-bearing Mysticeti.

Friday 9:45

THE ROLE OF VERTEBRATE PALEONTOLOGY IN FORECASTING FUTURE ECOLOGICAL CHANGE

BARNOSKY, Anthony, Univ. of California, Berkeley, CA

Sustaining ecosystem dynamics and services is one of the most critical issues facing humanity. There is now growing agreement that the information relevant to maintaining Earth's ecological health can only be obtained through more seamless mergers of the detailed, near-time ecological record with the temporally longer, but more time-averaged, paleontological record. Vertebrate paleontology, though under-utilized in this regard, has much to offer, providing rich sources of data to: (a) differentiate significant anthropogenic effects on ecosys-

tems from fluctuations that also occur in the absence of humans; (b) trace ecological metrics, such as species richness, through varying scales of space and time; (c) estimate and forecast the likelihood of species extinctions; and (d) diagnose trajectories towards abrupt transitions to alternative ecosystem states. Here I use data compiled from FAUNMAP, MIOMAP, individual Pleistocene and Miocene localities, and modern fauna of the American West to examine the 'ecological baseline' of mammalian communities at varying spatial and temporal scales. Methods include constructing species-area curves for various regions and time-slices, locally tracking species richness through time within size and trophic categories, and examining abundance patterns through time and space. Results are used to forecast how (or if) basic features of mammalian communities might be expected to change over the next century or so, given projected rates of global change.

Friday 11:00

EVIDENCE FOR POST-NESTLING GREGARIOUS BEHAVIOUR IN THE BASAL CERATOPSID DINOSAUR *PSITTACOSAURUS*

BARRETT, Paul, The Natural History Museum, London, United Kingdom; ZHAO, Qi, Institute of Vertebrate Paleontology and Paleoanthropology, Beijing, China

Elaborate cranial ornamentation (horns, frills) and evidence from paucispecific bonebeds indicate that many neoceratopsian dinosaurs had complex social behaviours, including living in herds and intraspecific display. However, many of these features are unknown or poorly developed in basal ceratopsians, which have relatively unadorned skulls and do not occur in bonebeds. Here, we report an exceptionally preserved group of the basal ceratopsian dinosaur *Psittacosaurus* from the Lujiatun Beds of the Yixian Formation (Barremian: Lower Cretaceous) in Liaoning, People's Republic of China. The specimen consists of six juvenile individuals that were apparently killed in a mass mortality event. All the individuals are oriented in the same direction and the skeletons are complete and articulated indicating that no post mortem transport occurred. Developmental Mass Extrapolation permits reconstruction of the age profile of this group: the youngest individual was aged just over one year, while the oldest was just under three years old. This profile is consistent with the presence of individuals from several different clutches within the same group and suggests that *Psittacosaurus* lived in small stable herds including several age classes. We interpret this as the first evidence of post-nestling gregarious behaviour in a basal ceratopsian. This indicates that potentially complex social behaviours emerged early in the evolutionary history of the clade and preceded the appearance of the spectacular cranial ornamentation that characterises neoceratopsians.

Neoceti Symposium, Saturday 8:30

THE ORIGINS OF REPETITIVE DEEP DIVING IN THE NEOCETI: EVIDENCE FROM AVASCULAR NECROSIS

BEATTY, Brian, Univ. of Chicago, Chicago, IL; ROTHSCCHILD, Bruce, Arthritis Center of Ohio, Rootstown, OH

Most modern whales repetitively dive deep to feed and should be susceptible to decompression syndrome, though they are not known to suffer the symptoms associated pathologies. Avascular necrosis has been recognized as an indicator of diving habits of extinct marine amniotes. Vertebrae of 331 individual modern and 996 fossil whales were subjected to macroscopic and radiographic examination. Avascular necrosis was found in some specimens of Oligocene basal odontocetes (Xenorophoidea) and in some geologically younger mysticetes, including specimens of *Aglaocetus* (considered a sister taxon to Balaenopteridae + Eschrichtiidae clade by some). These are likely representative of early "experiments" in repetitive deep diving before the development of diving physiology, indicating that the Odontoceti and Mysticeti may have independently converged on their similar, yet different, specialized diving physiologies.

Poster Session III

A JUVENILE SKULL OF *DIACERATHERIUM LEMANENSE* (RHINOCEROTIDAE) FROM THE AQUITANIAN MOLASSE OF SWITZERLAND: SYSTEMATICS, BIOSTRATIGRAPHY AND PALEOBIOGEOGRAPHY

BECKER, Damien, Section d'archéologie et paléontologie, Porrentruy, Switzerland; BÜRGIN, Toni, OBERLL, Urs, Naturmuseum St. Gallen, St. Gallen, Switzerland

We report the discovery of a skull of a juvenile rhinocerotid from the Swiss locality of Eschenbach. Computed tomography revealed the presence of the unerupted adult teeth P4 and M3 and their three dimensional virtual reconstructions. Typical morphological features of this skull and the comparison with other European specimens, thanks to the virtually extracted adult teeth, ascribe the Eschenbach specimen to *Diaceratherium lemanense* (Pomel, 1853). *Diaceratherium* has only been reported from Western Europe and probably originated from an Asiatic *Brachypotherium*. Its first occurrence is *D. lamilloquense* of Lamilloque (France), mammal zone MP29, at the beginning of a Late Oligocene regional climatic crisis. During MN1 (Early Miocene), *Diaceratherium* shows a relatively high diversity, it is represented by three species (*D. lemanense*, *D. asphaltense*, *D. tomerdingense*) spreading from southwestern France to the eastern Switzerland and southern Germany. *D. lemanense* probably ranges from MP30 (latest Oligocene) with *D. aff. lemanense* (Thezel, France) to the base of MN2 (*D. lemanense* of Montaigu-le-Blin, France) and appears as the dominant form during MN1. During MN2 *Diaceratherium* is still represented by three species (*D. lemanense*, *D. aginense*, *D. cf. aurelianense*). At this time, it shows its widest geographic repartition, spreading also into the Iberian Peninsula and northwestern Germany. Since MN3, only *D. aurelianense* persists, essentially in the Iberian Peninsula

and in France, whereas the genus disappears in Germany in MN3 and in Switzerland in MN4. At the end of MN4 (latest Early Miocene), just after the Proboscidean event, *Diaceratherium* definitively disappears to be replaced in MN6 by the first true European *Brachypotherium*. Consequently, the reported Eschenbach specimen is a new biostratigraphical pinpoint within the "Granitische Molasse Formation" (Lower Freshwater Molasse, Swiss eastern Molasse Basin), and clearly indicates an Early Miocene age for this formation. Moreover, the Eschenbach specimen is the easternmost occurrence of *D. lemanense*, in agreement with the observed eastern paleobiogeographic extension of *Diaceratherium* in MN1 and at the base of MN2.

Saturday 3:30

REVISION OF THE DRYOPITHECINI

BEGUN, David, Univ. of Toronto, Toronto, ON, Canada

Dryopithecus is one of the first fossil genera to be recognized as a great ape ancestor, and has been central in debates about hominoid evolution since the mid 19th century. Currently, four species of the genus are recognized. Moyá Solá et al. (2005) describe a new genus, *Pierolapithecus*, which they think is related to *Dryopithecus* and pongines (orangutans and *Sivapithecus*). However, *Pierolapithecus* shares a number of synapomorphies with specimens traditionally attributed to *Dryopithecus* and hominines (African apes and humans). Reanalysis of the hypodigm of the species of *Dryopithecus* and *Pierolapithecus* indicates that two genera are indeed represented, but that *Pierolapithecus* is a junior subjective synonym of *Dryopithecus*, and that the available nomen *Neopithecus* (Abel, 1902) needs to be resurrected for the more derived members of the Dryopithecini. The Dryopithecini are cladistically more closely related to hominines than pongines. This has implications for reconstructing the paleobiogeographic origins of the hominine clade, suggesting a Eurasian origin of the hominines.

Friday 10:30

POST-MORTEM DAMAGE TO BONE SURFACES IN THE MODERN LANDSCAPE ASSEMBLAGE OF AMBOSELI PARK, KENYA, WITH IMPLICATIONS FOR THE FOSSIL RECORD

BEHRENSMEYER, Anna, Washington, DC; FAITH, J. Tyler, George Washington Univ., Washington, DC

Modern bones in subaerial environments acquire evidence for surface exposure in the form of weathering, abrasion, insect damage, trample marks, rodent gnawing, and other features that can be used to interpret pre-burial taphonomic history in fossils. These types of damage accumulate over the post-mortem "lifetime" of a bone and differ from early post-mortem damage caused by large predators and scavengers. In general, once flesh-eaters and/or bone-consumers have processed a carcass, any remaining bones disintegrate over years to decades unless they are buried. Damage acquired during the period of exposure can be taphonomically and ecologically informative, but diagnostic evidence for the agents responsible is usually preserved only on unweathered to lightly weathered bone surfaces. Mammalian carcasses documented in Amboseli Park, Kenya, since 1975 show that bones of ungulates 150 kg and larger can survive for several decades on the soil surface in a semi-arid, tropical ecosystem. Bone surfaces capable of preserving trace fossils usually weather away in 6 to 20 years, however, thus defining a limited time span when burial must occur in order to preserve informative post-mortem surface damage. Progressive weathering stages relate to increasing years since death, allowing estimates for how long a fossil bone was exposed on the surface prior to burial. There are significant error-bars on these estimates because weathering rates also depend on body size and the degree of exposure to sun and moisture in micro-environments where bones occur. Applying modern weathering stages to fossils is problematic because weathering features can be obscured or mimicked by diagenesis or altered by preparation techniques. Nevertheless, it often is possible to separate completely unweathered fossil bones from those in early vs. later weathering stages. This three-part categorization provides a useful framework for examining pre-burial taphonomic history in fossil bone assemblages.

Friday 12:00

THE IMPACT OF THE SPOTTED HYAENA, *CROCUTA CROCUTA* AS A TAPHONOMIC BIAS IN THE LARGE MAMMAL BIODIVERSITY PATTERNS OVER 300 KY IN UBEIDIYA (ISRAEL) AS ITS IMPLICATIONS TO PALEOECOLOGICAL RESEARCH

BELMAKER, Miriam, Harvard University, Cambridge, MA

Theories have emphasized the importance of climate change in the formation of faunal communities as opposed to biotic factors. Distinguishing between such hypotheses requires in depth analyses of faunal communities over various temporal and spatial scales. Faunal communities derived from fossil assemblages are subjected to a wide variety of taphonomic process which may alter their composition compared to the living populations. This study presents a paleoecological and taphonomic analysis of six successive mammalian fossil assemblages from the Pleistocene site of 'Ubeidiya (Israel) spanning ca. 300 Ka. Results indicate that despite geomorphological evidence for local climatic change, the observed change in the biodiversity of the mammalian community may be attributed to taphonomic bias. The accumulation behavior of the spotted hyaena, *Crocota crocuta*, and the preferences towards specific prey, best explains the changes in presence absence of taxa, abundance of small- medium cervid and biodiversity indices patterns through time at the site.

Results of the study emphasize the importance of taphonomic analysis prior to paleoecological analysis.

Poster Session II

NEW DATA FROM THE CONTINENTAL LATE CRETACEOUS FAUNAS FROM NORTHERN MEXICO

BENAMMI, Mouloud, Instituto de Geofísica, UNAM, Mexico; MONTELLANO-BALLESTEROS, Marisol, Instituto de Geología, UNAM, Mexico

During recent years field work had been carried out in the continental and transitional marine Late Cretaceous deposits in the northern areas of the states of Coahuila and Chihuahua. As a result several fossiliferous sites bearing dinosaur, other vertebrates and plant remains had been located. Sediment for screen-washing was collected and microvertebrates were recovered.

The geological framework in this area is practically unknown. To determine the stratigraphic position of each fossiliferous site, five sections were established. A marine section represents the lowest part and it is characterized by alternating calcareous shale, shale, silty shale and phosphate nodule facies with interbedded sandstones. The sandstone layers yield poorly preserved gastropods and bivalves, and well preserved shark teeth. The continental section is characterized by a sequence of variegated mudstones and sandstones with conglomeratic lags of paleo-caliche nodules, it suggests a fluvial environment in a deltaic coastal plain and inland floodplain. There is no evidence of faulting or folding.

Samples were collected from the five sections for magnetostratigraphic analysis. All of them showed normal polarity which correlates to the Chron C33n.1n and corresponds to the upper Campanian age. It is interesting to mention that ceratopid remains identified as *Chasmosaurus mariscalensis* are stratigraphically in higher position than titanosaurid remains. This is contrary to the order present in the Big Bend National Park, Texas. The record of the titanosaurid supports the hypothesis that the group was present during the Campanian in North America. The ceratopid record is congruent with the age suggested by the magnetostratigraphy results. This new geological information and that provided by the fossils will help to establish a more detail relationship with the Late Cretaceous outcrops of the Big Bend National Park.

Thursday 2:30

ARTICULATION AND FUNCTION OF THE PTEROID BONE OF PTEROSAURS

BENNETT, S., Fort Hays State Univ., Hays, KS

For over 100 years most pterosaur workers have accepted the traditional reconstruction of the pteroid, articulated in the fovea of the preaxial carpal and directed medially along the anterior margin of a small propatagium in order to control it. A few workers have rejected the traditional reconstruction and advocated an alternative reconstruction with the pteroid directed anteriorly, spreading and controlling a large propatagium extending as far laterally as the second interphalangeal joint of the wingfinger. Recently they argued that the fossil record does not provide sufficient information to resolve the debate about pteroid function; however, that is incorrect.

Some articulated specimens of *Eudimorphodon*, *Peteinosaurus*, *Dorygnathus*, *Rhamphorhynchus*, *Pterodactylus*, *Anhanguera*, and *Pteranodon* preserve a sesamoid associated with the tendon of M. extensor carpi ulnaris in the fovea of the preaxial carpal, and thus the preaxial carpal acted as a strut to increase the leverage of M. extensor carpi ulnaris for wrist extension. No specimen preserves the pteroid articulated in the fovea, and because the sesamoid articulated there the pteroid could not. Therefore, both the traditional and alternative reconstructions, which are based on the assumption that the pteroid articulated in the fovea, are falsified. The pteroid did articulate with the preaxial carpal, but because there is much variation in the morphology of the articular end of pteroid there is also much variation in the location and manner of articulation. In both *Pteranodon* and *Anhanguera*, the pteroid articulated with the medial side of the carpal, but whereas in *Pteranodon* the articulation was a loose ball and socket joint, in *Anhanguera* it was a saddle joint. In *Nyctosaurus*, the pteroid articulated with the ventral side of the carpal. In those taxa, the pteroid can only be articulated when directed medially to control a small propatagium, and could be extended and depressed to increase wing area, camber, and lift or flexed to fold the propatagium. Thus, although the traditional reconstruction of the pteroid articulation is incorrect, the traditional view of pteroid function is correct.

Thursday 1:30

MULTIPHASIC ALLOMETRIC ANALYSIS IN LIONS (*PANTHERA LEO*): LIFE HISTORY EXPRESSED THROUGH MORPHOMETRICS

BENOIT, Matthew, Yale Univ., New Haven, CT

Lions (*Panthera leo*) are the only social-living felids alive today. They have complex pride structures and life histories that reflect a great deal of behavioral modification in order to allow for group living. These life histories have been studied extensively, and ontogenetic studies of lions have attributed a great deal of knowledge to our understanding of their development. However, few researchers have examined how these life histories may be expressed in the skeletal features of lions (the only features that survive in the fossil record).

I took 34 measurements from 94 lion skulls using a Microscribe G2X 3D digitizer. The age range of the lions spanned from a few days postnatal to old adults. I plotted the logged measurements of each feature against the logged skull length (LOGSKL, a proxy for developmental age). For each set of data, several multiphasic regressions were run allowing for

increasing numbers of phases. While correlations tend to rise with more phases, I used the Model Selection Criterion (MSC, an adaptation of Akaike's Information Criterion) to determine which multiphasic regression best fit the data.

Braincase width (BCW) showed a highly correlated ($r^2 = 0.98$) growth allometry with three phases (MSC = 3.77). The first phase captures brain growth in early postnatal development. The second phase shows a period of relative inactivity. The third and final phase, however, shows an increase in growth rate of the braincase width. This growth does not reflect growth of the brain, but rather a thickening of the braincase itself. This final growth phase begins shortly before the age of subadult dispersal from natal prides. Dispersal is usually forced by invading adult males, who kill any subadults that cannot defend themselves and drive out those that can. The implications of this growth pattern in such a life history are discussed.

Morphometric analyses of this nature provide evidence of life history patterns. Because skeletal features are generally the only ones that survive in the fossil record, analyses of these features can inform us about the possible life history and ontogenetic strategies of extinct taxa.

Student Poster Session

THE TAXONOMY, SYSTEMATICS AND EVOLUTION OF THE BRITISH THEROPOD DINOSAUR, *MEGALOSAURUS*

BENSON, Roger, Univ. of Cambridge, Cambridge, United Kingdom

Megalosaurus, a theropod dinosaur from the Bathonian of Oxfordshire, was the first dinosaur to be formally named and described. Since its original description at least 38 species have been referred to the genus, spanning a temporal range from the Late Triassic to the Late Cretaceous. Much of this material has subsequently been transferred to other genera (representing a wide range of theropod groups) or represents *nomina dubia*.

Of the remaining material very little is unambiguously referable to the genus. A dentary from the type series, OUMNH J13506, is now considered to represent the lectotype of the type species, *Megalosaurus bucklandi*. The remainder of the syntype series is not formally associated with this specimen and recent suggestions that more than one species of large theropod is represented in the Stonesfield fauna have cast doubt on the taxonomic assignment of this material. Most recent authors who have commented on the genus agree that a major revision is long overdue and it has been suggested that its retention obscures the diversity of Middle Jurassic European theropods.

Recent finds of relatively complete material of basal tetanurans and allosauroids from England, France, Portugal, Argentina, Antarctica, China and Japan are difficult to fit into a phylogenetic framework due to the outdated legacy of megalosaur taxonomy, which clouds our understanding of character evolution along the lineage leading to derived coelurosaur clades (including Aves) making reliable diagnosis of higher-level taxa difficult.

I am currently engaged in a comprehensive revision of all material that has been referred to *Megalosaurus* in order to clarify the taxonomy and systematics of the genus. I will be using this opportunity to present some of my initial findings.

Poster Session II

DATA CHECKS AND OTHER TYPES OF DATA COLLECTION STRATEGIES: TWO CASE STUDIES AT BADLANDS NATIONAL PARK

BENTON, Rachel, National Park Service, Interior, SD; HARGRAVE, Reko, Science Applications International Corporation (SAIC), Norman, OK

Two paleontological field projects at Badlands National Park provide important examples of the use of data checks in paleontological field collection. Both of these projects have lasted for several years and have included a large number of participants. The Big Pig Dig was discovered in 1993 and has been operating for over 12 field seasons. During the past 6 years, park staff and partners have also completed 2 major paleontological field surveys which documented several new paleontological localities within the park. To provide consistency in data collection, detailed protocols for note taking, excavation, grid setup and total station operation have been drafted for both the Pig Dig and the field surveys. Often one mode of data collection is not entirely reliable. For example, at the Pig Dig, both a total station and a meter grid system are used to document the position of each bone found at the site. Total station readings are constantly compared with associated grid locations. At the beginning of each mapping session, 3 reference points are taken to determine any potential errors during data collection. Data is exported into Arcview on a weekly basis to track any potential errors. During field surveys, both GPS (Global Positioning System) units and high resolution aerial photos are used to document new paleontological localities. Due to the dissected nature of the badlands topography, satellite signals can not always be received. Localities can be marked on aerial photos and digitized into Arcview. Because shape files are generated for both the paleontological field surveys and quarry collection, detailed metadata is developed to document all aspects of GPS and GIS (Geographic Information System) data collection. Metadata provides a way to document the type of equipment and software used, gives details on data collection methods and lists any type of problems encountered and their subsequent resolution. It also includes a listing of people involved and their contact information. Because paleontological locality data can be highly sensitive, metadata includes a discussion on data access and recommended security levels.

Neoceti Symposium, Saturday 12:00

MYSTICETE PHYLOGENY: THE ROLE OF STEM TAXA AND CHARACTER EVOLUTION IN THE TRANSITION TO MODERN MYSTICETES

BERTA, Annalisa, San Diego State Univ., San Diego, CA; McGOWEN, M., GATESY, J., Univ. of California, Riverside, Riverside, CA; DEMÉRÉ, T., San Diego Natural History Museum, San Diego, CA

We report results of our study on the phylogeny of mysticetes. A total evidence analysis included 30 taxa (19 extinct, 11 extant) and >27,000 characters. We found a monophyletic Mysticeti and Neobalaenidae + Balaenidae positioned as successive sister taxa to Eschrichtiidae + Balaenopteridae. Several well substantiated relationships among extinct taxa emerged from our analyses: 1) a toothed mysticete clade composed of monophyletic Aetiocetidae and *Mammalodon* assumed a basal position; 2) Eomysticetidae robustly grouped with other edentulous taxa; and 3) "cetotheres" diverged between Eomysticetidae and modern lineages.

To explore the role of stem taxa, and document key evolutionary changes in the skull and mandible, we optimized morphological characters onto our most parsimonious tree. The anterior position of the nares, elongate nasals, dorsally placed supraorbital processes, long intertemporal parietal exposure, and flat palate with teeth in aetiocetids reflects their dorodontine ancestry. A key transformation in later diverging mysticetes involved expansion of the volume of the oral cavity. Modern mysticetes rely on cranial, rostral and mandibular kinesis to accommodate the increased volume of the oral cavity. Aetiocetids possess features associated with mandibular kinesis (e.g. ligamentous mandibular symphysis) but lack features associated with kinesis of the rostrum (e.g. lack of fusion between maxilla and premaxilla) and cranium (e.g. lack of fusion between maxilla and vomer, maxilla and frontal and maxilla and palatine) seen in modern mysticetes. The stem edentulous mysticete *Eomysticetus* exhibits rostral kinesis and may possess some features of cranial kinesis, although the latter cannot be confirmed due to poor preservation. Character optimization suggests that mandibular kinesis was present 30 Ma. Rostral kinesis evolved by 28 Ma and this same date marks the initial evolutionary loss of the adult dentition. Cranial kinesis was present in "cetotheres" (e.g. *Cophocetus*, *Pelocetus*, *Parietobalaena*) by at least the middle Miocene (15 Ma). Advanced cranial kinesis developed later (10 Ma) in stem balaenopterids.

Wednesday 9:00

POSTNATAL ONTOGENETIC CHANGES IN THE CRANIUM OF *VARANUS EXANTHEMATICUS* WITH COMPARISONS TO OTHER VARANOIDS AND APPLICATIONS TO THE FOSSIL RECORD

BHULLAR, Bhart-Anjan, The Univ. of Texas at Austin, Austin, TX

Fossils are anatomically incomplete both because many structures are not preserved and because the generally low sample sizes of fossil taxa preclude the dense sampling of anatomical variation that collections of extant taxa or repeated examination of individual living organisms provide. Diagnoses and phylogenetic analyses commonly use a vaguely-defined "adult" stage for comparative purposes although anatomy changes throughout the life of an organism. In order to securely refer fossils at different ontogenetic stages to clades and to examine the full four-dimensional spread of anatomy across vertebrates, data concerning the ontogeny of extant taxa are required.

The skull is a complex and phylogenetically informative structure, and its full ontogeny needs documentation. Though a number of general ideas exist of the ways in which skulls vary through ontogeny, there is remarkably little documentation of this variation, especially postnatal variation, and many of the existing data lack an explicit phylogenetic context. Thus, the postnatal ontogeny of the skull within Varanoidea, a lizard clade with a good fossil record, was examined by bracketing the clade using a dense sample (five size stages) of *Varanus exanthematicus* and sparser samples of *Varanus salvator* and both extant species of *Heloderma*. Changes in individual elements were emphasized in order to cover cranial osteology thoroughly and to apply the data to fragmentary and disarticulated fossils. Variation throughout postnatal ontogeny was found, especially in the braincase, but also in the remainder of the cranium and the dentition. This variation included character state transitions from plesiomorphic to apomorphic at different levels, which would affect phylogenetic analysis, including specimen diagnosis. Systematic differences in ontogenetic variation were also observed among the taxa. Finally, the data were applied to two problems in varanoid paleontology: the ontogenetic stages of the small specimens of *Heloderma texana* from the Miocene of Texas, inferred to be relatively adult, and that of the holotype of *Aiolosaurus oriens* from the Cretaceous of Mongolia, inferred to be relatively juvenile.

Wednesday 12:15

RECONSTRUCTION OF ANCIENT DIETS AND HABITATS OF CENOZOIC RHINOS FROM NORTHWEST CHINA BASED ON STABLE ISOTOPES

BIASATTI, Dana, Florida State Univ., Tallahassee, FL; DENG, Tao, Chinese Academy of Sciences, Beijing, China; WANG, Yang, Florida State Univ., Tallahassee, FL

Cenozoic localities in the Linxia Basin, Gansu, NW China have produced a great diversity of rhino fossils. Previous studies have indicated that the Linxia Basin was a mixed woodland/steppe biome from the late Oligocene through the Miocene and became more arid with time. Many hypotheses regarding feeding and habitat preferences of these rhinos have been formed based on cranial and limb morphology. In order to investigate ancient diets and habitats and to test previous hypotheses, bulk carbon and oxygen isotopic analyses of tooth enamel from 37 individuals and serial analyses of 14 individuals were performed. The spec-

imens in this study range in age from 25 to 6 Ma and include individuals from 5 genera within the families Hyracodontidae and Rhinocerotidae. The results of this study suggest the following: 1) *Paraceratherium* at 25 Ma spent most or all of its time in a forested habitat near a water source or in mud wallows, was a specialized browser, and lived in a climate that was colder and/or wetter than later rhino genera from this area; 2) *Alicornops* at 17 and 13 Ma was an unspecialized browser that spent most of its time near a water source in a forested habitat and lived in a climate that was warmer and/or drier than that of *Paraceratherium*; 3) *Hispanotherium* at 14 Ma lived in a warmer and/or drier climate than did its predecessors, lived in a more open habitat, was probably a grazer, but remained near a water source; 4) *Parelasmotherium* at 11.5 Ma inhabited a more open environment and spent more time away from its water source compared to all other rhinos analyzed, was a highly specialized feeder that probably grazed on C3 grasses and lived in a climate that was warmer and/or drier than that at 17 Ma; and 5) *Chilotherium* at 9.5 and 7.5 Ma was probably a forest-dweller, spending most of its time near or in water and either grazed and/or browsed very close to a water source, while *Chilotherium* at 6 Ma moved to a more open habitat, further away from its water source and was a grazer. Also, *Chilotherium* lived in a climate that became progressively warmer and/or more arid from 9.5 to 6 Ma.

Wednesday 11:30

ORIGIN, PALEOECOLOGY, AND PALEOBIOGEOGRAPHY OF EARLY BOVINI

BIBI, Faysal, Yale Univ., New Haven, CT

Bovines (clade Bovini) are geographically widespread bovids, including wild and domesticated species such as the African buffalo, the American bison, the Asian water buffalo, and the progenitor of domesticated cattle, the auroch. The earliest bovines until now have been reported from between about 7 and 6 Ma from Africa, and it has long been known that the clade itself originated in the Miocene from "Boselaphini," a paraphyletic assemblage of early Bovinae including also the living nilgai and chousinga. A description and analysis of fossil material of certain late Miocene "Boselaphini" from the Siwalik deposits of India and Pakistan demonstrates that: 1) the earliest members of the bovine lineage are present by at least 8.9 Ma; 2) the origins of this clade appear to be in Asia south of the Himalayas; 3) bovines represent a boselaphine lineage that expanded the ancestral dietary niche to include roughage, probably graze, in more open environments prior to the global expansion of C4 habitats; and 4) that this clade's diversification and range extension coincided with global vegetation changes in the latest Miocene. These conclusions are based on assessments of diagnostic morphology, functional morphology (including mesowear), and a paleobiogeographic review of late Miocene faunas of Eurasia and Africa.

Preparators Symposium, Thursday 9:30

THE TREATMENT OF THE HAGERMAN PETRIFIED LOG

BILZ, Malcolm, Canadian Conservation Institute, Ottawa, ON, Canada

A six-and-a-half-foot log which was about 95% petrified was found at the Hagerman Fossil Beds in southern Idaho. It was delivered to the Canadian Conservation Institute in Ottawa, Canada for treatment. This essentially amounted to cleaning and consolidating the log. Controlled suction was used to remove as much of the covering sand matrix as possible without removing the actual log surface. Several materials were tested for their suitability for consolidating the log, including cyclododecane as a temporary consolidant. Conservare OH Stone Strengthener (tetraethylorthosilicate) in ethanol was determined to be satisfactory as a first stage in holding the log substance together. Following that, the very porous material was further consolidated by penetrating the structure with a 5% solution of Butvar B-90 in an ethanol carrier solvent. Plaster was injected under the log to fill the cavity between the log and its casing that had formed by loss of sand in transit. The log in its casing was placed on a metal supporting frame to facilitate moving it in the future.

Thursday 1:45

TEMPORAL VARIATION IN TOOTH FRACTURE AND TOOTH WEAR AMONG RANCHO LA BREA SABERTOOTHED CATS

BINDER, Wendy, Loyola Marymount Univ., Los Angeles, CA; VAN VALKENBURGH, Blaire, UCLA, Los Angeles, CA

Several extinct carnivores preserved in the late Pleistocene Rancho La Brea deposits display a high incidence of teeth broken during life as compared with modern species. This might reflect greater carcass utilization during prey consumption in the Pleistocene relative to the present. This possibility was considered in a previous study on dire wolves, *Canis dirus*, which explored tooth fracture and wear between two localities at Rancho La Brea, in which significant differences were found. As in the previous study, we compared tooth fracture frequencies and tooth wear in two deposits at Rancho La Brea, one dated about 16 ka (part of Pit 3) and another about 12 ka (Pit 61/67). In this study, however, we focused on a different carnivore, the sabertoothed cat *Smilodon fatalis*. Unlike many species of canids, felids, especially sabertoothed cats, are classified as hypercarnivores. We were interested in how a hypercarnivore would compare to a more omnivorous carnivore in terms of tooth wear and breakage, as canid diets tend to include harder items such as bone. *S. fatalis* in Pit 3 had significantly more fractured teeth than in Pit 61/67. However, contrary to the dire wolves, the cats did not also exhibit significantly heavier tooth wear. To eliminate the possible effects of individual age on probability of tooth fracture, we estimated individual age of *S. fatalis* from pulp cavity dimensions of lower canine teeth. Like the *C. dirus* sample, pulp cavity analysis indicated no significant difference between pits in the age structure of the preserved populations. These results indicate a decoupling between tooth breakage and

wear for *S. fatalis*. At times, the big cats may have been under pressure to more fully utilize carcasses (consume bone) resulting in increased tooth breakage, but their diets as a whole did not shift to greater bone consumption and associated heavier tooth wear.

Poster Session II

LATE QUATERNARY MAMMALIAN FAUNA FROM HERRING PARK CAVE, SOUTH PARK, CENTRAL COLORADO

BLACK, Victoria, Northern Arizona Univ. Dept. of Geology, Flagstaff, AZ

Herring Park Cave is a small overhang located in the Mosquito Range, bordering the southwestern edge of South Park, central Colorado. The surrounding area today consists of montane grasslands and forests with Ponderosa and bristlecone pine. Remains from the deposit include modern *Bison*, which have been extirpated from the area since the 1880s. Other remains consist of mostly rodents, including *Neotoma*, *Microtus*, and several species of Sciuridae. Lagomorphs and small carnivores are also present. A charcoal layer taken from near the bottom of the excavation was radiocarbon dated at 1930 ± 60 years BP, placing the deposit during the late Quaternary. Site taphonomy at Herring Park Cave is complex, with at least two taphonomic agents depositing bone at the site: (1) *Neotoma* and (2) raptor. This study provides the first baseline examination of a late Holocene faunal community in central Colorado.

Poster Session III

NEW MAMMAL-BEARING QUARRY FROM THE EARLIEST TIFFANIAN (EARLY LATE PALEOCENE) OF THE EASTERN CRAZY MOUNTAINS BASIN, MONTANA

BLOCH, Jonathan, Univ. of Florida, Gainesville, FL; BOYER, Doug, KRAUSE, David, Stony Brook Univ., Stony Brook, NY

A new earliest Tiffanian mammal-bearing quarry, Donald Quarry (Q), was discovered during a Florida Museum of Natural History-Stony Brook University field expedition in the eastern Crazy Mountains Basin (CMB) during the summer of 2005. Preliminary collecting yielded at least 16 mammalian jaw fragments and 109 isolated teeth. Fossils are concentrated in 10-20 cm thick grey mudstone lenses that bear freshwater mollusks and amber, and have patchy exposure laterally, over 140 meters of outcrop. To date, 30 mammalian species have been identified. These include, but are not limited to, multituberculates (*Anconodon*, *Neoplagiaulax*, *Ptilodus*), pantolestids (*Aphronorus*, *Paleotomus*, *Propalaeosinopa*), a cimolestid (*Acmaeodon*), "plesiadapiforms" (*Elphidotarsius*, *Ignacius*, *Nannodectes*, *Palenochtha*, *Picrodus*), "condylarths" (*Ectocion*, *Phenacodus*, *Promioclæus*, *Thryptacodon*, *Chriacus*), a large viverravid carnivoran, and a didelphid marsupial (*Peradectes*).

Prior to the discovery of Donald Q, Bingo Q was the lowest richly fossiliferous site in the Melville Formation, and the oldest quarry with mammals indicating a Tiffanian (Ti) age in the CMB. Donald Q extends the record of Ti mammals (*Nannodectes*, *Ectocion*, and *Aphronorus orieli*) to ~75 m below Bingo Q. This narrows the stratigraphic distance between the lowest Ti site and the highest Torrejonian (To) site (Kansas Q) to ~100 m, and substantially improves stratigraphic resolution from well-sampled localities in this critical interval of the eastern CMB. Additionally, paleomagnetic analysis indicates a reversed field orientation that can be attributed to Chron C27r, and limits the numerical age of this site to less than 61.9 Ma. Similarities among Donald Q, Bingo Q, the Bangtail locality, and others (persistence of *Acmaeodon*, a small paromomyid, and presence of *Ectocion* with relatively large premolars) correspond to differences with Douglass Q (type locality for Ti1), suggesting an extended "transitional To-Ti" faunal zone.

Wednesday 8:15

RESPONSE OF GROUND SQUIRRELS (*SPERMOPHILUS BEECHEYI*) TO THE LAST 20,000 YEARS OF ENVIRONMENTAL VARIATION

BLOIS, Jessica, FERANEC, Robert, HADLY, Elizabeth, Stanford Univ., Stanford, CA

Body size change is a common response to habitat variability in small mammals and can indicate both ecological and evolutionary responses to fluctuations in the environment. Mammals generally react to temperature directly or indirectly through response to vegetation change and body size tracks these forces in different ways. For example, using Bergmann's Rule as a theoretical framework, body size should decrease with increasing temperature if mammals respond directly to climatic warming. However, if mammals respond to vegetation changes, we expect a more individualistic response based on the natural history of the organism and the nature of the vegetation change. One of the most dramatic periods of environmental change to affect extant animals was the Pleistocene-Holocene transition. Many environmental changes occurred during this transition, including climatic warming and vegetation change (potentially caused by both climate and megafaunal extinction). In order to reveal how the ground squirrel, *Spermophilus beecheyi*, responds to climate, we quantified diastemal length and mandibular toothrow length on two temporal groups of specimens: museum specimens dated to the Last Glacial Maximum from two caves in northern California (Samwel and Potter Creek Caves) and modern museum specimens from throughout the range of this species. First, we found that ground squirrels conform to Bergmann's Rule using modern populations distributed along a latitudinal gradient throughout California. We then quantified the amount of body size change over the past 20,000 years to determine the extent and direction of body size evolution. Our data will provide us with clear predictions for the response of these mammalian survivors of the Pleistocene extinction event to future global warming.

Poster Session II

A NEW MARINE VERTEBRATE ASSEMBLAGE FROM THE LATE NEOGENE PURISIMA FORMATION AT POMPONIO STATE BEACH, CALIFORNIA

BOESSENECKER, Robert, Montana State Univ., Bozeman, MT

The late Neogene marine Purisima Formation of central California is a series of marine sandstones and siltstones representing shoreface to continental slope depositional settings. The formation outcrops in numerous tectonic blocks from Santa Cruz to Point Reyes, California. The Purisima Formation exposures at Pomponio State Beach (PSB) comprise 7 km of a 25 km section of coastal cliffs; deposits at PSB lie within the Pigeon Point block, bounded by the San Gregorio fault to the east. The rocks here have traditionally been mapped as the late Miocene (5-6 Ma) Tahana Member of the Purisima Formation. However an ash bed here has previously been correlated with the late Pliocene (2.5 Ma) Ishi Tuff. Researchers have questioned both age determinations.

Preliminary results of paleontological research at PSB have recorded seven elasmobranchs (*Squatina*, *Cetorhinus*, *Carcharodon*, *Isurus*, *Sphyrna*, *Dasyatis*), and calcified skeletal elements of an unidentified batoid, one teleost (*Thunnus*), a flightless auk (*Mancalla*), otariid bones referred to *Thalassoleon*, indeterminate odontocete vertebrae, and cranial elements of a baleenopterid whale near *Plesiocetus*. The composition of the assemblage reinforces previous interpretations that the Purisima Formation at PSB represents middle shelf depositional settings. The presence of the stingray, *Dasyatis centroura*, is the first record outside its modern Atlantic distribution; this occurrence may have paleoecologic and biogeographic implications.

Several vertebrate taxa allow a refinement of previous age determinations for the Purisima Formation at PSB. Vertebrate taxa from PSB are indicative of an early to late Pliocene (4.5-2 Ma) age. This new data will aid in understanding the stratigraphic relations of Purisima Formation deposits on either side of the San Gregorio fault.

Wednesday 10:45

FOSSIL HIPPOPOTAMIDAE AND SUIDAE FROM TOROS-MÉNALLA, CHAD, CENTRAL AFRICA: OUTLINING LATE MIOCENE BIOPROVINCIALISM IN AFRICA

BOISSERIE, Jean-Renaud, Muséum National d'Histoire Naturelle, Paris Cedex 05, France; VIGNAUD, Patrick, BRUNET, Michel, Université de Poitiers, Poitiers Cedex, France; MACKAYE, Hassane Taïso, LIKIUS, Andossa, Université de N'Djaména, N'Djaména, Chad

Toros-Ménalla (TM) forms a large area located in the Djouab desert, about 600 km NNE from Lake Chad. This locality is formed by several hundred fossiliferous sandstone patches isolated by modern sand dunes. Since 1997, the Mission Paléoanthropologique Franco-Tchadienne (MPFT) unearthed at TM more than 8,000 fossils of vertebrates, mostly from a sedimentary facies named 'Anthracotheriid Unit' (AU). The AU fauna notably associates the anthracotheriid *Libyosaurus*, a very primitive *Loxodonta*, the early hominid *Sahelanthropus*. The AU was biochronologically correlated to the lower Member of the Nawata Formation at Lothagam, Kenya. Thus the AU provided unique evidence for African vertebrate diversity and biogeography during the late Miocene, particularly for hippopotamids and suids. Among the AU vertebrates, the hippopotamid *Hexaprotodon garyam* is the most commonly collected species, with more than 1,500 specimens. This species is slightly smaller than the extant *Hippopotamus amphibius*. It clearly differs from *Archaeopotamus* (Lothagam, Kenya; Baynunah Formation, Abu Dhabi) by its cranial and mandibular features, whereas its mandibular anatomy recalls the Asian Neogene *Hexaprotodon*. A smaller hippopotamid is associated with *H. garyam*, but, being extremely rare, its affinities remain uncertain. Suids are represented by a primitive member of the genus *Nyanzachoerus*, known through several fragmentary mandibles and crania and a large sample of tooth rows. This material should allow a better assessment of morphological variation and relationships between basal species within *Nyanzachoerus*, with consequences on their relevance for biochronology. Whereas suid dispersal is more likely influenced by terrestrial habitat distribution, hippopotamids are particularly dependent on aquatic habitats, with dispersion abilities linked to hydrographic dynamics. Comparisons between hippopotamids and between suids from TM and other localities from northern and eastern Africa should, therefore, allow for complementary approaches of African late Miocene bioprovincialism.

Vertebrate Development Symposium, Wednesday 8:45

PELVIC EVOLUTION DURING THE TRANSITION TO LAND: COMPARATIVE DEVELOPMENT OF THE AUSTRALIAN LUNGFISH AND THE MEXICAN AXOLOTL

BOISVERT, Catherine, Uppsala Univ., Uppsala, Sweden

During the fish-tetrapod transition, the pelvic girdle was transformed from a unipartite element uncoupled with the vertebral column as observed in sarcopterygian fishes such as *Eusthenopteron* to a tripartite weight-bearing structure connected to the vertebral column through an ilium and a sacral rib as in tetrapods such as *Acanthostega* and *Ichthyostega*. Despite careful study of these forms and the pelvic girdle of *Panderichthys*, the morphology alone is still insufficient to explain how tetrapod characters such as an ischium, an ilium and a complete ventro-mesial contact between left and right moieties were acquired. The use of developmental data from extant organisms provides clues as to how a structure evolved. Given that a certain morphology remained substantially unchanged during the course of the evolution of a lineage, it is more parsimonious to assume that the development

of that morphology has remained substantially unchanged too. When comparing the development of that structure in extant organisms and verifying hypotheses against the fossil record, it is possible to understand how novel structures arose. In this case, the Australian lungfish *Neoceratodus forsteri* has been chosen as a representative of the sarcopterygian fishes since it is the only one that has been successfully raised in captivity. As for the tetrapods, the Mexican Axolotl *Ambystoma mexicanum* has been chosen since its morphology is close to that of early tetrapods and it can also be easily raised in captivity. Growth series of *Neoceratodus forsteri* and of *Ambystoma mexicanum* have been cleared and stained and immunostained to study the development of muscles, cartilage and bone of the pelvic girdle and appendicular skeleton. Comparison in the development of insertion points for homologous muscles in relation to the pelvic girdle, the study of the comparison of the formation of the ventro-mesial connection between the left and right moieties of the pelvic girdle as well as the sequence of development of the tetrapod ischium and ilium in relation to tetrapod-specific muscle groups provide hypotheses about how novel structures arose and how the tetrapod pelvis evolved during the transition.

Wednesday 3:45

A PECULIAR PALAEOORYCTID-LIKE MAMMAL FROM THE MAASTRICHTIAN OF MONGOLIA

BOLORTSETSEG, Minjin, New York, NY; MINJIN, Chuluun, Mongolian Univ. of Sciences and Technology, Ulaanbaatar-46, Mongolia; GEISLER, Jonathan, Georgia Southern Univ., Statesboro, GA

Unlike North America, the record of Maastrichtian mammals in Asia is poor. Excluding India, which was separate from Asia at the time, the only definitive Maastrichtian mammal from Asia is an undescribed metatherian skull from Guriliin Tsav, Mongolia. A possible second record consists of the multituberculate *Buginbaatar transaltaiensis*, which is known from Mongolian locality of Khaichin-I. The reported fauna of this locality is meager and is consistent with a Late Cretaceous or Paleocene age. In the summer of 2005, we collected additional vertebrate fossils from Khaichin-I. Although the focus of this abstract is the mammal fossils we discovered, we also found fragmentary remains of non-avian theropods, which together with the stratigraphic position of Khaichin-I, establishes the age of this locality as late Maastrichtian.

Our most important discoveries from Khaichin-I are 3 specimens of mammals. The first of these is a partial dentary of the metatherian *Deltatheridium pretrituberculare*, which was formerly restricted to Campanian age strata from Mongolia and Kazakhstan. The remaining two specimens, including a partial skull, represent a new and unusual species of eutherian mammal. Remarkable features of this species are large "saber-like" upper canines, loss or extreme reduction of lower incisors, and only two lower premolars. Like *Cimolestes* and Palaoryctidae, our new taxon has talonids narrower than trigonids, trigonids that tower above the talonids, transversely elongate upper molars, and P4 paracone higher than those on the molars. Like palaoryctids, the paracone and metacone on M1 and M2 are twinned and have steep lingual and labial faces. These similarities suggest that our new mammal is more closely related to Cretaceous and Paleocene taxa from North America than to other Cretaceous, Mongolian, endemic mammals. A similar argument has been put forth for *Buginbaatar*, thus the late Maastrichtian may have been a period of increased faunal exchange between Asia and North America.

Poster Session II

THE FORELIMB OF THE BASAL SAUROPODOMORPH MELANOROSAURUS AND THE EVOLUTION OF PRONATION, MANUS SHAPE, AND QUADRUPEDALISM IN SAUROPODS

BONNAN, Matthew, Western Illinois Univ., Macomb, IL; YATES, Adam, Univ. of the Witwatersrand, Johannesburg, South Africa

The evolution of a quadrupedal limb posture is characteristic of the earliest sauropod dinosaurs and involved secondarily modifying a non-supporting forelimb into a pronated support column with a semi-circular metacarpus. *Melanorosaurus readi* is a basal sauropodomorph phylogenetically close to the earliest sauropods, and the morphology of its forelimb sheds additional light on the origins of manus shape and pronation in sauropods. The osteology of a complete forelimb from *Melanorosaurus*, as well as partial referred specimens, show that forelimb elements of this taxon comprise a mosaic of basal sauropodomorph and basal sauropod characteristics. The humerus retains the plesiomorphic morphology of basal sauropodomorphs. However, like sauropods, the forearm of *Melanorosaurus* clearly shows the development of a proximal cranio-lateral process on its ulna and a shift in the position of the radius to a more cranial orientation relative to the ulna. The manus of *Melanorosaurus* was not semi-circular as in eusauro-pods; instead its metacarpals were arranged closer to the orientation more typical of theropods and basal sauropodomorphs. A recurved, medially-divergent pollex claw and straighter, blunter claws on digits II and III were present, yet it appears that there was phalangeal reduction in the central three digits of the manus. We suggest that the characteristic U-shaped manus of eusauro-pods and neosauro-pods may have evolved through a process of mosaic evolution. The forelimb morphology of *Melanorosaurus* suggests manus pronation occurred early in basal sauropods through a change in antebrachial morphology, but that changes to manus morphology followed later in eusauro-pods, perhaps due to selective pressures such as refining the pronation and weight-bearing efficiency of the manus. We conclude that changes to antebrachial morphology and manus morphology were not temporally linked in sauropods and constitute separate phylogenetic events.

Romer Prize Session, Thursday 8:15

A NEW AVIFAUNA FROM THE EARLY TERTIARY OF THE OULED ABDOUN BASIN, MOROCCO: CONTRIBUTION TO HIGHER-LEVEL PHYLOGENETICS OF MODERN BIRDS (NEORNITHES)

BOURDON, Estelle, Muséum National d'Histoire Naturelle, Paris, France

A convention between the Muséum National d'Histoire Naturelle (France), the Office Chérifien des Phosphates (Morocco) and the Ministry of Energy and Mines (Morocco) has led to the recent discovery of the first avian remains from the Ouled Abdoun Basin. Fossil birds are Upper Paleocene to Lower Eocene in age and represent the oldest modern birds (Neornithes) from Africa.

The Ouled Abdoun avifauna is almost exclusively composed of seabirds. The Odontopterygidae constitute the dominating group and are among the oldest representatives of the pseudo-toothed birds (Odontopterygiformes). The first two species of Odontopterygidae, *Odontopteryx toliapica* and *Dasornis londinensis*, are also known from the Lower Eocene London Clay (England). The third Odontopterygidae is a new genus and species that represents the smallest known pseudo-toothed bird. A new charadriiform-like seabird is described as *Abdounornis marinus* gen. et sp. nov. (Abdounornithidae fam. nov.). *Lithoptila abdounensis* is the oldest known representative of the Prophaethontidae.

Cladistic analyses based on osteological characters have been performed to assess the phylogenetic position of the Ouled Abdoun seabirds within the Neornithes. A new phylogenetic hypothesis for the earliest divergences of the Neognathae is proposed: the Galliformes are sister to the remaining Neognathae. The latter taxon splits into Odontoanserae (Anseriformes plus Odontopterygiformes) and Neoaves (all others). Three new higher-taxa are defined within the Neoaves: Phaethontiformes (Phaethontidae and Prophaethontidae) plus Procellariiformes, Ardeiformes plus redefined Pelecaniformes (Steganopodes sensu Cracraft 1985) and Abdounornis plus Charadriiformes.

Wednesday 12:00

NEW MORPHOLOGICAL DATA FOR MYOTRAGUS BALEARICUS (ARTIODACTYLA, CAPRINAE), FROM THE BALEARIC ISLANDS (WESTERN MEDITERRANEAN)

BOVER ARBOS, Pere, American Museum of Natural History, New York, NY

Myotragus balearicus was a dwarf fossil bovid from the upper Pleistocene-Holocene of the Balearic Islands (Western Mediterranean Sea). The species displays very unusual derived characteristics acquired throughout its insular evolution. Among these features we must emphasize in the short and stout limb bones, the reduction of mobility in some limb joints and fusion of small limb bones (some carpal and tarsal bones). *M. balearicus* displayed a low-gear locomotion.

Thanks to the important amount of *M. balearicus* bones curated in the vertebrate collection "Museu de la Naturalesa de les Illes Balears" (MNIB), new morphological features have been studied and they have shed light on locomotion and body size of this species.

The joint angles between femur and tibia (mainly measured in the distal femoral condyles) and humerus-radius (measured by the angle formed by the humerus diaphysis and the radius diaphysis) let us establish that *M. balearicus* had fore and hind limbs that were placed relatively wide apart and not just under the body as in other related extant bovids. Also, the morphology of the greater trochanter, which was very short in *M. balearicus*, suggests again that the femur was placed wide apart with respect to the sagittal plane of the animal. These observations fit well with the morphology of the iliac wings of the pelvis bone and some fossil footprints found in Pleistocene aeolianites from Mallorca. The relatively perpendicular position of the iliac wings with respect to the sagittal plane of the body (in cranial view), as can be observed in *Syncerus caffer*, suggests that the abdominal region of *M. balearicus* was very wide, not allowing the hind limb to be placed under the body. These characteristics show that this bovid was probably heavier than expected for its body height. Therefore, this bovid species displayed an extremely low locomotion, a heavy body and a very limited movement capacity, all related to its long evolution in a predator-free environment.

3D Imaging Symposium, Friday 9:00

3D RE-EVALUATION OF THE DEFORMATION REMOVAL TECHNIQUE BASED ON JIGSAW PUZZLING

BOYD, Alec, MOTANI, Ryosuke, Univ. of California, Davis, Davis, CA

Retrodeformation is the process of removing distortions in fossils caused by tectonic or overburden stress. These methods are very important for vertebrate paleontologists because they can be used to estimate true fossil shapes necessary for studies in functional morphology and phylogenetics. Deformation is brittle, breaking but retaining the original shape, or plastic, altering the original shape without breakage. The effects of plastic deformation are often overlooked in fossils with extensive brittle deformation. Anthropological studies dealing with deformed bones tend to rely on simple "jigsaw puzzle" reconstruction, in which fractured pieces are manually or digitally placed back together. These methods assume that most of the deformation is brittle, and that the original fossil shape can be restored without plastic retrodeformation. We tested the validity of these assumptions by using 3D computational techniques.

A cranium of a Woolly Monkey (*Lagothrix lagotricha*) was digitized using a 3D Laser scanner. The digitized specimen was then arbitrarily divided into 10 to 40 separate pieces. Each piece was then "eroded" by removing its boundary to mimic the loss of material caused by fracturing and diagenetic processes. The pieces were then linearly deformed at an

oblique angle, making the skull asymmetrical. Each piece was then virtually fitted onto a geometric average of the deformed skull, which is symmetrical but different from the true shape of the original skull.

The pieces were found to fit well onto the outline of the geometric average skull in all cases, and the reconstructed skull was measurably symmetrical. The symmetry score improved with increasing numbers of divisions of the skull. The result shows that “jigsaw puzzle” methods can lead to inaccurate specimen reconstruction. We conclude the plastic deformation must be removed before “jigsaw-puzzle” fossil reconstruction.

Poster Session II

A CONTRIBUTION TO THE STRATIGRAPHY OF THE MIOCENE/PLIOCENE PISCO FORMATION, PERU

BRAND, Leonard, Loma Linda Univ., Loma Linda, CA; URBINA, Mario, Museo de Historia Natural, Lima, Perú; CARVAJAL, Cristian, Loma Linda Univ., Loma Linda, CA; DEVRIES, Thomas, Univ. of Washington, Seattle, WA; ESPERANTE, Raul, Geoscience Research Institute, Loma Linda, CA

The Pisco Formation was deposited during the most recent of three major marine transgressions along the southern Peruvian coast, in the Pisco Basin. These transgressions produced a marine sedimentary sequence from Eocene to Pliocene, with a rich vertebrate fossil record, followed by Pleistocene deposits. The Middle Miocene through Early Pliocene Pisco Formation contains abundant and unusually well preserved cetaceans, seals, ground sloths, marine birds, sharks, and fish. We present progress on developing a stratigraphic framework for the Pisco Formation to facilitate further study of the paleobiology of this fauna. This work has concentrated on two areas where the most paleontological work is being done. These areas are the vicinity of Lomas, and the Ica valley from the contact with the Chilcatay Formation near Cerro Yesera de Amara to the highest Pisco Formation exposure on north Cerro Blanco, near Ocucaje.

The data in this study includes measured sections at several locations and geological mapping using GPS. In the Ica valley section a number of marker beds were identified, with distinctive geological and/or paleontological characteristics, that were laterally extensive. These beds were walked out, GPS positions and altitudes taken at successive intervals, and strikes and dips of the sediments determined. Faults and folds were identified throughout the section. A composite section was then measured and described for the entire Pisco Fm exposure in the Ica Valley.

The more extensive modern sand cover in some parts of the area around Lomas made structural study difficult. Sediment thickness in part of the area was estimated, based on the altitude change and strikes and dips of the sediment. A section was measured in the valley of Aguada de Lomas, with its extensive sequence of well-exposed beds. Available data on diatom zones, vertebrate collecting sites, mollusks, and radiometric dates are being correlated with this new stratigraphic information.

Saturday 9:30

RHIZODONTID (STEM-TETRAPOD) HYOMANDIBULAE: INSIGHTS INTO THE PALEOBIOLOGY OF AN EXTINCT AQUATIC PREDATOR

BRAZEAU, Martin, Evolutionary Biology Centre, Uppsala, Sweden; JEFFERY, Jonathan, International School of Amsterdam, Amsterdam, Netherlands

The hyomandibular bone is an integrated element of the feeding and respiratory mechanisms of the skull of basal jawed vertebrates. In digitated stem-tetrapods, the hyomandibular underwent a major morphological and functional transformation to become the stapes of the middle ear. The hyomandibulae of basal, fish-like, stem-tetrapods therefore provide data on the primitive conditions preceding this important change. Previous workers have made numerous conjectures about the morphological homologies and soft-tissues associated with this bone, but few well-preserved examples are known, hampering wide-ranging comparisons.

We present the first examples of hyomandibulae from a basal stem-tetrapod clade, the Rhizodontida. The specimens, from Canada, the UK and Turkey, are generally well-preserved and present a range of sizes. All are robust and show a consistent suite of characters which distinguishes them from all other known sarcopterygian hyomandibulae. Probable bone remodeling in the largest specimen suggests rapid changes to the structure and shape of this bone during ontogeny. Together, these specimens provide new insights into the morphological diversity of the hyomandibular in fossil sarcopterygians. They allow a detailed examination of muscle insertion scars, and new insights on innervation and vascularization. Comparisons with other stem-tetrapod hyomandibulae reveal considerable variation in musculature, suggesting that there was substantial diversity in feeding and respiratory mechanics, possibly related to the size variation among fish-like stem-tetrapods.

Marine Reptiles Symposium, Wednesday 3:45

NEW CHELONIOD TURTLES FROM THE LATE CAMPANIAN OF NORTH AMERICA

BRINKMAN, Donald, Royal Tyrrell Museum, Drumheller, AB, Canada; JAMNICZKY, Heather, Univ. of Calgary, Calgary, AB, Canada; DE LEON DAVILA, Claudio, AGUILON-MARTINEZ, Martha, Secretaría de Educación y Cultura, Saltillo, Mexico; HART, Maggie, San Diego Natural History Museum, San Diego, CA

Two new cheloniods from the late Campanian of North America provide new data on the early diversification of the group. The first is *Nichollsemys baieri*, a primitive cheloniod

from the late Campanian Bearpaw Formation of Alberta, Canada, and DeGrey member of the Pierre Shale of South Dakota. It is similar to *Toxochelys* and primitive with respect to *Ctenochelys* in exhibiting a narrow triturating surface that does not incorporate the vomer, a large foramen palatinum posterius, and a well-developed processus pterygoideus externus on the pterygoid. It is derived relative to *Toxochelys* in the presence of a reduced area of exposure of the basisphenoid on the ventral surface of the braincase, a mid-ventral ridge on the palate extending between the basisphenoid and vomer, a rod-like rostrum basisphenoidale, and a foramen caroticum laterale larger in diameter than the foramen anterior canalis carotici interni. Based on these features *Nichollsemys* is interpreted as phylogenetically intermediate between *Toxochelys* and *Ctenochelys*. The presence of *Nichollsemys* in Alberta and South Dakota demonstrates that it was widely distributed in the northern region of the Western Interior Seaway during the late Campanian. The second turtle is a member of the genus *Euclestes* from the late Campanian Cerro del Pueblo Formation of Coahuilla State, Mexico. It is represented by both isolated skulls and associated skeletons. It differs from late Maastrichtian species of *Euclestes* in exhibiting a shorter face, deeper labial ridge on the maxilla, and longer transverse process of the pterygoid. Based on the latter two features, it is interpreted to be the most primitive member of the genus. These new cheloniods demonstrate the presence latitudinal differentiation in the cheloniod assemblages of the late Campanian of North America and support the interpretation that marine turtles were more abundant in southern localities at this time.

Friday 2:30

THE PHYLOGENETIC RELATIONSHIPS OF GAVIALOID CROCODYLIANS: NEW FOSSILS, NEW GENES, OLD CONFLICTS

BROCHU, Christopher, Univ. of Iowa, Iowa City, IA; WILLIS, Ray, DENSMORE, Llewellyn, Texas Tech Univ., Lubbock, TX

The historical conflict between morphological and molecular data sets regarding the relationships of the modern Indian gharial (*Gavialis*) has yet to be resolved. Continuing analyses of morphology, including high-resolution CT data and new fossils from the Late Cretaceous and Paleocene, continue to reflect the historical morphological view that *Gavialis* is basal to other living crocodylians, but new molecular data, including some robust nuclear sequence data sets, continue to reinforce the view that *Gavialis* is closer to the Indonesian false gharial (*Tomistoma*). Resolution of the debate has important bearing on understanding crocodylian morphological evolution and the use of Crocodylia as a model clade in the development of molecular dating methods. Combined analyses reflect different levels of signal strength and do not help resolve the relationships of fossil taxa if living species are constrained to reflect the morphological view. If current morphological data sets support an incorrect topology, resolution will come not from new characters, but from two sources of new taxa—new early members of *Borealosuchus* and *Pristichampsinae*, groups which currently fall out as proximal outgroups to the non-gavialoid crocodylian clade; and long-snouted forms lying within a 20-million-year block of time (the “Gharial Gap”) between the disappearance of “thoracosaur” in the early Ypresian and the reappearance of gavialoids in the Priabonian. Some later thoracosaur preserve suites of characters resembling those found in tomistomines, though the phylogenetic distribution of states is not hierarchical and, at present, does not overturn the prevailing signal. Ironically, cranial morphology of thoracosaur and early tomistomines suggests that even if *Gavialis* and *Tomistoma* are extant sister taxa, their derived rostral shapes might have been derived independently.

Poster Session II

CYCLODODECANE AS A TEMPORARY SEALER AND FILLER IN MOLDING SPECIMENS WITH POROUS AND PENETRABLE SURFACES

BROWN, Gregory, Univ. of Nebraska State Museum, Lincoln, NE

One of the exceptional properties of silicone RTV molding compounds is their ability to flow and thereby capture and reproduce extreme detail from the object being molded. One of their less admirable properties is their somewhat limited tear-strength. When these two properties meet on a specimen with deep cracks, open sutures, exposed cancellous bone or remnant porous matrix, there can be grave results. RTV may flow into these areas, penetrate the specimen deeply and tear during de-molding, ruining not only the mold but the specimen as well. Residual silicone RTV is impossible to remove from these deep interstices without damaging the specimen. There are several traditional methods of preventing unwanted penetration of RTV into these areas, but each has its own shortcomings. Clay and wax fillers are themselves difficult to remove, especially from very narrow sutures and cracks, as are thick consolidants from porous areas. Using a thixotropic (non-flowing) RTV may result in less detail-capture and a greater risk of mold flaws from air-entrapment. Choosing a molding compound with higher tear-strength could result in specimen failure rather than mold failure during de-molding.

Cyclododecane (C₁₂H₂₄) is waxy hydrocarbon that sublimates completely over time at room temperature. This property makes it extremely useful as a temporary filler and consolidant. Applied as a melt, it provides a very effective fill or seal to penetrable or porous areas of specimens, and then simply disappears after de-molding. A case study of molding an exquisitely preserved juvenile *Castoroides* skull recently donated to the museum readily demonstrates the tools, techniques and benefits of using cyclododecane as a conservationally-sound temporary filler/sealant, allowing us to take full advantage of RTV properties to produce high-resolution, high-quality molds while minimizing risk to the specimen.

Preparators Symposium, Thursday 9:45

A SIMPLE PROCESS FOR FABRICATING SMALL DISPLAY MOUNTS

BROWN, Matthew, VAN BEEK, Constance, HOLSTEIN, James, Field Museum of Natural History, Chicago, IL

Occasionally preparators are called upon to perform duties that, while not outside our job description, may be outside our normal experience. For a preparator without experience mounting a cast specimen, the task may at first seem daunting. Here we examine a recent project mounting a small dromaeosaur for display. In the absence of a suitable mount-making facility or metal shop, techniques were developed through trial and error to easily mount the cast skeleton. Most materials were obtained from a local hardware store, and the work was performed using tools already present in most prep labs. The final design required an internal armature to optimize aesthetic appeal, which introduced a challenge in balancing a dynamic and anatomical pose with the need to hide a structure within the gracile elements.

Poster Session II

NEW USES OF A RELATIONAL DATABASE TO IMPROVE THE CONSISTENCY AND QUALITY OF FOSSIL LOCALITY DATA IN ACADEMIC INSTITUTIONS AND ENVIRONMENTAL CONSULTING FIRMS

BROWNE, Ian, RANDALL, Kesler, San Diego Natural History Museum, San Diego, CA
The paleontological collections of the San Diego Natural History Museum have grown considerably since the inception of the California Environmental Quality Act in 1970. The museum provides paleontological mitigation services through its Department of PaleoSVC and serves as a repository for private mitigation firms. This creates an almost constant influx of specimens and related locality data. In the past, specimens were logged daily into a handwritten ledger and field tags were handwritten for each bucket and cardboard flat of material associated with a field number. This system was prone to a number of common problems and errors: including project and developer/donor names being recorded incorrectly, missing data, and illegible handwriting.

In an attempt to improve data quality and consistency a relational database was developed to alleviate these problems. Users select the project name from a list linked directly to the contract management table; project and donor information is then automatically associated with the field number. Information about the field site is then entered, including: geologic formation, elevation, UTM coordinates, types of fossils recovered, and brief notes specific to the field number. The user then enters the number of field tags they require and the system prints them.

What makes this system particularly useful are the added features that have taken this system beyond being a simple data entry tool. The system automatically sends daily e-mails detailing the day's collections to key curatorial staff. Prior to the implementation of this system erroneous or missing data were usually not discovered until the beginning of the formal curation process (several months after the initial collection). E-mail notification allows curatorial staff to remedy data inconsistencies within 24 hours of collection. Additionally, daily notifications to contract and project management staff improve communications with clients and government oversight agencies. Ultimately this system increases locality data accuracy, benefiting researchers, students, and citizens.

Saturday 11:45

BASAL ABELISAURID AND CARCHARODONTOSAURID THEROPODS FROM THE ELRHAZ FORMATION (APTIAN-ALBIAN) OF NIGER

BRUSATTE, Stephen, SERENO, Paul, Univ. of Chicago, Chicago, IL

Carcharodontosaurids, abelisaurids, and spinosaurids constitute nearly all large-bodied theropods from Cretaceous horizons on Gondwana. The Elrhaz Formation of Niger (Aptian-Albian, ca. 112 Ma) has yielded the earliest Gondwanan spinosaurid *Suchomimus tenerensis* and also preserves the remains of a basal abelisaurid and carcharodontosaurid. The abelisaurid is known from a single individual preserving the maxilla, pelvic girdle and sacrum, vertebrae, and ribs. The maxilla is textured externally, has subquadrate alveoli, and otherwise is quite similar to that of *Rugops primus* from Cenomanian-age horizons. The ilium, in contrast, is noticeably more primitive than that of *Majungatholus atopus* and closest of kin; it has a deeper preacetabular process, a shorter postacetabular process, and a more robust pubic peduncle. The basal carcharodontosaurid is known from isolated teeth and cranial bones, including the maxilla, frontal, and postorbital. The blade-shaped teeth are smooth and do not have the marginal enamel wrinkles that characterize *Carcharodontosaurus* and *Giganotosaurus*. Compared to these genera, the maxilla is not as deep, is not textured externally by vertical grooves, and has both promaxillary and maxillary fenestrae. Compared to *Acrocantiosaurus*, the new taxon has a broader antorbital fossa bordering the ventral margin of the antorbital fenestra. The prominent postorbital brow extends anteriorly to contact the lacrimal and exclude the frontal from the orbital margin, but the postorbital-lacrimal contact is not nearly as well-developed as in known carcharodontosaurids. Phylogenetic analysis places these taxa near the base of their respective clades and suggests that large-body size and many of the cranial features that characterize abelisaurids and carcharodontosaurids were already in place by the mid-Cretaceous.

Neoceti Symposium, Saturday 9:30

DEVELOPMENTAL TRANSITIONS IN CETACEAN VERTEBRAL COLUMN EVOLUTION

BUCHHOLTZ, Emily, Wellesley College, Wellesley, MA

Developmental biology proposes that both anatomy and development are modular in organization, providing new insights into the mechanisms and possible pathways of major evolutionary transitions. Developmental changes are categorized as homologous (diversifying), meristic (count / segmentation), homeotic (regional identification / *Hox*) and associational (hierarchical).

In this project, *Hox*-defined units (cervical, thoracic, etc.) of the vertebral column of extant mammal outgroups were tested for association using correlations of count and shape to predict the modular hierarchy present in the cetacean ancestor: {cervical [(thoracic lumbar) sacral]} (caudal). Changes to this ancestral pattern were mapped onto a consensus phylogeny. Early archeocetes retained the terrestrial modular pattern but introduced meristic increases precaudally (in the (thoracic lumbar) module) instead of caudally, likely associated functionally with hind limb-based propulsion. Protocetids lost modular identity of the sacrum (which was incorporated into the lumbos) and subdivided the caudal module (to produce the fluke) in two associational changes to yield a new hierarchical pattern: [cervical (thoracic lumbar)] [(prefluke caudal) (fluke)]. Variations on this pattern define three distinctive groups of basilosaurids as well as basal neocetes. The Archeoceti / Neoceti transition is marked by meristic reduction of the (thoracic lumbar) unit, reversing the innovation of the earliest cetaceans and likely associated functionally with elaboration of fluke-based propulsion. Delphinoid odontocetes display a second and radical hierarchical reorganization, in which the lumbar and prefluke caudal units become associated: {cervical [(thoracic) [(lumbar) (prefluke caudal)]] fluke}. The highly correlated and inverse relationship between count and shape in the [(lumbar) (prefluke caudal)] unit strongly suggests that the pre-somitic mesoderm is assigned regional identity before its subdivision in the process of segmentation. Vertebral morphology of three aberrant dwarf or elongate neocetes (*Kogia*, *Caperea*, *Lissodelphis*) confirms the change in association of the lumbar module on either side of this dramatic reorganization.

Poster Session I

THE RANGE OF MOTION OF THE GLENOHUMERAL JOINT OF THE THERIZINOSAUR *NEIMONGOSAURUS YANGI* (DINOSAURIA: THEROPODA)

BURCH, Sara, Univ. of Chicago, Chicago, IL

Increasingly the orientation of the glenoid (shoulder socket) has been studied in non-avian theropods to understand what condition was the likely precursor to that of modern birds. The morphology of the glenoid is the prime factor in determining the range of motion of the humerus, which greatly affects the functionality of the forelimb. Elements of the pectoral girdle from a single well-preserved specimen of the therizinosaur *Neimongosaurus yangi*, including a complete, undistorted furcula, were reconstructed and articulated, and a unique orientation of the glenoid relative to known orientations in other theropods and extant birds was discovered and described. The glenoid was found to be oriented primarily laterally with a slight ventral component. The enlarged scapular and coracoid margins are oriented dorsally and ventrally around the socket instead of anteriorly and posteriorly as in most other non-avian theropod glenoids and those of extant birds.

This reconstruction, along with an associated humerus, was then used to determine the range of motion of the glenohumeral joint. The unusual morphology of the scapular and coracoid margins restricted the overall range of motion in the dorsoventral direction, although the lateral position of the glenoid allowed for a more extensive dorsal excursion of the humerus than has been previously described. The humerus was also found to be capable of considerable anterior protraction. The total dorsoventral motion of the humerus was measured as 72° in anterior view, and the total anteroposterior motion was measured as 110° in dorsal view. The overall range of motion was roughly circular and directed laterally and slightly ventrally, which differs from the more oval and posteroventrally directed ranges of motion that have been described for other theropods. Such extensive protraction is very different than the flight stroke of extant birds, indicating that this glenoid morphology was most likely not an evolutionary transition to the morphology of modern birds. Therizinosaurus may have used this ability to extend their arms forward considerably for activities such as reaching for and grasping foliage.

Student Poster Session

A NEW LATE PALEOCENE VERTEBRATE FAUNA FROM THE OHIO CREEK CONGLOMERATE OF WESTERN COLORADO

BURGER, Benjamin, Univ. of Colorado at Boulder, Boulder, CO

Despite recent drilling for hydrocarbon tight-gas resources in conglomerates and sandstones in the Piceance Creek Basin, controversy exists over the age and lateral extent of these deposits. This controversy originated from the proposition that these deposits belonged in the Upper Cretaceous Mesa Verde Group. However, recent pollen analyses suggest a Paleocene age. Here I report the first fossil vertebrate fauna from these deposits, which corroborates the Paleocene age and further refines it to late Paleocene or Tiffanian NALMA.

Identified fossils comprise several genera of mammals and reptiles. Reptilian fossils consist of a dorsal osteoderm of a eusuchian with affinity to *Borealosuchus* and a partial hyoplastron of the turtle *Compsemys*. Both genera range from the late Cretaceous through the Paleocene. Mammalian taxa represented are: *Gelastops*, *Haplaletes*, *Promioclaenus*, *Colpoclaenus*, and *Mimotricentes*, which range from the Torrejonian into the early part of

the Tiffanian NALMA. Presence of *Nannodectes* further constrains the deposits to an early Tiffanian age (Ti1 to Ti3 biostratigraphic zones), since *Nannodectes* first occurrences in the Tiffanian.

Lithologically the Ohio Creek Conglomerate is characterized by the absence of coal and shale, and the presence of tan mudstones and siltstones spaced between thick and wide-spread units of clay pebble conglomerates and sandstones. The revised age and unique lithic characteristics of the Ohio Creek Conglomerate excludes it from the late Cretaceous Mesa Verde Group. The apparent absence of early Paleocene strata in the basin indicates that the basin formed later than the surrounding Green River, Washakie, South Park, and Denver Basins. Revising the biostratigraphic zonation of the late Cretaceous and early Tertiary strata of the Piceance Creek Basin is important for understanding the complex tectonic history of the Rocky Mountain Region.

Poster Session I

THE VALIDITY OF *MOSASAURUS DEKAYI* (REPTILIA) BASED ON TWO NEW SKULLS FROM SOUTH DAKOTA, AND THEIR RELATIONSHIPS WITHIN THE MOSASAURIDAE

BURROWS, Rebecca, South Dakota School of Mines and Technology, Dyer, IN

Two undescribed mosasaurid specimens from the Museum of Geology, South Dakota School of Mines and Technology (SDSM), were analyzed based on morphological characteristics and compared with known specimens from the Mosasaurinae and Tylosaurinae. These Campanian specimens share a unique feature, a highly-faceted, prismatic tooth structure. This character had previously been associated with *Mosasaurus dekayi*, identified in 1830 from Maastrichtian deposits of New Jersey and diagnosed based on a single tooth. With the type specimen now lost, the description of two mosasaur skulls which seem to exhibit this diagnostic character is of great value to the classification of the Mosasauridae.

Although, SDSM 74869 and SDSM 6819, have faceted teeth, they have other distinct characteristics unique to two different genera from two subfamilies. The premental rostrum and the pattern of the premaxillary suture places SDSM 74869 within the Tylosaurinae and subsequently within *Tylosaurus*. A unique species is indicated by the well defined asymmetrical prismatic teeth, the premental rostrum with localized foramina on the anterior end of the snout, a dorsally domed, and laterally broad premaxillae. SDSM 74869 then broadens the subfamilial definition to include a species with highly-faceted teeth.

SDSM 6819, is unequivocally nested within the Mosasaurinae, based on highly-faceted symmetrical teeth, the smooth reversed "L"-shaped premaxilla-maxilla suture, and the lack of a premental rostrum. The two skulls are very different members of the Mosasauridae, both sharing the previously thought apomorphic highly-faceted tooth structure. The characters outlined for each specimen prove faceted teeth as described by DeKay, while important, are not diagnostic and can not be used alone to differentiate species.

Poster Session II

PODOCNEMIDIDAE AND CHELIDAE TURTLES FROM THE EARLY MIOCENE, MIDDLE MAGDALENA VALLEY, COLOMBIA: THE OLDEST RECORD OF *PODOCNEMIS* AND *CHELUS* IN SOUTH AMERICA

CADENA RUEDA, Edwin, Smithsonian Tropical Research Institute, Panama; PARAMO, Maria, Universidad Nacional de Colombia, Bogota, Colombia; GAONA, Tatiana, Instituto Colombiano de Geología y Minería- INGEOMINAS, Bogota, Colombia; TORRES, Vladimir, Instituto Colombiano del Petróleo, Piedecuesta, Colombia; JARAMILLO, Carlos, Smithsonian Tropical Research Institute, Panama

The Podocnemididae and Chelidae turtles are members of the megaorder Pleurodira or side neck turtles, a significant element of extant and fossil faunas of South America. Its fossil record is abundant in Cenozoic sequences especially from early Paleocene (VilaVila, Bolivia), late Paleocene (Cerrejón, Colombia), late Miocene (La Venta Fauna, Colombia and Urumaco Formation, Venezuela), and late Miocene-Pliocene (Solimoes Formation, Brazil). Two important genera of extant pleurodire turtles in Northern South America are: *Podocnemis* (Podocnemididae family) and *Chelus* (Chelidae family). *Podocnemis* has six extant species, some of them in extinction risk, and at least five fossil forms. *Chelus* has only one extant species *Chelus fimbriatus* (Matamata turtle) and two fossil forms. Very little is known about the origin and radiation of these genera and their phylogeny is still poor understood. The earliest record of *Podocnemis* is a few fragmentary shell bones poorly described and collected by Royo y Gomez in 1944 in Coyaima, Tolima, Colombia. For the oldest record of *Chelus* are two late Miocene species *Chelus colombianus* and *Chelus lewisi*. Twenty turtles, well preserved, with nearly complete plastrons, carapaces, pelvic bones and forelimbs were found in 2005 during a paleontological expedition funded by the INGEOMINAS at Pubenza, Cundinamarca, Middle Magdalena Valley Basin, Colombia. Based on key morphological characteristics: (shape and contacts of bones and scutes shell, pelvic and axillary scars and carapace decoration) we assigned the fossils to the Family Podocnemididae (16 specimens) and the genus *Chelus* (2 specimens). The Pubenza reptile layer as we have named the bed, is part of a sequence of claystones interbedded with gypsum and some conglomerate belonging to the Barzalosa Formation. The formation has been dated as early Miocene using pollen. The facies, and palynofacies indicate that the Barzalosa formation was accumulated in an extensive freshwater lake developed in the eastern border of the Central Andes of Colombia. Also, together with these turtles we found an excellent cranial and forelimb material from crocodiles that remains to be studied.

Marine Reptiles Symposium, Wednesday 4:30

REVISITING THE 'LOST' TYPE SPECIMEN OF *MESOPHIS NOPCSAI* BOLKAY, 1925

CALDWELL, Michael, Univ. of Alberta, Edmonton, AB, Canada

Cenomanian (Upper Cretaceous) limestones deposited in a variety of Tethyan basins, now outcropping or being quarried in Slovenia, Croatia, Bosnia-Herzegovina, Lebanon, and the West Bank, have produced a large number of marine squamates, most notably including both rearlimbed and limbless snakes. *Mesophis nopcsai* Bolkay, 1925, is the second snake taxon known from the western most region of Bosnia-Herzegovina; the first was *Pachyophis woodwardi*. *Mesophis* was differentiated from *Pachyophis* as not demonstrating a high degree of pachyostosis in either the ribs or vertebrae, and by having an exceptionally small skull; the original description likened the body proportions of *Mesophis* to those of a modern sea snake or sea krait. *Mesophis* was assigned to the Chelophiidae Nopcsa, 1923, Family Pachyophiidae, Nopcsa, 1923. The original description was based on part and counterpart slabs of the specimen; the counterpart is 'lost' in a private collection, while the part survived the Balkan Conflict (1992-1995) and is available for study. Redescription recognizes a distinction from *Pachyophis* on the basis of the degree of pachyostosis; however, based on size criteria it is suggested these differences could be ontogenetic. Bolkays (1925) characterization of the size of the skull, and his identification of various cranial elements, is contradicted by identification of only a fragment of the pterygoid and a partial basicranium; the skull is small because it is fragmentary, not because *Mesophis* is a small-headed animal. The best preserved vertebrae on the part show similarities to *Simolophis*; however, as the skull is virtually absent, few other characters assist with the phylogenetic placement of *Mesophis*. Bolkay's arguments in support of a marine origin for snakes are neither refuted nor supported by the available data from *Mesophis*.

Poster Session I

THE DISCOVERY OF A SINGULAR FAUNA: THE SAUROPODS FROM THE LATE JURASSIC AND EARLIEST CRETACEOUS OF SPAIN

CANUDO, José, Zaragoza, Spain; RUIZ-OMENACA, José, MUJA, Colunga, Spain; BARCO, José, Univ. of Zaragoza, Zaragoza, Spain; GARCÍA-RAMOS, José, PIÑUELA, Laura, MUJA, Colunga, Spain

In Spain there is a good record of Kimmeridgian to Berriasian continental and coastal facies. It is common to find fragmentary remains of dinosaurs, many of them linked to transition environments. Particularly interesting are the remains of sauropods, usually included in Diplodocidae and Camarasauridae, families typical of the end of Jurassic in North America (Morrison Fm). The description of more complete specimens and new studies of fragmentary material has made possible to interpret a new scenario. The phylogenetic proposals represented by postcranial remains (*Galvesaurus*, *Losillasaurus*), locate them outside Neosauropoda or as polytomies with other basal Neosauropoda. This part of the cladogram is poorly resolved, but according to our data it is the position occupied by some of the Iberian sauropods. In addition, the sauropod teeth from the Late Jurassic and earliest Cretaceous are included in two groups, one of them, the non-neosauropod eusauro-pods, with markedly spatulate teeth. The second has pencil like teeth (diplodocimorphs) from the Kimmeridgian of Asturias and the Berriasian of Galve (Teruel). This second group have slightly spatulate apex distinguishing them from the Diplodocidae, may be located as more primitive Diplodocimorpha. Noteworthy is the absence of Titanosauriformes such as Brachiosauridae, and even other macronarians such as Camarasauridae. This association implies that part of the Iberian Peninsula maintained more primitive sauropods than those present in adjacent areas of Gondwana and Laurasia, in spite of being situated in an intermediate paleogeographical position between these two great continental masses. This would suggest the isolation (endemism?) of the north-east of the Iberian Peninsula, at least its sauropods, during Late Jurassic and earliest Cretaceous.

Preparators Symposium, Thursday 11:45

VOLUNTEERS AS FORCE-MULTIPLERS IN RESEARCH AND IN THE FOSSIL LAB

CARPENTER, Kenneth, Denver Museum of Nature & Science, Denver, CO

The 1467 volunteers at the DMNS contributed over 182,326 hours in 2005. Of these, 125 are active in the Dept. of Earth Science. In many museums, volunteers are an under utilized resource in both research and in the fossil preparation laboratory. Volunteers can be viewed as a threat ("why keep staff if the volunteers can do the work for free?") or as a force multiplier. At the Denver Museum of Nature & Science, volunteers have logged 131,456 hours doing fossil preparation during just the past 10 years, which is equivalent to over 6.25 full time staff (40 hr/wk, no leave or vacation). This compares with 2.25 staff members the Museum currently has. During the same 10 years, the volunteers have logged an additional 30,128 hours of field work, which is equivalent of 5.75 full time staff in the field for 3 months/yr. (40 hr/wk). Thus, the field and lab work combined is equivalent to 7.75 full time staff. Our utilizing volunteers has resulted in very high rates of output, but does require considerable staff time in supervision. A mandatory 8 week, 2 h/wk preparation class weeds out volunteers who discover the romance of preparation is not reality, and gets volunteers up to a certain level of competency for integration with more seasoned lab volunteers. Volunteers have also used in research, with over 28 abstracts and peer reviewed publications, and 24 presentations at scientific meetings. Volunteers bring a commitment and dedication to their research not seen in many graduate students. Volunteers who are retired also approach research with a maturity not yet developed in young graduate students and are more willing

to admit what they don't know. This makes guidance of research easier than with some graduate students ("like having graduate students without the whining"). The use of volunteers has resulted in an extraordinary high level of productivity for the department than if only by staff.

Poster Session I

IS *GUANLONG* A TYRANNOSAURID OR A SUBADULT *MONOLOPHOSAURUS*?

CARR, Thomas, Carthage College, Kenosha, WI

Guanlong wucaii is a purported Late Jurassic basal tyrannosauroid from the Shishugou Formation of northwestern China. *Guanlong* bears a tall and fenestrated nasal crest that extends along the top of the snout, as in *Monolophosaurus jiangi*, a carnosaur that is about twice the size as *Guanlong*, from a lower level in the same unit. The original cladistic analysis of *Guanlong* used a data matrix relevant to resolving the relationships among basal theropods, which reconstructed it as a basal tyrannosauroid. However, the similarities shared between *Guanlong* and *Monolophosaurus* in the crest prompted a test of the original hypothesis using a data matrix based on characters relevant for resolving ingroup relationships of Tyrannosauroidea.

The data matrix includes 201 characters and 34 theropod species. The matrix was analyzed in PAUP* 4.0b under a heuristic search; *Guanlong* was reconstructed as a carnosaur, and as the sister species of *Monolophosaurus*. This relationship is supported by the shape of the rostral ramus of the maxilla; a sagittal, elongate, pneumatic, and fenestrate crest along the top of the snout; and a foramen in the pubic process of the ischium. *Monolophosaurus* is distinguished from *Guanlong* by a longer crest that includes the premaxilla and lacrimal, a rostrally-positioned maxillary fenestra, a deep maxilla, a long jugal process of the quadratojugal, and a subocular process on the postorbital. *Guanlong* is distinguished from *Monolophosaurus* by a wide snout tip, short squamosal process of the postorbital, a concave orbital margin of the postorbital, a cornual process on the jugal, the antorbital fossa is deeply excavated into the jugal, absence of a caudal surangular foramen, fewer dentary teeth, apneumatic cervical centra, presence of a rostradorsal notch in the ilium, and the presence of a pubic tubercle. These results suggest two alternative hypotheses for *Guanlong*: it is either the sister taxon, or it is a subadult, of *Monolophosaurus*.

Friday 8:15

A NEW PERSPECTIVE ON NON-AVIAN DINOSAUR DIVERSITY

CARRANO, Matthew, Smithsonian Institution, Washington, DC

The taxonomic diversity of non-avian dinosaurs through the Mesozoic Era is very poorly understood. Although counts of known taxa are available (and form the basis for our only existing estimates), the relationship between these samples and true diversity is complex and largely unexplored. More surprisingly, current estimates are entirely empirical; no explicit hypotheses of dinosaur diversity have been offered or tested.

Here, I propose the first hypothetical taxonomic diversity curve for non-avian Dinosauria. This curve was generated *a priori*, based on inferences from large-vertebrate ecology, land area constraints, and biome distributions. It describes an initial steep increase in diversity from the Late Triassic through the end of the Early Jurassic, coincident with the originations and early radiations of all major dinosaur groups. A shallower increase follows through the close of the Jurassic, at which time continental fragmentation spurs a second, steep (exponential?) diversity rise via geographic isolation and increased biome variability. The end-Cretaceous event is considered to have been geologically instantaneous.

Total dinosaur diversity was integrated as the area under this curve. Two "metabolic models" of taxonomic longevity were used: crocodylian and mammalian. These models generate considerably different totals, indicating that physiological considerations should not be ignored when estimating diversity on macroevolutionary scales.

Next I selected five temporal "point samples" from which global dinosaur diversity could be extrapolated. These provided taxonomically rich samples that were rarefied to project the likely total standing diversity at each interval. The shape and scale of a "best fit" curve to these samples was then compared to the hypothesized curve. This provided a first-order test of the model, and a potential source for development of a second model curve. Taphonomic, human-induced, and other sampling biases remain important limiting factors, but these new models provide a new approach for understanding the dynamics of diversification in an important vertebrate radiation.

Marine Reptiles Symposium, Wednesday 1:30

MARINE ADAPTATION IN REPTILES: A MODEL FOR THE STUDY OF LARGE SCALE PATTERNS AND PROCESSES OF EVOLUTION

CARROLL, Robert, McGill Univ., Montreal, QB, Canada

Adaptation of reptiles to locomotion, feeding, and reproduction in an aquatic environment resulted in changes throughout the skeleton equivalent in scope to the modifications that occurred in the transitions between fish and amphibians and the origin of birds from dinosaurs. The transitions from terrestrial to aquatic ways of life among reptiles differ, however, in that they occurred many times, independently, from among many distinct lineages: e.g. from initially terrestrial turtles, crocodiles, squamates, sphenodontids, basal lepidosauromorphs, basal archosauriformes, and basal diapsids. Their diversity of ancestry makes this a natural experiment from which one can analyse various patterns and modes of evolutionary changes. The scientific achievements of Betsy Nicholls provide a very informative model for how such research can proceed—via thorough analyses of the func-

tional anatomy, biogeography, and environmental distribution of a wide range of aquatic reptiles, especially those near the base of their initial radiation. Her work has demonstrated the major differences between these groups at their first appearance in the fossil record, and emphasizes the necessity for new approaches to establishing more specific sister-group relationships for the diverse aquatic taxa. The necessity for establishing specific relationships for each clade separately is also shown by the extreme disparity in the results of recent phylogenetic analyses: e.g. turtles are nested within lepidosauromorphs as a sister-taxon of sauropterygians; sauropterygians at the base of archosauromorphs together with ichthyosaurs and thalattosaurs; thalattosaurs nested with lepidosauromorphs or archosauromorphs. Betsy's analyses of broad aspects of adaptation have provided data necessary to determine plausible sequences of ancestor-descendant relationships. Her approach demonstrates how future studies can lead to determining the actual antecedents of the numerous derived lineages and establish the sequences of change that occurred in the early stages of the many transitions between water and land.

Poster Session II

A CURSORIAL BIRD FROM THE MAASTRICHTIAN OF ANTARCTICA

CASE, Judd, Saint Mary's College of California, Moraga, CA; REGUERO, Marcelo, Museo de La Plata, La Plata, Argentina; MARTIN, James, South Dakota School of Mines and Technology, Rapid City, SD; CORDES-PERSON, Amanda, Sam Noble Oklahoma Museum of Natural History, Norman, OK

A left femur from the early Maastrichtian, Cape Lamb Member of the Lopez de Bertodano Fm. on Vega Island, Antarctic Peninsula, shows striking similarities to modern cursorial predatory birds of South America (Seriemias, Cariamidae) and of Africa (Secretarybirds, Sagittariidae). The size of the Antarctic femur is nearly identical to those of both modern bird families and thus the Antarctic specimen would be about the same size, at around a meter in height. The crucial features in demonstrating the habit of this Maastrichtian bird are: the enlarged and posteriorly prominent tibiofibular crista; the laterally expansive lateral epicondyle; and the highly planar and vertically oriented fibular trochlea. These apomorphic features are present in the modern yet unrelated cursorial birds and are equally developed in the Antarctic specimen. Considering the proximal femoral features, the biogeographical location and the presence of phororhacoids in the Eocene of Antarctica, then this specimen may represent a taxon which may be ancestral to both cariamids and phororhacoids or it is the basal cariamid which is then ancestral to the phororhacoids, rather than being their descendant.

Poster Session III

ON THE LEFT-RIGHT ASYMMETRY IN DINOSAURS

CASTANHINHA, Rui, Loures, Portugal; MATEUS, Octávio, Museu da Lourinhã & Universidade Nova de Lisboa, Lourinhã, Portugal

The study of different kinds of morphological left-right (L-R) asymmetries in all taxa is a very powerful tool to understand evolution since it is a way to measure the developmental stability of an organism against environmental perturbations. Excluding every pathologic or subtle asymmetry and all cases of taphonomic distortion, this work focuses only on two kinds of unambiguous asymmetries: fluctuating and adaptive asymmetry. There are several cases of conspicuous left-right asymmetry in dinosaurs and is probably more common than previously thought. The pneumatic cavities systems in skull and vertebrae of theropods and sauropods are the most common cases reported. The shape (but not the occurrence) of pneumatic cavities might have been exposed to weak selective pressure becoming more random than other body structures. Asymmetries are rarer in the appendicular bones possibly because it represents a strong handicap in the function of the limbs, consequently in the locomotion of the individual. Teeth counting show many exceptions to the typical L-R symmetry. Peculiar cases of adaptive asymmetry are related with the plates of stegosaurs and the ear displacement in the skull of the troodontids, which may have an important role in the physiology and ecology of the animals. The asymmetric displacement maximizes the surface exposure of the stegosaurs dorsal plates. This is an advantage, either the plates were used for thermoregulation, display or specific identification. Work in progress on the braincases of some troodontids specimens shows asymmetric ear openings, which suggests that can be an analogy resulting from convergent evolution between troodontids and strigiformes birds, used for 3D directional acoustics. Asymmetries are more common in animals that develop under stress. Animals that lived under dramatic environmental changes periods—like mass-extinctions episodes are believed to be—should present more asymmetries. However, much more sampling and time accuracy is required in order to be able to relate dinosaur asymmetries to extinction episodes. Asymmetries show strong intra-individual variation and should be taken in consideration in taxonomical studies.

Poster Session II

ON THE PRESENCE OF THE DIRE WOLF *CANIS DIRUS* FROM THE VALSE-QUILLO BASIN, PLEISTOCENE OF PUEBLA, CENTRAL MEXICO

CASTILLO, Jesus, Univ. Autón. Edo. Hidalgo, Pachuca, Hidalgo, Mexico; BRAVO, Victor, CABRAL, Miguel, Museo de Paleontología, Pachuca, Hidalgo, Mexico

Since the latest 19th century, several authors have reported on the Pleistocene megafauna from Valsequillo as a very important fossiliferous region. The fossil material has been recovered from fluviolacustrine deposits with a faunal assemblage that indicates Ranchoabrean and possibly Irvingtonian ages.

Recent paleontological work carried out on new localities from the Basin, allowed

recovering scarce but significant specimens assignable to *Canis dirus*. The sample includes a partial skull with the right zygomatic arch, the posterior portion of the left parietal, part of the sagittal crest, and a portion of the right maxilla with M1-3 as well as the posterior alveolus for the P4; a left mandible fragment with m1-2 and the alveolus for m3; and an isolated left M1.

This record gives additional information on the presence of these carnivores in Central Mexico. The Mexican record includes fossils from the states of Nuevo Leon, Mexico, Aguascalientes, Jalisco, San Luis Potosi and Puebla. Likewise, it constitutes one of the most southern occurrences of the group in North America.

Poster Session II

PRELIMINARY DEPOSITIONAL MODEL FOR AN UPPER CRETACEOUS EDMONTOSAURUS BONEBED

CHADWICK, Arthur, Southwestern Adventist Univ., Keene, TX; SPENCER, Lee, Southern Adventist Univ., Collegedale, TN; TURNER, Larry, Southwestern Adventist Univ., Keene, TX

GPS surveying and GIS mapping have enabled us to obtain accurate three dimensional data on the position and distribution of *Edmontosaurus* bones from an extensive monotypic bone bed in the Upper Cretaceous Lance Formation of eastern Wyoming. The bone bed occurs over an area in excess of one square kilometer, but bones appear to be concentrated in an area of about 40 hectares. While we do not yet have quantitative bone data covering the entire area, the main quarries and six test quarries have yielded a consistent picture. Estimates based upon these quarries, extrapolated over the known extent of the 40 hectares, suggest the bones of 10,000 to 25,000 animals are interred here.

The bones occur as individual disarticulated elements or rarely, as partially disarticulated assemblages. The mass mortality event is preserved within a normally graded bed in a poorly consolidated claystone or mudstone with large limb bones at the base, grading upward to vertebrae and toe bones at all quarry sites. The bones universally exhibit little evidence of weathering; abrasion and other transport degradation are also conspicuously absent. The claystone is conformably overlain by a fine-grained, well-sorted immature sandstone showing evidence of rapid accumulation. We propose that a large population of ornithopods (greater than probable herd size) was catastrophically decimated and initially accumulated in a nearshore freshwater environment. Subsequently, the disarticulating remains were remobilized and transported basinward to a deeper water setting as a graded bone bed.

Saturday 4:00

COMBINED LANDMARK AND OUTLINE MORPHOMETRIC APPROACHES FOR ANALYZING THE SHAPE OF ORGANISMS—FILLING A NEEDED GAP WITH POWERFUL BUT INTUITIVE METHODS

CHAPMAN, Ralph, Pocatello, ID

A wide variety of quantitative approaches are available for the analysis of the shape of organisms and their parts. Each has its strengths and weaknesses. Outline and landmark approaches—often referred to as geometric morphometrics—especially illustrate this. Landmark methods are the most powerful but can really provide information only on the change of the landmark positions. This often leaves much of the structure in question unstudied. Outline methods can be applied more broadly but are often less powerful because they are not typically anchored with landmarks. Further, many outline methods rely on fitting complex mathematical functions to outlines (e.g., Fourier analysis) that can make the analytical procedures difficult to do and interpretation within biological contexts very complicated. A powerful alternative is to combine outline and landmark methods in a single analysis, taking advantage of the strengths of both approaches. Further, the outline methods used should be those that use the simpler algorithms, making interpretation easier. There are three methods that can provide such an approach. First, one the original forms of Procrustes analysis (least-square and resistant-fit) allows the carrying of associated outlines along with the landmark fit and should be seriously considered for many studies. Second, defining outlines as a series of pseudolandmarks—anchored by as many real landmarks within the outline as possible—provides a very powerful system for extracting detailed shape information. Finally, there is a simple and graphical outline method—the original Theta-Rho Analysis developed by Benson in 1967—that allows for the plotting of data that contains both landmarks and outlines within polar coordinate space. Supplementing this with ordination and clustering models provides a powerful but easily understandable set of results. Examples will be given using these methods including analyses of dinosaur footprints and stegosaur plates.

Poster Session III

DEVELOPMENTAL PATTERNS OF THE JUVENILE CARBONIFEROUS COELACANTH *RHABDODERMA EXIGUUM*

CHAREST, France, CLOUTIER, Richard, Université du Québec à Rimouski, Rimouski, QB, Canada

Studies about developmental patterns in fossil taxa are relatively rare owing to the scarcity of abundant well-preserved specimens, the anatomical incompleteness and rare ontogenetic series. More than 100 juvenile specimens of the actinistian *Rhabdoderma exiguum* were found in the Middle Pennsylvanian deltaic paleoenvironment of the Mazon Creek area (Illinois). This size series (from 36 to 202 mm in total length) represents growth stages from egg to advanced juveniles including yolk-sac-bearing specimens. In order to describe devel-

opmental patterns of the postcranial skeleton, morphometric and meristic measures were taken and ossification sequences were described. Regressions and principal components analyses revealed allometric and isometric growth patterns. Ossification sequences show that: (1) most endoskeletal postcranial elements are ossified at the earliest growth stages, (2) the number of vertebra remains stable during ontogeny, whereas (3) the numbers of ossified branchial arches and lepidotrichia increase, and (4) basal plates ossify after yolk sac resorption. Developmental patterns will be compared with other sarcopterygians including the living coelacanth *Latimeria chalumnae*.

Wednesday 2:15

A NEW FOSSIL LOON FROM THE LATE CRETACEOUS OF ANTARCTICA AND EARLY RADIATION OF FOOT-PROPELLED DIVING BIRDS

CHATTERJEE, Sankar, Texas Tech Univ., Lubbock, TX; MARTINIONI, D., Cadiac-Conicet, Ushuaia, Argentina; NOVAS, F., Mus Argentino de Cs Naturales, Buenos Aires, Argentina; MUSSEL, F., Universidad de Buenos Aires, Buenos Aires, Argentina; TEMPLIN, R., National Research Council, Ottawa, ON, Canada

Well-preserved skeletons of neognathous birds from the Cretaceous deposits are extremely rare worldwide. A new and gracile species of a fossil loon *Polarornis* from Upper Cretaceous strata on Vega Island of Antarctica fills a critical gap in the origin and early evolution of neognathous birds. It is about the size of a red-throated loon and is considerably smaller and slender than its sympatric species *Polarornis gregorii*. *Polarornis* was recognized previously as a foot-propelled diving bird but the intact wing material of the new species suggests that it had also developed sophisticated powered flight, indicating dual mode of locomotion. We calculate the flight performance of this new species of *Polarornis* (using mass = 1.2 kg; wingspan = 0.86 m; aspect ratio = 6.7; wing area = 0.11 m²; and wing loading = 107.3 N/m²) through a computer simulation model, indicating that it was capable of continuous flapping flight. The hindlimbs were less specialized for diving than those of living loons, as indicated by its relatively long and slender femur and short cnemial crest. Apparently foot-propelled adaptations in loons were gradually superimposed on a body plan adapted for powered flight. The new species of *Polarornis* has striking similarity to the fossil and extant loons, displaying remarkable evolutionary stasis of Gaviidae over 65 million years. The most informative specimens of Late Cretaceous neognaths come from Antarctica including loons, as well fragmentary remains of anseriforms, and charadriiforms. Apparently Antarctica was the cradle of basal neognaths that survived the KT extinction and dispersed to lower latitudes during the early Tertiary. The new fossil loon is the only known example of modern bird that is sufficiently preserved from the age of dinosaurs to permit the study of flight performance. It provides another example of high latitude heterochroneity and favors a Late Cretaceous origin of neognaths rather than an explosive radiation in the early Tertiary.

Poster Session III

BIODIVERSITY OF FOSSIL AND LIVING OSTARIOPHYSANS IN CHINA

CHEN, Pingfu, Lawrence, KS

In China, ostariophysan fishes are represented mostly by Cypriniformes and Siluriformes. Only 2 families, 2 genera and 2 species are recognized in Gonorynchiformes, and so far no fossil has been found yet. The order Cypriniformes is the most diversified with about 163 genera and about 651 living species. Among cypriniforms, Cyprinidae and Cobitidae are the largest families. 122 genera and 451 species (or subspecies) are recognized in Cyprinidae in contrast to the 23 genera and about 131 species included in Cobitidae. Fossil representatives of Catostomidae have been recently reported from Eocene deposits of southern China, and fossil cyprinids of the subfamilies Barbininae, Cyprininae, Gobioninae, Leuciscinae, and Danioninae have been also found in Eocene deposits. Although the earliest fossils are of Eocene age, most fossil cyprinids have been recovered in Miocene or younger deposits. About 30 genera and 40 fossil species have been recognized in the Cyprinidae. About 15 genera and 100 species are recognized in Siluriformes in China, and fossil representatives are only found after Miocene. Characiformes and Gymnotiformes are not known in China.

Poster Session III

SPECIES INTERACTIONS AND HABITAT PREFERENCES IN THE EARLY EOCENE MAMMAL FAUNA OF THE CENTRAL BIGHORN BASIN, WY

CHEW, Amy, SUNY Stony Brook, Stony Brook, NY

Approximately 1000 fossil localities from the central Bighorn Basin, WY, have yielded a dense, well-studied sample of Early Eocene fossil mammals. Paleosols from nearly 700 of these localities have been analyzed and classified according to a scale of relative development from thick, immature stage 0 paleosols deposited rapidly near ancient stream channels to thin, mature stage 5 paleosols deposited far from stream channels on the ancient floodplain. Laterally contiguous sets of fossil localities deposited nearly simultaneously and documenting a progressive increase in paleosol maturity have been described as pedofacies, or lateral environmental transects from stream channel to distal floodplain. As there is no evidence of post-mortem transport in the central Bighorn Basin, faunal variation along the gradient of paleosol maturity in a pedofacies may reflect species preferences for particular sub-habitats. Evidence both for and against relationships between relative paleosol development and faunal composition has been presented.

This analysis is based on total faunal composition across two previously described pedofacies as well as across a much larger sample of 43 coeval fossil localities. These results suggest a strong relationship between paleosol development and faunal composition, and

consistent patterns likely reflect both species interactions and preferences for particular sub-habitats in the ancient environment. Across both pedofacies, small species had highest relative abundances in the mature paleosols of channel-distal settings, while large species were most abundant at an intermediate distance from ancient stream channels, and intermediate-sized species were most abundant in the immature paleosols of channel-proximal areas. At a higher taxonomic level, a basin-wide pattern in community composition was discovered in which localities were dominated either by Equidae or by Hyopsodontidae, with relatively large proportions of Adapidae and Dichobunidae. Those communities dominated by equids were found closest to the ancient stream channels, while those dominated by hyopsodontids, adapids and dichobunids tended to occur farther out on the floodplain.

Neoceti Symposium, Saturday 12:15

THE PHYLOGENETIC POSITION OF PYGMY RIGHT WHALES (MYSTICETI: NEOBALAEINAE): SEPARATE AND COMBINED ANALYSES

CHURCHILL, Morgan, BERTA, Annalisa, San Diego State Univ., San Diego, CA; DÉMÈRE, Thomas, San Diego Natural History Museum, San Diego, CA

One of the most debated issues in mysticete phylogenetics concerns the position of the extant pygmy right whale (*Caperea marginata*), a rare and little known species, and the sole representative of Neobalaenidae. Previous analyses based on morphological data consistently support this taxon as sister to right whales (balaenids), in the clade Balaenoidea. In contrast, molecular data supports a sister relationship with rorquals and gray whales (Balaenopteroidea).

To examine the systematic position of *Caperea*, phylogenetic analyses of mysticetes were conducted using 100 morphological characters and a molecular data set containing published nuclear and mitochondrial gene sequences. Bayesian, parsimony, and maximum likelihood methods of phylogenetic inference were employed. Strong support for Balaenoidea was found in all morphological analyses, although weak support for this relationship was found in parsimony analyses of total evidence and molecular data sets. Weak support for a sister relationship of *Caperea* with balaenopteroids was found using Bayesian and maximum likelihood analyses of molecular data. A Bayesian total evidence analysis resulted in mostly unresolved relationships.

Previous workers have suggested that morphological support for Balaenoidea is due to convergence in feeding styles between balaenids and neobalaenids. To test this hypothesis, characters functionally correlated with feeding were either deleted or given lesser weight in separate phylogenetic analyses. This resulted in a small decrease in support values. The addition or deletion of extant and fossil taxa also had no significant effect on analyses. Characters were also partitioned to examine phylogenetic signal. Strong support for a relationship with balaenids is found in characters of the skull and mandible, while characters of the ear and postcranial skeleton support a sister relationship with balaenopteroids. Long-branch attraction, due to the early and rapid radiation of mysticetes, is the most likely explanation for incongruence in molecular and morphologic phylogenies, although a reliance on skull characters in mysticete systematics may also have a detrimental effect.

Saturday 10:15

A NEW TITANOSAURIFORM SAUROPOD WITH ABUNDANT SKULL MATERIAL FROM THE CEDAR MOUNTAIN FORMATION, DINOSAUR NATIONAL MONUMENT

CHURE, Daniel, Jensen, UT; BRITT, Brooks, GREENHALGH, B., Brigham Young Univ., Provo, UT

The study of sauropods is hampered by a dearth of skulls. Most skulls pertain to Middle and Late Jurassic taxa and the Cretaceous skull record is extremely limited. Here, we here report a new titanosauriform represented by multiple skulls. The specimens were recovered from a fluvial sandstone posited in the middle of the Cedar Mountain Fm., 32 m above the contact with the underlying Morrison Formation. Cranial materials include 1) a spectacularly complete 3-D skull, 2) a nearly complete disarticulated skull, 3) the front one-third of an articulated skull, and 4) a braincase. The skulls were found with associated postcranial elements. This taxon is the best known Cretaceous sauropod for cranial material & has one of the best skull records for the group.

Salient skull characters include an incomplete internarial bar, retracted and confluent external nares, narial fossa absent, quadrate vertical, basiptyergoid processes short, dentary with external mandibular fenestra and retroarticular process, unexpanded tooth crowns, tooth to tooth wear, and low tooth count (4 pmx, 10 max, 13 dent). The cervical centra are long, camellate, and bear elongate ribs spanning three centra. Dorsal rib heads have large pneumatic foramina. The humerus is long and gracile.

Preliminary phylogenetic analysis places this sauropod as a basal titanosauriform. The skull, however, differs markedly from those of basal macronarians (*Camarasaurus*, *Brachiosaurus*, and *Euhelopus*) in 1) lacking a large arching internarial bar, 2) having small, confluent external nares, and 3) lacking a narial fossa. In these features it more closely resembles the skull in diplodocoids and the titanosaurs *Rapetosaurus*, *Nemegtosaurus*, and *Quaesitosaurus*. This suggests that the skull morphology of the basal macronarians is derived and the similarity between diplodocoids and titanosauriforms did not evolve in parallel but instead represents the general skull architecture for the Neosauropoda.

3D Imaging Symposium, Friday 8:15

ANATOMY OF THE VERY TINY: TOMOGRAPHIC INSIGHTS INTO MORPHOLOGY OF EXTINCT AND EXTANT FISHES

CLAESON, Kerin, UT Austin, Austin, TX; LUNDBERG, John, Academy of Natural Sciences, Philadelphia, PA; HAGADORN, Whitey, Amherst College, Amherst, TX

Small size and sparse number of specimens raise difficulties for detailed examination of the skeletal anatomy for several groups of fossil and extant fishes. Comparative morphologic and phylogenetic research on these groups is thus rendered more difficult. Their inclusion is potentially significant for studying central questions of evolutionary biology such as miniaturization.

In an effort to address these problems, we began an investigation of the potential of microfocus X-ray computed tomography (microCT) for resolving osteological details necessary for comparative anatomy and phylogeny studies. The initial phase of this research centered on tiny (<20mm) extant species of catfish *Sarcoglanis simplex* (Siluriformes: Trichomycteridae). Previous analyses of this fish (and others like it) were minimal and described only external and soft-tissue anatomy. CT revealed skeletal morphology never before described without the need to dissect, disarticulate, or otherwise modify rare specimens. Successful microCT analysis on extant fishes prompted examination of fossil taxa of approximately the same size.

The next phase of our research centers on recognition and discussion of the convergent morphologies present in other fishes and fish larvae of approximately the same size. We are examining osteichthyan material from the Eocene (Teleostei), Pennsylvanian (Paleonisciformes), and Devonian (Dipnoi). Each specimen is under 30 mm standard length. Fossil specimens are contained within either limestone, sandstone, or shale matrices. Our preliminary results suggest that microCT provides a useful tool for studying fossil and recent osteology with comparable and complementary data sets.

Thursday 2:45

EVOLUTION OF THE RESPIRATORY APPARATUS AND BREATHING MECHANISMS IN PTEROSAURIA

CLAESSENS, Leon, College of the Holy Cross, Worcester, MA; UNWIN, David, Museum für Naturkunde, Berlin, Germany; O'CONNOR, Patrick, Ohio Univ., Athens, OH

An analysis of the postcranial anatomy of basal and derived pterosaurs, including computed tomography (CT) of three-dimensionally preserved remains of the pterodactylid *Anhanguera santanae*, has identified numerous skeletopulmonary specializations consistent with a model for flow-through ventilation of the lungs, suggesting the capacity for highly efficient gas exchange. Pneumatic postcranial bones in pterosaurs imply the existence of a highly-heterogeneous pulmonary system, with both exchange and nonexchange (i.e., air sacs) regions, similar to that known in extant birds and inferred in saurischian dinosaurs. The absence of intermediate ribs in pterosaurs, including basal forms such as *Eudimorphodon* and derived pterodactylids such as *Pteranodon*, indicates a decrease in the degrees of freedom of movement of the thorax relative to the basal diapsid condition. The structure of the broad sternal ribs, which articulated with relatively immobile vertebral ribs proximally and a large sternal plate ventrally, indicates that the largest volumetric changes during lung ventilation occurred in the posteroventral thoracoabdominal region. Posteroventral volumetric changes are further enhanced by a mobile neomorphic prepubis that articulated with an elongate anteroventral condyle on the puboischiadic plate. CT evidence for the presence of pulmonary air sacs in pterosaurs, combined with estimates of the likely range of expansion and contraction of the posteroventral trunk region, supports a skeletal kinematic model for ventilating a flow-through style pulmonary system, specifically adapted for active flapping flight. Pterodactylid pterosaurs exhibit evidence of further specialization of the respiratory apparatus, including increased fusion within the thoracic skeleton and enhanced postcranial pneumaticity. Such pulmonary specializations likely played a central role in the evolution and diversification of pterosaurs.

Friday 8:45

THE FAUNA OF THE MIDDLE-UPPER JURASSIC SHISHUGOU FORMATION, WESTERN CHINA

CLARK, James, Washington, DC; XU, Xing, Institute of Vertebrate Paleontology and Paleoanthropology, Beijing, China; FORSTER, Catherine, Stony Brook Univ., Stony Brook, NY

Joint expeditions of the Institute of Vertebrate Paleontology and Paleoanthropology, Beijing, and George Washington University from 2001-2005 collected a large number of fossil vertebrates from the Shishugou Formation. As detailed in David Eberth's presentation at this meeting, the Shishugou Formation comprises alluvial and paludal deposits with interbedded tuffs radiometrically dated at 161-159 Ma, spanning the Middle-Upper Jurassic boundary. This suggests that a faunal transition within the formation is related to a dramatic worldwide cooling event at the end of the Middle Jurassic followed by warming in the earliest Late Jurassic.

Our most recent discoveries are mainly from the upper part of the formation at Wucaiwan. These include the oldest known tyrannosaurid, *Guanlong wucai*, represented by two nearly complete skeletons. This crested form pushes the record of this superfamily back to the early Late Jurassic and is one of the oldest coelurosaurs represented by relatively complete skeletons. A second new taxon from Wucaiwan is *Yinlong downsi*, the oldest and most primitive known ceratopsian. *Yinlong* preserves features of both ceratopsians and pachycephalosaurs, providing new evidence for marginocephalian monophyly.

Abundant small crocodyliforms from Wucaiwai represent two taxa of shartegosuchids, and comparison with material from the Late Jurassic Morrison Formation of Colorado demonstrates that it is also referable to this family.

Neoceti Symposium, Saturday 9:00

STABLE ISOTOPE EVIDENCE FOR THE EVOLUTION OF DIFFERENT FEEDING STRATEGIES WITHIN THE NEOCETI

CLEMENTZ, Mark, Univ. of Wyoming, Laramie, WY; FOX, David, EDWARDS, R., Univ. of Minnesota, Minneapolis, MN

The Eocene-Oligocene transition marks a major advance in cetacean evolution with the appearance of the earliest representatives of each of the modern groups of cetaceans, the Mysticeti and the Odontoceti. These two groups diverged rapidly during the Oligocene, adopting two distinct styles of feeding: mysticetes became bulk feeders, filtering plankton and small fish from seawater, whereas odontocetes adapted to locating and ingesting individual prey items including fish, squid, and other marine mammals. To determine when this divergence in feeding strategy occurred within the Neoceti, we have begun analysis of two complementary stable isotope systems preserved within cetacean bio-apatite: carbon isotopes ($\delta^{13}\text{C}$) as a measure of nearshore vs. offshore foraging and calcium isotopes ($\delta^{44}\text{Ca}$) as a measure of trophic level within marine food webs. Extant cetaceans foraging in offshore foodwebs typically have lower $\delta^{13}\text{C}$ values (<-10‰) than nearshore foragers (-9.0‰) as a result of differences in the mean $\delta^{13}\text{C}$ values of primary producers in nearshore and offshore foodwebs. Analysis of $\delta^{44}\text{Ca}$ in modern cetacean bioapatite has found that species foraging at lower trophic levels yield values that are up to 2‰ greater than those for species foraging at much higher trophic positions.

We have sampled enamel and bone from late Eocene archaeocetes and Oligocene odontocetes and mysticetes (both toothed and baleen-bearing species) for C and Ca isotope analysis. Archaeocete $\delta^{13}\text{C}$ values (~-8.0‰ VPDB) are typically enriched in ^{13}C relative to later occurring neocetes, which shows that earlier, more basal whales were foraging in nearshore habitats and suggests that offshore foraging may not have evolved until after the divergence of Neoceti. Calcium isotope results from archaeocetes and Oligocene mysticetes are pending, but values for fossil odontocetes are extremely low (~-2.0‰) and comparable to values for extant species, supporting use of $\delta^{44}\text{Ca}$ values as a proxy for trophic level within ancient marine foodwebs. When combined with the $\delta^{13}\text{C}$ results, $\delta^{44}\text{Ca}$ values provide a powerful tool for examining the evolution of cetacean dietary preferences and feeding strategies through time.

Saturday 9:00

SALTATORY ONTOGENY AND DEVELOPMENTAL MODULARITY IN THE LATE DEVONIAN OSTEOLEPIFORM *EUSTHENOPTERON FOORDI*

CLOUTIER, Richard, LEBLANC, Joël, Université du Québec à Rimouski, Rimouski, QB, Canada

Recent evidences suggest that the early development in living fishes is characterized by alternate periods of steady steps and rapid thresholds giving a saltatory ontogenetic trajectory. Such trajectories can be inferred based on sequences of ossification in living and extinct vertebrates. In addition, these developmental sequences provide empirical data to identify developmental patterns and processes (e.g., phenotypic modularity). Direction of ossification within anatomical systems (e.g., paired and median fins) has been used to describe patterning modules. The presence of all appendicular and axial bony elements (ca. 350 structures excluding the lepidotrichia) of the Late Devonian osteolepiform *Eusthenopteron foordi* (Miguasha, eastern Canada) were recorded for 65 specimens ranging from 27 to 270 mm in standard length. Different directions of ossification have been inferred for the appendicular skeleton: distal to proximal (all fins), posterior to anterior (pectoral and second dorsal fins), anterior to posterior (pelvic and anal fins), and bidirectional (caudal fin). The general pattern of ossification shows a saltatory ontogeny [i.e., sequence of steady steps (slow) and rapid thresholds (accelerated development)]. The first threshold (standard length of 42 mm) is associated with the formation of the "dorsal + anal fins" and "caudal fin" modules as well as the branching of the lepidotrichia (ossification of the posterior propulsive system). The second threshold corresponds to the ossification of the anterior part of vertebral column (standard length of 160 mm). Recent actinopterygian developmental modules (positioning and patterning) were recognized in a Late Devonian sarcopterygian (*E. foordi*). However, differences of ossification patterns in the paired and median fins suggest co-option or dissociation of modularity.

Poster Session II

A COMPLETE SKULL OF *ALLODAPUSUCHUS PRECEDENS* NOPCSA, 1928 (EUSUCHIA) AND A REASSESSMENT OF THE MORPHOLOGY OF THE TAXON BASED ON THE ROMANIAN REMAINS

CODREA, Vlad, Universitatea Babeş-Bolyai, Cluj Napoca, Romania; FOLIE, Annelise, SMITH, Thierry, Institut Royal des Sciences Naturelles de Belgique, Bruxelles, Belgium; DELFINO, Massimo, Università di Firenze, Firenze, Italy

A new eusuchian skull from the Maastrichtian locality of Oarda de Jos in the southwestern Transylvanian Basin of Romania represents the best-preserved known specimen of *Allodaposuchus precedens* Nopcsa, 1928. These new remains allows us to clearly characterize the *A. precedens* skull morphology and to exclude, as recently suggested, that such taxon could be considered a nomen dubium. The parsimony analysis confirms earlier phylogenetic hypotheses based on the fragmentary holotype from the Maastrichtian of Valioara

in Hateg Basin (Romania) as well as on putative conspecific remains from approximately coeval localities in Spain and France: *A. precedens* is the sister taxon of the crown-group Crocodylia. However, some relevant morphological traits differ from what was previously reported for this taxon: the external naris is large and antero-dorsally directed; the lateral profile of the skull is not festooned in dorsal view; the suborbital fenestrae reach the eight alveolus; the postorbital bars are lightly built and inset from the jugal margin; the skull table is approximately planar or medially concave; the skull table does not markedly overhangs the supratemporal fenestrae; the exoccipitals are not significantly involved in the basioccipital tubera. Since the condition of most of these characters, unknown in the holotype, was previously evaluated on non-Romanian remains only, the morphological discrepancies between Romanian and western European fossil could suggest the presence of different taxa, possibly of infra-generic rank. *Allodapo-suchus* and presumably *Hylaeochamps* are the only Eusuchians showing a laterally open cranioquadrate passage.

Friday 12:15

THE VERTEBRATE SKULL AS HABITAT FOR INVERTEBRATE ANIMALS

COLBERT, Matthew, EKDALE, Eric, Univ. of Texas, Austin, TX; EKDALE, Allan, Univ. of Utah, Salt Lake City, UT

The confined cavities and passageways within vertebrate skulls represent a unique sedimentary environment. These limited spaces not only constrain the deposition of sediment but also constrain subsequent sediment modification by bioturbating organisms and diagenetic agents. High-resolution X-ray CT scanning (HRXCT) provides a method for non-destructive investigation of these cryptic features, allowing access to a hitherto unexplored aspect of vertebrate taphonomy. Here, we focus on the use of the vertebrate skull as a habitat exploited by invertebrate organisms. The presence of these invertebrates is inferred by the ichnofabric of traces that they leave when passing through the sediment. Analysis of these traces testifies to the often-complicated history of vertebrate animals after death and burial.

The use of the skull as habitat by invertebrates is illustrated here with several fossils that were recovered from terrestrial and marine depositional settings. We focus on the skull of a Cretaceous chelonoid turtle from the marine Bearpaw Formation of Alberta, Canada. While thorough bioturbation has obliterated any primary sedimentary features within this skull, HRXCT data reveal a complex ichnofabric that includes the following ichnotaxa: *Zoophycos*, *Chondrites*, *Planolites*, and possibly *Taenidium* and *Arenicolites*. Taking advantage of the three-dimensional nature of the CT data, we isolated several of these traces revealing irregularly restricted, or stenomorphic morphologies—a consequence of their confining habitat. The distribution of these traces is reminiscent of the tiering of ichnofaunas that has been documented in other marine environments, and indicates the complexity of the ichnofabric. This ichnofabric, in conjunction with the confined setting, has influenced subsequent diagenetic cementation as indicated by X-ray attenuation. This illustrates the forensic potential of CT analysis for not only documenting the postmortem use of the skull by invertebrates, but also for revealing diagenetic aspects of fossilization and preservation.

Poster Session III

CHEMICAL ANALYSES OF RATITE BONE COMPOSITION: A BASELINE FOR COMPARISON TO THEROPOD FOSSILS

COLLIER, Timothy, North Carolina State Univ., Lucama, NC

As the extant taxon most closely related to dinosaurs, birds are commonly used to test many hypotheses regarding dinosaurian biology, including biomechanics, growth, and physiological strategies, including reproductive physiology. Ratites (ostriches, emus) are the most primitive extant avian taxon, and share more characteristics with dinosaurs than do more derived groups. Even though ratites are the most appropriate model for most aspects of dinosaur biology, there is a paucity of data, particularly biochemical data, relating to many of these characteristics. The goal of this study is to characterize chemical differences between medullary (reproductive) and compact bone tissues in ratites. Medullary bone is a gender-specific, highly vascular, well mineralized tissue, deposited on the endosteal surface of long bones only during ovulation. In galliformes (chickens, quails), the group for which most data exist, medullary has been shown to be biochemically distinct from compact and trabecular bone, but similar studies have not been conducted in ratites. We will apply Nuclear Magnetic Resonance Spectroscopy (NMR), Fourier Transform Infrared Spectroscopy (FTIR), immunological assays, and differential histochemistry (High-Iron Diamine, HID), to identify chemical components unique to medullary bone tissues of ratites. The presence of morphologically similar reproductive bone tissues in a well preserved *Tyrannosaurus rex* suggests the possibility of retrieving biochemical data for direct and objective comparison of non-avian theropods and extant birds.

Wednesday 8:45

A COMPLETE CRETACEOUS IGUANIAN (SQUAMATA) FROM THE GOBI

CONRAD, Jack, NORELL, Mark, American Museum of Natural History, New York, NY

We describe a new Cretaceous iguanian from the Mongolian Gobi Djadokhta Formation. The new taxon is the earliest known complete skeleton of an iguanian and offers important insights into the historical skeletal morphology of Iguania. The only known specimen (IGM 3/858) is an articulated skeleton missing only parts of the right limbs, the distal pedal phalanges, and tail tip. IGM 3/858 is diagnosed by a combination of character states including the presence of a frontoparietal fontanelle, absence of enlarged *M. spinalis capitis* fossae, and absence of flared tooth crowns, among others. We performed a phylogenetic analysis

including 39 iguanian terminal taxa, 14 scleroglossans, and the outgroup Rhynchocephalia, scored for 202 informative morphological characters. A strict consensus of the 46 shortest recovered trees reveals an endemic clade of five Cretaceous Gobi iguanians (including IGM 3/858) diagnosed by strong medial processes of the maxillae, a weakly inclined maxillary nasal process, medially forked postfrontal, mediolaterally elongate prefrontal, and absence of a dorsal process of the squamosal.

Our phylogenetic hypothesis places the Gobi clade in a nested position within Pleurodonta (Iguanidae *sensu lato*). This result is important because 1) most extant pleurodontan radiations are primarily or exclusively North or South American; 2) exclusively fossil radiations of iguanians were previously limited to the acrodontan group Priscagamidae; 3) the new clade possesses plesiomorphic features unexpected in a nested pleurodontan clade. These data offer new insights into the paleobiogeography of iguanians, indicate a more complex story of character evolution, and suggest the appearance of numerous radiations of pleurodontans before the end of the Cretaceous.

Wednesday 12:15

PLESIOSAUR TAPHONOMY—FEEDING BEHAVIOURS AND STERNAL BASKETS

COOK, Alex, Queensland Museum, South Bank, Australia; McHENRY, Colin, Univ. of Newcastle, Callaghan, Australia; WROE, Stephen, Univ. of New South Wales, Sydney, Australia; EVANS, Mark, New Walk Museum, Leicester, United Kingdom

Despite the importance of plesiosaurs in Jurassic and Cretaceous marine ecosystems, their ecologies remain much debated. How did long-necked plesiosaurs use their extraordinary neck in catching food? Were gigantic plesiosaurs capable of consuming truly large prey, or were they restricted to prey small enough to swallow whole?

Taphonomic and trace fossil evidence provide an invaluable complement to morphology-based interpretations. Plesiosaur fossils from Lower Cretaceous deposits of Great Artesian Super Basin (GASB), Australia, are commonly preserved with stomach contents. Many specimens referable to Elasmosauridae preserve gastroliths with exotic provenance, suggesting that they travelled some distance to obtain stomach stones. Elasmosaurids are usually described as nekton feeders, but preservation of hard shelled benthic prey in two GASB specimens suggests that gastroliths may have had important digestive benefits, and that elasmosaurid diets were broader than has been supposed.

Two *Kronosaurus* contain marine reptile remains, confirming that these plesiosaurs were apical predators. The presence of a c. 1 tonne plesiosaur in one suggests that they could eat prey too large to be swallowed whole and were capable of shake or twist feeding.

Taphonomic evidence can also throw light upon basic questions regarding plesiosaur functional anatomy. The arrangement of the limbs, with two pairs of large hydrofoils providing thrust for swimming, is unique and thus there has been no consensus on the functional morphology of the limb, girdle, and trunk regions. Most reconstructions assume that plesiosaurs lacked a sternum, but the Nicholls and Russell model argues the presence of a sternal basket based upon ontogenetic, functional and comparative phylogenetic evidence. Taphonomic and morphological evidence from a number of plesiosaur families is consistent with this model, further suggesting that an assumption of absence of a sternum in plesiosaurs is problematic. The Nicholls and Russell model has important but relatively unexplored implications for the functional morphology of the plesiosaurian pectoral girdle.

Student Poster Session

UPPER CRETACEOUS SELACHIAN FAUNA FROM THE KASKAPAU FORMATION NEAR WATINO ALBERTA CANADA

COOK, Todd, Univ. of Alberta, Edmonton, AB, Canada

Due to the poor preservation of the cartilaginous endoskeleton, the chondrichthyan fossil record largely consists of isolated teeth, dermal denticles, spines, and calcified vertebrae. An assemblage of selachian teeth has been produced at three localities on the banks of the Smoky River, near Watino in the northwestern region of Alberta, Canada. The fossil dentitions are found in a sandstone matrix derived from the lowest beds of the Kaskapau Formation and are of early Turonian age. During this time, the Western Cretaceous Interior Seaway was in a transgression phase and the Watino site would have been situated along its western margin.

A previous study of the Watino assemblage yielded a rich abundance of actinopterygian fish fossils including *Ichthyodectes*, *Apateodus*, *Cimolichthys*, *Belonostomus*, *Enchodus* and *Dercetidae*. The chondrichthyan fauna of this assemblage is just as diverse. To date, the selachian taxa include *Hybodus* sp., *Ptychodus decurrens*, *Carcharias amonensis*, *Scapanorhynchus raphiodon*, *Johnlongia parvidens*, *Archeolamna kopingensis*, *Cretalamna appendiculata*, *Cretoxyrhina mantelli* and *Squalicorax falcatus*.

These species represent the first reported occurrence within the Kaskapau Formation. It is also the first description of *Ptychodus decurrens*, *Carcharias amonensis*, *Scapanorhynchus raphiodon*, *Johnlongia parvidens*, *Cretalamna appendiculata*, *Cretoxyrhina mantelli* and *Squalicorax falcatus* from the province of Alberta. As such, this assemblage represents the most northern described selachian fauna of the Western Cretaceous Interior Seaway.

Neoceti Symposium, Saturday 8:15

HETEROCHRONY IN GENE EXPRESSION IN EOCENE AND OLIGOCENE CETACEANS

COOPER, Lisa, THEWISSEN, J.G.M, NEOUCOM, Rootstown, OH

Most mammals have a generalized phalangeal formula with two phalanges in the thumb and three in the remaining digits. Cetaceans are different and have more than three phalanges per digit (hyperphalangy). The functional reasons for evolving hyperphalangy are unknown. These reasons are probably unrelated to simple digit elongation, as bats have greatly elongated fingers, but are not hyperphalangeous. Fossil evidence shows that Eocene archaeocetes have normally patterned forelimbs, but hyperphalangy evolved during the Oligocene. Surprisingly, cetacean dentition also lost standard patterning during this time, giving rise to homodonty and polydony in toothed whales, and baleen in some whales. These dental and phalangeal pattern changes may have been caused by altering the timing of expression of a developmental switch. Studies of gene expression during dolphin embryogenesis indicate that at least one protein, *fgf-8*, is active during dental and forelimb development. Specifically, it appears that the protein *fgf-8* is expressed while the forelimb bud is projecting from the body wall up to the first or second month of gestation. *Fgf-8* expression probably ceases as patterning of the digital rays, and subsequent digit elongation begins, unlike the generalized mammalian pattern, suggesting that heterochronic changes in timing of expression took place.

Poster Session III

LEPTOTRAGULINE DIVERSITY IN THE MIDDLE EOCENE UINTA FORMATION, UTAH

COPE, Dana, College of Charleston, Charleston, SC; TOWNSEND, K, School of Medicine, Case Western Reserve Univ., Cleveland, OH

Leptotraguline artiodactyls are among the most abundant elements of the fossil mammal assemblage from the Uinta Formation. The two leptotragulines from this region, *Leptoreodon* and *Leptotragulus*, are known mainly from dental remains. Both taxa exhibit very similar molar morphologies yet are only distinguished at the generic level by differences in the lower P4. Because their molars are often not associated with lower premolars, most leptotraguline molars have been catalogued as *Leptotragulus*, leaving the impression that *Leptoreodon* is a rare species.

In this study, we evaluated molar characters for both *Leptotragulus* and *Leptoreodon*. We evaluated leptotraguline specimens with molars (N=48), most catalogued as *Leptotragulus*. Molar specimens of *Leptoreodon* were identified by an associated lower P4 that exhibits a sharp crest running the entire length of the tooth, small rather than bulbous cusps and a vertical rather than horizontal, lingual "talonid". Two distinct molar morphs (A and B) were observed. In morph A, the cristid obliqua does not merge with the proto-cristid but instead curves back toward the entoconid. In morph B, the proto-cristid and cristid obliqua do merge near the metaconid and form a "bridge" linking the trigonid and talonid. Upper molars present an analogous dichotomy. In morph A, the postprotocrista and prehypocrista do not merge, in morph B they do. In specimens with more than one molar we found no cases where they did not appear as the same morph. With one exception, in 16 cases with associated molars and lower P4s, morph A is found in *Leptotragulus* and morph B is found in *Leptoreodon*. In the total sample there were only five cases where specimens could not be placed in this simple dichotomy. Although still less common than *Leptotragulus*, our results indicate that *Leptoreodon* was by no means a rare taxon.

Poster Session I

TWO NEW MANDIBLES OF *RANGWAPITHECUS GORDONI* FROM THE EARLY MIOCENE OF WESTERN KENYA

COTE, Susanne, Harvard Univ., Cambridge, MA; NENGO, Isaiiah, DeAnza College, Cupertino, CA

Rangwapithecus is an enigmatic and poorly known Early Miocene catarrhine. Originally named as a subgenus of *Proconsul*, *Rangwapithecus* is now regarded as a separate genus. Features that distinguish *Rangwapithecus* from all other Miocene catarrhines, including *Proconsul*, are the presence of mesiodistally elongated molars with long shearing crests, and an elongated p4. The only species, *Rangwapithecus gordonii*, is known from a single locality: Songhor in Western Kenya. Songhor is located in the Kapurtaay Agglomerates and is radiometrically and biostratigraphically dated to between 19 and 20 Ma.

Here, we report two new mandibles that we assign to *Rangwapithecus gordonii*: KNM SO 22228 from Songhor; and KNM KT 31234 from a new locality, Lower Kapurtaay. Lower Kapurtaay is located two kilometers from Songhor and is thought to be roughly contemporaneous with the main Songhor deposits. Both sites are located in the same geological formation (the Kapurtaay Agglomerates), and show no obvious differences in their faunal assemblages.

These new mandibles add substantially to our knowledge of the paleobiology of *Rangwapithecus gordonii*. First, they provide additional details on the mandibular morphology of *R. gordonii*. For example, the mandible does shallow posteriorly, but to a lesser degree than *Proconsul africanus*. Second, they permit improved identification of isolated teeth previously assigned to *Rangwapithecus* and *Proconsul*—particularly the canines. Third, they demonstrate that *Rangwapithecus gordonii* is significantly more sexually dimorphic than had previously been assumed. KNM SO 22228 is inferred to be female, while KT 31234 is male. The canine of KNM SO 22228 is much smaller than those previously identified as *Rangwapithecus* female canines. Fourth, they provide further details on the degree

of intraspecific variation in size and morphology present in *Rangwapithecus gordonii*. In particular, KNM KT 31234 shows interesting differences from other male *Rangwapithecus* mandibles including an uncharacteristically short P4. It also demonstrates that there is significant variation in male canine size, though not beyond the range of variation seen in modern catarrhine species.

Poster Session II

PHOSPHATE OXYGEN ISOTOPIC VARIATION IN MARINE TURTLE BONES AND ITS POTENTIAL ECOLOGICAL UTILITY

COULSON, Alan, Univ. of South Carolina, Columbia, SC

While stable isotope analyses of vertebrate fossils can provide paleoecologic information, it is important to first study modern analogs to better understand how the isotopic composition can vary within a living animal in order to avoid erroneous data interpretation. To this end, the oxygen isotope content of modern marine turtle bone is being studied to assess the utility of fossil marine turtle bone geochemistry for paleoenvironmental reconstruction. Phosphate oxygen has been the focus of analysis; given the strength of the phosphorous-oxygen bond, it offers the best chance for preservation of the original isotopic content of bone.

In accordance with CITES regulations, samples were taken from deceased loggerheads (*Caretta caretta*) and leatherbacks (*Dermodochelys coriacea*) and are being analyzed to better understand how the bone phosphate oxygen isotopic signal varies within both a population and an individual animal. Preliminary data indicate that samples taken from bones near the body core of sub-adult and adult individuals may record the average seawater isotopic value experienced during bone growth, similar to the correlation found between the bone phosphate oxygen of certain non-marine turtle taxa and their ambient water. Variation in the data between distal and proximal skeletal elements may result from temperature gradients along the extremities. Different isotopic values between large- and small individuals within a population may reflect differences in body water turnover rate or thermoregulatory capability. More data is forthcoming to test these hypotheses.

Wednesday 5:15

THE EARLY MIOCENE CHUCAL FAUNA, NORTHERN CHILE: NEW SPECIMENS AND A DESCRIPTION OF ITS XENARTHANS

CROFT, Darin, Case Western Reserve Univ., Cleveland, OH; WYSS, André, Univ. of California—Santa Barbara, Santa Barbara, CA; BURNS, Megan, Case Western Reserve Univ., Cleveland, OH; FLYNN, John, American Museum of Natural History, New York, NY; GRANA, Susan, Illinois Wesleyan U., Bloomington, IL

The late early Miocene Chucal Fauna of the Chilean Altiplano is the northernmost fauna referable to the Santacrucian South American Land Mammal "Age." Located ca. 30° north of classic Patagonian Santacrucian localities, it presents a unique opportunity to examine South American provinciality during this interval. Presently, only the endemic ungulates of Chucal (Notoungulata and Litopterna) have been described in detail. We here describe the xenarthans and discuss other important new specimens recovered during our most recent (2004) field season.

Xenarthans are uncommon at Chucal and include only three cingulates (armored forms); in contrast, cingulates and pilosans (sloths) are speciose and abundant in contemporaneous Patagonian localities. Glyptodontid specimens, almost certainly from the same individual, include a mandible, partial carapace, and articulated limb bones. The species is unique among glyptodontids in having a complex, imbricated anterior mandibular dentition (n1-3) and a carapace with relatively large central figures positioned along the posterior edge of each osteoderm. A dasypodid roughly the size of the diminutive *Prozaedyus* (Euphractini) is represented by several fragmentary specimens. It most closely resembles, but is much smaller than, *Stenotatus* (Eutatini) from Patagonia; its osteoderms bear three distinct longitudinal ridges and a distal row of prominent piliferous pits. Two isolated peltephilid osteoderms do not differ significantly from Patagonian *Peltephilus*. The large proportion of novel cingulates at Chucal (67%) and the apparent absence of sloths suggest a marked regional endemism during the early Miocene.

Specimens collected in 2004 provide abundant additional material of the oldest known chinchilline rodent and document at least three previously unrecorded species: a small rodent (*Acarechimys*); a tiny caenolestoid (?pichipiline) marsupial; and an anuran, the first Tertiary amphibian known from Chile, represented by at least two partial skeletons. The mammal fauna presently includes seven notoungulates, one litoptern, at least four rodents, three cingulates, at least one marsupial, and one tiny indeterminate species.

Poster Session II

UPPER PLEISTOCENE *PLIOMYS LENKI* (RODENTIA, MAMMALIA) IN IBERIA: A TALE OF FLICKERING EXTINCTION

CUENCA-BESCÓS, Gloria, Univ. of Zaragoza, Zaragoza, Spain; GONZÁLEZ-MORALES, Manuel, Univ. of Cantabria, Santander, Spain; BARCO, Juan, Zaragoza Univ., Zaragoza, Spain; STRAUS, Lawrence, Univ. of New Mexico, Albuquerque, NM

Beside Neandertals, other mammal species vanished locally or totally in Europe during a short period—an instant in the geological time scale—between about 40-17 ky BP. They did not disappear suddenly, but rather in waves of local withdrawals, Lazarus effect, that ultimately led them to final extinction. A good example is in the sequence in El Miron (Cantabria, North Spain), that yields a rich rodent collection, well ¹⁴C-dated, representing the time span of the middle upper Pleistocene (UP) through the mid-Holocene (41-2 ky BP).

In El Miron, we can trace the extinction history of *P. lenki*, an arvicoline rodent that persisted in Iberia after its extirpation in the rest of Europe at the beginning of the UP. An initial disappearance from the El Miron occurs just above a level (L) in which it is relatively well represented (late Mousterian, L130, 41 ky BP) and coincides with a faunal turnover (post-Mousterian, L128, 27 ky BP, and above) that also (presumably) includes the disappearance of the Neandertals in North Spain. The Lazarus effect is detected between El Miron levels 130-120, with *P. lenki* reappearing again in L120, dated between 17-19 ky BP. Then it went extinct. Mousterian localities with Neandertals outside of Cantabria do have *P. lenki*, though in lesser frequencies. As in Cantabria, the species disappears for a short period, but then reappears in post-Mousterian times dated to roughly 20 ky BP. For the moment, there is no record of this species in younger levels, thus indicating that its extinction did take place around this time. This in turn seems to suggest that conditions adequate for *P. lenki* existed at least in some areas of Iberia (although not in other regions of Europe) during the mid UP. The harsh conditions of late MIS3—early MIS2 probably forced its local, step-wise extirpation in anticipation of its final extinction. Something similar may have happened to the Neandertals some 10,000 years earlier.

Poster Session II

THREE-DIMENSIONAL RECONSTRUCTION OF THE SKULL OF *RAPETOSAURUS KRAUSEI* (SAUROPODA: TITANOSAURIA)

CURRY ROGERS, Kristina, Science Museum of Minnesota, St. Paul, MN; HERTEL, Janice, Research Casting International, Beamsville, ON, Canada; GROENKE, Joe, SUNY Stony Brook, Stony Brook, NY

Rapetosaurus krausei, a titanosaur from the Late Cretaceous Maevarano Formation of Madagascar is known from a sample of cranial and postcranial material. The holotype adult skull (UA 8698) includes paired and single elements that articulate precisely along sutural margins, and represent the rostrum, mandible, and basicranium. A referred juvenile skull (FMNH PR 2184-2192, 2194, 2196, 2197, 2209, 2210) preserves elements from the braincase and cranial vault, as well as isolated teeth, which also articulate precisely. Both skulls preserve pterygoids, basioccipital and paroccipital processes, quadrates, surangulars, and teeth, all of which share autapomorphies that distinguish *Rapetosaurus*. A 3-D reconstruction of the skull of *Rapetosaurus* proves challenging given the ontogenetic variation in preserved bones and the lack of most contralateral elements in either skull. Here we utilize 3-D laser scanning and rapid prototype printing to clarify *Rapetosaurus* cranial morphology through three-dimensional reconstructions of juvenile and adult skulls.

Each of the *Rapetosaurus* elements were rendered with a Minolta Vivid 9i non-contact 3-D digitizer and Polyworks 9.1.6 software, and printed with a ZPrinter 310 rapid prototype printer. The point cloud manipulation software allowed us to compare the same bones in juveniles and adults in the same three dimensional space, digitally compare articulations, mirror scans to print missing contralateral elements, and digitally scale elements to fit each skull. The percentage of size change observed in overlapping bones (e.g., surangular, quadrate) informed the scaling of printed elements. Juvenile bones were scaled up by ~200% for articulation with preserved adult elements, and adult bones were scaled down by ~50% to articulate with preserved juvenile elements. In the final reconstructions of the skulls, prints were articulated, and only the articular, quadratojugal, postorbital, and premaxilla were sculpted. The articulated *Rapetosaurus* skulls indicate that the rostrum is "stepped," the external nares are more laterally positioned, and the expanded antorbital fenestra is proportionally closer to those of other macronarians.

Marine Reptiles Symposium, Wednesday 5:30

A NEW PLIOPATECARPINE MOSASAUR (SQUAMATA: MOSASAURIDAE) FROM THE PIERRE SHALE (LOWER CAMPANIAN) OF SOUTHWEST MANITOBA

CUTHBERTSON, Robin, MALLON, Jordan, CAMPIONE, Nicolas, Carleton Univ., Ottawa, ON, Canada; HOLMES, Robert, Canadian Museum of Nature, Ottawa, ON, Canada

A new species of mosasaur from the Lower Campanian (Pembina Member, Pierre Shale Formation) of southwestern Manitoba is described. It shares with *Platecarpus tympaniticus* the following derived feature: a square median extension of the anterior margin of the parietal that invades the posterior margin of the frontal, resulting in a frontoparietal suture of distinctive configuration; and the following primitive features: a ventral quadrate condyle with a transversely oval outline, a pointed suprastapedial process, a long premaxillo-maxillary suture that terminates dorsally directly above the gap between the second and third maxillary tooth, and an anterodorsally directed ilium. With *Plioplatecarpus*, the new taxon shares the following derived features: a robust humerus, a rectangular preorbital frontal shield, a "peg in slot" postorbitofrontal-jugal articulation, a transversely directed ectopterygoid process of the pterygoid, a robust quadrate, an unossified gap in the ventral wall of the basioccipital, and at least 11 pygal vertebrae. Features of the new taxon apparently intermediate between *Platecarpus* and *Plioplatecarpus* include a scapula similar in shape to that of *Plioplatecarpus*, but approximately the same size as the coracoid, a moderately large parietal foramen that reaches the frontoparietal suture, but does not invade the frontal, an incipient process of the maxilla that wraps medially around the base of the posterior premaxillary tooth, and rib shafts with a proximally circular cross section. Although the new taxon is clearly a plioplatecarpine mosasaur close to the *Platecarpus-Plioplatecarpus* clade, it cannot be accommodated in either genus as presently diagnosed.

Poster Session II

FOOTPRINT MORPHOLOGY AND BIOMECHANICS OF SMALL ORNITHISCHIAN DINOSAUR ICHNOGENUS *ANOMOEPIUS* FROM THE LOWER JURASSIC OF WESTERN MASSACHUSETTS

DALMAN, S., Univ. of Massachusetts, Chicopee, MA

Multiple trackways of small ornithischian dinosaurs belonging to the ichnogenus *Anomoeopus* were discovered in the Lower Jurassic (Hettangian) deposits of the East Berlin Formation on private land belonging to Gary Gaulin, a resident of Holyoke, MA. This new material consists of 11 *in situ* trackways in close proximity to each other, and 28 slabs containing small footprints and manus impressions associated with the trackways. The trackways display excellent preservation of digital pad impressions, and claw marks are discernible in some tracks. These features allow reconstruction of the pedal digits and metatarsal parts by applying osteometric analysis.

The footprints provide evidence for various locomotory behaviors in possibly juvenile, small ornithischian dinosaurs. Metatarsal and manus imprints suggest unusual quadrupedal walking in 7 trackways. The longest trackways, which consist of 10-15 pes impressions, represent variations in footprint morphology in the presence of impressed distal parts of metatarsals four and two.

The repertoire of locomotory behaviors represented in these trackways lays the groundwork for future research on small ornithischian dinosaurs. In particular, future work will address the importance of substrate effect on locomotory behavior as shown by the various body weight distributions on pes digits. These differences are detectable in the longest trackways with various stride and pace lengths. Additionally, the proximity of the trackways to one another provide possible evidence of grouping behavior previously unrecorded for the ichnogenus *Anomoeopus* from the Connecticut Valley.

Poster Session I

***ALLOSAURUS* AND OTHER THEROPODS OF THE DRY MESA QUARRY (UPPER JURASSIC, MORRISON FORMATION), COLORADO**

DANGERFIELD, Anne, BRITT, Brooks, SCHEETZ, Rodney, Brigham Young Univ., Provo, UT

In addition to an array of sauropod and ornithischian dinosaurs, the Dry Mesa (DM) assemblage includes 1203 theropod elements pertaining to *Allosaurus* (MNI 13, 62% of the theropod fauna), *Ceratosaurus* (MNI 3, 14%), and *Torvosaurus* (MNI 2, 10%), with *Coelurus*, *Stokesosaurus* and *Marshosaurus* (MNI 1) each comprising 5% of the theropod fauna.

Two species of *Allosaurus* are recognized in the Morrison Fm., *A. fragilis* and *A. jimmadseni*. Based on skull morphology, the only allosaur present at DM is *A. jimmadseni*, with femora ranging in size from ~120 to 960 mm (average length = 702 mm). By contrast, the *Allosaurus* femora at the Cleveland Lloyd Dinosaur Quarry (CLDQ) average 502 mm.

At DM, the theropod bones are loosely associated, with substantial overlap of individual scatters, making it difficult to assign bones to a specific individual. The most complete associated skeleton pertains to a very large *Allosaurus* consisting of a cranium, caudal vertebrae, scapacoracoid, and hind limbs (femur length = 960 mm).

The dominant taphonomic features of the theropod elements are insect foraging traces, which occur on 11% of the bones and consist of circular shallow pits 0.5-13mm wide and 5mm deep. The pits occur in small groups, massive clusters, and lineations, and are most common on limb, ventral pelvic, and elongate bones such as ribs and metapodials. The traces show no affinity for specific taxa.

No other quarry preserves such a wide range of *Allosaurus* ontogenetic stages. It is noteworthy that only one species, *A. jimmadseni*, is present at DM, and *A. fragilis* is the only identified species at CLDQ. Although these two quarries represent an impressive *Allosaurus* sample, neither quarry contains both species, suggesting an ecological or temporal separation.

Poster Session II

ASSEMBLING AN ARCHIVAL MARKING KIT FOR PALEONTOLOGICAL SPECIMENS

DAVIDSON, Amy, ALDERSON, Samantha, American Museum of Natural History, New York, NY; FOX, Marilyn, Yale Peabody Museum of Natural History, New Haven, CT

Will the number you put on your specimen, its tag, box or other housing, be legible in one hundred years? Is it rub-proof, water-proof, fade-proof? Will a future worker be able to remove it if necessary?

This poster will present a plan for assembling an archival marking kit, adapted for fossils from a similar kit for anthropological objects. Having a well-designed kit saves time and can help improve and standardize marking practices. The proposed kit includes a variety of high quality materials, including India ink, acrylic paint, Acryloid/Paraloid B72 in a convenient nail-polish bottle and also in a tube, Japanese and archival papers, Bristol board and various dispensers, brushes, pens, etc. Possible additions to the kit (such as disposable pens) will be discussed.

Even the best materials can fail if not used well! This poster illustrates marking failures and solutions for problematic fossil surfaces (dark, rough, friable, very small or fragile, etc.) and problematic materials such as coated surfaces and plastics. Also included are a discussion of permanence and removability, looking both at the materials included in the kit and others that could be used or have been used in the past.

Friday 2:30

REEXAMINATION OF THE NORTH AMERICAN PROBOSCIDEAN DATUM USING FAUNAL SIMILARITY ANALYSIS

DAVIS, Edward, Univ. of California Berkeley, Berkeley, CA; PROTHERO, Donald, Occidental College, Los Angeles, CA; HOPKINS, Samantha, National Evolutionary Synthesis Center, Durham, NC

The "Proboscidean Datum" was proposed as a marker of the late Barstovian (middle Miocene, about 14.5 Ma) in North America. Subsequently, a number of pre-late Barstovian proboscidean fossils have been reported, casting doubt on the validity of the Proboscidean Datum. The oldest of these is the late Hemingfordian Massacre Lake local fauna of north-west Nevada, which produces a single proboscidean tooth fragment. Magnetic stratigraphy conducted on these beds places them within earliest Chron C5Br (16.4-17.3 Ma). In addition, a number of other early Barstovian magnetostratigraphic sections with Proboscidea date between 15.8 and 16.2 Ma. We used the Morisita index of ecological similarity to compare late Hemingfordian and early Barstovian sites with Proboscidea to sites from this interval without Proboscidea. Our results suggest that the early occurrences are simply the first places colonized by the immigrating proboscideans and are not united by paleoecology or taphonomic history. This pattern is unexpected because the ecology of extant proboscideans suggests that these animals would diffuse across the landscape to all suitable habitats in a geologically instantaneous interval; this is why proboscideans were initially considered a good biochronological marker for North America. Sampling biases may be involved, but such large taxa are usually not overlooked in mammalian fossil assemblages. A more likely explanation is that the middle Miocene proboscidean taxa that invaded North America were not ecologically as similar to their modern relatives as previously thought. Something about these animals stretched their spread across the continent over almost two million years.

Vertebrate Development Symposium, Wednesday 8:30

THE HOMOLOGY OF THE PAIRED APPENDAGE SKELETON: RECONCILING DATA FROM FOSSILS, EMBRYOS, AND GENES

DAVIS, Marcus, Univ. of Chicago, Chicago, IL

Ever since Carl Gegenbaur, comparative anatomists have debated whether there is an ancient pattern of development that is common to the paired appendage skeletons of all jawed vertebrates (gnathostomes). This debate has been rekindled in recent years, as developmental geneticists have attempted to apply experimental data derived from teleost fin development to tetrapod limbs. New data from the analysis of fin development in basal actinopterygian fishes and in chondrichthyan reveal that aspects of both teleost and tetrapod patterning mechanisms are primitive; thus supporting the notion of a fundamental developmental plan for vertebrate paired appendages. These observations suggest that the major patterning mechanisms of fin and limb development were set up very early in gnathostome evolution. The distinct ways in which teleosts paired fins and tetrapod limbs develop largely involves the loss of patterning mechanisms seen in the development of more primitive gnathostome pectoral fins. This scenario of differential loss, rather than addition has clear implications for developmental genetics and paleontology; understanding the commonalities of paired appendage development across vertebrate diversity will require increased focus on basal taxa, both extant and extinct.

Preparators Symposium, Thursday 9:15

DISCOVERY, EXCAVATION, AND PREPARATION OF THE SKULL OF A NEW CENTROSAURINE CERATOPSID FROM THE WAHWEAP FORMATION OF GRAND STAIRCASE-ESCALANTE NATIONAL MONUMENT (GSENM), SOUTHERN UTAH

DE BLIEUX, Donald, Salt Lake City, UT; KIRKLAND, James, Utah Geological Survey, Salt Lake City, UT; TITUS, Alan, Bureau of Land Management, Kanab, UT

The Utah Geological Survey (UGS), in cooperation with the Bureau of Land Management (BLM), has been conducting a multi-year project to inventory the paleontological resources of the Wahweap Formation (middle Campanian) of GSENM. In 2002, the partial skull of a ceratopsian dinosaur was discovered eroding out of a sandstone ledge in the middle mudstone member. Collection of bone on the surface and cleaning of the block revealed a nearly complete skull lying on its left side; part of the right side had eroded away, but over half of the skull remained imbedded in the rock. After obtaining an excavation permit from the BLM, we spent eight days over the next three years using a gas-powered cutoff saw to separate the block containing the skull from the surrounding ledge. We trimmed the block to the point where it weighed approximately 1,000 pounds, and encased the exposed bone with a standard plaster jacket to prepare it for transport. In September 2005, the block was transported by helicopter to a truck waiting on a nearby road and driven to the UGS preparation lab in Salt Lake City. Several hundred hours of preparation have been completed on this skull, which represents a new genus of long-horned centrosaurine ceratopsid. A variety of electric, pneumatic, and hand tools have been used to free this specimen from the enclosing sandstone matrix. Large-scale removal of rock has been done using the large gas-powered cutoff saw equipped with a 14-inch diamond blade. An electric angle-grinder with a 4-inch diamond blade has been used for small-scale rock removal. A variety of pneumatic air scribes have been employed to remove the rock adjacent the bone. We describe additional tools and techniques that we have found most useful during this process.

Poster Session I

A LATE CRETACEOUS (MAASTRICHTIAN) SCLERORHYNCHID FROM JORDAN AND ITS PHYLOGENETIC RELATIONSHIPS (CHONDRICHTHYES: BATOIDEA)

DE CARVALHO, Marcelo, Universidade de São Paulo, Ribeirão Preto, Brazil; MUSTAFA, Hakam, Yarmouk Univ., Irbid, Jordan; SMADI, Ahmad, Pella Museum, Amman, Jordan; ZALMOUT, Iyad, The Univ. of Michigan, Ann Arbor, MI

A Late Cretaceous (Maastrichtian) batoid from the Muwaqqar Chalk Marl Formation of Jordan is described here as a member of the extinct family Sclerorhynchidae. Sclerorhynchids were medium-sized batoids that resembled living sawsharks (Pristiophoriformes) and sawfishes (Pristiformes) in having a hypertrophied, sawlike rostrum. They occur in Lower to Upper Cretaceous sediments (Tertiary records are probably reworked), usually as isolated rostral spines, oral teeth, or fragments of rostral blades. Some taxa are preserved as articulated skeletons (e.g. *Sclerorhynchus atavus* from the Cenomanian of Lebanon). Sclerorhynchid fossils have been found in Europe, Africa, the Middle East, Asia, and North and South America, but basic research on their anatomy and relationships is still needed, and the validity of many of the 20 or so sclerorhynchid genera remains to be substantiated. The Jordanian form is known from a single specimen, exposed dorsolaterally, measuring about 150 cm (specimen is broken posterior to the synarcual cartilage). Morphological details of the Jordanian sclerorhynchid include a rostrum that is widest proximally (well anterior to nasal capsules—a sclerorhynchid synapomorphy), an elongated synarcual cartilage with anterior lateral stays, two sharklike dorsal fins represented by basal elements, neural arches anterior to first dorsal fin and in between dorsals, and a low and long caudal fin (which could have afforded only limited propulsion). Pectoral and pelvic girdles and fins are not preserved, however. The Jordanian sclerorhynchid resembles the Lebanese *Sclerorhynchus* in general proportions and configuration of its dorsal and caudal fins, and is similar to *Micropristis*, also from Lebanon, in presenting an extremely elongated synarcual cartilage. It differs from both genera, however, in its unique rostrum (more broadly rounded and basally wider), and in having minute or reduced rostral spines. Preliminary results of our anatomical investigations of the Jordanian sclerorhynchid are presented, including comparisons with other sclerorhynchids known from holomorphic remains and a phylogenetic appraisal of the group.

Poster Session I

ON THE SYSTEMATICS OF HAPALOPS (XENARTHRA: MEGATHERIOIDEA)

DE IULIIS, Gerardo, Toronto, ON, Canada; PUJOS, François, Institut Français d'Etudes Andines, Lima 18, Perú

Hapalops is the most abundantly recovered fossil sloth from the early to middle Miocene Santacrucian of Patagonia. Its remains have been known for more than a century, but all important systematic work on this genus predates 1910. Until recently xenarthran paleontologists had long clung to the idea that the main sloth clades (Mylodontidae, Megalonychidae, Nothrotheriidae, and Megatheriidae) developed from Miocene forms, and that *Hapalops* occupied a phylogenetically central position among later sloths. Although Santacrucian sloths could provide a wealth of information on sloth evolution and diversity, their basic taxonomy, particularly of *Hapalops*, remains poorly understood, and this has hindered higher level systematic studies. Some 26 *Hapalops* species are still formally recognized, even though most are based on partial or fragmentary specimens from a limited geographic region of Patagonia. A revision is clearly required, particularly in view of the wide range of intraspecific variation established recently for other sloth species by several authors. Two main reasons for the lack of progress is that available remains, including several collections in major North and South American institutions, have not been studied as a whole, and that strict stratigraphic information is not available for the older collections. Recent field work in the coastal exposures of the Santa Cruz Formation between Rios Coyle and Gallegos led by S.F. Vizcaíno and M.S. Bargo (Museo de la Plata) and R. Kay (Duke University) has yielded several reasonably complete new *Hapalops* specimens, including skulls and mandibles with associated skeletons. A preliminary morphological and metric analysis based on skull and dental characters of these remains and those of the classical Santacrucian fauna recovered by the Princeton Expeditions at the end of the 19th century suggest the existence of four main size and morphological types. Further analyses will include *Hapalops* remains in collections in Buenos Aires, Chicago, and New York. Understanding the systematics of *Hapalops*, the oldest osteologically well-known sloth, is fundamental to further phylogenetic analyses of fossil and extant sloths.

Wednesday 4:30

EVOLUTIONARY TRENDS IN THEROPOD FORELIMB EVOLUTION

DECECCHI, T. Alexander, LARSSON, Hans, Redpath Museum, McGill Univ., Montreal, QB, Canada

The evolution of Aves from within Theropoda has been intensely researched in recent decades. Unfortunately the large-scale trends that shaped theropod evolution and constrained avian origins are less well studied. Much work has been done to generate large numbers of characters and a plethora of phylogenies that encompass nearly the entirety of theropod evolution. This vast body of work was used to compile a set of nearly two hundred osteological characters of the forelimb and pectoral girdle. These characters were scored for nearly one hundred and fifty fossil and extant theropod taxa. Patristic distance analyses were used to examine the relative rates of evolutionary among all major theropod lineages. Characters were subdivided into modules to examine the evolutionary trends with-

in the pectoral girdle, stylopodium, zeugopodium, and autopodium independently and as a whole. Results indicate multiple short periods of relatively high rates of character change throughout theropod evolution. These spikes reflected increased evolutionary rates within single modules that rarely coincided with spikes in other modules. This pattern indicates that the system did not evolve as a single unit, but in a punctuated manner focusing on different regions within the forelimb. The node Aves did not correlate with a large amount of novel character appearance, highlighting that the transition between Paraves and Aves was not a period of extreme changes in the forelimb osteology. This study indicates that the bauplan for avian forelimbs predate the origin of the clade, but the evolutionary rates were punctuated at discrete non-avian theropod clades.

Poster Session II

EDUCATING THE GENERAL PUBLIC ABOUT CONTROVERSIAL SUBJECTS: ENGAGING EXHIBIT AUDIENCES ABOUT WAYS OF KNOWING

DECK, Linda, Idaho Museum of Natural History, Pocatello, ID

Vertebrate paleontology is at the center of a several controversial subjects that generate significant public interest and test people on their understanding of scientific knowledge. This includes the existence of cryptic prehistoric animals (e.g., the Loch Ness Monster) and the long public dialog on evolution. The continued popularity and controversy of these subjects exposes public confusion about “how we know.” The Idaho Museum of Natural History had the opportunity to create an exhibit that directly addresses perceived conflicts between ways of knowing, a critical issue in the public’s perception and acceptance of scientific knowledge about topics such as evolution. The exhibit explores three major ways of knowing: the scientific method, faith, and folklore/ traditions. Each is defined, developed, and illustrated using compelling concrete examples. Other concepts explored include fact, evidence, documentation, interpretation, theory, hypothesis, truth, and belief. The ways we communicate what we know—language, illustration, music, mathematics, and literature—help to flesh out the exploration. The exhibit team included scholars from Idaho State University and southeast Idaho representing expertise in scientific thought, philosophy, language, literature, mythology, folklore, traditional knowledge and religion. The goals of the exhibit are to insure that visitors realize there are different ways of knowing, and to appreciate the differences, strengths and weaknesses among them. Audience front-end surveying was used to understand starting knowledge of the themes we explored and how best to communicate them; formative evaluations as a mock-up of a theme unit were used to test the interpretive and design approach, and a summative evaluation during the early run of the exhibit showed whether the learning objectives were met.

Friday 2:45

A REVISION OF DUBOIS CROCODYLIANS: GAVIALIS BENGAWANICUS AND CROCODYLUS OSSIFRAGUS FROM THE EARLY PLEISTOCENE HOMO BEDS OF JAVA

DELFINO, Massimo, Università di Firenze, Firenze, Italy; DE VOS, John, Naturalis, Nationaal Natuurhistorisch Museum, Leiden, Netherlands

Along with the “*Pithecanthropus erectus*” remains that broadened the late nineteenth-century views about human evolution, the Dubois expeditions to Java discovered abundant fossil reptiles represented by crocodylians, turtles, monitors and pythons. In 1908, on the basis of the remains still preserved at Naturalis—the Nationaal Natuurhistorisch Museum of Leiden (The Netherlands), Dubois briefly described—without illustrations—a new turtle, *Hardella isoclina*, and two new species of crocodylians, *Crocodylus ossifragus* and *Gavialis bengawanicus*. Few years later, in a paper concerning the crocodylian remains from the same Homo-beds of Java and collected during the “Selenka-Trinil” expedition (now belonging to the Museum für Naturkunde of the Humboldt-Universität, Berlin), Janensch accepted the species created by Dubois.

The turtle remains have been afterwards revised by Das and referred to the extant genus *Mauremys*, whereas a proper identification of the crocodylians has not been verified in recent times and the phylogenetic position of these taxa has not been assessed with a phylogenetic approach. At present, *Crocodylus ossifragus* is considered as a possible synonym of the living species *C. siamensis* while the name *Gavialis bengawanicus* apparently disappeared from scientific literature.

The morphology of *C. ossifragus* does not allow to diagnose a new species and its identification as *C. siamensis* is supported by the presence of well developed “squamosal horns” despite the absence of an evident interorbital ridge. Conversely, *G. bengawanicus* can be considered a valid fossil species characterized by a shorter snout (smaller number of maxillary and dentary teeth), a modest maxillary process developed into the lacrimal, a W-shaped maxillo-palatine suture, a planar skull table and rather rounded supratemporal fossae.

3D Imaging Symposium, Friday 11:00

3D APPROACHES IN PALEOANTHROPOLOGY USING GEOMETRIC MORPHOMETRICS AND LASER SCANNING

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The emergence of 3D GM (geometric morphometric) techniques as a way of quantifying

morphology has significant implications for 21st century paleontology. Not only is it possible to easily collect data in a true 3D sense, such as sets of homologous landmarks or complete surfaces, but it is now also possible to analyze such data in increasingly complex and elegant ways that were computationally impossible even a few years ago. We present an exciting new study that integrates techniques of 3D data collection with computer graphics and computationally complex multivariate analyses to place biological shape change within an evolutionary context. The basic aim of this project is to infer (“reconstruct”) the 3D cranial shape of hypothetical intermediate (“ancestral”) taxa along an a priori evolutionary tree. We focus on the papionin cercopithecids (Old World monkeys), a taxon well-represented in the modern biota which underwent a major Pliocene-Pleistocene radiation in Africa. Our baseline cladogram and its divergence dates are estimated using molecular data from living papionins. The mean cranial shape of each taxon (separately by sex) is calculated from large datasets of homologous 3D landmarks collected with a Microscribe digitizer. Highly accurate surface models of exemplar crania for each taxon are also produced using a high-resolution Minolta laser surface scanner. These scans are then warped to “fit” the shape of each taxon-sex mean as determined by the landmark dataset, thus giving greater statistical power to all subsequent analyses. These data in turn can be warped “along” the branches of the existing tree using an algorithm that assumes a Brownian motion model of evolutionary change. These last two steps are conducted using our specifically designed software, Landmark. We produce statistically inferred (interpolated) 3D virtual papionin crania at any point on the tree (including nodes) which can be fully visualized and explored in all orientations. Using extant taxa, the technique produces 3D models of crania that are biologically meaningful, visually appealing, and analyzable using GM. The next step is to statistically compare the virtual crania with fossils branching from a similar point on the tree and to incorporate fossil data directly into the tree and subsequent shape analyses, to compare observed and estimated evolutionary change. Our first-stage model of evolution is oversimplified, but will be modified to account for mosaicism and functional integration, and retrodeformation of distorted fossils is under development.

Poster Session I

STATISTICAL ANALYSES OF A VERTEBRATE MICROSITE FROM THE MESAVERDE FORMATION, WYOMING

DEMAR, JR., David, CLEMENTZ, Mark, CASSILIANO, Michael, Dept. of Geology and Geophysics, Univ. of Wyoming, Laramie, WY; BREITHAUP, Brent, The Geological Museum, Laramie, WY

A study of the Barwin Quarry/Fales Rocks (BQFR) vertebrate microsite in the Upper Cretaceous (Campanian) Mesaverde Formation of Wyoming was conducted to infer its paleoenvironment based on the sedimentology, nonmammalian taxonomic diversity, and known ecological niches of extant taxa. Results from this study suggest that BQFR was primarily a subtropical, freshwater community. Current statistical analyses of BQFR encompassing rarefaction (an ecological statistical method which estimates the number of species one might expect to find in a random sample of individuals from a community), minimum number of individuals (MNI), numbers of elements per taxon, and relative abundances of individuals (% total of MNI or species evenness) were used to supplement evidence for paleoenvironmental interpretations. A recent quantitative study of a vertebrate microsite (Bonebed 105 of the Oldman Formation, Alberta) using standardized sampling methodology has shown that analysis of large samples yields no significant differences in diversity and abundance when compared to data gathered through controlled subsampling. Application of this methodology was used to compare previous results of species richness (number of taxa in a community) at BQFR, as well as to determine species evenness. Results were compared to Bonebed 105 (a similar sedimentologic and taxonomic geologic unit) to determine common paleoecologic patterns.

In addition to newly identified nonmammalian taxa from BQFR, the presence of *Eodelphis* (Marsupialia, Stagodontidae), based on a fragmentary lower left m_2 , represents the southern-most occurrence of this taxon from the Western Interior. A right lower molar of an indeterminate stagodontid featuring a double cristid obliqua and conical hypoconid has also been recognized, possibly signifying a new species. Results of this analysis on BQFR can be used for future studies of associations among different contemporaneous microsites for taxonomic paleobiogeographic distributions throughout the Upper Cretaceous of North America.

Neoceti Symposium, Saturday 11:15

PALEONTOLOGICAL AND MOLECULAR EVIDENCE FOR THE TRANSITION FROM TEETH TO BALEEN (MAMMALIA: CETACEA: MYSTICETI)

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Preparation of the palate of the holotype of *Aetiocetus weltoni*, a late Oligocene toothed mysticete from the Yaquina Formation of Oregon, reveals a series of small foramina on the lateral half of the maxilla. Each foramen occurs posterior to a shallow sulcus and is closely positioned near the lingual margin of the dentition. We propose that these palatal foramina are homologous with the prominent baleen nutrient foramina in edentulous mysticetes. This indicates that baleen and teeth were both present in aetiocetids.

The lateral portions of the palates are marked by numerous foramina and associated sulci that accommodate passage of the rich blood supply and innervations to the baleen racks. In fetal specimens the lateral foramina have not yet formed. Instead there is a dis-

tinct open alveolar groove running along the lateral edge of the flat palate. Embryologically, this alveolar groove is the site of the developing temporary dentition, which passes through the bud, cap, and bell stages before degradation and resorption. Dermal papillae of the rudimentary baleen plates begin to develop coincident with deciduous tooth degradation. At the same time the open alveolar groove starts to ossify until finally the distinct lateral foramina begin to form.

Although dentin is produced during development of the deciduous dentition, well-developed enamel tissue does not. Given that edentulous mysticetes descended from fully toothed ancestors, we predict that enamel-specific genes should be present but non-functional in modern mysticetes. Analysis of AMBN and ENAM (ameloblastin and enamelin) in modern mysticetes found frameshift mutations. These nonsense mutations demonstrate that edentulous mysticetes retain both developmental and genetic evidence of their ancestral toothed heritage. The evolutionary transformation from toothed ancestor, to the intermediate condition with both teeth and baleen, to the derived state with only baleen in adults, mirrors the ontogenetic trajectory in extant mysticetes.

Poster Session III

COMPARISON OF DENTAL MICROWEAR AMONG SPECIES OF CARNIVOROUS, HERBIVOROUS, AND DUROPHAGOUS FOSSIL MAMMALS

DEWAR, Eric, Univ. of Massachusetts Amherst, Amherst, MA

Stereomicroscopy of dental microwear has helped to reconstruct the diets of living and extinct species of mammals, especially ungulates, primates, rodents, and carnivorans. Previous studies have focused on Recent mammals or fossil species from within a single family in order to develop a comparative database of use-wear. This approach has yielded a coherent understanding of the microwear patterns of these groups and the state spaces that describe particular dietary modes of living mammals.

Despite these advances, less is known about the use-wear of archaic fossil groups or the earliest fossil members of some modern clades. Though the diets of these animals have been hypothesized using dental morphology or other evidence, microwear analysis can add further resolution to those dietary reconstructions. For this study, I molded teeth from more than 60 fossil species, representing the orders Artiodactyla, Perissodactyla, “Condylarthra,” Tillodontia, Primates, Carnivora, and Creodonts. The resulting casts were read for the appearance and numbers of scratches, pits, puncture (seed) pits, and gouges. For the more herbivorous mammals, I read the microwear on the second molar and compared their wear patterns to the ungulate and primate database from the literature. For the carnivores and creodonts, I read the carnassials or first upper molar and related those wear patterns to the microwear database of living carnivorans that I developed.

Within the ungulates, I found strong evidence for browsing in the rhinocerotids, isecotophids, tapirids, and early equids as well as the arctocyonid “condylarths.” Most of the other “condylarths,” artiodactyls, and primates grouped into a more mixed feeder/fruit diet based on the numbers of pits and scratches as well as the presence of puncture pits. I found that most of the canids, amphicyonids, and hyaenodontids grouped into the “meat and bone” space among living carnivorans; I found few indications of meat specialization (i.e., few species habitually chewed bones) in my sample. A PCA using all species recovered a first axis related to omnivory (18.4%) and a second axis indicating a fruit/abrasive food range (17.4%).

Poster Session I

BIOMECHANICS OF THE VERTEBRAE AND ASSOCIATED OSTEODERMS OF THE EARLY PERMIAN TEMNOSPONDYL *CACOPS ASPIDEPHORUS*

DILKES, David, Univ. of Wisconsin Oshkosh, Oshkosh, WI; BROWN, Lauren, Illinois State Univ., Normal, IL

Two series of osteoderms associated with the anterior three-quarters of the presacral vertebral column of the dissorophoid temnospondyl *Cacops aspidephorus* have important implications for biomechanics of the axial skeleton. An internal series consists of an osteoderm fused to the distal tip of each neural spine. Lying dorsal to the internal series and overlapping each internal osteoderm is a second external series. The orientation of the zygapophyseal facets implies modest lateral flexion with limited coupled axial rotation of the column. However, the osteoderms restricted any possible lateral flexion through their inverted V-shape, strongly angled overlap between each external osteoderm and its neighbouring internal osteoderms, and the presence of a midsagittal flange on the ventral surface of each external osteoderm that fits into grooves on the anterior and posterior edges of the neighbouring internal osteoderms. This configuration allowed vertical flexion of the vertebral column with little lateral flexion. The rod-like nature of osteoderms with the anterior three-quarters of the presacral vertebrae suggests a restricted form of forward movement for *Cacops* unlike that of other early tetrapods.

Friday 10:15

NEW DISCOVERIES IN CHINA HIGHLIGHT AN ADAPTIVE RADIATION OF BASAL CERATOPSIDS

DODSON, Peter, Univ. of Pennsylvania, Philadelphia, PA; YOU, Hailu, Institute of Geology, Chinese Academy of Geological Sciences, Beijing 100037, China; TANOUE, Kyo, Univ. of Pennsylvania, Philadelphia, PA

In the decade since the celebrated discovery of Early Cretaceous birds, and feathered non-avian theropods in northeastern China, a series of less heralded discoveries of small ceratopsians has uncovered a remarkable diversity of primitive ceratopsians both in Liaoning

Province in northeastern China and in Gansu Province and the Inner Mongolian Autonomous Region in northwestern China. Taxa described in the last ten years include the psittacosaurid *Hongshanosaurus* (You et al. 2003), and basal neoceratopsians *Archaeoceratops* (Dong and Azuma 1997), *Chaoyangsaurus* (Zhao et al. 1999), *Magnirostris* (You and Dong 2003), and *Auroraceratops* (You et al. 2005). *Auroraceratops* from the Mazongshan region of Gansu is short-faced and has very broad nasals and frontals, giving the skull a turtle-like appearance. Other autapomorphies include blunt, striated premaxillary teeth and a mushroom-cap expansion of the dorsal end of the lacrimal. *Auroraceratops* shares several apomorphies with more derived ceratopsians, including exclusion of the basioccipital from the foramen magnum and a broad, deep coronoid process. *Auroraceratops* occupies a derived position within basal Neoceratopsia, and is more derived than *Liaoceratops* and *Archaeoceratops* but is less derived than *Protoceratops* and other coronosaurs. Exquisite preservation and delicate preparation of the new specimens permits access to poorly described palatal structures, allowing important new details to be detected. Evolutionary trends in the palate and in dental features are elucidated.

Marine Reptiles Symposium, Wednesday 2:30

A PHYLOGENY OF PLESIOSAURIA (SAUROPTERYGIA), WITH EMPHASIS ON THE SYSTEMATIC STATUS OF *LEPTOCLEIDUS*, ANDREWS 1922

DRUCKENMILLER, Patrick, RUSSELL, Anthony, Univ. of Calgary, Calgary, AB, Canada
Leptocleidus Andrews, 1922 is a poorly known plesiosaur genus from Lower Cretaceous successions of the UK, South Africa, and Australia. Historically, there has been little consensus regarding its phylogenetic position within Plesiosauria, largely due to its unusual combination of a relatively small skull and short neck. As a result, a diverse array of potential sister groups have been posited for *Leptocleidus*, including long-necked Cretaceous elasmosaurids, Early Jurassic "rhomaleosaurs", and Middle to Late Jurassic pliosaurids. A cladistic analysis including *Leptocleidus*, and a new, apparently morphologically similar specimen from Alberta, TMP 94.122.01, was undertaken to assess their phylogenetic position within Plesiosauria.

A character-taxon matrix was assembled afresh, consisting of 28 taxa sampled broadly among plesiosaurs, scored for 152 critically reanalyzed and redefined cranial and postcranial characters. The results indicate a basal dichotomous split into the traditionally recognized pliosauroid and plesiosauroid clades. Nested within Pliosauroida, a monophyletic Leptocleididae was recovered, consisting of *L. superstes*, *L. capensis*, and an unnamed Australian taxon AM F99374. In contrast to earlier suggestions, *Leptocleidus* neither clusters with *Rhomaleosaurus*, which was found to be paraphyletic, nor with large-skulled pliosaurid taxa, such as *Simolestes*. Rather, a sister group relationship between Cretaceous Polycotylidae and Leptocleididae was recovered. Although TMP 94.122.01 is superficially similar to *Leptocleidus*, several discrete characters of the skull indicate that this new taxon is nested within Polycotylidae.

Poster Session II

TYMPANIC PNEUMATICITY IN ARCHOSAURIA: RECOGNIZING PATTERNS OF ORGANIZATION AND HOMOLOGY

DUFEAU, David, WITMER, Lawrence, Ohio Univ., Athens, OH

The tympanic cavity of archosaurs gives rise to a variety of epithelial diverticula that pneumatize the bones of the braincase and suspensorium. Tympanic pneumaticity is not well understood with regard to its ontogeny, morphological variability, and phylogenetic distribution. Moreover, the relationship of true tympanic pneumaticity to other pharyngeal pneumatic systems in the braincase has been completely unexplored. We present here a preliminary survey of braincase pneumaticity in Archosauria and tests of homologies of the associated pneumatic recesses. Methods include computed X-ray tomography (CT), microCT, and 3D visualization of the CT scan data, which together provide a detailed characterization of the pneumatic recesses relative to the skeleton, otic labyrinth, and brain cavity. Additionally, CT scans of extant taxa, coupled with dissection, give insight into the soft-tissue associations of the diverticula. To shed light on the highly derived condition of adult crocodylians, ontogeny of pneumatic sinuses is being traced via microCT in a growth series of American alligator. Morphological similarities between examined fossils and extant taxa were examined in a phylogenetic context, allowing tests of hypotheses of homology. Of particular interest is the evolution of the modern condition in the two clades of extant archosaurs. Study of the avian condition is further advanced, and focal theropod taxa include the ceratosaur *Majungasaurus*, the allosauroids *Acrocanthosaurus* and *Allosaurus*, as well as nonavian coelurosaurs such as tyrannosaurids, oviraptorosaurs, ornithomimids, troodontids, and dromaeosaurids. Homologies of median pharyngeal sinuses in the basicrania of archosaurs remain equivocal. The rostral tympanic recess, however, is the most widely distributed of the paratympanic sinuses whereas the dorsal tympanic recess may be restricted to coelurosaurian clades where it shows high levels of homoplasy.

3D Imaging Symposium, Friday 11:15

3D IMAGING AND BIOMECHANICS: BRINGING 3D FINITE ELEMENT MODELING TO COMPARATIVE BIOLOGY

DUMONT, Elizabeth, WERLE, Sean, GROSSE, Ian, UMass Amherst, Amherst, MA

The development of 3D imaging techniques has given comparative morphologists the ability to visualize and compare structures in exciting new ways. Work in our lab focuses on taking 3D data a step beyond imaging by transforming them into finite element models that serve as the basis of comparative biomechanical analyses. Finite element analysis (FEA) is

a physics-based numerical technique routinely used by engineers to predict and optimize the behavior of engineered products. FEA is relatively new to functional morphology but clearly can provide a truly novel qualitative, as well as quantitative, perspective on form-function relationships. In the engineering world, engineers use powerful computer aided design (CAD) tools to rapidly create a mathematically geometric model of the product that is required for FEA. However, in the biological world geometries of organic systems are highly irregular and not amenable to construction by CAD tools. Instead, the complex geometries of many biological structures must be digitally reconstructed from stacks of 2-D image scans. This digital reconstruction process from raw image data to 3-D mathematical geometric models is the most significant impediment to the widespread use of comparative FEA. Our lab has been working to simplify this process and thus make FEA more available to vertebrate morphologists. In this symposium, we present new, efficient methodologies which facilitate the development of finite element models of vertebrate structures. The development of these improved finite element modeling techniques are part of a larger research project to study the biomechanical links between cranial morphology, bite force and biting behavior in mammalian evolution.

Marine Reptiles Symposium, Wednesday 5:00

AIGIALOSAUR MORPHOLOGY: IMPLICATIONS FOR MOSASAUROID SYSTEMATICS

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Aigialosaurs are a group of Cenomanian and Turonian squamates found in marine rocks of Croatia, Slovenia, Italy, Israel, and Mexico. Aigialosaurs are typically diagnosed by a series of cranial synapomorphies, including an intramandibular hinge and sickle-shaped quadrate morphology, and a postcranial morphology very similar to that of extant varanids. While only half a dozen relatively complete specimens are known worldwide, the systematic relationships of aigialosaurs are important due to their hypothesized basal positions within Mosasauroida (aigialosaurs and mosasaurs).

In numerous systematic analyses of the mosasauroid lineage aigialosaurs have been found to represent a paraphyletic assemblage of sequential sister taxa to the family Mosasauridae. However, a recent study found that several aigialosaur taxa actually nested within the family Mosasauridae, suggesting that the paddle-like limb of mosasaurs evolved on several separate occasions.

Examination of the data matrix used in this most recent analysis showed a large amount of missing data amongst aigialosaur taxa, resulting in large amounts of homoplasy in the preferred trees. In an attempt to fill in as much of the missing data as possible, several of the key basal taxa were reexamined. *Aigialosaurus dalmaticus* and *Opetiosaurus buccichi*, the two most complete aigialosaur specimens, were redescribed and the resulting anatomical information was added to the existing data matrix. Ensuing trees that incorporated the new and modified data showed little support for multiple evolutionary origins of the paddle-like limb in mosasauroids. However, the relationships of aigialosaurs remain poorly resolved, indicating the need for new specimens and further examination of key taxa, the 'Trieste aigialosaur' in particular.

Poster Session III

FRESHWATER HYBODONT SHARKS FROM THE LOWER CRETACEOUS OF SAHARA

DUTHEIL, Didier, Musée National d'Histoire Naturelle, Paris, France

The Elrhaz Formation (Aptian) of the Gadoufoua area in north-eastern Niger has yielded an abundant vertebrate fauna for around 40 years. Most of the taxa are terrestrial and they belong to turtles (*Platycheiloides*, *Teneremys*, *Taquetochelys*), crocodiles (*Anatosuchus*, *Sarcosuchus*, *Stolokrosuchus*), and dinosaurs (*Lurdusaurus*, *Ouranosaurus*, *Nigersaurus*, *Suchomimus*). Freshwater taxa have also been recorded (Unionids, *Mawsonia*, *Asiatoceratodus*, *Pliodetes*).

Recent fieldwork in the Elrhaz Fm has focused on the research of microsites. Tons of raw sediment have been sampled via dry screening, underwater screen washing and heavy liquid separated. Thousands of fossil remains have been found and numerous teeth of elasmoobranchs have been sorted under binoculars. At least a hundred teeth of two taxa of hybodont sharks have been found. A first set of teeth have crowns with a principal low and rounded cusps with two or three pairs of lateral cusplets decreasing in size laterally. The roots have an anaulachorize stage. This tooth morphology suggests a strong relationship with the genus *Polyacrodus*. The second set of teeth is more numerous (around 200). The teeth are small (less than 2.5 mm), gracile, and narrow labiolingually. The crowns are unornamented with any cusp. The occlusal face shows a crushing surface. The roots are wider than the lowermost part of the crown as in the teeth of *Lonchidion*. The roots have small foramina placed irregularly but with a holaulachorize stage. If this kind of tooth belongs to a hybodont taxon, this last character is unusual among this clade and the relationships with previously described taxon is difficult. In front of these isolated teeth, some fin spines of hybodonts have been found *in situ*. They are striated. A complete one is 100 mm long.

Wednesday 2:30

THE HESPERORNITHIFORM BIRD *ASIAHESPERORNIS* FROM KUSHMURUN, NORTHERN KAZAKHSTAN

DYKE, Gareth, Univ. College Dublin, Dublin, Ireland; MALAKHOV, Dmitry, Institute of Geological Sciences, Almaty, Kazakhstan; CHIAPPE, Luis, Natural History Museum of Los Angeles County, Los Angeles, CA

Fossil bird material is exceptionally rare in the Mesozoic of western Asia. With the notable exception of the Upper Cretaceous foot-propelled diving bird *Asiahesperornis bazhanovi* from northern Kazakhstan, the only bird fossils described from this region have been bone fragments from the Upper Cretaceous of Uzbekistan. We review all the material referred to date to the hesperornithiform *Asiahesperornis* and present a re-description. In addition to the original collections from the holotype locality of Kushmurun, we add new postcranial bones to this taxon. We also discuss the taxonomic history and likely affinities of this ocean-going bird. Records of *Asiahesperornis* from Kushmurun corroborate the taxonomic distinctiveness of this taxon and provide further evidence for the terminal Cretaceous connection between the Arctic Ocean, the northern Siberian Sea, and the southern Tethys at this time. Outcrop sequences in both eastern Russia and Kazakhstan document the extent of the Turgay Strait in the Late Cretaceous, bounded by the Ural Mountains to the west and the Kazakhstan Shield in the east. Hesperornithiforms were wide-ranging: at maximum extent, the Late Cretaceous Turgay Strait is thought to have been more than 650 km in length and wider than 300 km. However, just as is the case in many extant ocean-going seabirds, hesperornithiforms appear to have been restricted to the northern hemisphere, although whether this truly represents the biogeography of these birds is open to question. By far the majority of hesperornithiform fossils have been found in marine, or marginal marine, sediments. Although it has been argued that this environmental bias may reflect a taphonomic effect, this is unlikely given the sampling extent of the non-neornithine Upper Cretaceous fossil record. Correlated with their foot-propelled swimming adaptations, it is more likely that hesperornithiforms were the dominant sea-going predatory birds during the Late Cretaceous.

Friday 9:00

THE DINOSAUR-BEARING SHISHUGOU FORMATION (JURASSIC, NORTH-WEST CHINA) REVEALED

EBERTH, David, Royal Tyrrell Museum, Drumheller, AB, Canada; XU, Xing, Institute of Paleontology and Paleoanthropology, Beijing, China; CLARK, James, The George Washington Univ., Washington, DC; MACHLUS, Malka, HEMMING, Sidney, Lamont-Doherty Earth Observatory of Columbia Univ., Palisades, NY

The Shishugou Formation is exposed in northeastern Junggar Basin, Xinjiang, China, and is famous for fossils of vertebrates and wood. At Wucaiwan, an intensively studied area, the formation is 378 meter-thick, rests sharply on the Xishanyao Fm, and is unconformably overlain by sediments of suspected Cretaceous age. At Jianguanmiao the formation is only partially preserved.

We recognize a lower, red, upward-fining interval; a thick, middle interval consisting of red-orange, upward-coarsening/fining successions; and an upper, orange-tan, upward-coarsening interval. Alluvial fan/plain facies in the lower half of the formation give way to caliche- and tuff-rich alluvial and paludal deposits in the upper half, recording an increase in volcanism, seasonal aridity, and a lowering of depositional slope. In the uppermost interval, caliches are rare, indicating less aridity, an increase in sediment supply, or both. The previously proposed Wucaiwan Formation is broadly equivalent to portions of the lower and middle intervals, but is not adequately defined.

Cm-scale bentonites occur through most of the formation, whereas m-scale, white-tan zeolitic tuffs are limited to the upper half. $^{40}\text{Ar}/^{39}\text{Ar}$ dating of sanidines yields an age range of 161-159 Ma for the upper half of the formation, and suggests that the Shishugou likely spans the M-U Jurassic boundary. The stratigraphic distribution of vertebrates indicates a faunal transition up through the middle of the formation, corresponding roughly to the inferred M-U Jurassic transition.

Vertebrates are preserved in a variety of taphonomic modes and underscore stratigraphic changes in sedimentology. Preservation quality is poor in the lower Shishugou, reflecting frequent exposure and reworking in paleochannels. In the middle, fossils are better preserved and occur often in massive mudstones, caliches and splay deposits, indicating a bias for preservation in overbank settings and ephemeral water bodies. In the upper Shishugou, excellently preserved medium/small vertebrates, especially non-avian theropod dinosaurs, occur in massive, thick paludal deposits, suggesting rapid burial and limited reworking in wetland settings.

Student Poster Session

MORPHOLOGICAL AND FUNCTIONAL DIFFERENCES BETWEEN RHAMPHORHYNCHOID AND PTERODACTYLOID PTEROSAURS WITH EMPHASIS ON FLIGHT

EINARSSON, Elisabeth, Lund, Sweden

To explain how morphological differences between suborders Rhamphorhynchoidea and Pterodactyloidea affected flight performance and life styles wings and claws of pterosaur fossils from collections in Uppsala and Munich were measured. The measured specimens studied are from Jurassic limestones and shales in Solnhofen, Eichstätt and Holzmaden, and include the taxa *Dorygnathus*, *Campylognathoides*, *Rhamphorhynchus*, *Anurognathus*, *Pterodactylus*, *Germanodactylus* and *Gallodactylus*. Morphometric results indicate differences between Rhamphorhynchoidea and Pterodactyloidea in wing construction and claw length. Moreover, differences in wing construction indicate different flight performance between the suborders. The shorter innermost part of the wing indicates flapping flight in Rhamphorhynchoidea while the longer innermost part of the wing indicates soaring in Pterodactyloids. Calculation on the narrowness of the wing has been done on three different specimens of *Rhamphorhynchus*, demonstrating a narrow distal part of the wing that

probably was wider towards the body. Variation and divergence from the general morphological pattern creates diversity within both suborders, suggesting three different flight performance types in Rhamphorhynchoidea and two in the Pterodactyloidea. The three flight performances proposed for Rhamphorhynchoidea are (1) Mixed gliding and flapping flight with broad wings, (2) Flapping flight with narrow wings and (3) Flapping flight with elliptical wings. The two flight performances proposed for Pterodactyloidea are static and dynamic soaring. Measurements indicate that the claws of the finger and toes were of the same size in Pterodactyloidea, while the claws on the fingers were longer than those of the toes in Rhamphorhynchoidea, indicating climbing abilities. Soaring flight, morphological characteristics similar to these in birds, and development of hollow bones are all indications that pterosaurs probably had air sacs that were primitive in Rhamphorhynchoidea but well developed in Pterodactyloidea.

Poster Session III

NEW LATE PLIOCENE BATS (CHIROPTERA) FROM AHL AL OUGHLAM, CASABLANCA, MOROCCO

EITTING, Thomas, Univ. of Michigan, Ann Arbor, MI; GERAADS, Denis, CNRS, Paris, France; GUNNELL, Gregg, Univ. of Michigan, Ann Arbor, MI

The 2.5 Ma site of Ahl al Oughlam near Casablanca in Morocco has produced a large collection of late Pliocene vertebrates including nearly 200 bats, the largest sample of North African fossil microchiropterans known. This sample can be compared with other late Pliocene localities such as the Shungura Formation, Omo Valley, Ethiopia, and Weze 1, near Dzialosyzn, Poland.

The Ahl al Oughlam sample contains at least six microchiropterans including three vespertilionids, an emballonurid, a hipposiderine, and a rhinolophid. The vespertilionids are similar in most respects to extant myotins *Myotis* and *Lasionycteris* although associated canines suggest that at least one of these taxa may instead be a vespertilionin. Based on comparisons with modern taxa, the three Moroccan vespertilionids ranged in size from about 6 to more than 25 grams.

The Moroccan emballonurid has a prominent and anteriorly extended lower molar paracoid, typical of extant members of this family. Lower molar talonids are short relative to trigonids, a characteristic of some emballonurids such as *Emballonura*. Tooth size is consistent with that of *Coleura afra*, the smallest extant African emballonurid, although the Moroccan form has somewhat longer and narrower molars.

Rhinolophus from Ahl al Oughlam is the second most abundant chiropteran. Compared with extant *Rhinolophus*, the Moroccan form is relatively large with an estimated body weight of nearly 25 grams. The hipposiderine from Ahl al Oughlam is very rare but appears to have been of moderate size, smaller than those from Omo Shungura.

The Ahl al Oughlam sample compares well with the other contemporaneous sites in terms of species diversity, with at least six species present, but it consists of a distinct assemblage of microchiropterans. The Shungura sample contains five species but lacks vespertilionids completely, whereas they are the most abundant and diverse group at Ahl al Oughlam. The Weze assemblage includes eight species and is also dominated by vespertilionids. However, no emballonurids or hipposiderines are known from Weze. These differences are probably the result of both ecological and historical factors.

Student Poster Session

VARIATION AMONG PROBOSCIDEAN PETROSALS FROM A PLEISTOCENE CAVE DEPOSIT IN TEXAS

EKDALE, Eric, The Univ. of Texas at Austin, Austin, TX

Isolated petrosals representing a minimum of 37 proboscidean individuals were recovered from Pleistocene deposits in Friesenhahn Cave, central Texas. This sample provides a unique opportunity to study variation within the ear region, as well as expand our knowledge of the anatomy of the middle ear of extinct elephants. The petrosals are identified as proboscidean by the confluence of the fenestra cochleae and cochlear canicularis, a feature characteristic of extant tethytheres. Both *Mammuthus* and *Mammot* are represented by teeth in the cave. The petrosals are provisionally assigned to *Mammuthus*, although they are not directly associated with any dental material.

The overall structure of the petrosal is consistent among all specimens in the sample, although minor morphological variation is observed. The variation includes shape of the fenestra vestibuli, closure of the facial canal, and connection between the crista fenestralis and the posterior aspect of the petrosal. The morphological differences may be the result of a biological factor, such as ontogeny or phylogeny, given that a growth series represented by teeth of both mammoths and mastodons is preserved in the cave. Alternatively, the variation may reflect aspects of the taphonomic history of the specimens because Friesenhahn Cave was a former carnivore den, and so some of the morphology of the petrosals may have been affected by postmortem damage.

Saturday 8:00

A NEW FAMILY OF HETEROSTRACANS (AGNATHA) FROM THE LATE SILURIAN OF THE CANADIAN ARCTIC

ELLIOTT, David, Northern Arizona Univ., Flagstaff, AZ

Early vertebrates occur abundantly in the Boothia Uplift regions of Prince of Wales, Somerset, and Cornwallis islands (Nunavut Territory). The Boothia Disturbance was active during the Late Silurian and Early Devonian and resulted in the formation of the elastic red-bed facies of the Peel Sound and Somerset Island formations close to the uplift and the

marine carbonates of the Drake Bay Formation to the east where the influence of the uplift was slight. Early vertebrates were first reported from this area in 1955 and since then a large number of taxa, particularly heterostracans, have been described. Although the endemism of the fauna has made biogeographic analysis difficult this area does seem to have been a locus of adaptive radiation for a number of heterostracan taxa, with the best documented example to date being the Pteraspidiiformes.

Newly recognized taxa from the lower Member of the Peel Sound Formation and the Somerset Island Formation on Prince of Wales and Somerset islands represent a new taxon of advanced heterostracans related to the Pteraspidiiformes. The new species are characterized by: a well-developed subrostral lamina; no separate branchial plates; a posteriorly directed branchial opening; ventrally directed lateral laminae; well-developed lateral brims; and a posterior median spine. New information on the cyathaspidid *Ariaspis* indicates that this also shows the same suite of characters. Analysis of their relationship indicates that together with *Ariaspis* the new species form a sister-group to the Pteraspidiiformes plus *Listraspis*, providing further evidence that the Pteraspidiiformes originated and developed initially in the Boothia Uplift region.

3D Imaging Symposium, Friday 10:15

RECONSTRUCTING DENTAL OCCLUSION IN 3D: FROM CARNIVORANS TO ASFALTOMYLOS

EVANS, Alistair, Univ. of Helsinki, Helsinki, Finland; MARTIN, Thomas, Forschungsinstitut Senckenberg, Frankfurt am Main, Germany; FORTELIUS, Mikael, JERNVALL, Jukka, Univ. of Helsinki, Helsinki, Finland

A longstanding problem in dental morphology has been how to visualize and represent how teeth fit together in occlusion. Comparison of wear facets, a widely-used method for interpreting occlusion, has generally been done in two dimensions. Furthermore, methods such as imbedding casts into probable positions of occlusion and sectioning often give only limited opportunities to grasp the full 3D position and movement of the occluding teeth.

Here, we use 3D surface scans of mammal teeth in a virtual computer environment to examine occlusion between opposing tooth rows. With complete skulls available, the position and shape of the condyles can be used to more accurately reconstruct occlusion. This was done for a group of modern carnivorans. A comparison of the occlusal stroke directions and movements during occlusion show that the direction of tooth movement varied according to occlusal shape, with a more vertical movement of the lower jaw in felids compared with canids and mustelids.

The situation is more difficult, however, for most fossil material. We adapted the method to try to reconstruct the upper dentition and occlusion of *Asfaltomylos* (Australosphenida). 3D scans were taken of the lower molars. Then, using the 3D shape of lower molars we generated possible 3D shapes of occluding upper molars, which are unknown in the fossil record. This allows us to test hypotheses of upper molar 3D shape and the mode of occlusion between the opposing molar rows.

Saturday 9:00

HIGH-RESOLUTION LAMBEOSAURINE DINOSAUR BIOSTRATIGRAPHY, DINOSAUR PARK FORMATION, ALBERTA: SEXUAL DIMORPHISM RECONSIDERED

EVANS, David, Mississauga, ON, Canada; CURRIE, Philip, Univ. of Alberta, Edmonton, AB, Canada; EBERTH, David, Royal Tyrrell Museum, Drumheller, AB, Canada; RYAN, Michael, Cleveland Museum of Natural History, Cleveland, OH

Cranial crest morphotypes of the lambeosaurine hadrosaurids *Corythosaurus* and *Lambeosaurus* from the Campanian Dinosaur Park Formation are frequently cited as examples of sexual dimorphism in dinosaurs. Each taxon is known from over 15 skulls that comprise growth series. Distinctive crest morphs at presumed maturity have been linked to sexual dimorphism, with sexes identified by the relative prominence of the crest. Employing new stratigraphic and GPS data we have established a biostratigraphic framework in which the sexual dimorphism hypotheses can be tested.

Crest morphs of each genus are not randomly distributed within the formation. The two *Corythosaurus* morphs are stratigraphically segregated, with the large-crested presumed male (originally named *C. casuarius*) occurring stratigraphically below all specimens of the putative female morph (*C. intermedius*). Three adult-sized *Lambeosaurus* morphs have been recognized, but their interpretation is not consistent; *L. clavinitialis* has been posited as the female of *L. lambei* as well as of *L. magnicristatus*. In addition, a high degree of crest variation makes the identification of some specimens difficult. Small-crested specimens that have a posteroventrally-directed spike cluster low in section relative to larger-crested specimens. *L. magnicristatus*, the largest crested morph, occurs stratigraphically higher than all other lambeosaurines.

The biostratigraphic succession of these cranial morphotypes is not consistent with previously proposed sexual dimorphism, and, instead, indicates that the Dinosaur Park Formation hosts a taxonomically diverse assemblage of lambeosaurines that form two distinct lineages. Morphological change within each lineage is concentrated in subtleties of crest shape, and is consistent with an anagenetic interpretation where temporal ranges do not overlap significantly.

Poster Session I

SHAPE-SEARCHING IN DENTAL MORPHOLOGY USING THE MORPHO-BROWSER

EVANS, Gudrun, FORTELIUS, Mikael, JERNVALL, Jukka, PLJUSNIN, Ilja, EVANS, Alistair, Univ. of Helsinki, Helsinki, Finland

A number of challenges are faced when we try to make comparisons of 3D morphology. First, it can be very difficult to make any meaningful comparison between two dissimilar 3D shapes. This is certainly true in dental morphology, where the diversity of mammalian teeth mirrors that of ecology. Second, the problem is greatly compounded when a very large number of shapes are involved. This is becoming a common situation due to the explosion of 3D data collection methods in recent years.

We have addressed these issues by implementing shape descriptor and shape-searching algorithms in MorphoBrowser, an online database that contains a diverse range of 3D tooth morphologies. Over 120 mammalian species are represented in the database, covering extant and extinct taxa. The shape descriptors represent automatically-calculated characteristics of the shape using mathematically-defined manipulations of the 3D data. These include cusp angularity, tooth elongation, surface complexity and surface relief. A significant advantage of these descriptors is that they are user-independent, as they do not require interpretations of the morphology by the user. Comparisons between objects can then be based on the similarity of the shape descriptors. Likewise, a shape search can be carried out among a large number of teeth. These techniques have been found to be useful in reconstructing diets from dental morphology.

Friday 10:15

CHANGING PATTERNS OF CARNIVORE MODIFICATION IN THE MODERN LANDSCAPE BONE ASSEMBLAGE OF AMBOSELI PARK, KENYA

FAITH, J. Tyler, George Washington Univ., Washington, DC; BEHRENSMEYER, Anna, Smithsonian Institution, Washington, DC

Differential representation of vertebrate skeletal elements in fossil assemblages has long been used as an indicator of taphonomic processes such as fluvial transport and carnivore destruction, based on observations and experimentation with modern bones. This study investigates landscape-scale skeletal part survival patterns in the modern bone assemblage in Amboseli Park, Kenya, comparing samples recorded in 1975 and 2002-04. Lions (*Felis leo*) were the dominant predator in Amboseli in the earlier sampling period, and spotted hyena (*Crocuta crocuta*) were dominant in the later period. Changes in the abundances of these predators between the two sampling intervals made Amboseli a natural laboratory for assessing the taphonomic signal of carnivore-mediated bone consumption and destruction under differing ecological conditions and varying levels of inter- and intra-specific competition. The Amboseli surface bone assemblage documents variation in the patterning of carnivore modification to ungulate species of different size classes as well as within equivalent size classes. Changes in the proportions of axial vs. appendicular elements, patterns of differential destruction of limb ends, and the strength of the correlation between limb end abundance and bone mineral density all provide measures of the intensity of carnivore modification to the Amboseli assemblage. This increases our ability to infer levels of carnivore impact on fossil assemblages from limb element survival patterns and provides paleobiologists with enhanced ability to understand the taphonomic significance of skeletal element abundances in Cenozoic mammalian faunas. It also provides a basis for testing whether skeletal element survival patterns in the zooarchaeological record likely relate to carnivore modification, hominin transport of appendicular elements, or both.

Saturday 2:15

EVOLUTION AND ANATOMIC ORIGIN OF THE FRONTAL SINUS COMPLEX IN CERATOPSID DINOSAURS

FARKE, Andrew, Stony Brook Univ., Stony Brook, NY

Ceratopsid dinosaurs possess an unusual frontal sinus complex overlying the endocranium and underlying the supraorbital horns. However, the developmental origin of this sinus is problematic in that no pneumatic source (e.g., nasal cavity, tympanic cavity, or pharynx) has been identified.

Shared morphological and developmental characteristics support homology of the frontal depression of non-ceratopsid neoceratopsians (e.g., *Prenoceratops* and *Protoceratops*) with the frontal sinuses of ceratopsids. Combined with developmental and anatomical data for ceratopsids, the fronto-parietal foramen (a connection between the endocranium and frontal sinus) is autapomorphic for ceratopsids, and this foramen probably bears no relevance for inferring the origin or contents of the sinus. Thus, it is unlikely that the frontal sinus functioned primarily as a venous sinus. Furthermore, the extremely large size of the sinuses in many ceratopsids argues against glandular or other tissue(s) filling the sinus in its entirety. This suggests a pneumatic origin for the sinus, as commonly held.

Detailed morphological examinations and CT scans for a variety of taxa fail to disclose any foramen or canal which provides a direct connection between the sinus and nasal cavity or tympanic region. Thus, smooth-walled channels running between the supratemporal fenestrae and the sinus are here proposed as a possible path for the pneumatic source. These channels have been recognized for some time, but their function has proven enigmatic until now. The supratemporal channels qualify as a potential pneumatic path because: (1) they are present in some form or another in all ceratopsians with a frontal depression or frontal sinus; and (2) they are present throughout ontogeny. Although a nasal, tympanic or pharyngeal

source cannot be differentiated, it is likely that the pneumatic sac of the sinus gained access to the skull roof by traveling alongside the adductor musculature. This inference suggests that the evolution of cranial pneumaticity in ornithischian dinosaurs is much more complex than previously thought.

Poster Session II

FOSSIL SNAKES FROM THE PIPE CREEK SINKHOLE (LATE HEMPHILLIAN, GRANT COUNTY, INDIANA)

FARLOW, James, Indiana-Purdue Univ., Fort Wayne, IN; HOLMAN, J., Michigan State Univ., East Lansing, MI; ARGAST, Anne, Indiana-Purdue Univ., Fort Wayne, IN
The Pipe Creek Sinkhole (PCS; Grant County, Indiana) preserves an abundant and diverse assemblage of late Tertiary plants and animals in a sinkhole pond deposit. The deposit is largely unconsolidated, and large numbers of vertebrate microfossils have been recovered by screen-washing. Among these are abundant snake vertebrae; more than 300 vertebrae have been recovered to date, and the final count could be considerably larger.

Despite the small size of the PCS pond, the snake assemblage is quite diverse: hognose snakes (*Heterodon platirhinos* and *Paleoheterodon tiheni*), racers (*Coluber constrictor* and *Paracoluber storeri*), milksnake (*Lampropeltis triangulum*), greensnake (*Ophedrys vernalis*), foxsnake (*Pantherophis gloydi* or *P. vulpinus*), watersnakes (*Nerodia* cf. *N. erythrogaster* and possibly additional species), gartersnake (*Thamnophis* sp.), and massasauga (*Sistrurus catenatus*).

Extant representatives of PCS snakes occur in both aquatic (e.g. *Nerodia*, *Sistrurus*) and dryland (e.g. *Heterodon*, *Coluber*) habitats. Diets inferred for PCS snakes on the basis of their modern relatives are diverse, and in some cases consistent with the presence of other kinds of vertebrates in the fauna. The PCS ophidian fauna most closely resembles those of the middle (Lemoyne Quarry) and late (Mailbox Prospect locality) Hemphillian of Nebraska. Although the PCS mammalian fauna suggests an early Pliocene age for the PCS assemblage, the ophidian fauna is more like that of the late Miocene.

Friday 1:30

EVOLUTION OF BIPEDALITY IN DINOSAURS

FECHNER, Regina, Bayerische Staatssammlung für Paläontologie und Geologie, Muenchen, Germany

The success of dinosaurs is often explained by their locomotor capabilities. Thus, bipedality was acquired in basal dinosauriforms and improved in early dinosaur evolution. The assumption that basal dinosauriforms were bipedal is based on their elongated hindlimbs compared to relatively short forelimbs. However, detailed studies on the evolution of early dinosaur locomotion have not been done so far. In the study presented here, the evolution of the locomotor capabilities of basal dinosaurs were investigated on the basis of integrated data from osteology, myology, biomechanics, and trace fossils.

The hindlimb morphology of the basal dinosauriform *Lagerpeton chanarensis* equals the ancestral archosaurian condition and only the tarsus and pes were modified. The locomotor capabilities of *L. chanarensis* are reconstructed as habitual quadrupedal with the ability to run bipedal, comparable to recent lizards. In basal dinosauriforms, the hindlimb musculature began to modify significantly. The development or modification of the osteological correlates of musculature in *Marasuchus lilloensis*, *Pseudolagosuchus major*, and basal dinosaurs demonstrate the increasing importance of abduction of the femur and the simple flexion and extension of the hindlimb. The significance of adduction and long axis rotation was reduced and the posture of the hindlimbs changed from semi-erect to erect.

Accordingly, bipedal locomotion has been developed gradually from dinosauriforms to basal dinosaurs. This conclusion corresponds perfectly with the trace fossil record of the Middle to Upper Triassic, where the gradual transition from quadrupedal dinosauriform traces to bipedal theropod traces can be observed.

Student Poster Session

A RICH BONE BED OF SAUROPODOMORPH DINOSAURS IN THE EARLY JURASSIC (HETTANGIAN) MCCOY BROOK FORMATION

FEDAK, Tim, Dalhousie Univ., Halifax, NS, Canada

A bone bed of basal sauropodomorph dinosaurs has been recently discovered in the Early Jurassic (Hettangian) McCoy Brook Formation, on the shores of the Minas Basin in Nova Scotia. The new specimens demonstrate the McCoy Brook sauropodomorph is distinct from the genus *Ammosaurus*; lacking the distinct elongate preacetabular process of the ilium and the foramen in the rib of the second sacral vertebra.

All specimens collected from the site are affected by varying degrees of compression and fault displacement deformation, attributable to syndepositional faulting and high sedimentation rate in this small half-graben basin, as well as minimal permineralization of the fossil skeletons. Within the 10 m² area of strata that has been excavated, five fully and semi-articulated skeletons have been recovered, including one nearly complete and three partial large specimens, and a smaller articulated skeleton similar in size to the largest *Ammosaurus* specimen. Preliminary sedimentological evidence suggests the skeletons were buried rapidly by fluvial sediments after a short period of sub-aerially exposure.

The McCoy Brook sauropodomorph taxon has an elongate postacetabular process, a five vertebrae sacrum, and several unique cranial features. These specimens represent the oldest dinosaur skeletons in Canada and the richest deposit of sauropodomorph dinosaurs in North America.

Friday 8:00

DISCRIMINATING LANDSCAPE USE IN HOLOCENE MAMMALS USING STRONTIUM ISOTOPES

FERANEC, Robert, Albany, NY; HADLY, Elizabeth, PAYTAN, Adina, Stanford Univ., Stanford, CA

One way to understand how projected global warming will affect extant mammals is to look at what effect climatic change had in the past. An important aspect of a species that generally has been difficult to examine in ancient mammals is landscape use. Here, landscape use is examined by analyzing strontium isotope values found in mammalian hard tissues. This study specifically examines: (1) do strontium isotopes identify larger scales of space use for larger species as predicted?; (2) do mammals adjust scale of space use with climatic change? Strontium isotope values were obtained from 46 specimens from the Holocene deposits of Lamar Cave and Waterfall Locality in Yellowstone National Park, as well as from 13 modern ungulate specimens. ⁸⁷Sr/⁸⁶Sr values show medium and large-sized species having larger scale of space use than smaller species. Additionally, isotope values for specimens from both Lamar Cave and Waterfall Locality are similar across all stratigraphic levels suggesting no change in landscape use over the last 3000 years, even though climate is known to fluctuate at these sites over this time period. Climate change during the last part of the Holocene may not have been significant relative to the variation endured by species over the Pleistocene to cause landscape use changes. Further, this study verifies previous suggestions that the fossil localities derive from local fauna and that predator foraging radii have not changed during the late Holocene. Where bedrock geology is appropriate, the use of strontium isotope analyses appears a valuable tool for discerning home range, an important though generally difficult aspect of an ancient species niche to identify.

Marine Reptiles Symposium, Wednesday 4:15

PALEOBIOLOGICAL SIGNIFICANCE OF HYPERTROPHIED SALT-SECRETING GLANDS IN *GEOSAURUS ARAUCANENSIS* (CROCODYLIFORMES: METRIORHYNCHIDAE)

FERNANDEZ, Marta, GASPARINI, Zulma, Museo de La Plata, La Plata, Argentina

The natural cast of salt-secreting glands, housed at the antorbital cavity of the skull, has been described in two adults of the Tithonian metriorhynchid *Geosaurus araucanensis*. This finding represented the first directed evidence of an extra-renal osmoregulatory system in extinct marine archosaurs. A new juvenile specimen of *G. araucanensis* bearing similar antorbital structures as the two adults described before, has been recently found. The large gland size, and the number and sizes of the lobules found in *G. araucanensis* suggest that these glands had high secretory capacity. According to the model of gradual evolutionary specialization of marine reptiles from a freshwater ancestor, this metriorhynchid represents the final stage. The final stage implies hypertrophied salt-secreting glands allowing the maintenance of a constant plasma osmolality even when sea water and osmoconforming preys are ingested. In extant reptiles this final stage is represented by sea turtles, marine iguana and sea snake, but not crocodiles. We proposed that the salt-secreting glands of *Geosaurus* drained through the antorbital fenestra and that the antorbital fossa housed at least a portion of its ducts. The development of salt-secreting glands of high secretory capacity is also inferred in the other metriorhynchids *Metriorhynchus* and *Dakosaurus*. The size inferred of salt-secreting glands in the juvenile specimen, suggests that hatches had salt-secreting glands large enough to cope with the osmoregulatory demands of open sea life.

Wednesday 9:30

A POSSIBLE RECORD OF THE SOUTH AMERICAN MAMMAL ORDER LITOPTERNA IN MEXICO

FERRUSQUIA-VILAFRANCA, Ismael, Instituto de Geología, Universidad Nacional Autónoma de México, México City, México; MALVIDO-ARRIAGA, Roberto, México City, México

A fortuitous find of fossil material during the construction of a warehouse in eastern Mexico City might be the possible first record of the South American order Litopterna not only in Mexico but in North America as well. The fossils were found in a ditch excavated on late Pleistocene strata of volcanarenitic, poorly consolidated clastics.

The material belonged to a ~bull-sized mammal, it includes an atlas, a thoracic vertebra, a sacrum fragment, and a lower molar; it is large [92 mm high, 58 mm long and 20 mm wide], inward curved, hypsodont, rootless, and thickly enameled. The occlusal pattern consists of two subequal lobes, the anterior is roughly L-shaped with the short arm wide and antero-lingually directed; the long arm tapers rearwardly (thus becoming wedge-like) and is set parallel to the molar medium plane; it shows a little bulge in the medial part, from where narrow ribs (stylids?) emerge on the labial and lingual sides. The posterior lobe is a bit smaller, slightly postero-labially set with respect to the medium plane, and placed a little more labially than the anterior lobe; this displacement significantly increases downward; its outline is seleniform (more so downward), with a median concavity that corresponds to a shallow sulcus on the labial side. The tooth has growth lines (~12 to 14 per 1 cm), set as numerous fine striae alternating with a few thicker ones.

This molar built is unlike that of the perissodactyls and artiodactyls, but resembles that of the South American Pleistocene macrauchenid litopterns in being simple, hypsodont, and formed by two, relatively narrow, semilunate lobes; however, the Mexican specimen is more thickly-enameled and more hypsodont than any macrauchenid. This taxon is well known in the late Pleistocene of South America, from Argentina to Venezuela, but has not

been recorded in Central America. If this specimen is indeed a litoptern, it would be the first record of this order in North America; its presence in Mexico would add to the recent discovery in Michoacan, Central Mexico, of another previously unrecorded South American mammal order, represented by a toxodont notungulate.

Poster Session I

PRIMATE DIVERSITY AND ABUNDANCE DURING THE EARLIEST EOCENE (BIGHORN BASIN, WYOMING)

FET, Elizabeth, STRAIT, Suzanne, Marshall University, Huntington, WV
The Bighorn Basin, Wyoming has yielded the most diverse and abundant Paleocene/Eocene fossil mammals in North America. Collecting in the Honeycombs region of the southeastern Bighorn Basin has resulted in the recovery of approximately 3,300 mammalian specimens from the basal Wasatchian NALMA (Wa-0 biochron). These Wa-0 localities occur within the Carbon Isotope Excursion (CIE) and the Paleocene/Eocene Thermal Maximum (PETM) and therefore this fauna is significant for examining patterns of faunal change in response to climatic warming. Over 90% of the specimens thus far collected are from a single screen wash locality (UCMP V 99019, Castle Gardens). Additional specimens have been recovered from both surface prospecting and collection at anthills.

Primates from this region show moderate diversity, with three species being recognized including, *Cantius torresi*, *Arctodontomys* sp. nov., and *Niptomomys favorum*. Both *Cantius* and *Arctodontomys* are merely represented by a single specimen each. Additionally, both of these taxa were collected from anthill localities and none have been found in the 13 tons of matrix that has been processed from the main locality of Castle Gardens.

Approximately 80% of the mammals recovered from Castle Gardens have an estimated body mass of less than 350 grams. These small bodied taxa include species from Primates, Multituberculata, Lipotyphla, Marsupialia, Proteutheria, and Apatotheria. The only primate known from Castle Gardens is *N. favorum* which is substantially smaller than either earlier and/or later occurring *Niptomomys* species. Although *N. favorum* was originally known from a single specimen, more than 300 isolated teeth have been now found. This primate comprises 11% of the Castle Gardens specimens; only the lipotyphlan *Macrocranium junnei* and the multituberculata *Ectypodus tardus* are more abundant at this locality. *Niptomomys* is typically very rare, even at other Paleocene/Eocene localities dominated by small-bodied taxa. Given the abundance of this taxon, *N. favorum* may have responded favorably to the warm climatic conditions associated with Wa-0 and the PETM.

Thursday 2:15

AN EVALUATION OF BODY SIZE TRENDS IN NORTH AMERICAN, TERRESTRIAL CANIFORM TAXA (CARNIVORA: MAMMALIA)

FINARELLI, John, Univ. of Chicago, Chicago, IL
Body size often has been described as the fundamental variable of organismal biology. Among modern mammals, body size has been correlated to a diverse suite of life history and ecologic variables that are of interest to paleobiologists. A previous investigation into reconstructions of body size incorporating data from fossil taxa for the carnivoran subclade Caniformia reconstructed small-bodied ancestors at the base of several clades that today are represented exclusively by large forms, implying parallel trends toward increasing body size in several clades. Evidence also was found for decreased body size among the musteloids.

Observed directional trends can be the result of both active and passive mechanisms. Here, an analysis of the underlying mechanisms for the observed trends in body size for terrestrial, North American caniform taxa is undertaken. Fossils provide insight into the causal mechanisms of evolutionary trends, by increasing understanding of the timing of shifts in body size, and determining whether these are constant across lineage history or if change is episodic and accumulated coincident with presumed increases in competition or evacuation of niche space recorded in the fossil record.

First and last appearances and body mass estimates were compiled for 243 North American, terrestrial caniform species, including 199 fossil taxa. With multiple independent trajectories of body size discovered, a simultaneous analysis across all Caniformia is not likely to generate accurate results. As such, body masses were tabulated for monophyletic clades through sequential time slices. Using the multinomial support function, likelihoods were calculated to determine the bias of change with respect to increase or decrease in both minimum and maximum size for each clade. Superficially similar patterns of increased body size are observed among several independent fossil caniform lineages (e.g., Borophaginae and Hesperocyoninae). However, preliminary analyses indicate that these are the result of different underlying mechanisms, and that trends observed in several lineages are not constant, but rather body size increases coincide with extrinsic biotic events.

Wednesday 5:15

DINOSAURIA AND AVES FOSSIL FOOTPRINTS FROM THE LOWER CANTWELL FORMATION (UPPER CRETACEOUS), DENALI NATIONAL PARK, ALASKA

FIORILLO, Anthony, Dallas Museum of Natural History, Dallas, TX; BREITHAUPT, Brent, Univ. of Wyoming, Laramie, WY; McCARTHY, Paul, Univ. of Alaska, Fairbanks, AK

The Cantwell Formation (Upper Cretaceous to lower Tertiary) is a thick rock unit that crops out in much of the central part of Denali National Park. The lower part of this succession is dominantly comprised of fine-grained channel and floodplain sedimentary facies.

Floodplain deposits contain abundant evidence of weak pedogenesis, including root traces, blocky structure, iron oxide mottles and nodules, suggesting widespread poorly drained conditions in a highly aggradational setting. The upper Cantwell succession is largely volcanic. The lower Cantwell Formation correlates in age with the famous dinosaur-bearing rocks of the Prince Creek Formation of the North Slope of Alaska, as well as the dinosaur-bearing Chignik Formation of Aniakchak National Park in southwestern Alaska.

Three new vertebrate fossil sites have been discovered in Denali National Park. The first locality, located in the Igloo Creek drainage, yielded the natural cast of an isolated right pes of a medium-sized theropod. The track measures approximately 22 cm in length and 15 cm in width, which provides an estimated hip height of approximately 90 cm and a body length of approximately 3 m.

A second site, located on Double Mountain, produced an impression of a theropod approximately the same size as the previous. The remaining locality, also on Double Mountain, is in a lacustrine facies and has yielded dozens of tracks attributable to medium-sized wading birds, approximately the size of a modern Willet or an American Avocet. The morphology of the tracks indicates the substrate was still very wet when these birds walked on the surface. There are also numerous small, nearly circular depressions, approximately 3 mm in diameter, on the same bedding plane. These features are likely the feeding traces of these shore birds. Combined, these tracks represent the first record of Late Cretaceous fossil vertebrates from Denali National Park as well as the Alaska Range.

Friday 2:45

TUSK CEMENTUM DEFECTS RECORD MUSTH BATTLES IN AMERICAN MASTODONS

FISHER, Daniel, Univ. of Michigan, Ann Arbor, MI
Combat between adult male American mastodons (*Mammuth americanum*) has been hypothesized to explain cases of cranial injury that were evidently caused by an upwardly directed thrust of an opponent's tusk tip. Additional injuries corroborated the inference of lethal combat, and details of tusk anatomy and growth records supported association of these injuries with musth episodes. However, the only direct evidence of combat noted previously involved events causally related to death. A previously unrecognized type of recurring, anomalous structure in tusk dentin and cementum is here interpreted as a direct record of musth battles in prior years, long before death. Arcuate tracts of cementum defects parallel the growing margin of the tusk and the strike of periradicular incremental topography. These features occur in the proximal portion of tusks of adult males, along the outside curve of the tusk. Arc-length of each feature varies, but is usually less than one third of tusk circumference. These cementum defects resemble dental hypoplasias, a phenomenon usually explained as due to an episode of physiological stress during tooth development. In thin section, externally visible pits and irregularities of the cementum surface can be followed as contorted and irregular cementum laminae and subjacent tracts of sclerotic dentin. These anomalous histologic features are interpreted as produced by cementoblasts and odontoblasts (respectively) damaged by mechanical trauma near the time of their differentiation, when they were located at the growing margin of the tusk. The inferred cause of this damage is rotational displacement of the tusk due to reaction forces produced by thrusting the tusk tip into an opponent during a musth battle. In normal use, the growing margin of the tusk is protected from impact with alveolar bone, but supercritical forces produced during musth battles displaced the tusk within its alveolus, causing localized damage to the margin along the outer curve of the tusk. Tracts of cementum defects record multiple prior bouts of combat in mid-spring to early summer, yielding a history of musth in adult males.

Poster Session II

DOCUMENTING THE ANATOMY OF AN ENIGMA: THE HIND LIMB MYOLOGY OF *AILURUS FULGENS*

FISHER, Rebecca, HICKS, Michelle, ELROD, Clay, Midwestern Univ., Glendale, AZ
The red panda (*Ailurus fulgens*) is an endangered species living in the temperate forests of the Himalayas and southern China. Weighing 3-6 kg, red pandas are scorial but feed primarily on the forest floor, subsisting largely on a diet of bamboo. Since the time of their initial description in 1821, the classification of the red panda has been the subject of much debate. Morphological and molecular studies have supported a wide range of possible taxonomies, including close ties to ursids, procyonids, arctoids (ursids and pinnipeds) and musteloids (procyonids, mustelids, and mephitids).

This study provides additional morphological data, including muscle maps, for *Ailurus*. Three red panda cadavers from the National Zoological Park were dissected, including an adult male of unknown age and twelve year old and five month old females. In addition, two red panda skeletons from the NMNH were studied and digitally photographed. The hind limb muscles of the three cadavers were dissected, described and digitally photographed. Points of origin and insertion were recorded on transparencies overlying digital photos of each hind limb bone, producing muscle maps. In addition, moment arms, muscle mass, and muscle fiber length and angle were recorded for the right hind limb in the adults.

Dissections revealed a great deal of variation among the three red panda specimens, including fusion of adjacent muscle bellies, subdivision of muscle bellies, and tendon variations. A table comparing the morphology of the red panda to other carnivore species will be presented. Interesting findings include the presence of both gluteofemoralis and abductor cruris caudalis, and the presence of a muscle located deep on the plantar pes and inserting onto the metatarsophalangeal joint of digit one. This plantar muscle appears to be

unique to *Ailurus*. Additional dissections of the red panda fore limb, tail, and muscles of mastication are currently ongoing. Data from these dissections may shed further light on the phylogenetic relationships of this species. In addition, muscle maps generated by this project may prove useful to paleontologists studying related fossil carnivores.

Poster Session I

A NEW HUMERUS OF *HOMUNCULUS* FROM THE SANTA CRUZ FORMATION, (EARLY-MIDDLE MIOCENE, PATAGONIA)

FLEAGLE, John, Dept. of Anatomical Sciences, Stony Brook, NY; KAY, Richard, Dept. of Biological Anthropology and Anatomy, Durham, NC

Postcranial bones of are particularly rare in the fossil record of platyrrhine primates and, when known, are most often fragmentary. A humerus from the Atlantic coastal Miocene deposits of Santa Cruz Formation found at Puesto Estancia La Costa (~51 degrees S) is the most completely preserved early Miocene (~16.5 Ma) primate humerus from South America. The only taxon known from this locality and level is *Homunculus patagonicus*. Previous postcranial bones from this site include a femur, a fragment of the distal humerus, and a radius, all apparently associated with facial fragments, collected by Carlos Ameghino in the late 19th Century. The only other platyrrhine known from substantial parts of a skeleton is the pitheciid *Cebupithecia* from ~12 Ma in Colombia.

The distal end of the new humerus is virtually identical to the one collected by Ameghino and figured and described by Bluntschli, but now lost. The distal end is also similar to that of *Cebupithecia* but larger. The new humerus shows an unusual mix of features compared with many extant platyrrhines. The distal end has an entepicondylar foramen, a medially projecting medial epicondyle, a spool-shaped trochlea and rounded ventrally flexed capitulum. The olecranon fossa is shallow. Overall the distal end is most similar to that of pitheciids and very different from extant cebids or atelids. However, the proximal end is much broader and more robust than that of any extant platyrrhine and has a pronounced ectoepicondylar crest similar to that found in many prosimians and Eocene-Oligocene African anthropoids. Likewise, a strong supinator crest and broad brachialis flange reaches almost halfway up the shaft resembling early anthropoids. The morphology of the humerus suggests arboreal quadrupedalism and the predominant locomotor mode with no evidence of adaptations for either clinging or suspensory behavior.

Wednesday 8:30

A REMARKABLE CONVERGENCE: INDEPENDENT EVOLUTION OF THE MURINE CHEVRON

FLYNN, Lawrence, Peabody Museum of Archaeology and Ethnology, Cambridge, MA

This year paleontologists documented the Lazarus Effect in rodents, discovery of a younger record of a taxon thought to be long extinct. Living *Laonastes* of Southeast Asia was recognized as a member of the Family Diatomyidae, first named for fossils and otherwise last known in the Miocene of southern Asia. The Diatomyidae are a distinct group clustering with gundis as the sister taxon to Hystricognathi. Early diatomyids attributed to the Oligocene genus *Fallomus* are abundantly preserved primarily at Bugti in Baluchistan, Pakistan, and nearby to the northeast in the Zinda Pir Dome. Younger rocks near the Olig/Miocene boundary (loc. Z113) of the Zinda Pir Dome yield a new diatomyid. The Z113 diatomyid differs greatly from *Fallomus*. It has multicusped and large premolars dominating the molar tooth rows. Accessory cusps on the upper deciduous premolar form an arcade resembling the chevron of murines. Analysis of abrasion patterns shows the functions of the individual cusps in some detail. Function differs from that of true murines. Still, the upper deciduous premolar is remarkably similar to the murine M1 in having a chevron (like the murine second chevron) composed of the enterostyle, protocone, and paracone. There are many differences in the teeth of the Z113 diatomyid from those of Murinae. Still, the Z113 genus demonstrates independent development of a complex dental structure: the murine chevron. The murine chevron has been accepted as a synapomorphy for Muridae, but recent molecular data cluster gerbils, which lack chevrons, with them. Under this hypothesis either chevrons developed more than once, or gerbils lost chevrons. The Z113 diatomyid shows that features similar to chevrons can arise independently, although significant differences from true murine structures remain. Conflict in character distribution disappears, given careful definition and detail.

Wednesday 8:15

ORIGIN OF THE AMPHISBAENIAN LIZARDS IN EUROPE

FOLIE, Annelise, SMITH, Richard, SMITH, Thierry, Royal Belgian Institute of Natural Sciences, Brussels, Belgium; SIGÉ, Bernard, Université Claude Bernard-Lyon 1, Villeurbanne, France

Amphisbaenians are burrowing, wormlike limbless lizards characterized by a strong skull and by short, reduced jaws with usually five to nine teeth in modern forms. Their origin is thought to be in the Jurassic of Gondwana, based on the abundance of amphisbaenians in Africa and South America today. In Europe, the oldest clearly identified amphisbaenian is known from the Campanian of Laño (Spain), although this record is only based on vertebrae. The first amphisbaenian jaws were found in the middle Paleocene of Hainin (Belgium), a locality that has yielded the oldest Cenozoic mammalian fauna of Europe (reference-level MP1-5). These jaws present primitive characters and differ from those of mod-

ern amphisbaenians by having proportionally longer, straight dentaries bearing twelve teeth. A similar form is present in the late Paleocene of Cernay (MP6, France). Conversely, in the earliest Eocene Dormaal fauna (MP7, Belgium), an amphisbaenian taxon, with a short, anteriorly curved jaw, bearing eight to nine labio-lingually compressed teeth is abundantly present, representing the earliest modern European amphisbaenid. Similar taxa also occur in the middle early Eocene of Condé-en-Brie (MP8+9, France) and the late early Eocene of Prémontré (MP10, France). This suggests that modern amphisbaenids first migrated into Europe around the Paleocene-Eocene boundary. Because the contemporaneous North American amphisbaenians are exclusively composed of the morphologically different rhineurids, with strong longitudinal striae and a denticulate posterior border of the neural arch on the vertebrae in dorsal view, North America is unlikely to be the region of origin for the European modern amphisbaenians.

Poster Session III

PICK YOUR POISON: THE DISTRIBUTION OF CANINE GROOVES IN VERTEBRATES AND INFERENCE OF VENOM DELIVERY IN EXTINCT TAXA

FOLINSBEE, Kaila, REISZ, Robert, Univ. of Toronto at Mississauga, Mississauga, ON, Canada; MÜLLER, Johannes, Humboldt-Universität, Berlin, Germany

Venom has evolved in most animal lineages for defense, food procurement and chemical pre-digestion. In terrestrial vertebrates, a venom delivery system (VDS) is defined as modified teeth connected to specialized venom glands. The presence of grooved teeth has been used to infer the presence of VDSs in various extinct reptiles and synapsids. However, canine grooves are widely present in extant non-venomous taxa including cercopithecoid monkeys, suids, and hippos. In cercopithecids for example, deep grooves extending into the root occur on the anterior face of the upper canine. Wear commonly occurs along the edges of the groove where the lower canine occludes anterior to the upper, and along the distal edge where the upper canine is honed against the lower third premolar. Hippos and suiforms show similar groove/occlusion morphology; the lower canine is honed against the upper on the mesial edge and the groove occurs on the opposite (distal) side. In extinct taxa, the presence of grooved dentition alone provides insufficient justification for inferring a complex VDS in the absence of a strong phylogenetic association supporting homology (e.g. fossil snake fang indicates the presence of venom in extinct viperid and elapid snakes).

In extinct taxa, inference of venomous capability requires either multiple skeletal indicators of a VDS to be present (i.e. grooved teeth and a duct or pocket in jaw) or phylogenetic proximity to extant venomous taxa. There are several fossil terrestrial vertebrates that possess correlated skeletal and dental indicators of venom (e.g. *Euchambersia*, a South African theropod and *Uatchitodon*, a North American Triassic reptile). Alternative hypotheses for the function of canine grooves in fossil and extant mammals include: storage of bacteria laden saliva (analogous to the komodo dragon), increasing the structural strength of the tooth during bites or occlusion if the canines are honed against the opposing teeth, or permitting rapid puncture and withdrawal of the tooth after biting. The latter two hypotheses will be tested using stress-analysis techniques.

Neoceti Symposium, Saturday 11:45

AN UNEXPECTED DIVERSITY OF BASAL BALEEN WHALES: LATE OLIGOCENE EOMYSTICETIDAE FROM NEW ZEALAND

FORDYCE, Ewan, Univ. of Otago, Dunedin, New Zealand

New species of late Oligocene Mysticeti from New Zealand help revise and expand the archaic family Eomysticetidae, with implications for mysticete phylogeny. The fossils (Geology Museum, University of Otago) are from the mid-outer shelf Kokoamu Greensand and Otekaika Limestone (~ 24-28 Ma) of the Waitaki Valley region, South Island. Specimens with associated skulls, jaws, and earbones include juveniles (OU12918, OU22163) and adults (OU22044, OU22235), and the holotype of "*Mauicetus*" *lophocephalus* Marples. Other less-complete specimens, including the holotype of "*Mauicetus*" *waitakiensis* Marples, have tympanoperiotics and associated elements.

In OU22044 (cbl ~1.80 m) and 22235 (~1.95 m), the rostrum is long (70-75 % of cbl), narrow, and toothless, with few ventral "baleen" grooves. Long nasals (~25% of cbl) indicate an anterior blowhole. Large temporal fossae separated by long, narrow, deep parietals at the intertemporal region imply large temporal muscles. Frontals are delicate without large temporalis origins. Zygomatic processes are long, large and grooved medially. Each mandible is bowed slightly outwards, with a ligamentous symphysis and low, long, posteriorly situated coronoid process. The periotic has a compressed plate-like anterior process, a small and rather smooth body, a prominent lateral tuberosity, a large pars cochlearis and a variably elongate posterior process not fused with the bulla. The bulla is robust and bilobed; its short robust triangular posterior process has a prominent lateral face. The atlas and axis are robust, with unfused more-posterior cervicals anteroposteriorly flattened.

The putative eomysticetids probably had "gulp" filter-feeding habits that differed in detail from living rorquals. The ~4 m.y. record of New Zealand eomysticetids overlaps with putative stem Balaenidae, stem Balaenopteridae, late-surviving archaeocetes, diverse putative stem Platanistoidea, and rare stem Delphinoidea. The Eomysticetidae are amongst the most basal and oldest toothless mysticetes; they are phylogenetically distant from Balaenopteridae and Balaenidae, but relationships with the *Cetotherium* clade, and Neogene history, remain uncertain.

Saturday 3:45

DATA QUALITY, SIGNAL DETECTION, AND METHODOLOGICAL ROBUSTICITY IN THE ANALYSIS OF LARGE FOSSIL DATASETS

FORTELIUS, Mikael, University of Helsinki, Helsinki, Finland; PUOLAMÄKI, Kai, Helsinki University of Technology, Espoo, Finland; JERNVALL, Jukka, MANNILA, Heikki, GIONIS, Aristides, Univ. of Helsinki, Helsinki, Finland

The development and increasing use of public fossil databases in paleontological research draws attention to issues of data quality, detection of signals in noisy datasets, and robusticity of results with respect to analytical methods employed. Here we address issues arising in the analysis of fossil data compiled from disparate sources, using examples drawn from the NOW database of Old World Neogene land mammals (<http://www.helsinki.fi/science/now/>).

In the NOW data, several of the main spatial and temporal patterns were already detectable in a small dataset (1996, 511 locs) and have subsequently been found in analyses using updated and eventually much larger datasets (1753 locs for the same area in 2006). Among these robust patterns are the development in the Middle Miocene of Europe a contrast between a humid West and a dry East, the confinement of the abrupt turnover of the Vallesian Crisis in the early late Miocene to western Europe, and several trends involving trophic level, body size and ecomorphology. However, increased sampling and improved methodology has also revealed significant additional detail as well as general trends not originally detected.

One of the main issues in the analysis of fossil data concerns stratigraphic resolution and correlation between local zonations. Recent work on computational biostratigraphy has revealed that techniques based on entirely different principles, such as Appearance Event Ordination, Spectral Ordering, Monte Carlo Markov Chain methods, and Finding Partial Order, all generate broadly similar temporal patterns based on taxon occurrence alone, especially when only the most common taxa are included. The results correspond well to those based on recorded 'database age', derived from subjective assignment to time units or direct geochronology, but appear to have somewhat better time resolution. As an example we present a detailed study of how soon extinction of a taxon follows a decline in its observed commonness, using multiple, independently computed chronologies and two different versions of the NOW data.

Wednesday 11:00

MICROVERTEBRATE SITES IN THE MORRISON FORMATION (UPPER JURASSIC) OF THE WESTERN UNITED STATES: DEFINITION OF TAPHONOMIC MODES

FOSTER, John, Museum of Western Colorado, Grand Junction, CO; CARRANO, Matthew, Smithsonian Institution, Washington, DC; TRUJILLO, Kelli, Univ. of Wyoming Geological Museum, Laramie, WY; MADSEN, Scott, Dinosaur National Monument, Jensen, UT

In the Morrison Formation of western North America (Late Jurassic), microvertebrate specimens are known from a number of localities, but nine sites in particular have yielded abundant fossils. These nine sites combine for a vertebrate sample of 5000+ specimens and range in represented diversity from as few as 10 to as many as 45 taxa. The taphonomic and lithologic characteristics of some sites and their fossil material seem to be consistent and define three taphonomic modes of microvertebrate occurrence: Type I, characterized by thin, dense accumulations of abundant disarticulated microvertebrate remains in relatively hard green-gray siltstones and claystones; Type II, characterized by thicker layers of sparse accumulations of articulated to disarticulated microvertebrates in light gray to gray claystones (sometimes with minor silt); and Type III, characterized by thick layers of moderately dense accumulations of disarticulated microvertebrates in soft green-gray claystones that screen-wash to produce abundant fragmentary remains. Type I deposits are exemplified by Quarry 9 at Como Bluff, the Little Houston Quarry, and the Small Quarry; Type II by the Fruita Paleontological Area sites, Rainbow Park 96, and the Wolf Creek Quarry; and Type III by Ninemile Hill and Mile 175. Rainbow Park 94 may be a Type II/III locality. The differences in frequency of articulation and in bone deposit density between deposits of Types I and II are striking. One likely would never mistake matrix with bone from Quarry 9, Small, or Little Houston as coming from the Fruita Paleo Area or Wolf Creek, for example; and in fact, in hand sample, matrix from Little Houston and the Small Quarry can be literally indistinguishable. Environments of preservation for the different modes include abandoned channels and levee/splays for Type I, and overbank deposits for II and III. These modes suggest possible lithologies in which to find new microvertebrate sites and, along with environmental interpretations, may provide clues as to the reasons for preservation of microvertebrates in certain conditions at different sites.

Poster Session III

TERRESTRIAL LATE CRETACEOUS STRATIGRAPHY OF NORTH AMERICA AND THE UTILITY OF CERATOPSIDS IN BIOSTRATIGRAPHY

FOWLER, Denver, Stockport, United Kingdom

A comprehensive stratigraphy is presented for the terrestrial Late Cretaceous units of North America. This combines published radiometric dates, magnetostratigraphy, and reviews ranges of known taxa, paying particular attention to ceratopsids. While the stratigraphic relationships of Campanian strata are well constrained, the majority of the Maastrichtian is still largely unresolved. In the Campanian, integrity of the recently proposed Kirtlandian age is maintained. Uppermost deposits of the Two Medicine Fm, Montana, are demonstrated as early Kirtlandian in age. Purported north-south provinciality of dinosaurs is shown to

be mostly an artefact of stratigraphic incongruence. Exceptions are two biogeographically distinct chasmosaurine lineages present in the Judithian, and the presence of sauropods in the south, but not the north during the Edmontonian. Contrary to much recent work, stratigraphy and new material tentatively supports a single anagenetic lineage for centrosaurines. Most Late Cretaceous sauropod material from North America is attributed to *Alamosaurus sanjuanensis* and this has been used to infer same-age relationships for *Alamosaurus*-bearing strata. There is little evidence to support this. The form taxon *Alamosaurus* is unknown before the Maastrichtian, but is otherwise shown to be stratigraphically uninformative. We should not expect all ceratopsids found in formations bearing *Alamosaurus* to be the same taxon. If the pattern of speciation seen in the Campanian is followed, it is likely that many more species of chasmosaurine remain to be discovered from 70.5-66Ma. Rapid stepwise acquisition of characters in ceratopsids suggests that careful analysis of ceratopsid taxonomy and distribution presents them as the best biostratigraphic markers to be used where radiometric dates are not available.

Friday 8:45

CARBON AND NITROGEN ISOTOPIC RECONSTRUCTION OF TROPHIC RELATIONSHIPS BETWEEN HERBIVOROUS MAMMALS FROM SALTVILLE, VIRGINIA

FRANCE, Christine, Univ. of Maryland, College Park, MD; ZELANKO, Paula, Lehigh Univ., Bethlehem, PA; KAUFMAN, Alan, HOLTZ, Thomas, Univ. of Maryland, College Park, MD

Stable isotopic data from terrestrial herbivores in the Saltville Quarry, Virginia (late Rancholabrean) indicates a range of potential feeding strategies and digestive mechanisms. Nitrogen isotopic values of bone collagen are used to indicate trophic relationships while carbon isotopic values examine partitioning between browsers and grazers. Observations include a range of $\delta^{15}\text{N}$ values with the two most common herbivorous digestive mechanisms (i.e. ruminants and non-ruminants) clustering in two groups. A giant sloth exhibits isotopic values indicative of a non-ruminant herbivorous feeding strategy as opposed to alternate hypotheses of carnivorous or omnivorous strategies. A mammoth juvenile exhibited a relatively high $\delta^{15}\text{N}$ value which may be due to the previously noted nitrogen isotopic enrichment of mammalian milk. The $\delta^{13}\text{C}$ values indicate a dominance of C-3 plant browsers which may imply the absence of extensive or open C-4 grasslands in this region. This study, combined with currently ongoing analyses of Pliocene and Pleistocene specimens from Florida and California, will be used to examine trophic collapse at the end of the Pleistocene. The larger data set produced by these additional sites in conjunction with the Saltville data will provide new insight into the end Pleistocene mass extinction and the controversy between the human-driven versus the climate-driven hypotheses governing this event.

Poster Session II

THE FIRST RECORD OF *COAHOMASUCHUS* (ARCHOSAURIA: STAGONOLEPIDIDAE) FROM THE CARNIAN OF EASTERN NORTH AMERICA

FRASER, Nicholas, Virginia Museum of Natural History, Martinsville, VA; HECKERT, Andrew, Appalachian State Univ., Boone, NC; LUCAS, Spencer, New Mexico Museum of Natural History, Albuquerque, NM; SCHNEIDER, Vincent, North Carolina Museum of Natural Sciences, Raleigh, NC

A partial, articulated aetosaur that preserves a large portion of the bony armor, and more than 20 isolated osteoderms from a quarry in the Pekin Formation, (Carnian) of the Deep River basin of North Carolina most closely resemble the Carnian aetosaur *Coahomasuchus*. This genus was previously described from a single specimen from the Colorado City Formation (Otischalkian) of Texas. The sculpturing pattern in the new material is similar to *Coahomasuchus*, particularly in the largest paramedians, and exhibits a pattern of faint, sub-parallel grooves on the anterior dorsal paramedians and a better-developed "star-burst" radiating pattern of pits and grooves on more posterior osteoderms. The overall proportions of the new osteoderms, the absence of spikes on the lateral osteoderms and the lack of prominent bosses on the paramedian osteoderms, are also consistent with *Coahomasuchus*. Further preparation needs to be performed on the articulated specimen before a definitive species diagnosis is possible, so the North Carolina material is referred to *Coahomasuchus* sp. A second taxon is represented by a handful of associated caudal osteoderms, and they are referred to *Longosuchus*. Finally a caudal paramedian and a caudal lateral osteoderm with prominent bosses and a pitted ornamentation most closely resemble *Stagonolepis wellsi*. All fossils were recovered from spoils of a mining operation, but the *Longosuchus* and *Coahomasuchus* material were found in a different sediment type to that of the possible *S. wellsi* fossils. *Longosuchus* (including "*Lucasuchus*") has previously been reported from the Deep River Basin and is an index taxon of Otischalkian (Carnian) age. *Coahomasuchus* now co-occurs with *Longosuchus* in both the Chinle of Texas and the Pekin Formation of North Carolina and thus may be an index taxon of Otischalkian age.

Poster Session I

FAUNAL TURNOVER DETERMINED USING TAPHONOMICALLY EQUIVALENT ELEMENTS FROM MICROVERTEBRATE ACCUMULATIONS IN THE JUDITH RIVER (CAMPANIAN) AND HELL CREEK (MAASTRICHTIAN) FORMATIONS OF MONTANA

FREEDMAN, Elizabeth, WILSON, Laura, Museum of the Rockies, Bozeman, MT
Microvertebrate accumulations have historically been used for comparing paleocommuni-

ties across time and space, but with little consideration of the taphonomic biases caused by different hydraulic equivalencies of skeletal elements. In this study, four Judith River Formation assemblages were screenwashed and two Hell Creek Formation assemblages were quarried for microvertebrate remains. Statistical analyses show that population comparisons are possible between assemblages when comparing taphonomically similar elements of morphologically similar organisms, such as the scales of ganoid fish or the vertebrae of caudates. First applied to microvertebrate assemblages from the Maastrichtian Hell Creek Formation, this methodology was then tested on similar assemblages from the Campanian Judith River Formation. In both cases, taphonomically similar elements are not significantly different within their respective formations. Because there is a large carry-over of taxa from the Campanian to the Maastrichtian of the Northern Great Plains, direct population comparisons are possible between the paleocommunities. Chi-squared tests of taphonomically similar elements show significant differences within ornithischian, saurischian, and caudate abundances between the two formations. Turtles and ganoid scale-bearing fish abundances are not significantly different between assemblages. In Q-mode eigenanalysis, assemblages cluster by formation, indicating significant differences in faunal abundances between the Judith River and Hell Creek Formations. This study shows that analyses of taphonomically similar elements can be used to compare intraformational assemblages as well as trace population changes between formations, providing a new avenue for future paleoecological research.

Saturday 3:45

STABLE ISOTOPE COMPARISONS AMONG LATE CRETACEOUS DINOSAUR LOCALITIES: CAN INFERENCES RELATED TO HADROSAUR HABITAT PREFERENCE AND MIGRATION BE DRAWN IN LIGHT OF DIAGENESIS?

FRICKE, Henry, Colorado Springs, CO; ROGERS, Raymond, Macalester College, St. Paul, MN

Stable isotope ratios were measured for samples of hadrosaur tooth enamel, hadrosaur dentine, and gar scale ganoine from four contemporaneous Late Cretaceous (Campanian) localities in the Western Interior Basin. These include sites in the upland facies of the Kaiparowits Formation (Utah) and Two Medicine Formation (Montana), and the coastal facies of the Judith River Formation (Montana) and Dinosaur Park Formation (Alberta). In each formation isotopic offsets were observed between enamel and dentine from the same teeth, with dentine being characterized by higher and more variable carbon and oxygen isotope ratios. Also in each case, isotopic offsets between gar ganoine and hadrosaur enamel were observed that are of the same magnitude and in the same direction. Focusing on hadrosaur data, overlap in isotope ratios only occurred between sites in the Judith River Formation and the Dinosaur Park Formation.

The lack of isotopic overlap among localities could be due to diagenetic resetting of isotope ratios such that they reflect local groundwater effects rather than primary biogenic inputs. However, the large range in carbon isotope ratios, the consistent taxonomic offsets for enamel/ganoine data, and comparisons of enamel-dentine data from the same teeth all suggest that diagenesis did not entirely overprint primary isotopic information. Different hadrosaur species are known from each formation, and thus another possible explanation of isotopic differences among localities is that sampled taxa relied on food and water resources with different average carbon and oxygen isotope ratios regardless of geographic location, or that these taxa had systematically different diet-tooth enamel, water-tooth enamel isotopic offsets regardless of geographic location. A third reasonable explanation given the latitudinal transect we sampled is that hadrosaurs from the targeted formations were eating plants and drinking waters with distinct isotopic ratios. One implication of this last hypothesis is that hadrosaurs in the Late Cretaceous of the Western Interior did not migrate to an extent that would obscure local isotopic signatures.

Thursday 2:45

NEW PERSPECTIVES ON THE EVOLUTIONARY RADIATION OF ACANTHOMORPH TELEOSTS

FRIEDMAN, Matt, Chicago, IL

Although a major component of modern marine ichthyofaunas, acanthomorphs were uncommon until the early Paleogene, by which point they had diversified prolifically. While the magnitude of the acanthomorph radiation is unquestionable, its tempo has been unclear due to the paucity of fossil material from the Maastrichtian and Danian. New investigations have helped to illuminate this critical interval of acanthomorph history. The Maastrichtian acanthomorphs of Holland include polymixiids and 'berycooids', while the Danian faunas of Scandinavia also bear a strong Cretaceous signature, with taxa similar to those of the Maastrichtian. These Danian forms are complemented by two perciforms, one of which bears highly modified jaws, but there is no indication of the disparate clades that first appear near the Paleocene/Eocene boundary.

Additional uncertainties surrounding the acanthomorph radiation concern the disproportionate effect a few localities might have on the fossil record. Monte Bolca (Lutetian) has been cited as a profound contributor to this 'lagerstätten effect', but such claims have gone untested. Although the number of acanthomorph families originating in the Lutetian exceeds that of any other stage in the group's history, origination rates during this stage were in fact lower than those in either the Danian, Thanetian, or Ypresian. Articulated remains of fossil fishes permit examination of patterns of morphological diversification as a complement to those based entirely upon taxonomic measures, and provide another test of the influence of individual faunas on the overall pattern of the acanthomorph radiation.

Romer Prize Session, Thursday 8:30

ECOMORPHOLOGY OF SMALL MAMMALIAN CARNIVORES AND EVIDENCE FOR COMPETITION BETWEEN CARNIVORANS AND CREODONTS IN THE NORTH AMERICAN EOCENE

FRISCHIA, Anthony, Univ. of California, Los Angeles, Los Angeles, CA

An ecomorphological study of small mammalian carnivores from the North American Eocene strengthens the case for possible competition between carnivorans and creodonts. The basis of this analysis was a study of extant small extant carnivorans, including members of the families Canidae, Mephitidae, Mustelidae, Procyonidae, Herpestidae, and Viverridae. This earlier study demonstrated that dietary groups can be distinguished using quantitative morphological characters and revealed trends in differences between dietary classes, including longer carnassial blades in carnivorans, as opposed to larger molar grinding areas, larger post-canine dentitions, and wider fourth premolars in omnivores/hard-object feeders. Insectivores were not consistently distinguished from other dietary types, although they did tend to have weaker dentaries and shorter temporalis muscle moment arms. These trends were used to help interpret morphologies of extinct taxa of uncertain ecologies. Generic diversity curves of creodonts and carnivorans through the Eocene demonstrate the classic "double-wedge" pattern of diversity overlap between the two orders. Temporal analyses show both groups evolving from mainly generalized, small forms into larger, more hypercarnivorous forms. In carnivorans this is accomplished with an expansion of ecomorphological space, while in creodonts this occurs at the expense of generalized ecotypes. This ecological similarity enhances the case for competition, although the turnover itself may have been triggered by a climatic change.

Saturday 1:45

A NEW BASAL THERAPSID FROM THE MIDDLE PERMIAN MEZEN COMPLEX OF RUSSIA AND THE EARLY DIVERSIFICATION OF THERAPSIDA

FROEBISCH, Joerg, REISZ, Robert, Univ. of Toronto at Mississauga, Mississauga, ON, Canada

The late Paleozoic documents a drastic faunal shift in the terrestrial realm from "pelycosaur"-dominated faunas in the Early Permian to therapsid-dominated faunas of the Middle and Late Permian. The transition between these faunas is best represented by the Mezen Complex in the northern Fore-Ural region of European Russia. The Mezen vertebrate fauna exclusively contains amniotes and is characteristically dominated in numbers by parareptilian taxa such as *Nyctiphruetus*, *Macroleter*, *Nycteroleter*, *Lanthaniscus*, and *Bashkyroleter*. However, this fauna also includes an exceptionally diverse synapsid fauna, including the varanopids *Mesenosaurus* and *Pyozia* as well as the caseid *Ennatosaurus*. Therapsids are represented by five distinct taxa, the enigmatic nikkasaurids *Nikkasaurus tatarinovi*, *Reiszia gubini*, and *R. tippula*, the possible basal dicephalian *Naftasuchus zekkei*, and the basal biarmosuchian *Biarmosuchus tagax*. Although less abundant, the therapsids always co-occur with basal synapsids in nine localities straddling the Kazanian-Tatarian boundary, although the Mezen Complex covers a wider time range of about 10 Ma.

Undescribed new material from the Mezen Complex represents a basal therapsid and is referable to what has previously been described as *Biarmosuchus tagax*. The holotype of this species consists of a fragmentary skull that preserves the posterior half of the skull and lacks most of the snout, occiput, lower jaws, and all teeth. It was assigned to the genus *Biarmosuchus* on the basis of overall similarity, only differing from the type species *B. tener* in the shape of the orbit and temporal opening. The new material consists of an almost complete skull and lower jaws with associated postcranium. The skull is laterally compressed, but reveals important anatomical structures including the snout, palate, and dentition. Most importantly, the new specimen exhibits an almost complete tooth row that clearly shows intermeshing incisors, lacks a large caniniform, and has tricuspid cheek teeth. The combination of these dental characters and the presence of a preauricular indicate that "*B. tagax*" represents a basal therapsid distinct from *Biarmosuchus*.

Romer Prize Session, Thursday 8:45

THE EVOLUTION OF PREAXIAL DOMINANCE IN TETRAPOD LIMB DEVELOPMENT

FROEBISCH, Nadia, McGill Univ., Montreal, QB, Canada

Limbs adapted for terrestrial locomotion are a hallmark of the tetrapod body plan. Despite the wide range of shapes and sizes that accompany a vast variety of limb functions, their development follows a very conservative pattern of *de novo* condensation, branching, and segmentation. Development of the zeugopodium and digital arch typically occurs in a posterior to anterior sequence, referred to as postaxial dominance, with a digital sequence of IV-III-V-II-I. The only exception to this pattern in all of living Tetrapoda can be found in salamanders, which display a preaxial dominance in limb development, a *de novo* condensation of a *basale commune* (distal carpal/tarsal 1+2) and a precocious development of digits I and II. These divergent patterns have puzzled researchers for over a century leading to various explanatory hypotheses, but despite many advances in research on tetrapod limb development, the divergent evolution of these two different pathways and their causes are still not understood.

An examination of more than 600 specimens of the branchiosaurid *Apateon* (Temnospondyli) from a wide range of ontogenetic stages formed the basis for the investigation of the pattern in its limb development. The exceptional preservation of the specimens allowed for the reconstruction of ossification sequences in the fore- and hind limbs and their comparison with the patterns found in extant tetrapod taxa. The results show that preaxial

dominance in limb development, a character previously considered to be unique and derived for modern salamanders, was already established in branchiosaurids in the Upper Carboniferous. When considered in the framework of competing hypotheses of basal tetrapod relationships, the evolution of this character provides new data for the discussion of the highly controversial relationships of the three modern amphibian groups among the possible Paleozoic antecedents, as well as the time of the divergence of these lineages.

Student Poster Session

COSTAL FUNCTIONS OF QUADRUPEDS FOR BODY SUPPORT AND RECONSTRUCTION OF THE SCAPULAR POSITION

FUJIWARA, Shin-ichi, Tokyo, Japan

Extant archosaur and mammal scapulae do not have the skeletal joint with the vertebral column, and therefore it is hard to reconstruct their position. In extant quadruped archosaurs and mammals, the trunk is suspended between the forelimbs when standing on each forelimb by the serratus ventralis muscle. The muscle originates from each lateral side of dorsal and cervical ribs, and inserts to the proximal portion of the medial side of the shoulder blade. Therefore, not only the forelimbs, but also parts of the cervical and dorsal ribs are supposed to have mechanical adaptation to body support. The following hypotheses can be proposed: (1) the ribs of quadrupeds beneath the scapulae have higher strength to vertical compression than the posterior ribs; (2) the scapulae are located near the most robust rib; (3) thoracic ribs of bipeds have no significant distribution in their strength like quadrupeds. To calculate the strength of ribs and validate these hypotheses, two-dimensional-finite-element analysis is carried out for the costal morphology. Materials examined of several extant taxa, such as crocodiles, aves, and mammals, are stored in the National Science Museum, Tokyo, and Graduate School of Medicine, The University of Tokyo. The geometry of ribs and corresponding vertebra are outlined in its articulation. As a boundary condition, the vertebral body and spinous process are fixed, and a compressive load is applied vertically to the distal end of each rib. The maximum equivalent stress in the rib, and inversely the allowable compressive load for the rib by considering the allowable stress of the rib were estimated. The analyses suggest that anterior ribs of quadrupeds attached by the serratus are more strengthened against the vertical forces than the posterior ribs which have no origin of the muscle. The arrangements of ribs with greater strength suggest the arrangements of the serratus and also the most probable position of the proximal portions of scapulae. Ribs of bipeds do not have the significant correlation with the scapular position. Thus, the significant role of anterior ribs in quadrupeds is suggested, and the reliable scapular positions in quadrupeds are reconstructed by comparing the strength of the series of ribs from mechanical point.

Saturday 2:30

CRANIAL MORPHOLOGY OF EARLY CRETACEOUS MONJUROUCHID CHORISTODERES (REPTILIA: DIAPSIDA) FROM LIAONING PROVINCE, CHINA, AND EVOLUTION OF THE CHORISTODERAN PALATE

GAO, Ke-Qin, Peking Univ., Beijing, China; DUAN, Ye, HU, Dongyu, LI, Li, Shenyang Normal Univ., Shenyang, China; KSEPKA, Daniel, American Museum of Natural History, New York, NY

The Monjurosuchidae are a small clade of medium-sized, blunt-snouted choristoderes, known only from two closely related genera (*Monjurosuchus*, *Philydrosaurus*) from the Early Cretaceous (Barremian-Aptian), western Liaoning Province, China. The occurrence of fully articulated monjurosuchid fossils in lacustrine deposits, along with superb preservation of soft tissue impressions of webbed feet in some *Monjurosuchus* specimens, implies an aquatic or semi-aquatic lifestyle for these animals. Though monjurosuchids have been known for more than 60 years, only recently have new discoveries revealed details of their anatomy. New specimens of *Philydrosaurus* from the Early Cretaceous Chiuftotang Formation near Chaoyang provide useful data on palatal structure, virtually unknown before in monjurosuchids. Study of the new specimens indicates that many purported synapomorphies of the Neochoristodera were acquired earlier in choristodere history, and thus, are diagnostic of a more inclusive clade. These features include an extensive vomer-maxilla contact, a long midline contact of the pterygoids, and presence of a distinct nasopalatal trough. Comparison of the palate in major choristodere subclades with that in basal diapsids shows that the choristodere palate has become progressively adapted to an aquatic way of life. Significant modifications include elongation of the vomers, posterior shifting of the choanae, development of the nasopalatal trough, opening of the palatal foramen at the juncture of the three palatal elements, and reduction and posterior location of the interpterygoid vacuity. The available evidence strongly supports the monophyly of Monjurosuchidae and the placement of this clade closer to Neochoristodera than to Cteniogenidae within the phylogenetic framework of the Choristodera.

Poster Session I

LUNGFISH BURROWS FROM THE MISSISSIPPIAN (CHESTERIAN) OF NORTH-WESTERN KENTUCKY

GARCIA, William, Univ. of North Carolina Charlotte, Charlotte, NC; STORRS, Glenn, Cincinnati Museum Center, Cincinnati, OH; GREB, Steve, Kentucky Geological Survey, Lexington, KY

Aestivation is a common behavior among certain modern amphibians and lungfish. The

earliest definitive record of vertebrates exhibiting aestivation is from the Lower Permian. Both lungfish and lysorophid tetrapods are preserved in aestivation burrows from Kansas, Texas, and Oklahoma. Material from the Hancock County, Kentucky locality (Mississippian, Chesterian) preserves lungfish burrows considerably older than those preserved in Kansas. Articulated lungfish of the genus *Tranodis* are preserved within slightly calcareous siltstone nodules along a single horizon within an abandoned channel. These nodules resemble lungfish burrows from Hamilton, Kansas in their morphology and composition. The channel is interpreted as a filled oxbow lake, with periodic marine influence in the lower half of the deposit, and brackish to fresh water conditions during deposition of the upper half. Burrows are oriented sub-vertical to bedding within dark gray shales in the upper half of the deposit. The lungfish are the only faunal element preserved in this manner. Rooting structures on the flanks of the channel indicate a period of aerial exposure. The presence of lungfish burrows within a subaerially-exposed horizon provides evidence for aestivation in lungfish during the Mississippian.

Poster Session II

VERTEBRATE TRACKS FROM THE LATE JURASSIC (KIMMERIDGIAN) OF ASTURIAS (NORTH SPAIN)

GARCÍA-RAMOS, José, PIÑUELA, Laura, RUIZ-OMENACA, José Ignacio, Museo del Jurásico de Asturias, Colunga, Spain

Dinosaur tracks are frequent in Asturias. Tracksites are located in several cliffs in a 50 km long strip of Upper Jurassic rocks, and form part of a tourist route started in 1997: La Costa de los Dinosaurios (The Dinosaur Coast). The Asturian dinosaur tracksites, together with some others of Spain and Portugal, are World Heritage Site candidates. Among dinosaurs, there are tracks of theropods, sauropods, ornithopods and stegosaurs. In addition to dinosaur ones, there are also tracks of lizards, turtles, crocodiles and pterosaurs. Tracks are preserved as true tracks and undertracks, but more frequently as natural casts, sometimes with skin impressions and/or skin displacement on the sediment. The tracksites pertain to the Gijón-Ribadesella Basin, and are found in three Formations: Vega (fluviatile), Tereñes (coastal mudflat in a small semi-closed marine basin), and Lastres (deltaic). Besides the tracksites, natural casts are housed in the Museo del Jurásico de Asturias, constituting one of the biggest and most diverse collections in Europe. Only one lizard track is known, probably the first Jurassic lizard track in the world. Turtle tracks are assigned to *Emydhipus* and to other unnamed ichnogenera. Crocodiles are represented by several tracks. Pterosaurs tracks, diverse and of several sizes, are assigned mainly to *Pteraiichnus*; some of them preserve skin and interdigital web impressions in the foot. Theropod dinosaurs are represented by big morphotypes (*Hispanosauropus* and others, up to 82 cm in length) and small ones (some with only 4 cm in length), including bird-like theropods. Among sauropod tracks, *Gigantosauropus* is remarkable by its gigantic size (up to 125 cm in diameter). Skin impressions in natural casts show small polygonal tubercles. Ornithopod dinosaurs are represented by big bipedal iguanodontians and by small *Dinehichnus*-like ones. Small ornithopods show both gregariousness and occasional quadrupedality, with manus functionally tridactyl. Stegosaur footprints are plantigrade and functionally tridactyl; associated manus are short and lateromedially expanded, with no digit marks.

Saturday 8:45

A NEW SPECIES OF GRYPOSAURUS (DINOSAURIA: HADROSAURIDAE) FROM THE UPPER CAMPANIAN KAIPAROWITS FORMATION OF UTAH

GATES, Terry, SAMPSON, Scott, Utah Museum of Natural History, Salt Lake City, UT

Gryposaurus is a non-crested (hadrosaurine) hadrosaur characterized by a deep and massive skull possessing an arched nasal "hump" anterior to the orbits. Three species are currently recognized, *G. notabilis*, *G. incurvimanus*, and *G. latidens*, based on the relative position of the nasal hump, shape of the posterior nares, and relative size of the dentition. Recent work in the Kaiparowits Formation, exposed within Grand Staircase-Escalante National Monument, south-central Utah, has yielded a fourth *Gryposaurus* species, making this genus the most diverse within Hadrosauridae. The new species, represented by multiple skull and postcranial specimens, is differentiated from its congeners by the following characters: relatively deep, hyperrobust skull; anteroposteriorly narrow infratemporal fenestra; subcircular supratemporal fenestrae; and elongate, narrow paraoccipital process. The overall shape of the skull, as well as the morphology of the nasal, most closely resembles that of *G. notabilis*. Collected skeletal remains demonstrate this new species is by far the largest known member of *Gryposaurus*. The latter finding is in keeping with taxonomic variation in body size among other late Campanian hadrosaurines from the Western Interior Basin, which tend to be significantly larger in the southern portion of the basin than in the north. The discovery of *Gryposaurus* in southern Utah expands the known geographic range of this taxon roughly 2000 km relative to contemporaneous occurrences of *G. notabilis* and *G. incurvimanus* in Alberta, making this genus one of the most widespread Campanian hadrosaurines. Nevertheless, the presence of a distinct taxon at the species level is consistent with the pattern observed for other late Campanian dinosaur clades found in both northern and southern portions of the Western Interior Basin, supporting the provincialism hypothesis.

Saturday 12:00

HOW *TYRANNOSAURUS* DIDN'T MOVE: CONSTRAINT-BASED EXCLUSION OF LIMB POSES FOR RECONSTRUCTING DINOSAUR LOCOMOTION

GATESY, Stephen, Brown Univ., Providence, RI; BÄKER, Martin, Institut für Werkstoffe, Braunschweig, Germany; HUTCHINSON, John, Royal Veterinary College, Herts, United Kingdom

Animation and simulation software allows paleobiologists to tackle fundamental questions about dinosaur locomotion using digital models. Yet the power of these computational tools to generate motion creates a new problem—how to choose among countless hypotheses? The skeleton provides crucial evidence, but bones alone are insufficient for determining how a dinosaur positioned and coordinated its joints to stand or move. Redundancy of limb segments precludes a unique solution, yielding a wide spectrum of potential hip heights and poses. One option is to reduce the number of choices by arbitrarily selecting a pose or by invoking simplifying geometric rules. We prefer a second alternative, in which demonstrably realistic constraints are used to exclude, rather than include, possible limb motions. Before attempting to reconstruct complete strides, we begin with a mid-stance pose at high speed, a time when the musculoskeletal system is most stressed. The goal is to constrict the “configuration space” of mid-stance poses as narrowly as possible using kinematic (motion-based) and kinetic (force-based) criteria from extant animals.

We undertook a case study in 2-D using *Tyrannosaurus rex*. Sensitivity analyses varying the center of mass, center of pressure, muscle mass, co-contraction of knee flexors, and ground reaction force magnitude converge on similar regions of configuration space. Very crouched poses can be excluded based on insufficient extensor muscle mass. Exceedingly erect running poses unrealistically position the knee behind the ground reaction force vector, limit limb excursion, and preclude higher hip heights during walking. A family of viable poses remains between these extremes. These feasible alternatives are starting points for more speculative sequences of poses reconstructing full stance phases and strides.

Neoceti Symposium, Saturday 10:15

A NEW BASAL ODONTOCETE (MAMMALIA: CETACEA) FROM THE ASHLEY FORMATION (RUPELIAN) OF SOUTH CAROLINA AND ITS PLACE IN ODONTOCETE PHYLOGENY

GEISLER, Jonathan, Statesboro, GA; SANDERS, Albert, The Charleston Museum, Charleston, SC

In 1985, James Malcom, a volunteer with the Charleston Museum, collected a partial skull of a primitive odontocete from the banks of the Ashley River near Charleston, SC. The specimen was found in the Ashley Formation (Rupelian), and its geographic position, near the center of a structural high, suggests that it is from the lower part of this formation. Although incomplete, this skull represents a new genus that is not referable to any described family. Unique features include parietal forming much of the posteromedial part of the temporal ridge, region between the external nares and supraoccipital is flat, occipital condyles lack necks, and pachyostotic basioccipital. Other characters indicate that this taxon is one of the most archaic odontocetes ever discovered, including nasal opening well anterior to orbits, supraorbital process of frontal not completely overlapped by maxilla, supraorbital process only slightly overhangs the temporal fossa, and long intertemporal region. We added this new taxon and the late Oligocene odontocete *Simocetus* to our previously published data matrix, and found *Xenorophus* and similar forms to be the basal clade of odontocetes and our new taxon as the most basal member of the clade that includes *Simocetus*, *Agorophius*, and all extant odontocetes. Although *Simocetus* has a few eutherian-like features, our analysis strongly supports the placement of *Simocetus* as a basal odontocete, in large part based on its primitive degree of cranial telescoping. We also mapped geography on our trees, and the radiation of the extant suborders is optimized to have occurred in the Western Atlantic. This biogeographic picture will become more complicated as more fossil cetaceans from the Pacific are included; however, it highlights the importance of the Charleston, SC area for understanding the early history of Odontoceti and Mysticeti.

Poster Session II

EXPLORING THE IMPACT OF APOMORPHIC IDENTIFICATION ON PALEOECOLOGIC INTERPRETATIONS

GEORGE, Christian, The Univ. of Texas at Austin, Austin, TX

Paleoecologists have used several key assumptions to draw conclusions about paleoclimate from fossil specimens. It is often assumed both that specimens are accurately identified to the species level and that climatic tolerances of the fossil species have not changed in their modern counterparts. The identification of fossil taxa is traditionally based on overall similarity rather than on apomorphic characters that can be evaluated phylogenetically. In addition, identification of fossils is often facilitated by comparing specimens to living species that are found near the fossil site. Identifying fossils using apomorphies has two distinct advantages. Identifications are based on morphologic characters from as broad a geographic sample as possible. This may recognize taxon range shifts more often than when identifications are based in part on geography. Second, identification of taxa based on apomorphic characters should facilitate communication among paleontologists and between paleontologists and other scientists wishing to use our data.

I explored the impact of apomorphic identification of North American shrews, because shrews are commonly used in paleoecologic reconstructions. Cranial and dental characters were extracted from dichotomous keys and other published descriptions of shrew species and were converted to coded phylogenetic characters. I scored these characters for a broad

sample of North American shrews from mammalogy collections in an effort to identify apomorphic characters, understand the nature and quality of the characters, and to determine their power for taxonomic resolution. I found at least one apomorphic character for each genus of North American shrew. Species level resolution was only supported in *Blarina*. In their present form, traditional characters have limitations when trying to identify most species of shrews. New characters and quantitative characters may yield additional apomorphies to more confidently identify fossil taxa.

Friday 1:45

DYROSAURID INNER EAR MORPHOLOGY AS EVIDENCE FOR LOCOMOTOR BEHAVIOR

GEORGI, Justin, Stony Brook Univ., Stony Brook, NY

The unusual morphology of the otic region of the dyrosaurid *Rhabdognathus* is examined via x-ray computed tomography (CT). It is shown that the drastic expansion of the otic regions of the lateral braincase wall results solely from an elaboration of the vestibular region of the inner ear. Comparison of the dyrosaurid inner ear to other aquatic crocodylians and a broad array of anapsids and aquatic diapsids suggests a novel hypothesis of locomotion in these forms.

No similar elaboration of the vestibular region is found in any other crocodyliform. In particular, this morphology is absent in other fully or mostly aquatic forms such as the teleosaurids, metriorhynchids or *Gavialis*. This suggests that the inner ear of *Rhabdognathus* is adapted to the sensory requirements of a mode of locomotion different from those employed by these other aquatic crocodylians.

A degree of vestibular expansion analogous to that seen in dyrosaurids can be found in several groups of aquatic turtles. Within the chelid family, there are several instances of dramatic vestibular expansion such as *Chelus fimbriatus*, and *Chelodina longicollis*. Examples of vestibular expansion also can be found within cryptodiran taxa such as *Chelydra serpentina* and *Macrochelys temminckii*. All these turtles with expanded vestibular regions exhibit only moderate to poor swimming capability and preferentially locomote along the floor of their aquatic habitats. In contrast, capable swimmers, such as the cheloniids, do not show a similar degree of vestibular expansion.

The presence of analogous elaboration of the vestibular region of the inner ear in the dyrosaurid *Rhabdognathus* and bottom walking turtles suggests that the dyrosaur's equilibrium and balance sensation was adapted for walking along the sea floor, not for swimming. This hypothesis of dyrosaurid locomotion may help explain many other aspects of their morphology including the absence of paddle-like limbs and the absence of a heterocercal tail.

Poster Session II

PALEONTOLOGY IN A LEGAL CONTEXT: THE VICTORIA BY THE BAY PROJECT, HERCULES, CALIFORNIA

GERIKE, Christian, MATZEN, Benjamin, LSA Associates, Inc., Pt. Richmond, CA

Paleontological research, best known as an academic pursuit of universities and museums, also exists in the realm of legislation designed to preserve paleontological resources for future study. The California Environmental Quality Act (CEQA) requires the implementation of mitigation measures to protect significant, nonrenewable paleontological resources at state and local levels. In this study, the General Plan of the City of Hercules, Contra Costa County, California, required the Victoria by the Bay housing development project to monitor ground disturbance to locate and recover paleontological resources and associated environmental data in paleontologically sensitive Late Pleistocene sediments within the project area.

LSA Associates, Inc. (LSA) was retained by the Santa Clara Valley Housing Group (SCVHG) to address the requirements and conditions of CEQA and of the City of Hercules Planning Department regarding impact to paleontological resources for this project. LSA submitted a project specific paleontological resources impact mitigation plan guided by the Society of Vertebrate Paleontology 1995 conformable impact mitigation guidelines. Specimens recovered by LSA during monitoring of project ground disturbance were prepared, identified, described in a report of findings, and curated into the California Museum of Paleontology collections. By undertaking these tasks to comply with CEQA and the City of Hercules legal requirements, the SCVHG mitigated the projects impact to paleontological resources.

Monitoring activities recovered the large mammals *Mammuthus* sp., near *columbi*, and *Bison* sp. In addition, 486 kilograms of sediment was processed for microvertebrate fossils, which yielded 163 specimens, 16 of which were diagnostic. Similar Late Pleistocene fossil localities near the project area allowed a comparison of taxonomic lists. This study describes one new taxon, the chipmunk *Eutamias* sp., and noted that certain taxa known from nearby localities, such as *Reithrodontomys raviventris*, the Salt Marsh Harvest Mouse, were absent. This different taxa and presence of fish and ray teeth suggest the project area was a near-shore delta environment as recently as the Late Pleistocene, though the project area is now at 60 meters elevation above sea level with no stream flow. As the Victoria by the Bay project shows, the implementation of environmental legislation designed to protect significant, non-renewable paleontological resources preserves fossils and contributes past environmental data to our field of study.

Preparators Symposium, Thursday 10:15

COLLECTION AND USE OF TAPHONOMIC DATA FROM VERTEBRATE LOCALITIES: LESSONS FROM SIX YEARS OF PALEONTOLOGICAL INVENTORY AND EXCAVATION IN GRAND STAIRCASE-ESCALANTE NATIONAL MONUMENT, UTAH

GETTY, Mike, LOEWEN, Mark, Utah Museum of Natural History, SLC, UT; ROBERTS, Eric, Univ. of the Witwatersrand, Johannesburg, South Africa

Since 2001, the Utah Museum of Natural History (UMNH) has been working in a collaborative agreement with the BLM to conduct paleontological surveys of the Late Cretaceous Kaiparowits and Wahweap formations of Grand Staircase-Escalante National Monument. In the course of this project, the UMNH has made field collections from more than 350 vertebrate localities and conducted extensive excavations at 10 of these sites. While a number of significant specimens have been collected and are being described as a result of this project, broader paleoenvironmental and paleoecological questions are now also being addressed as a result of taphonomic analysis of the data collected in association with these specimens. The field inventory of vertebrate localities involves the collection of considerable ancillary data along with the specimens themselves, which are collectively referred to as taphonomic data. Taphonomic data found to be most relevant in this type of survey include the sedimentologic and stratigraphic context of the locality; spatial and geographical context of the specimens obtained through excavation mapping; and categorization of localities according to their biological and preservational attributes (taphonomic modes). Additional taphonomic features observed on individual specimens following detailed preparation include: soft tissue preservation, weathering, traces of insect activity, trampling, and tooth marks. If collected systematically, taphonomic data reveal more detailed insights into the character of the paleoenvironments and paleoecology of the formations in question. Additionally, these data enable evolutionary and ecological interpretation beyond what is possible from the collection and study of the specimens alone.

Poster Session I

A NEW EUTHERIAN MAMMAL FROM THE CRETACEOUS OF MONGOLIA

GIALLOMBARDO, Andres, NOVACEK, Michael, American Museum of Natural History, New York, NY

Much of the debate about the placental mammal radiation focuses on the time of origination of extant placental orders, with competing hypotheses placing the origin of these groups either before or after the K/T boundary. Because of the critical period in mammalian evolution it represents, any finding of Cretaceous eutherian is crucial for understanding the early diversification of modern orders. Here we present a new eutherian from the Khugentislavkant sandstone facies (Dorn gobi Aimag, Eastern Gobi, Mongolia). As with most of the continental deposits of Central Asia, the stratigraphy of the Khugentislavkant sandstone facies is poorly constrained, but an Albian-Aptian (upper part of the Early Cretaceous) has been suggested based on faunistic correlation. The new taxon is represented by one fragmentary skull with associated jaws and postcranium, a second fragmentary skull, and two fragments of maxillae. The skull has a long and narrow snout, with the nasals wider posteriorly. The dental formula is $I4/3, C1/c1, P5/p5, M1/m1$. P4-5 and p5 are molariform teeth. The anterior lower incisors are hypertrophied and procumbent, with the enamel interrupted on the postero-lingual side. The last lower premolar is also molariform, and the lower molars have a compressed trigonid and a fully basinated talonid. The fibula is slender and distally fused to the tibia from the mid-shaft to the end. The astragalus has a deep trochlea and a short head with an undifferentiated neck.

A preliminary phylogenetic analysis places the Khugentislavkant taxon either as the sister group of Zalambdalestidae, or within Zalambdalestidae as the sister taxon of *Zalambdalestes*. The zalambdalestids are known from the late Turonian-early Campanian (Late Cretaceous), and have been alternatively proposed to be close relatives to Glires (rabbits and rodents), or they have been placed as a stem group of eutherians, outside the placental radiation. A detailed phylogenetic study is underway to establish the interrelationships among early eutherians in light of this new taxon.

Poster Session II

HEALTH HAZARDS OF THE RODENT-BORNE HANTAVIRUS. HOW TO DEAL WITH POTENTIALLY INFECTED STORAGE SIGHTS AT THE WYOMING DINOSAUR CENTER

GIBBEL, John, WAHL, William, Wyoming Dinosaur Center, Thermopolis, WY
Hantavirus pulmonary syndrome (HPS) is deadly and exhibits itself as cold or flu-like symptoms. The hantaviruses are primarily associated with *Microtus* species present in Wyoming. This is an opportunity to report on procedures of how to clean up storage areas and structures such as quarry sites that have been closed for any length of time.

Rodents pass HPS in their urine, saliva and droppings. High-risk activities include cleaning or occupying rodent infested barns, cabins, or vacant buildings; disturbing rodent-inhabited areas while camping or hiking; and working in enclosed spaces that have been infested with rodents. Storage of fossil material or field equipment would also fall into these categories.

It is generally agreed that three basic procedures are necessary to deal with this virus when cleaning. 1. Wear gloves and mask, 2. Use disposable rags rather than vacuuming or sweeping. 3. Spray dust with bleach solution of one cup per gallon of water. Also suggested is the procedure of airing out structures and exposure to sunlight any potentially infected areas.

As the quarries at the Wyoming Dinosaur Center are open to the public, there is the potential of infection and transport. Though the chances of having a contaminated rodent within structures are slim and while there is no known cases of person to person transfer, it is still a very deadly disease. Although the best way to prevent hantavirus is to use whatever means to keep rodents out, reliable sanitation is the best defense.

Student Poster Session

IDENTIFICATION OF THE FIRST *THEROPIITHECUS* (ORDER PRIMATES) FROM BOLT'S FARM, SOUTH AFRICA

GILBERT, Christopher, Stony Brook Univ., Stony Brook, NY

The remains of the large cercopithecoid primate *Theropithecus oswaldi* were recently recognized in the Bolt's Farm collection at the Transvaal Museum in Pretoria, South Africa. The material consists of an isolated tooth fragment as well as one badly damaged but very large mandible preserving parts of both corpora and elements of a worn dentition. The specimens were compared to other large Plio-Pleistocene cercopithecoid monkey taxa from South Africa, specifically *T. oswaldi* and *Dinopithecus*. After comparison, the specimens were attributed to *T. oswaldi* on the basis of their overall size and distinctive mandibular/dental morphology. These specimens therefore represent the first documentation of *Theropithecus* at Bolt's Farm, a site which has also produced other cercopithecoid monkey specimens. The site is estimated to be approximately 1.5–2.0 Ma, and preliminary paleoenvironmental reconstructions indicate a grassland mosaic with some small bush and trees. Interestingly, a water source is also reconstructed nearby. Previous authors have noted that *T. oswaldi* is almost exclusively found in paleoenvironments with a large source of water nearby, and the presence of *T. oswaldi* at Bolt's Farm seems to support this hypothesis. In addition, the presence of *T. oswaldi* at Bolt's Farm further illustrates the success of this species in South Africa during the Plio-Pleistocene and adds to a relatively large cercopithecoid fauna at the site containing other species such as *Parapapio broomi*, *Parapapio whitei*, *Papio robinsoni*, and *Cercopithecoidea williamsi*.

Vertebrate Development Symposium, Wednesday 10:30

HOW TURTLES FORM SHELLS: HETEROTOPY AND HETEROCHRONY

GILBERT, Scott, CEBRA-THOMAS, Judith, Swarthmore College, Swarthmore, PA

The turtle shell is an evolutionary novelty that constitutes the basal synapomorphy for Chelonians. It is composed of two main parts, the dorsal carapace and the ventral plastron. The carapace forms by the displacement of the ribs into the dorsal dermis rather than their forming a rib cage. Our evidence suggests that FGF signaling directs the rib precursor cells into the dorsal dermis of the carapacial ridges. Once in the dorsal dermis, each rib acts as a signaling center that ossifies the surrounding dermal cells. The dermis ossifies in both directions from the rib, forming the costal bones of the carapace. Bone morphogenetic proteins (BMPs) appear to be the major signaling molecules in this ossification. Such proteins are made during the normal endochondral ossification of the rib. Thus, once ribs enter the dermis, forming a shell might be easily accomplished. The plastron forms much like the skull and the facial bones, by intramembranous ossification. HNK-1 staining and Dil labeling provide evidence that these bone-forming cells are derived from the trunk neural crest. We hypothesize that a population of trunk neural crest cells stays in a "staging area" above the neural tube, loses Hox gene expression, and becomes capable of forming bone. Thus we propose that carapace formation involves heterotopy (changing the placement of structures) while plastron formation may involve heterochrony (changing the timing of events.) Preliminary results suggest that alligator gastralia are also HNK-1 positive, suggesting a similar origin.

Romer Prize Session, Thursday 9:00

***KUEHNEOTHERIUM*: ENIGMATIC STEM MAMMAL FROM THE MESOZOIC FISSURES OF SOUTH WALES**

GILL, Pamela, Univ. of Bristol, Bristol, United Kingdom

The Late Triassic- Early Jurassic *Kuehneotherium* is one of the earliest known mammals but, in spite of its importance to mammalian phylogeny, it has not previously been fully described due to the fragmentary nature of the material. The largest collections are from fissure deposits in South Wales, comprising approximately 1,000 isolated teeth and jaws. The dentition of *Kuehneotherium praecursoris* is reconstructed, with representative teeth for each locus. The lower dental formula is $5? 1. 6. 6$, and the upper formula is assumed to be similar. There is unexpected taxonomic diversity in the Welsh fissure samples and two new species are proposed. *Kuehneotherium* is fully diphyodont, with differentiated premolars and molars and a consistent alveolar row. There is evidence that this had been only recently established, including a suppressed third replacement wave and continuum of form between the deciduous premolars and mesial molars. Initial uncertainty in reconstructing the dentition centred on a number of small plesiomorphic molars, some of which are similar to the teeth of a derived cynodont, with less crown triangulation and incompletely divided roots. These teeth are the postcanines of a different kuehneotheriid and in one fissure there is continuity of form between them and *Kuehneotherium*. Conservatism in the form of the dentary but wide variation in molar crown triangulation suggests that the latter may have evolved more than once. The molar occlusion is reinterpreted to argue that effective shearing occurs without crown remodelling. The wear seen on the more plesiomorphic kuehneotheriid molars is compared with that on molars of *Kuehneotherium* suggests that improvements in shearing efficiency may have driven selection for divided roots and a less bulbous crown. A cladistic analysis places *Kuehneotherium* within the mammalian crown

group which would support to the possibility that both the molar cusp triangulation and the separation of the middle ear from the dentary are homoplastic.

Friday 1:30

EARLY WHALES *ICHTHYOLESTES* AND *PAKICETUS* (MAMMALIA, CETACEA): TERRESTRIAL, AQUATIC, OR BOTH? CAVEAT EMPTOR!

GINGERICH, Philip, Univ. of Michigan, Ann Arbor, MI

Ichthyolestes was named in 1958, based on a maxilla from the early middle Eocene of Pakistan with teeth interpreted to represent a fish-eating mesonychid. A second larger genus *Pakicetus* was named in 1981 from the same provenance, based on an archaeocete skull with both aquatic and terrestrial characteristics. These are classified as Pakicetidae, and from 1983 were interpreted to be an amphibious stage in the evolutionary transition of whales from land to sea. Some later studies interpreted pakicetids as fully aquatic, or fully terrestrial, but neither extreme is justified.

Evidence favoring a terrestrial habitus for pakicetids includes (1) preservation with land mammals in continental red beds; and (2) retention of a periotic integrated in the basicranium, multiple contacts between the tympanic and basicranium, small mandibular foramen, unreduced crus longum of the incus, tympanic annulus and membrane, and semicircular canals of large radius. Evidence favoring an aquatic habitus includes (1) sharply pointed teeth and an elongated rostrum for feeding on fish; (2) a tympanic involucrum, sigmoid process on the bulla, and inflated incus for inertial hearing in water; and (3) tooth enamel with $\delta^{13}\text{C}$ values of low variability. Features shared by artiodactyls and later semiaquatic protocetids are not informative, but short cervical vertebrae enhancing hydrodynamic stability, and a short ilium minimizing any gluteal contribution to extension of the femur complicate a fully terrestrial interpretation.

Aquatic or terrestrial? The type specimen of the type species of the type genus of Pakicetidae has clear evidence for both, and new evidence from isotopes, periotics, and postcrania corroborates that pakicetids were semiaquatic. When a representative skeleton is found, it will indicate how pakicetids swam and how they should be exhibited. In the meantime, caveat emptor. Journalists write what they think we want to hear, and dealers sell what they think we will buy. Most of us are educators, in some capacity, and we should do our homework before we believe or buy extreme interpretations.

Neoceti Symposium, Saturday 10:30

ARAEODELPHIS NATATOR KELLOGG, 1957, THE MOST PRIMITIVE KNOWN MEMBER OF THE PLATANISTIDAE (ODONTOCETI, CETACEA), AND RELATIONSHIPS TO OTHER CLADES WITHIN THE PLATANISTOIDEA

GODFREY, Stephen, Calvert Marine Museum, Solomons, MD; BARNES, Lawrence, L.A. County Museum of Natural History, Los Angeles, CA; BOHASKA, David, Smithsonian Institution, Washington, DC

The extant river dolphins in the family Platanistidae, *Platanista minor* and *P. gangetica*, are amongst the most highly derived odontocetes. In contrast to *Platanista*, stem-ward Miocene platanistids like *Prepomatodelphis*, *Zarhachis*, and *Pomatodelphis*, are more diverse anatomically, more widespread geographically, and are marine in habitus. A partial cranium (USNM 526604) from the Plum Point Member that is low in the marine Calvert Formation (Early Miocene, Burdigalian) in Calvert Cliffs, Maryland, is identified as *Araeodelphis natator* Kellogg, 1957. Previously, this species was un-assignable to any odontocete family for lack of diagnostic cranial remains, but USNM 526604 demonstrates that *A. natator* is a member of the Platanistidae, and is its most primitive known member. *A. natator* has a suite of plesiomorphies providing a clearer picture of the cranial morphology for stem Platanistidae. Synapomorphies of *A. natator* that define the Platanistidae are: asymmetrical cranial vertex; frontals exposed between mesethmoid and nasals on the posterior wall of naris; elongate and narrow rostrum; mesorostral groove closed over dorsally on the anterior half of the rostrum by a meeting of the premaxillae at the sagittal plane; premaxillae and maxillae both reaching the anterior rostral extremity; distal ends of premaxillae and maxillae fused at the rostral extremity; posterior ends of premaxillae expanded posterolaterally; posterior maxillary foramina located far posteriorly; thickened frontals and maxillae comprising incipient supraorbital crests; zygomatic process of the squamosal flattened transversely and expanded dorsoventrally; and zygomatic process having a broad connection to the dorsoventrally reduced postorbital process of the frontal. Synapomorphies shared by *Araeodelphis* and other platanistoid families (Squalodontidae, Waipatiidae, Squalodelphinidae, and possibly Dalpiazinidae) are presence of a foramen spinosum, and loss of the coracoid process and supraspinatus fossa on the scapula. The Squalodelphinidae is the apparent sister taxon of the Platanistidae.

Poster Session III

IMAGING THE OTIC CAPSULES OF A Pliosaur

GOMEZ-PEREZ, Marcela, Univ. of Cambridge, Cambridge, United Kingdom; NOE, Leslie, NORMAN, David, The Sedgwick Museum, Cambridge, United Kingdom

Well-preserved pliosaurs (Reptilia: Sauropterygia) are rare, and those with high-quality braincase material are extremely uncommon. A new and undescribed genus and species of pliosaur from the Lower Cretaceous of Colombia, South America, is one of the very few pliosaur specimens which preserves the otic capsules and braincase substantially complete, articulated and uncrushed. The 3-D cranium of this new specimen has been acid-prepared, revealing the otic capsules and details of the internal osseous labyrinth. However, the bones surrounding the osseous labyrinth are fused and extremely fragile, so understanding the

detailed osteology and visualising the precise morphology of the semicircular canals is challenging. In order to obtain the fullest possible information from the fossil, the otic capsules were CT scanned and the images manipulated with the software MIMICS to produce a virtual 3-D 'cast' of the semicircular canals. The generation of this 3-D computer model of the otic capsules and the osseous labyrinth of this pliosaur, displays for the first time the full details of this region of the cranium in a sauropterygian marine reptile. Reconstructions of the osseous labyrinth are presented and the 3-D digital 'endocast' suggests that the balance and angular acceleration sensory system in this group of marine reptiles was developed so as to be equally sensitive in all three planes of space.

Poster Session I

DISCOVERY OF AN IMPORTANT HOMINID TRACKSITE, ?EARLY HOLOCENE OF COAHUILLA, MEXICO

GONZALEZ, Arturo, LOPEZ, Jose, Laboratorio de Paleontología, Saltillo, Mexico; ROJAS, Carmen, INAH, Saltillo, Mexico; LOCKLEY, Martin, Dinosaur Tracks Museum, Denver, CO

The Museo del Desierto (MUDE) collections include two well-preserved Holocene hominid tracks, with a previously obscure history. Although collected from a 'tufa-like' deposit near Cuatro Ciénegas, Coahuila, in 1961, since then, until 2006, the locality of origin was unknown. We report the discovery of a dozen hominid tracks in a similar 'tufa-like' deposit associated with the famous underground springs and pools from this same region. The new site, previously excavated for building stone, may be the same locality from which the original tracks were collected. The two MUDE tracks, a right and a left, are 24 cm long, 10 cm wide, and may be from the same trackway. They are well-preserved showing heel, ball and all five toe impressions. The new discovery includes an incomplete trackway of 11 footprints, of which 6 are also well-preserved, mostly with clear toe impressions. These tracks are 25 cm long and 10 cm wide with steps from 74-81 cm. Another area reveals another clear track on a trampled surface. Hominid (presumably *H. sapiens*) tracks from the Americas have recently generated much interest because of controversial claims of purported Mexican tracks that may date to 40,000 years. With the exception of one track from Chile dated at about 12,500 years, the oldest well-documented and well-preserved hominid tracks are from Nicaragua, California and Argentina and date to about 6-7,000 years BP. The Coahuila tracks are not yet dated, but it is well known that early humans were very active in this region around 9,000-10,000 BP.

Poster Session III

MUHI QUARRY, HIDALGO IN CENTRAL MEXICO, A POSSIBLE BREEDING AND NESTING SITE FOR LATE CRETACEOUS FISHES

GONZALEZ-RODRIGUEZ, Katia, BRAVO-CUEVAS, Victor, Museo de Paleontología, Universidad Autónoma del Estado de Hidalgo, Pachuca, Hidalgo, Mexico; FIELITZ, Christopher, Emory & Henry College, Virginia, VA

Mesozoic calcareous rocks belonging to El Doctor Formation (Albian-Cenomanian) outcrop in the northwestern portion of the State of Hidalgo, Central Mexico. The lower part of this Cretaceous unit consists of thinly to medium bedded light gray micritic limestones and black flint bands intertongued by fine-grain sandstone and marls, deposited in a pelagic environment above the continental shelf. From strata of this composition, an important marine fish community including over 400 specimens of sharks and teleosts has been recovered.

Although the complete diversity of the locality is unknown because of the newness of the discovery, it is surprising to find a diversity of small size fishes representing juvenile specimens of enchodontids, dercetids, ichtyodectids, beryciforms, and other taxa not yet identified. A new species of *Enchodus*, which is the most numerous fish in the locality includes many small individuals of different sizes, the smallest having a mandible length of 1.5 cm and the largest with a mandible measuring of 7.5 cm. Adult ichtyodectids are represented by only two specimens (one head and one incomplete trunk), but two complete juveniles have been found. Dercetids include five incomplete adult specimens and a complete juvenile. A new species of beryciform includes three juveniles and an adult specimen. This finding suggests that the site where the specimens were deposited was a breeding or nesting ground. Possible anoxic events followed by rapid burial allowed for the preservation of such small specimens.

Vertebrate Development Symposium, Wednesday 11:30

MODULARITY AND MORPHOLOGICAL DIVERSITY IN THE MAMMALIAN CRANIUM

GOSWAMI, Anjali, The Natural History Museum, London, United Kingdom

Variation is the raw material of evolution, but there is little understanding of how variation on a microevolutionary scale relates to large-scale evolutionary patterns. In particular, trait correlations have often been invoked as a possible constraint on variation, and thus a major influence on evolutionary change, but there are few empirical studies of the relationship between trait correlations and morphological evolution. The study of modules, autonomous sets of highly-correlated traits, allows for broad comparisons of trait correlations across large clades and across scales of evolutionary study, from genetics to paleontology.

I have used a quantitative framework, 3-D morphometrics, to assess modularity in crania of fossil and Recent mammals, including monotremes, marsupials, and placentals. This work has demonstrated that monotremes and placentals differ markedly in their patterns of

cranial modularity. Monotremes display only two cranial modules, while therians (marsupials and placentals) display six. Within therians, there are significant differences among modules and across taxa in the strength of within-module correlations. These differences show that modularity evolves, but it leaves open the question: "What is the evolutionary significance of modularity?"

I will present results from two approaches to addressing this fundamental question. First, do modules show significant differences in morphological disparity? As mentioned above, some modules are highly integrated (high trait correlations), and others are more weakly integrated. If trait correlations constrain variation, it may be expected that less integrated modules show higher disparity. I use data from over 100 species from the therian orders Primates, Carnivora, Dasyurimorphia, Peramelia, and Diprotodontia to compare disparity, measured with Procrustes distance, in each of the six modules observed in therians. Second, I conduct stochastic computer simulations of cranial shape evolution using different empirically-derived covariance matrices to demonstrate how different patterns of cranial modularity may influence long-term patterns of morphological diversity.

Thursday 3:00

A DISTINCTIVE NEW LATE OLIGOCENE BILLFISH FROM NEW ZEALAND

GOTTFRIED, Michael, Michigan State Univ., East Lansing, MI; FORDYCE, R., Otago Univ., Dunedin, New Zealand; RUST, Seabourne, Univ. of Auckland, Auckland, New Zealand

Billfishes (Xiphioidae) are large perciform teleosts characterized by greatly lengthened premaxillae that form a prominent rostrum. Fossil billfish are known from the Paleocene onwards; Miocene and younger billfish are typically considered to be closely related to either extant *Xiphias* (swordfish), or istiophorids (sailfish, marlin, and spearfish). Despite the wide southern ocean occurrence of several living xiphioid species, most fossil billfish reports are from the Northern Hemisphere, suggesting a considerable gap in our knowledge of the group's ancient diversity and distribution.

We report here on an associated partial skeleton of a large billfish from the mid-shelf upper Oligocene Otekaike Limestone of Hakataramea Valley, South Island, New Zealand (Geology Museum, University of Otago: OU 22396). The specimen includes premaxillae, maxillae, lower jaws, a partial neurocranium, partial vertebral column, and scattered fin elements and ribs, from a fish that measured ca. 3 m in total length. OU 22396 is assigned to the fossil genus *Aglyptorhynchus* (Xiphioidae) on the basis of the prominently developed ventral flanges on its enlarged maxillae, which are diagnostic for the genus, combined with the longitudinally ridged premaxillae and lower jaws. It is distinguished as a new species of *Aglyptorhynchus* primarily on the basis of its distinctive rostral and lower jaw proportions. *Aglyptorhynchus* has previously been recorded from the Oligocene of the Atlantic and Pacific coasts of the USA, and from northern Europe. The New Zealand species, which is the most complete and informative fossil billfish reported to date from the Southern Hemisphere, indicates that *Aglyptorhynchus* was broadly distributed by the late Oligocene. The new billfish adds further diversity to New Zealand's mid-Cenozoic marine record of sharks, other large teleosts, penguins, and cetaceans.

Friday 10:45

LANDSCAPE TAPHONOMY: BONES GALORE—A LATEST EOCENE SITE IN NORTHEASTERN COLORADO

GRAHAM, Russell, Penn State Univ., University Park, PA; EVANOFF, Emmett, Univ. of Northern Colorado, Greeley, CO; WEIS, Bart, Denver Museum of Nature & Science, Denver, CO

The Bones Galore site, in the uppermost Eocene White River Group of northeastern Colorado, contained fifteen separate bone clusters. Block excavations (ca. 240 m² and 144 m²) were conducted at two clusters about 100 m apart. A single stratigraphic unit that represents a splay deposit extended across the site and contained most of the bones in both clusters. All specimens larger than 5 cm were piece plotted in a 2 m x 2 m grid system with regards to their 3D position. Orientation and inclination was recorded for specimens with long axes. Laboratory studies included taxon identification, skeletal element identification and completeness, bone surface modification including weathering stage, fracture patterns and population demographics of rhinos and brontotheres. Analyses of these data and those collected during excavation suggest that one cluster represented an ephemeral waterhole (perhaps a brontothere wallow) that collected bones for an extended period of time. Extensive scavenging was also apparent. The other cluster appears to have been a flood plain surface with several scattered and incomplete brontothere skeletons that were covered quickly by the splay deposits. Scavenging was not a major factor. Although both clusters occur in the same stratigraphic horizon and on the same landscape, interpretations of paleoecology and/or biogeography based upon species composition of a single cluster would have been erroneous. To fully understand this record, and ones like it, large excavations must be conducted to effectively sample as many landscape facies as possible.

Poster Session III

IMPLICATIONS OF SCAPANORHYNCHUS TOOTH SIZE IN A CAMPANIAN (CRETACEOUS) ESTUARY AT ELLISDALE, NJ

GRANDSTAFF, Barbara, School of Veterinary Medicine, Univ. of Pennsylvania, Oreland, PA; PARRIS, David, GALLAGHER, William, New Jersey State Museum, Trenton, NJ
The Ellisdale Site preserves a diverse continental fauna, including dinosaurs, crocodylians, turtles, lizards, salamanders, anurans, and mammals in an estuarine deposit. This estuary

also preserves marine taxa (chondrichthyans, actinopterygians, chelonians, and mosasaurs). *Scapanorhynchus* is the most common shark preserved in the Ellisdale Local Fauna.

The selachian fauna recovered from outcrop at Ellisdale is dominated by small individuals. This is most notable in *Scapanorhynchus*; 65% of complete teeth (crown plus roots) recovered from outcrop are ≤ 2 cm in total height, with 24% of all teeth recovered being ≤ 1 cm in total height. Since the Ellisdale Site does preserve large teeth (approaching 5 cm in total height) there does not appear to be a taphonomic bias toward preservation of only small teeth at this site. The relative abundance of small *Scapanorhynchus* teeth at Ellisdale suggests a large proportion of small (juvenile) individuals in the fauna, and may indicate that this nearshore shark used the estuary as a nursery ground.

Poster Session II

FROZEN IN TIME: CONSERVATION OF EQUUS LAMBEI

GRANT, Tara, Canadian Conservation Institute, Ottawa, ON, Canada

A rare 26,000 year-old Pliocene horse skin was discovered at a mining operation near Dawson City, Yukon. The frozen skin was fairly complete with the body, mane, one ear, a whisker and the tail with vertebrae remaining. A separate leg with bones, skin and hoof was also recovered. The horse originated in North America and was one of the most common animals of the Ice Age until they became extinct on this continent about 10,000 years ago. This hide would be one of the best-preserved example of *Equus lambei*. This talk discusses the conservation treatment including cleaning, drying and sample collection of this unique hide.

Friday 9:15

PALEOECOLOGICAL DYNAMICS OF MAMMALIAN COMMUNITIES UNDER GLACIAL AND INTERGLACIAL CONDITIONS IN FLORIDA

GRAWE DESANTIS, Larisa, BLOCH, Jonathan, HULBERT, Richard, Univ. of Florida/FLMNH, Gainesville, FL

Sea-levels are rising and are predicted to continue increasing with global warming, tripling rates of rise by the end of the 21st century. Currently, Florida's coastal forests demonstrate declines in floral species richness with decreasing elevation and over time, in response to rising sea-levels. High-latitude sites demonstrate higher species richness during interglacial periods in the absence of glacial ice sheets. In contrast, lower latitude interglacial sites demonstrate declines in species richness and changes in the occupation and breadth of dietary niches, due to the reduction of land area available for flora and fauna communities. Comparing the occupied niches of taxa present at glacial and/or interglacial sites will help elucidate how mammalian communities respond to changing climates and sea-levels, beyond estimates of species richness.

We examine a series of interglacial and glacial fossil sites, including: late Blancan interglacial sites (Haile 15A, Macasphalt Shell Pit), latest Blancan glacial (Inglis 1A and 1C) and interglacial (De Soto Shell Pit) sites, and a late early Irvingtonian glacial site (Crystal River Power Plant). These sites, in addition to the newly discovered late Blancan Haile 7G site, span approximately 1.5 million years across the Pliocene-Pleistocene boundary. Stable carbon and oxygen isotopes of biogenic apatite were used to: 1) quantify seasonal variation using serial samples of hypsodont teeth; 2) compare the dietary niches of species present at multiple sites; 3) quantify the dietary niches of taxa unique to the glacial and interglacial sites; and 4) examine mammalian microfaunal niche partitioning through time and between interglacial and glacial sites. In order to quantify taxa specific dietary shifts, we compare the inferred diets of the herbivorous megafauna present at the majority of the sites, including: *Tapirus* sp., *Holmesina floridanus*, *Megalonyx leptostomus*, *Eremotherium eomigrans*, *Odocoileus virginianus*, and *Equus* spp. We also compare the occupied niche space of mammalian taxa unique to glacial or interglacial sites. This has immediate relevance to clarifying possible biotic responses to current global warming.

Poster Session II

A BIOMECHANICAL ARGUMENT TO EXPLAIN THE DOMINANT MASSETER/PTERYGOID MUSCLE COMPLEX IN SOME MAMMALS

GREAVES, Walter, Univ of Illinois at Chicago, Chicago, IL

The vector representing the resultant force of the jaw closing muscles generally divides the mammalian jaw into an anterior tooth-bearing region and a posterior toothless region. The lengths of these two regions can be *projected* onto lines perpendicular to the vector. These *projected* lengths, as opposed to the actual lengths, are typically in the ratio of 3:7. The sum of the bite forces is maximized when this ratio is present. Most commonly, a dominant and posteriorly oriented temporalis muscle inclines the vector posteriorly. Less often, and in just a few mammalian orders, a dominant and anteriorly oriented masseter/pterygoid complex inclines the vector anteriorly. Many of the animals with an anteriorly inclined vector appear to have jaws that have elongated over evolutionary time.

Beginning with a vector that is posteriorly inclined, lengthening only the anterior part of the jaw disturbs the 3:7 ratio resulting in a less efficient jaw mechanism. Moving the joint, the tooth row, or both can maintain this ratio, but such changes require major morphological disruption of the skull and lower jaw. However, this ratio can be preserved by simply rotating the muscle vector anteriorly. This maneuver does not change the skull or jaw and has no effect on the actual length of the posterior region itself, but it does increase the length of the *projection* of this region and so can conserve the 3:7 ratio. Anterior rotation occurs when the masses of the jaw closing muscles change so that the masseter/pterygoid complex, rather than the temporalis, is dominant. According to this view, if the anterior part of a jaw

elongates over evolutionary time, the relative sizes of the jaw closing muscles will also change to reorient the muscle vector so that it is anteriorly inclined. That increases the length of the *projection* of the posterior region of the jaw, keeps the 3:7 ratio in tact, and so maintains the efficiency of the jaw mechanism.

Student Poster Session

PRELIMINARY ANALYSIS OF MICROWEAR IN EXTANT XENARTHANS: CAN DENTIN MICROWEAR INDICATE PALEODIET?

GREEN, Jeremy, North Carolina State Univ., Raleigh, NC

Dental microwear is a well-established, quantitative method for analyzing paleodiet in extinct animals through direct comparison with extant taxa. However, previous research has focused predominately on food scar patterns in enamel. The question of whether microwear in dentin can indicate diet in extant or extinct animals has not been addressed. This issue particularly affects extant and extinct xenarthran taxa, as their teeth are comprised solely of dentin, and no enamel is present. Quantitative analyses of microwear patterns in extant xenarthran taxa (for which primary diet is known), will allow inference of textural composition of paleodiet in extinct xenarthrans and other vertebrates such as dicynodonts (Therapsida, Anomodontia), which do not possess enamel. Microscopic scar topography features were analyzed in a large sample of teeth (n=47) from three extant xenarthran families (Brachypodidae, Dasypodidae, Megalonychidae), using the new low-magnification light stereomicroscopy method. Features including number of small/large pits, fine/coarse scratches, presence/absence of cross scratches and puncture pits, and other features were recorded. A database correlating dentin microwear patterns with known primary diet for each respective taxon was established. Ecological morphospaces such as insectivore, leaf-browser, fruit-browser, etc. were created using this database. Microwear patterns in several extinct xenarthran taxa (i.e., *Eremotherium*, *Glyptodon*) were then analyzed and compared to this database to test the validity of dentin microwear in assessing paleodiet. The results of this study are significant not only in determining the significance of dentin microwear features in interpreting paleodiet, but also in allowing comparison of dentin microwear with previous accounts of enamel microwear in order to gain a broader understanding of the mechanics of food scarring on different dental tissues.

Poster Session III

PELVIC AND HIND LIMB MUSCULATURE OF *STAUROKOSAURUS PRICEI* COLBERT, 1970 (DINOSAURIA, SAURISCHIA)

GRILLO, Orlando, AZEVEDO, Sergio, Museu Nacional/UF RJ, Rio de Janeiro, Brazil

The study of pelvic and hind limb bones and muscles in primitive dinosaurs is important to understand the early evolution of bipedal locomotion in Saurischia. We reconstructed these features in *Staurikosaurus pricei* (Santa Maria Formation, Late Triassic of Rio Grande do Sul, Brazil) aiming to create a 3D model and to evaluate the movement capabilities of this primitive saurischian. The "extant phylogenetic bracket" method was used to infer which muscles were present in *Staurikosaurus* and its origin and insertion, and homologies of bone surfaces between extant taxa (Crocodylia and Aves) and *Staurikosaurus* was inferred based on phylogenetic information. In contrast to crocodylians, *Staurikosaurus* possesses a larger area for muscle origin in the ilium, the M. iliofemoralis (IF) is divided (anterior trochanter present but small). Two large depressions in the lateral surface of the ilium are the origin for the M. iliotrochantericus caudalis (ITC) plus M. iliofemoralis externus, anteriorly, and for M. iliofibularis, posteriorly. The preacetabular iliac border may be used to determine the anterior limit of ITC and IF since it is a feature of Aves, Crocodylia, and Lepidosauromorpha. The M. ambiens inserted onto the pubic tubercle as in extant Aves. This tubercle has been figured as absent in *Staurikosaurus*, but it was preserved in the left pubes (all current reconstructions are based on the right pubes) and is identical to that of *Herrerasaurus* and *Saturnalia*. The origin of the Mm. puboischiofemorales internus (PIFI) is similar to Crocodylia, but *Staurikosaurus* has only the point of insertion for PIFI2 in the anterior margin of the proximal femur. This suggests that during archosaurian evolution PIFI2 lost its posterior insertion point and, later, in Theropoda, was divided in Mm. iliotrochantericus cranialis and medialis. The Mm. caudofemorales are similar to Crocodylia, but *Staurikosaurus* is unique in bearing a surface (medial blade of the reduced brevis fossa) posteriorly projected for the insertion of the M. caudofemoralis brevis which increases the moment arm of this muscle.

Saturday 10:30

DELPHYDONTOS DACRIFORMES, REVISITED. NEW INFORMATION ON BABY MEAN-TEETH, A BEAR GULCH CHONDRICHTHYAN

GROGAN, Eileen, Saint Joseph's Univ., Philadelphia, PA; LUND, Richard, Carnegie Museum, Mount Holly, NJ; ATTANASIO, Alicia, Saint Joseph's Univ., Philadelphia, PA

The Bear Gulch fauna (Serpukhovian, Heath Formation of Montana) is especially notable in the high diversity of chondrichthyans that it records. *Delphyodontos dacriformes* Lund 1980, from which this material emanates, was originally described on the basis of two fetal specimens as a new species of holocephalan, the latter having since been described as the crown group of the Euchondrocephali (Class Chondrichthyes, Subclass Elasmobranchii and Subclass Euchondrocephali). Six additional specimens (male and female, including mature forms) have now been recovered, thereby offering additional information on the ontogenetic and phylogenetic status of *Delphyodontos*. All specimens are entirely placoid in squamation and exhibit a tear-drop shaped body with a single, spinous, long, low, scale covered dorsal fin. Dorsal and ventral lobes of the weak caudal fin are evident. The endoskeletal

mineralization conforms to a mode of tesserate mineralization that has been noted among chondrichthyans. The neurocranium presents with two cranial fissures and regularly preserved otoliths in addition to an unfused, autodiastylic palatoquadrate and cranially-subtended, nested branchial arches. Neither the palatoquadrate nor Meckel's cartilage bear teeth. Rather, tooth whorl-bearing premandibular and symphyseal cartilages formed the functioning oral margin. Observations confirm that whorls are generated as denticulate "tooth cusps" incrementally add to a fundamental scale-like whorl unit. The design of *Delphyodontos*' shoulder girdle is consistent with that of *Debeerius* and other euchondrocephalans, thus presenting as a plesiomorphic to primitive condition with the exception of a pectoral articular notch. The phylogenetic position of *Delphyodontos dacriformes*, although unresolved at this time, will be discussed with regard to the suite of such characters.

Vertebrate Development Symposium, Wednesday 11:00

HETEROCHRONIC INFLUENCES ON THE DEVELOPMENT OF POSTCRANIAL CHARACTERS IN HADROSAURID DINOSAURS

GUENTHER, Merrilee, Univ. of Pennsylvania, Philadelphia, PA

A goal of modern dinosaur paleobiology is to synthesize our understanding of dinosaurian development and phylogeny. However, evolutionary change can be difficult to study in taxa for which only fossils remain. Heterochrony is a potential mechanism for evolutionary change, but a difficult one to test with certain fossil groups. Methods have recently been developed in an attempt to utilize fossil data fully. This began with the development of "event pairing," which allows for the analysis of ontogenetic sequences by pairing developmental events and subsequently comparing their relative timing. Though it began as a qualitative rather than quantitative method, the event-pairing methodology has been quantified through "event-pair cracking."

The data set represented by the Hadrosauridae presents one of the greatest opportunities to study the ontogeny of a dinosaur group and apply the event-pairing methodology. Growth series are known for several taxa, the most complete being *Maiasaura peeblesorum*, which is included in this study. The use of this taxon, among others, allows for an analysis of the developmental differences within the Hadrosauridae and its two subfamilies, Hadrosaurinae and Lambeosaurinae, and with more basal iguanodontians. The study involves comparing the developmental sequences of several hadrosaurid taxa, including *Maiasaura*, *Hypacrosaurus*, *Corythosaurus* and *Lambeosaurus*, among others, with more basal iguanodontian forms such as the hadrosauroid, *Telmatosaurus*, and the iguanodontid, *Iguanodon*, among others.

Phylogenetically significant postcranial characters have been previously identified through a qualitative and descriptive study of the Hadrosauridae. Within the postcranial skeleton of hadrosaurs, characters can be used for taxonomic differentiation at the subfamily and, at times, generic level. The appearances of these characteristics throughout ontogeny serve as the basis for the developmental events that are "paired" in this method. The focus in this study has been on postcranial elements and the most distinctive characters have been identified among the appendicular and pelvic elements.

Poster Session III

RENEWED FRANCO-AMERICAN RESEARCH AT THE LATE VILLAFRANCHIAN LOCALITY OF SENEZE (HAUTE-LOIRE, FRANCE)

GUÉRIN, Claude, Université Claude Bernard-Lyon I, Villeurbanne, France; FAURE, Martine, Université Lumière-Lyon 2, Lyon, France; MONGUILLON, Angélique, DEBARD, Evelyne, Université Claude Bernard-Lyon I, Villeurbanne, France; DELSON, Eric, American Museum of Natural History and City Univ. of New York, New York, NY

The fossil site of Senèze, located in the Auvergne volcanic province of the French Massif Central, is well-known for its mammalian fauna and its role as the reference locality for the Late Villafranchian time interval, MN 18. This site is a filled-in volcanic explosion-crater lake (maar) where fossils are found in volcanoclastic sediments interfingering with lacustrine deposits at the lake margin. The Senèze mammals are generally considered to date between 2.2-1.5 Ma, but some have suggested that the local fauna is composed of two associations of different age. Moreover, little has been published about the geological setting or the processes of site formation. We are re-examining Senèze for the first time in 60 years with three main goals: 1) to clarify the local geology (stratigraphy, mineralogy) of this complex site and determine the taphonomic history of the fossil remains; 2) to utilize a combination of methods (argon and ESR dating; tephrochronological and paleomagnetic correlation) to definitively establish the age of the site and its fauna; and 3) to collect additional mammalian fossils (especially of rare animals such as carnivores, primates and rodents) and samples of the non-mammalian biota, including vertebrates (e.g., birds and fishes), terrestrial and lacustrine invertebrates, pollen and diatoms from known points within the revised and dated stratigraphy. Well-preserved, mostly articulated skeletons of *Dicerorhinus etruscus*, *Eucladoceros clenoides*, and *Allohippus stenonis senezensis* have been recovered, in addition to more fragmentary remains of "*Cervus*" *philiis*, *Mammuthus meridionalis*, *Pachyrococa perrieri*, *Acinonyx pardinensis*, and (for the first time at the site) *Miomys pitmyoides* and a castorid. The bones present few if any indications of carnivore ravaging, and a taphonomic working hypothesis is that periodic mudflows down the inside crater walls may have buried large animals and rolled them into the lake in an anoxic situation. Argon dating suggests that the main fossiliferous level (which can be traced over a wide area despite faulting) postdates 2.1 Ma. Additional paleomagnetic profiles should allow tighter chronological calibration.

Poster Session III

NEW PRIMATES (MAMMALIA) FROM GANDHERA QUARRY, EARLY EOCENE, BALOCHISTAN PROVINCE, PAKISTAN

GUNNELL, Gregg, Ann Arbor, MI; UL-HAQ, Munir, Geological Survey of Pakistan, Quetta, Pakistan; GINGERICH, Philip, Univ. of Michigan, Ann Arbor, MI; BLOCH, Jonathan, Univ. of Florida, Gainesville, FL; CLYDE, William, Univ. of New Hampshire, Durham, NH

Fieldwork conducted in Balochistan, western Pakistan, led to the discovery of Gandhera Quarry in the upper part of the Ghazij Formation. Sequence stratigraphy indicates that the Ghazij Formation spans the early Eocene (Ypresian). Gandhera Quarry dates to approximately 50 Ma with the lower Ghazij stretching to approximately 54.5 Ma. Thousands of vertebrate specimens have been recovered from Gandhera, thirty of which represent euprimates, including at least two new adapiforms and one omomyiform. The best represented adapiform is a new species of the primitive cercamoniine *Panobius*. *Panobius* differs from all other cercamoniines except European *Donrussellia* in retaining paraconids on lower molars—differs from *Donrussellia* in lacking distinct paraconid and metaconid on p4, m1-2 with higher paraconids, higher para- and protocristids, and straight cristid obliquae, and m1 with trigonid more open lingually. Another adapiform most closely resembles Eocene *Anchomomys* from Europe and Oligocene *Bugtilemur* from Dera Bugti, Pakistan. It differs from *Anchomomys* in being smaller, having a complete paracristid closing off the trigonid, a stronger preprotostylid, higher and shorter entocristid and a relatively shorter and broader talonid. It differs from *Bugtilemur* in being smaller, having a more lingually angled cristid obliqua, a preprotostylid, and a weaker protocristid and hypoconulid. *Bugtilemur* is a purported lemuriform, however its similarities to this new Gandhera taxon indicate that it may have had an adapiform ancestry, traceable to the early Eocene. The Gandhera omomyiform is smaller than other known omomyiforms with the exception of enigmatic *Altanius*. It differs from *Altanius* in having upper molars with broader and deeper trigon basins, more robust, bulbous, and marginally placed conules, having poorly developed pre-, postpara- and metaconule cristae, protocones more anteriorly placed and lingually extended, lacking a postprotocingulum, and having a small but distinct cingular hypocone. This taxon is primitive in lacking an upper molar postprotocingulum but does not share much in common with other omomyids that lack this feature.

Poster Session I

THE CETACEANS FROM BAHÍA INGLESA FORMATION (ATACAMA, CHILE): TAPHONOMIC APPROACH AND PALEO GEOGRAPHICAL IMPLICATIONS

GUTSTEIN, Carolina, Caldera, Chile; SUAREZ, Mario, Museo Paleontológico de Caldera, Caledra, Region de Atacama, Chile

The cetacean fossils are abundant and diverse at the bonebed of Bahía Inglesa Formation (Northern Chile), a sequence of phosphatic beds belonging to upper Miocene. The cetaceans taxa include very fragmentary baleen whales (Mysticeti indet.) and toothed whales (Physeteridae indet., Phocoenidae indet., Pontoporiidae: *Pliopontos* sp., *Brachydelphis mazeasi*, cf. *Brachydelphis* n. form, *Pontistes* sp.).

The most productive site is called "Mina Fosforita" where the bonebed is well exposed. The sequence of this deposit is part of a major transgressive-regressive cycle, in this site marked by the presence of coquina intercalated with sandstones culminating in the bonebed (different types of phosphatic conglomerates). Field observations revealed that the fossils are generally disarticulated and the long bones are all broken with a smooth and uniform surface. These taphonomic and lithologic features together with the presence of the bonebed layers, composed by a great abundance of fossils including approximately 70 taxa of vertebrates, indicate a reworking of the fossils, probably from a more ancient stratum. All the Neogene Pontoporiidae genera known and some new forms are recorded for the first time to the same site indicating major diversity for the clade. The Miocene record for *Pliopontos*, a *Pontistes* record to the Pacific coast and *Brachydelphis* recognized in two forms (short and long rostrum) extends in time, diversity and distribution the range of Pontoporiidae.

The broader distribution for all taxa mentioned above, most described only for tropical waters attributed to Pisco Fm. (Peru) could indicate independence of this aquatic mammals from currents and temperature barriers between Peru and Chile coasts as indicate from Neogene mollusk faunas. This genera appearing together in upper Miocene Pacific strata suggest a broader distribution to this group, considering reinterpretations and new findings of Pontoporiidae, from North Atlantic.

Wednesday 4:15

STRUCTURAL CHARACTERISTICS OF THE LIMBS OF RAPTORIAL BIRDS CAN PREDICT CHARACTERISTICS OF LOCOMOTION AND PREDATORY BEHAVIOR

HABIB, Michael, Johns Hopkins School of Medicine, Baltimore, MD

Raptorial birds (Falconiformes and Strigiformes) demonstrate a wide range of locomotor behavior, associated with a range of feeding strategies. Despite the fact that owls and true raptors are well-studied and charismatic groups, little detailed attention has been given to the relationships between the quantitative structural characteristics of their limbs and locomotor behavior. Such structural characteristics hold the possibility of being able to yield new information about locomotion diversity in raptorial birds, and may further allow for better estimates of hunting behavior (and thus dietary preferences) in fossil taxa.

Previously, it was demonstrated that avian locomotor guilds can be differentiated on the basis of forelimb to hindlimb ratios of bone strength, and also that these structural ratios are

more informative than length ratios for determining behavior and locomotion. Here I present a focused study on the structural characteristics of the limbs in falconiform and strigiform birds, as well as members of distantly related groups convergent with raptors.

This study demonstrates that measures of bending and torsional strength in the forelimb and hindlimb (and the ratios between them) carry signals related to hunting behavior. These structural ratios predict behavior more accurately than ratios of bone lengths, and do so using only a single pair of proximal limb bones per animal. This approach is highly applicable to fossil taxa. I include several fossil species in my analysis, such as a giant tytonid owl from Haiti (*Tyto ostologa*), and I compare these fossil taxa to their extant relatives.

By examining species that are not closely related to each other, but are behaviorally similar, I am able to quantify the differing degrees to which phylogeny and functional traits determine several aspects of osteological structure. In addition, I have found that, in some cases, a difference in hindlimb bone strength may exist between raptors and owls of similar size, possibly related to differences in talon force.

Saturday 4:15

ARE RARE SPECIES DOOMED? A PALEONTOLOGICAL PERSPECTIVE ON EXTINCTION

HADLY, Elizabeth, Stanford Univ., Stanford, CA

Rare species are commonly viewed as the species most likely to become extinct. Explanations for this include population fragmentation, decreased connectivity between populations, and reduction of genetic diversity due to population bottlenecks. In order to investigate the properties of commonness and rarity at various taxonomic scales, data from fossil assemblages of mammalian communities across almost 1,000,000 years and 3,500 km in North America were assembled. These data demonstrate a remarkable similarity of community composition across these vast scales of space and time. The use of Hubbell's neutral theory demonstrates that empirical communities show greater inertia than neutrally modeled communities, in large part due to the persistence of 'rare' taxa. Rare species maintain their abundance in mammalian communities much longer than the neutral model predicts. These species are always rare, but are found throughout 1,000,000 years and across 3500 km, while other species remain common at these scales of space and time. These results demonstrate that individual species and their roles in communities are persistent, yet distinct. Thus, although species are threatened by population size reduction due to the myriad of human-induced global impacts, the property of rarity itself may not necessarily lead to extinction. This distinction is a critical consideration as scientists try to predict the effects of climate change on biotic communities.

Wednesday 11:45

BOVINAE (ARTIODACTYLA: BOVIDAE) FROM MIO-PLIOCENE DEPOSITS OF THE MIDDLE AWASH, ETHIOPIA

HAILE-SELASSIE, Yohannes, Cleveland Museum of Natural History, Cleveland, OH; BIBI, Faysal, Yale Univ., New Haven, CT

Newly recovered fossils from Mio-Pliocene deposits of the Middle Awash, Ethiopia, comprise a diverse terrestrial vertebrate fauna that includes a significant proportion of bovids. This faunal assemblage derives from the Kuseralee Member of the Sagantole Formation (~5.2 Ma), and the Asa Koma Member of the Adu-Asa Formation (~5.5–5.8 Ma) and represents one of the most complete and best-dated assemblages of its age from the African continent.

Among the Bovinae, two bovines (Bovini) are present, a species of *Simatherium* from the Kuseralee Member, and a very primitive *Ugandax*-like species from the Asa Koma Member. A single, new, tragelaphine (Tragelaphini) species is also present in both the Kuseralee and Asa Koma Members. Known primarily from horn core material, this species exhibits a large range of variation but is generally intermediate in morphology between tragelaphines previously described from older (e.g. Lukeino) and younger (e.g. Apak Member, Lothagam) deposits. Boselaphines (Boselaphini) are also present, represented by more than one species, recording one of their latest African appearances in the younger Kuseralee Member. A new *Tragoptortax* species is described which bears affinities to other contemporaneous African species of this genus as well as to older species from the Siwaliks of Pakistan.

The Middle Awash material provides new specimens crucial to the reconstruction of bovid evolution in Africa during the late Miocene and early Pliocene. The Middle Awash fossils provide insight into the polarity of characters traditionally used to differentiate the different bovid tribes, particularly in the case of the bovine and tragelaphine material. Additionally, the evolutionary dynamics of Bovinae in Eurasia and Africa are further elaborated. Evolutionary trends within Bovidae are analyzed in terms of large-scale global environmental changes, including the expansion of C4 grasslands, that took place in the late Miocene.

Saturday 9:45

A NEW SPECIES OF THURSIUS (SARCOPTERYGII; OSTEOLEPIFORMES) AND ITS IMPLICATIONS ON MIDDLE DEVONIAN OSTEOLEPIDID RELATIONSHIPS

HALL, Patricia, ELLIOTT, David, Northern Arizona Univ., Flagstaff, AZ

A new species of the osteolepid *Thursius* is represented by completely articulated individuals from the Water Canyon Formation of northern Utah. This discovery is the first report

of osteolepiforms in the western region of the US. The genus was previously known only from the Middle Devonian of Scotland and China, making this find both morphologically and biogeographically significant. Although closely related to *Osteolepis*, *Thursius* differs by having a more posteriorly positioned first dorsal fin, a deeper orbital notch, and a variety of distinct cranial features. *Thursius* sp. nov. differs from other previously described species within the genus by possessing a squamosal, quadratojugal, and preopercular compound bone, a postorbital with a pronounced anterodorsal process and strongly convex posterior articulation with the compound bone, a lachrymal with a strongly convex anterior margin, and a distinct set of cranial morphometric ratios. The new species appears to be most closely related to *Thursius wudingensis* based on the array of bones within the skull roof, presence of the compound bone in the cheekplate, and sensory canal patterns, sharing these last two characters with *Kenichthys*, *Powichthys*, and *Youngolepis*.

Relationships among the 'Osteolepiformes' are still debated and the placement of basal forms such as *Kenichthys* remain problematic. The discovery of shared characteristics between *Thursius* sp. nov., *Thursius wudingensis*, *Kenichthys*, and *Powichthys* may help to strengthen previous evidence that these forms are perhaps closely related. In addition, apparently intermediate forms such as *Thursius* sp. nov. and *Thursius wudingensis* may provide evidence that *Thursius* provides a tentative link between the more basal *Kenichthys* and the more derived *Osteolepis*. In previous cladistic analyses *Osteolepis*, *Thursius*, and *Kenichthys* were either equally related or *Thursius* and *Kenichthys* formed a sister group to *Osteolepis*. New information gleaned from the fully-articulated material of *Thursius* sp. nov. may provide more characters to help clarify the placement of this genus within the Osteolepididae.

Poster Session III

MULTIPLE NEW DINOSAUR TRACKSITES FROM THE KAYENTA FORMATION, WASHINGTON COUNTY, SOUTHWESTERN UTAH

HAMBLIN, Alden, Cedar City, UT; LOCKLEY, Martin, Dinosaur Tracks Museum, Denver, CO; MILNER, Andrew, St. George Dinosaur Discovery Site, St. George, UT
At least a dozen new tracksites have been discovered in the Kayenta Formation within 40 km radius of the City of St. George, Utah. At least five sites are large (up to 1000 m²) with dozens of trackways of theropod dinosaurs. Trackways occur at the top of the Springdale Sandstone, which may represent a megatracksite surface, on locally, laterally-persistent sandstones 10-20 m above the Springdale and at other higher horizons in a predominantly fining upward sequence.

The majority of theropod tracks are large (ichnogenus *Eubrontes*) and deeply impressed on surfaces that are not suitable for preservation of small tracks. On some of these surfaces deep tracks reveal long heel traces or deep elongate impressions with no clear track morphology. At several sites parallel progression trackways of similar depth and regular inter-trackway spacing suggest gregarious behavior and a preferred trend to the W and SW. Other sites with better preservation have smaller *Grallator* and possibly *Kayentapus* tracks. One site provides evidence of a large running theropod (*Eubrontes* type) moving at an estimated 41 km/hr. This is the fastest speed estimate for a Lower Jurassic theropod and is close to the record speeds estimated for lower Cretaceous tracks from Texas and China.

Poster Session III

FELIX: A LATE PLEISTOCENE WHITE WHALE (*DELPHINAPTERUS LEUCAS*) SKELETON FROM CHAMPLAIN SEA DEPOSITS IN QUEBEC

HARINGTON, C. Richard, Canadian Museum of Nature, Ottawa, ON, Canada; PAIEMENT, Maxime, LEBEL, Serge, DE VERNAL, Anne, Université de Québec a Montreal, Montreal, QB, Canada

A nearly complete, articulated skeleton of an old white whale from Champlain Sea deposits at Saint-Félix-de-Valois, Québec is the best preserved specimen of its kind recorded from North America. It is one of 21 white whale specimens known from the Champlain Sea (an arm of the Atlantic Ocean that covered the St. Lawrence Lowland from about 12,000 to 10,000 BP). Collagen from a vertebra yielded an Accelerator Mass Spectrometry radiocarbon date of 10,700 ± 90 BP, which, with stratigraphic and paleoenvironmental data, is in accord with our knowledge of the past distribution of this species, its known habitat and habits. This study quantitatively traces regional sea-surface temperature, salinity and ice cover based on analyses of a series of samples from bottom to top of a section at the fossil site. Dinocysts indicate a change from cold to cool conditions in surface water during that period corresponding to the withdrawal of ice and the beginning of the Holocene.

Wednesday 2:00

NEW SPECIMENS OF THE ORNITHURAN BIRD *GANSUS YUMENENSIS* FROM THE XIAGOU FORMATION (LOWER CRETACEOUS) OF GANSU PROVINCE, CHINA

HARRIS, Jerald, Dixie State College, St. George, UT; YOU, Hailu, Ji, Qiang, Chinese Academy of Geological Sciences, Beijing, China; LAMANNA, Matthew, Carnegie Museum of Natural History, Pittsburgh, PA

Spectacular avian fossils from the Lower Cretaceous Jehol Gp. in NE China have provided extensive information on the early evolution of birds, including basal members of the Ornithuromorpha. However, none of these are *bona fide* members of the Ornithurae *sensu* Padian (MRCA of *Hesperornis regalis* and *Passer domesticus* and all its descendants). In the early 1980's, slightly younger lacustrine deposits of the Xiagou Fm. (Xinminpu Gp.) in Gansu, NW China, yielded a distal pelvic limb, the holotype of *Gansus yumenensis*. The

taxon's incompleteness rendered its affinities doubtful for two decades; however, excavations near the type locality have produced dozens of new, nearly 3D *Gansus* specimens that present abundant new morphological data. Among the elements, and the data they present, are cervical vertebrae (broad, short, heterocoelous cranially but opisthocelous caudally in series, low spinous processes, carotid sulcus on caudal elements); thoracic vertebrae (large pneumatic fossae, ventral processes cranially in series, no gastralia); synsacrum (10 or 11 vertebrae); scapula (shorter than humerus, cranially-directed acromion surpassing coracoid tuberculum); coracoid (deep scapular facet, hooked procoracoid process, large lateral process); sternum (apneumatic, sharp apex on carina that spans element, medial & lateral trabeculae, median sulcus, intermuscular lines, four sternal rib facets); humerus (domed head, transverse sulcus, pit on caudodistal end of bicipital crest); ulna (prominent bicipital tubercle); manus (extensor process on alular metacarpal, major metacarpal >2x diameter of minor, major digit phalanx 1 dorsoventrally compressed); pelvis (ilium overlaps caudalmost thoracic ribs, ischium with dorsal process, distal pubes unfused with boot); tibiotarsus (enlarged, proximally-projecting cnemial crests, astragalar ascending process, no supratricondylar pons); and tarsometatarsus (intercotylar eminence, extensor sulcus with proximal vascular foramen, unridged hypotarsus, proximoplantarly offset trochlea of metatarsal II, distal vascular foramen). The morphology of many of these elements supports the position of *Gansus* as an ornithuran.

Vertebrate Development Symposium, Wednesday 9:15

EVOLUTION OF AMNIOTE OSSIFICATION PATTERNS: A NOVEL APPROACH TO INFERRING ANCESTRAL DEVELOPMENTAL SEQUENCES

HARRISON, Luke, LARSSON, Hans, Redpath Museum, Montreal, QB, Canada

Heterochrony or changes in developmental timing are thought to be a major component of macroevolutionary change. However, the analysis of temporal developmental sequences in a phylogenetic context is difficult due to the lack of an absolute time scale for comparisons. The inference of ancestral developmental sequences is not only critical for the analysis of sequences across a phylogeny but to also examine hypothetical developmental sequences for extinct taxa. Event pairing has been used as a method to represent developmental sequences and to analyze the relationships between them. Previously, developmental sequences were coded into event pairs and parsimony with ACCTRAN and DELTRAN optimizations had been used to infer the ancestral developmental sequences so that changes between sequences could be analyzed along branches of the phylogeny. Parsimony, however, assumes that the highly non-independent event-pair data is independent; this leads to erroneous reconstructions at internal nodes, particularly under ACCTRAN and DELTRAN optimization. Here a novel method is demonstrated that makes no such assumptions. A genetic approach is taken, using the previously available Parsimov program as a scoring function to evolve optimal ancestral developmental sequences at internal nodes. The new method, Parsimov-Scored Genetic Ancestral Inference Method [PGAIM] was applied to a dataset of amniote post-cranial ossification sequences including therian and metatherian mammals as well as reptiles. For this dataset PGAIM assigns ancestral sequences that yield an approximately 30% shorter tree when compared to either optimization of parsimony. Timing shifts are concentrated more towards the root of the phylogeny. Interestingly, therian mammal sequences are almost as divergent from reptilian sequences as they are from metatherian mammal sequences. Finally, within this new framework, unlike parsimony-based analyses, hypotheses of developmental modularity, incorporating multiple sequence elements, may be investigated.

Saturday 3:00

TAXONOMY AND PALEOBIOLOGY OF FOSSIL CERCOPITHECIDS FROM THE PLIOCENE OF LAETOLI, TANZANIA

HARRISON, Terry, New York Univ., New York, NY

Renewed investigations at the Pliocene site of Laetoli in northern Tanzania have succeeded in recovering a large sample of additional fossil cercopithecids. The new specimens were recovered from the Upper Laetoli Beds, dated radiometrically to ~3.5-3.8 Ma. Previously, the cercopithecids from Laetoli have been referred to four species: *Parapapio ado*, cf. *Paracolobus* sp., *Colobinae* gen. et sp. indet. and cf. *Papio* sp. The majority of new specimens are isolated teeth, but a number of cranial, mandibular, and postcranial remains have also been recovered. These new finds allow a reassessment of the taxonomic relationships and paleobiology of the Laetoli monkeys. *Parapapio ado* is the most abundant species at Laetoli, and appears to be common at penecontemporaneous sites in East Africa. A newly recovered mandible, of an aged male individual, is the most complete specimen from the type locality of Laetoli. The large colobine, provisionally referred to *Paracolobus*, is currently considered to belong to a previously unrecognized taxon. The small species of colobine from Laetoli, previously known only from a few isolated teeth and postcranial elements, is now much better known, and is represented by a partial mandible, as well as additional teeth and postcranial specimens. Comparable material is known from other localities in East Africa, but this species has not yet been formally named. No additional specimens of cf. *Papio* sp. were recovered. The fossil cercopithecids at Laetoli are associated with what is inferred to have been a predominantly woodland and savanna setting. The postcranial remains attributed to *Parapapio* and "*Paracolobus*" indicate that these species were semi-terrestrial monkeys that lacked the highly derived specializations for terrestriality seen in most Plio-Pleistocene papionins and colobines. The smaller colobine was probably more committed to arboreal locomotion. The age structure of the individuals and the predominance of cranio-dental specimens relative to postcrania indicate that, like the fossil

hominins from Laetoli, the cercopithecoid assemblage was heavily influenced by carnivore predation and scavenging.

Poster Session I

ESTIMATING OSTEOLOGICAL NEUTRAL POSITION IN SAUROPOD AXIAL SKELETONS: COMPARING TWO-DIMENSIONAL AND THREE-DIMENSIONAL METHODS OF ANALYSIS

HARTMAN, Scott, SHINKLE, Levi, Wyoming Dinosaur Center, Thermopolis, WY

Recent attempts to reconstruct the posture and potential range of motion of sauropod dinosaurs have focused on estimating the undeflected state, or osteological neutral position (ONP) of sauropod axial columns. While the correlation between ONP and habitual posture is a subject of debate, determining ONP should provide a repeatable point of departure for additional functional analyses.

To date, the most common method of assessment of ONP has been compositing illustrations of presacral vertebrae in photo-manipulation software, such as Adobe's Photoshop. To check the repeatability of this method, Photoshop composites were created of *Apatosaurus louisae* CM 3018, *Diplodocus carnegii* CM 84, and *Mamenchiosaurus youngi* ZDM0083, and the recovered ONP was compared with previously published results. Significant discrepancies were found only in the composite of *Mamenchiosaurus*, and may be due to particularly strong postmortem distortion. Photoshop compositing of illustrations of *Apatosaurus* and *Diplodocus* recovered essentially the same ONP reconstructed by previous researchers. To test the reliability of using illustrated vertebrae to recover ONP, a Photoshop composite was made of photographs of the vertebral series of CM 84. The resulting ONP diverged strongly from ONP recovered from the composite of illustrations of CM 84.

High-resolution three-dimensional data was acquired by laser scanning two specimens of *Camarasaurus* sp. As with previous findings, limb proportions and back posture had strong effects on neck elevation in ONP. Contrary to some reports, ONP of the axial column showed the neck somewhat elevated above horizontal, though less than the degree of neck elevation seen in extant giraffes. Importantly, ONP of Photoshop composites made from photographs of the same specimens compared well with the ONP estimated from the three-dimensional data set.

These findings suggest caution must be taken in the use of illustrated vertebrae in assessing ONP, regardless of how convincing the illustrations appear. Composites of photographs reasonably approximate the ONP found with three-dimensional laser scans of axial columns, suggesting that photographic evidence is sufficient in cases where bones are too large or fragile to scan and/or physically manipulate.

Poster Session II

EVIDENCE FOR A PREHENSILE TAIL IN A LATE PLIOCENE PORCUPINE SKELETON FROM NORTH-CENTRAL FLORIDA

HASTINGS, Alexander, BLOCH, Jonathan, HULBERT, Richard, Univ. of Florida, Gainesville, FL

The extant North American porcupine, *Erethizon*, is thought to have emigrated from South America during the Great American Biotic Interchange ~2.8 Ma. Central and South American *Coendou* has been proposed as its sister taxon, having diverged from a common ancestor prior to the arrival of *Erethizon* in North America. *Coendou* is more arboreal than *Erethizon*, with many species having a prehensile tail, a feature absent in *Erethizon*. The first occurrence of *Erethizon* in western North America is in the late Blancan (~2.5 Ma) of Arizona. *Erethizon poyeri* appears slightly later in eastern North America, in the late Blancan (~2.0 Ma) of Florida. Prior to a recent find, early *Erethizon* has mostly been known from dental and fragmentary cranial material. A newly discovered partial skeleton of *E. poyeri* from the late Blancan Haile 7G locality in north-central Florida includes a crushed skull with a complete upper dentition, a complete mandible, most limb bones, 28 vertebrae, and elements of both hands and feet. In a previous *erethizontid* revision, 18 cranial characters were quantified for distinguishing between *Coendou* and *Erethizon*. Eight are preserved well enough in this new specimen for study and all plot within the range of *Erethizon*. However, the caudal vertebrae of *E. poyeri* resemble those of *Coendou*. Distal caudal elements of extant *Erethizon* have a single pair of transverse processes while *Coendou* has two pairs, a feature also found in ateline prehensile-tailed monkeys. These dual transverse process sets are present in *E. poyeri*. Another common theme of prehensile tails is that they have a greater number of vertebrae. Extant *Erethizon* has 13-18 caudal vertebrae, whereas *Coendou* has 28-33. While only 11 were recovered, we infer that *E. poyeri* had between 26 and 32 caudal vertebrae. We conclude that *E. poyeri*, while cranio-dentally similar to extant *Erethizon*, differs from this taxon in being more arboreal with a prehensile tail like extant *Coendou*.

Poster Session III

WALKING IN THE FOOTSTEPS OF BARNUM BROWN AND R.S. LULL: THE TRICERATOPS OF RED BUTTE

HATCHER, Joseph, Garfield County Museum, Jordan, MT

Located within the Trumbo Ranch USGS Quadrangle, Section 35, at N 47° 32' 26", W 107° 03' 48", east of the ranch road and approximately one mile south of the type locality for *Tyrannosaurus rex* (CMNH 9380), is a large table-shaped landform unofficially named Red Butte by Barnum Brown and R.S. Lull during the 1902 AMNH expedition to Hell Creek, Montana. Stratigraphic layering topped with red igneous pumice and scoria, Red

Butte is an easily distinguishable landmark in the Hell Creek badlands. Writing in the 1907 USGS Monograph on the Ceratopsia, R.S. Lull discusses the collection of one *Triceratops* specimen from jointed clay at the base of Red Butte and originally ascribed to *T. seratus* (AMNH No. 971).

Over one hundred years later, two additional *Triceratops* specimens were collected at the base of the north and south sides of Red Butte, respectively, by our field team during the 2005 field season in Garfield County, Montana. Specimens GCM 105 & GCM 106 have been ascribed to *T. horridus*, located at an average distance of 24 stratigraphic meters below the K/T Boundary. The two GCM specimens consist primarily of cranial material, while the AMNH specimen includes both cranial and post cranial material, including a humerus, radius, fibula, and four phalanges. The preservational matrix of the two GCM specimens was composed of bentonite-rich, fluvio-lacustrine sediments of fine grained mud and siltstones. This is consistent with Lull's notes on the preservational matrix of AMNH No. 971, thus revealing a regional pattern of preservation, indicative of a specific environment of deposition favorable to this taxon.

Student Poster Session

PORASPIDIDS FROM THE MOTH LOCALITY, MACKENZIE MOUNTAINS, NWT, CANADA: ANATOMY AND PHYLOGENY

HAWTHORN, Jessica, Univ. of Alberta, Edmonton, AB, Canada

The phylogenetic affinities of the cyathaspidiform heterostracan clade Poraspididae are poorly known. This project will investigate the relevance of poraspidid specimens from the Man On The Hill (MOTH) locality in the Mackenzie Mountains in the Northwest Territories of Canada to the systematics and origins of early vertebrates, based on phylogenetic reconstruction. I will extensively describe and illustrate the anatomy of the fossil vertebrate specimens. Morphological characters will be assessed to determine the species to which each specimen should be assigned and utilized in phylogenetic analysis. These data will be combined with biogeographic and temporal factors to explore the evolutionary history of poraspidids and early vertebrates.

Poster Session II

OSTEODERM HISTOLOGY OF STEGOSAURUS STENOPS (ORNITHISCHIA: THYREOPHORA): IMPLICATIONS FOR PLATE AND SPIKE GROWTH

HAYASHI, Shoji, Hokkaido Univ., Sapporo, Japan; CARPENTER, Kenneth, Denver Museum of Nature & Science, Denver, CO

Stegosaurus stenops has characteristic plates and spikes. Previously, the internal structures of *Stegosaurus* plates and spikes have been studied, and their functions have been discussed (plates for thermal regulation or display and spikes for weapon). *Stegosaurus* skeletons with different ontogenetic stages have been discovered from the Upper Jurassic Morrison Formation of Colorado and Wyoming, but the ontogenetic variations of plates and spikes never been studied. In this study, the ontogenetic variations of the osteoderm internal structures of juvenile (DMNH 33359), sub-adult (NSM PV 20380) and adult (DMNH 1483) individuals are examined using thin sections and the digital images of CT scan.

The spikes of a sub-adult individual are transversely flat and similar to plates in shape, whereas those of an adult are cylindrical. The bone histology of all plates and spikes show fibrolamellar tissue without LAGs. Remodeling of bone tissue is extensive only in DMNH 1483, confirming it is an adult. The adult specimen shows medullary cavity and thick cortical bones in the spike, which are not seen in the preserved materials of the other ontogenetic stages (thin cortical bones and medullary cavity absent in plates and spikes of the sub-adult and plates of the juvenile). The vascular network is absent in the juvenile plates, and an extensive vascular network, extending from the base of plates toward the edge, is present in the sub-adult plates. This network is absent in the spikes of the sub-adult and adult specimens although a previous study suggested its presence in *Stegosaurus* spikes.

The ontogenetic changes from the juvenile to sub-adult individuals occur only in the plate structures. The acquisition of the extensive vascular network in the sub-adult stage may indicate the network is used for thermal regulation and/or nutrient supply. The structures of the spikes change in its shape (flat to cylindrical), the thickness of cortical bones (thin to thick) and the medullary cavity (absent to present) from the sub-adult to adult forms. This suggests that the spikes may be used as weapon for defense in the late ontogenetic stage.

Vertebrate Development Symposium, Wednesday 9:30

DEVELOPMENTAL MECHANISMS IN THE EVOLUTION OF THE POSTCRANIAL SKELETON IN SNAKES

HEAD, Jason, Univ. of Toronto at Mississauga, Mississauga, ON, Canada; POLLY, Paul, Indiana Univ., Bloomington, IN

Multiple developmental mechanisms, including *Hox* domain shifts and postembryonic heterochrony, are recognized as agents of body plan evolution in animals. The postcranium of snakes is an important example of body plan change driven by changes in developmental processes; however, evolution of the axial skeleton within the clade is poorly understood. We examined the evolution of intracolumnar variation in vertebral morphology across snake phylogeny to determine whether changes are consistent with a single developmental mechanism. Vertebral morphology was sampled with Procrustes realigned landmark coordinates at regular intervals in the precloacal skeletons of representative taxa from all higher-order snake lineages. The variance in shape along each vertebral column, derived from PCA ordination of realigned coordinates, was used as an index of regionalization. The evolution of the axial skeleton within the clade is poorly understood.

lutionary changes in the variance index were tested against changes in *Hox*-mediated regional differentiation between snakes and other squamates, and changes in regionalization during snake ontogeny. Evolutionary trends in regional variation within snakes were analyzed by plotting the change in the variance index for each terminal and square-change parsimony reconstructed ancestral taxon against patristic distance from the base of the snake phylogenetic tree. Variance along the first principal component decreases with patristic distance for ancestral values, consistent with a hypothesis of decreasing regionalization throughout snake phylogeny. The pattern of change in intracolumnar variance suggests that heterochronic changes rather than *Hox* domain shifts were the primary mechanisms of body plan evolution. Calibration to stratigraphic first occurrences suggests an approximately continuous history of decreasing axial variability as opposed to dramatic transitions associated with ecological specializations or radiation of a particular clade.

Poster Session I

GEOMETRIC MORPHOMETRICS WORKS ON SAUROPODS TOO! CRANIAL AND VERTEBRAL LANDMARK ANALYSES OF THE SAUROPODOMORPHA

HEATHCOTE, Julia, Isleworth, United Kingdom

Phylogenetic systematics is a useful tool in palaeontological studies and descriptive papers seldom appear without a "token" cladogram. However, attention is rarely paid to the quality of the characters and their relative objectivity. Characters are selected, a decision is made about what constitutes "0" and "1" and a state is assigned to a given feature of a taxon. This process necessarily involves the subjective input of a human being, whose experience in the field may vary greatly. Geometric morphometrics can bring a greater degree of objectivity to the selection of characters, and even assist in the formation of phylogenetic hypotheses.

Five homologous landmarks and 25 sliding semilandmarks were used to delimit the jugal bone of 11 prosauropod and seven sauropod skulls in lateral view. The jugal bone was selected for its lack of importance in sauropodomorph systematics, featuring in just three out of 95 sauropod cranial characters. The landmarks were analysed using standard Procrustes techniques, and these results compared with those obtained for similar studies using the premaxilla and dentary. In each instance, the Sauropoda and Prosauropoda clustered in distinct groups with little or no continuous variation between the clades, supporting a monophyletic origin of the Prosauropoda. Clearly this needs to be reproduced in many more studies of cranial and postcranial elements before any formal conclusions can be drawn.

However, a major problem with sauropod cranial features is the lack of preservation associated with the delicate bones of the skull. A series of 26 caudal vertebrae from *Cetiosaurus stewarti* were analysed to investigate the application of morphometrics to postcranial features. The increased errors of using real bones rather than illustrations were apparent, and so the number of landmarks was reduced in favour of more sliding semilandmarks to mimic an eigenshape analysis. Continuous variation between each vertebra could be seen in the relative warp analyses. This has important implications for vertebral characters in cladistic studies, as well as the potential for ontogenetic analyses and digital identification of isolated elements.

Poster Session II

A DIVERSE NEW MICROVERTEBRATE FAUNA FROM THE UPPER TRIASSIC (REVUELTIAN: NORIAN) CUMNOCK FORMATION, SANFORD SUBBASIN, NORTH CAROLINA

HECKERT, Andrew, CAMP, Jessica, Dept. of Geology, Boone, NC; SCHNEIDER, Vince, North Carolina Museum of Natural Sciences, Raleigh, NC; OLSEN, Paul, NESBITT, Sterling, Lamont Doherty Earth Observatory, Palisades, NY

Screenwashing yields a diverse microvertebrate assemblage from exposures of the Upper Triassic Cumnock Formation near Moncure, NC. This locality (NCSM 1904) yields abundant osteichthyan fossils and rarer, but diverse, amniotes. Strata exposed at NCSM 1904 consist of 33 m of "red-bed" siliciclastics—mudstone and thin lenses of siltstone and sandstone—previously mapped as the Sanford Fm but laterally equivalent to Cumnock Fm strata elsewhere in the basin. The fossiliferous horizon is a lens of purplish gray, pedogenically modified siltstone, ~19 m above the base of local exposure. The fauna appears somewhat time-averaged, and is exceptionally diverse taxonomically, preserving a dozen taxa identified at the family level or lower as well as numerous specimens that probably represent other, less-well-known taxa. Osteichthyan fossils dominate the assemblage, including palaeoniscoid, redfieldiid, and semionotid scales as well as the first dipnoan teeth reported from the Newark Supergroup. We refer the latter to *Arganodus* sp. and note that they are the smallest reported teeth of the genus. The only possible amphibian fossils are a single inter-centrum and some textured bone fragments. Amniotes are represented primarily by teeth, but also by vertebrae and fragmentary limb elements. Macrovertebrate (cm-scale) teeth from the site represent phytosaurs, rauisuchians, and the first records of the crurotarsan *Revueltosaurus* from outside the southwestern USA. These teeth are similar to, but distinct from, the type species (*R. callenderi*). Other amniote records are of indeterminate reptiles, archosauriforms, a possible sphenodont, and at least two cynodonts, including teeth tentatively referred to *Microconodon* sp. and Traversodontidae indet. The occurrence of *Revueltosaurus* sp. supports correlation of Revueltian strata in the American Southwest to Cliftonian strata in the Newark Supergroup. This diversity and new records reported here (e.g., *Arganodus*, *Revueltosaurus*) demonstrates the value of microvertebrate studies generally, and screenwashing in particular, to maximize knowledge of vertebrate paleobiodiversity.

Poster Session II

EGG AND BODY MASS SCALING IN NON-AVIAN THEROPODS

HENDERSON, Donald, Royal Tyrrell Museum of Palaeontology, Drumheller, AB, Canada; ZELENIITSKY, Darla, Univ. of Calgary, Calgary, AB, Canada

Association between non-avian dinosaur remains and their eggs permits an investigation of the correlation between adult body mass and egg mass in non-avian theropods. Previous studies of extant theropods (birds) have shown a scaling relationship between adult body mass and egg mass given by $\text{egg mass} = 0.277(\text{adult mass})^{0.77}$. This scaling relationship demonstrates that bird eggs get relatively smaller with increasing body size. Based on known troodontid and oviraptorid egg clutches, a scaling relationship between egg mass and adult mass is derived for non-avian maniraptorans, where $\text{egg mass} = 0.0177(\text{adult mass})^{0.777}$. This scaling relationship shows that maniraptoran egg mass changes as a function of adult body mass at the same rate as in extant birds (0.77), even though the eggs are estimated to have been sixteen times heavier. Application of the scaling relationship to giant oviraptorosaur eggs (*Macroelongatoolithus*, 42.2 cm long) predicts a body mass of 1,100 kg and a body length of 6.5-7.5 m long for the adult. Allosauroid eggs from Portugal are smaller than the size predicted by the maniraptoran scaling relationship, possibly because this relationship does not apply to a different phylogenetic lineage and/or to larger adult body sizes. In comparison, the eggs of extant crocodylians are much smaller relative to body size than those of living and extinct maniraptorans. The maniraptoran scaling trend is intermediate between that of living birds and crocodylians. Both sauropodomorphs (titanosaurids and prosauropods) and ornithomorphs have very small eggs for their body size, demonstrating that egg-body scaling relationships are clade specific.

Poster Session II

A NEW AMPHIBIAN OCCURRENCE FOR THE MAZON CREEK BIOTA

HENDERSON, Michael, Burpee Museum of Natural History, Rockford, IL

The middle Pennsylvanian (Westphalian D) Mazon Creek Biota of northern Illinois contains one of the best known late Paleozoic tetrapod assemblages. While Mazon Creek fossils have been collected for more than 150 years by amateur and professional paleontologists, tetrapod remains are exceedingly rare. In the most recent review of Mazon Creek tetrapods only one neotridean amphibian species, *Ptonius marshii*, is recorded.

Here I report a new amphibian occurrence for the Mazon Creek Biota. The specimen consists of a siderite nodule containing 21 complete and two partial caudal vertebrae of a neotridean amphibian, preserved as a natural mold, collected from Pit 11 of the former Peabody Coal Company strip mine in Will County, Illinois. The size and shape of the neural and haemal spines of the new specimen demonstrate it is not referable to *Ptyonius*. Instead the caudals are virtually identical to those of *Ctenerepeton* remex, a neotridean amphibian known from two canal coal deposits: Five Points, Ohio and the classic site of Linton, Ohio.

Criteria exist which may be used to place an articulated series of *Ctenerepeton* vertebrae into their proper place in the caudal sequence. Based on their preserved morphology, caudals 5-25 are represented by complete vertebrae in the new specimen of *Ctenerepeton*. The new specimen provides another link between the tetrapod assemblage of Mazon Creek and the roughly contemporaneous sites of Linton and Five Points, Ohio.

Poster Session III

FIRST WIDELY SPACED CRANIAL GROWTH SERIES OF A SEYMOURIIDAE

HENRICI, Amy, Carnegie Museum of Natural History, Pittsburgh, PA; KLEMBARA, Jozef, Comenius Univ., Bratislava, Slovakia; BERMAN, David, Carnegie Museum of Natural History, Pittsburgh, PA; THOMAS, Martens, Museum der Natur, Gotha

For the first time it is possible to present a partial but widely spaced, ontogenetic growth series of the skull of the amphibian *Seymouria sanjuanensis* based on specimens from the Lower Permian Tambach Formation of the well-known Bromacker quarry locality in central Germany. The growth series, the first to be documented for any Seymouriid, is based on five skulls with midline skull lengths of 19.0, 20.0, 56.0, 87.9, and 94.6 mm. The series exhibits the expected, well-documented cranial transformations of proportions and structures, such as lengthening of the preorbital region, relative decrease in orbit length, closing of the nasal-lacrimal canal, increased degree of dermal sculpturing, etc. Only the skull growth sizes 56.0 mm, and 87.9 and 94.6 mm can be regarded confidently as representing subadult and fully mature individuals, respectively. The two smallest skulls, on the other hand, display a suite of characters typically ascribed to temnospondyl amphibians at either a late larval stage or undergoing metamorphosis. This confusion is not unexpected, because metamorphosis involves a large series of parallel but non-synchronous structural transformations occurring over a relatively short period of time and, therefore, cannot be delimited precisely at either end.

Although assignment of the two smallest skulls to one or the other growth stage may be problematical, the combination of small size and possession of numerous features typically recognized as middle to late metamorphic suggests that *Seymouria* reached and accelerated through metamorphosis at a very early growth stage, particularly in comparison to the discosauriscid seymouriamorphs. *Seymouria* has long been considered highly adapted to a terrestrial existence, and an early, accelerated metamorphosis would have conferred on it the added adaptive advantage over the majority of Paleozoic amphibians the ability to tolerate highly ephemeral limnic conditions.

Poster Session II

THE IMPORTANCE OF CT SCAN IN TESTUDINES TAPHONOMIC ANALYSES—A CASE STUDY IN PIRAPOZINHO SITE, SAO PAULO, BRAZIL

HENRIQUES, Deise, AZEVEDO, Sergio, Museu Nacional, Rio de Janeiro, Brazil; CAPILLA, Ramsés, PETROBRAS, Rio de Janeiro, Brazil

Testudine material, collected at the Pirapozinho Site (Bauru Group), has been macroscopically analyzed and mechanically prepared for several years. All the studies indicated that, due to the richness of the material and to the excellent state of preservation of it (based mainly on the presence of articulated individuals (carapace/plastron conditions)), a catastrophic event occurred in the site. However, analysis of the slices obtained in tomographic exams proved to be essential to the study of the Testudines group as, by that means, it is possible to visualize the internal structures of the turtle material without causing damage to them, resulting in accurate data to taphonomic interpretation. These data indicated that some of the macroscopically analyzed material was not as complete as it was imagined to be. The majority of the sample presented different stages of disarticulated internal condition. As a result, it could be determined to the Pirapozinho Site eight taphonomic classes, enclosing completely articulated to disarticulated elements: class I—articulated and complete skeleton, including skull and mandible; class II—partially articulated skeleton with no skull and/or mandible; class III—articulated skull and mandible isolated from the post-cranium elements; class IV—isolated skull or isolated mandible; class V—carapace/plastron with a reduced or without intern bone material; class VI—isolated carapace or isolated plastron; class VII—isolated post-cranium material; and class VIII—high degree of bone fragmentation. The taphonomic data together with sedimentary ones indicate both slowly and catastrophic events. They also indicate a reworking and a time-averaging processes. The present model postulates a multi-episodic event to the Pirapozinho Site, with a total of ten different moments of humidity and drought registered.

Poster Session III

MACROEVOLUTIONARY INSIGHTS BASED ON BIOMIC SPECIALIZATION OF MAMMALIAN ASSEMBLAGES: INTERCONTINENTAL COMPARISON AMONG AFRICA, SOUTH AMERICA AND EUROPE

HERNANDEZ FERNANDEZ, Manuel, Universidad Complutense de Madrid, Madrid, Spain; MORENO BOFARULL, Ana, ARIAS ROYO, Anton, Universidad Autonoma de Madrid, Cantoblanco, Spain; LUNA, Belen, Universidad de Castilla-La Mancha, Toledo, Spain; VRBA, Elisabeth, Yale Univ., New Haven, CT

Vrba's resource-use hypothesis, developed after the study of the mammalian fossil record from Africa, predicts that generalist species have lower speciation and extinction rates than specialists. We test several subsidiary predictions of this hypothesis using the biomic specialization index (BSI) for each mammal species, which is based on its geographical range within different climate zones. This index can be used globally allowing intercontinental and intertaxa comparisons. Our results, based on the study of extant African (A), South American (SA) and European (E) mammals, are consistent with the axioms of the resource-use hypothesis, which predicts (1) a high frequency of stenobiomic species, (2) that carnivores are more eurybiomic than herbivore clades, (3) the higher incidence of biomic specialists in the tropical rainforest, desert, steppe and tundra biomes, and (4) the fact that certain combinations of inhabited biomes occur more frequently among species than do others. We also found that the tropical deciduous woodland (A, SA), sclerophyllous woodland (E), nemoral forest (E) and taiga (E) are important sources of species, which is due to either the large size of these biomes or the high incidence of climatic cycles on them. These results can be explained within the premises of the resource-use hypothesis. The low incidence of tundra specialists in Europe might be due to the reduced extent of this biome in the continent. Other deviations from some predictions of the evolutionary hypothesis tested here are probably due to the high incidence of mountainous terrain on ecological specialization in European and South American mammals, or to the influence of the Pliocene Great American Biotic Interchange. The resource-use hypothesis and related habitat-theory suggest that a key to present-day macroecological patterns is found in the past: in the long term history of turnover (speciation, extinction) of clades, and in the palaeoclimatic and other geological changes of the areas in which the clades evolved. As a result of our work, here we present evidences based on extant assemblages that support an evolutionary theory originally based on the fossil record.

Poster Session III

LATE MIOCENE MAMMALIAN FAUNA INCLUDING LARGE HOMINOIDS FROM THE NAKALI FORMATION, RIFT VALLEY, KENYA

HIDEO, Nakaya, Kagoshima Univ., Kagoshima, Japan; YOSHIHIRO, Sawada, Shimane Univ., Matsue, Japan; YUTAKA, Kunitatsu, Kyoto Univ., Inuyama, Japan; MASATO, Nakatsukasa, Kyoto Univ., Kyoto, Japan; HARUO, Saegusa, Univ. of Hyogo, Sanda, Japan The branching age of the human clade from the other hominoids was estimated to be around five million years ago by the calibration of DNA sequence. Hominid fossils are reported from some localities over six million years ago (Senut et al. 2001, Brunet et al. 2002) post 20th Century. The late middle to early late Miocene (between 13 and 7 Ma) is the important age for revealing the human origins. *Samburupithecus kiptalami* (Ishida & Pickford 1997) from the Namurungule Formation (Rift Valley, Kenya) is the only hominoid fossil associated with a rich vertebrate fauna from Sub-Saharan Africa in this geologic age. The Namurungule Fauna was correlative with the Fauna Set VI (10 to 8 Ma) of mammalian biostratigraphy of Sub-Saharan Africa by Pickford (1981) (Nakaya et al. 1984, Nakaya

1994, Pickford et al. 1984, Tsujikawa 2004). Geologic age of the Namurungule Formation was determined as 9.6 Ma by K-Ar dating and magnetostratigraphy (Sawada et al. 1998). However, *S. kiptalami* is represented only by a single left maxilla with the upper cheek tooth row. Phylogenetic position of *S. kiptalami* is not yet established within the Hominoidea. The Japanese expedition team has excavated the Nakali Formation (Rift Valley, Kenya) since 2002. This team has collected more than 700 vertebrate remains including hominoid fossils (Nakatsukasa & Kunitatsu 2005, Nakatsukasa et al. 2005). We have identified 27 taxa of the following orders and families from the Nakali Fauna including unreported taxa by previous works. Reptilia: Crocodylia, Testudinata, Squamata (Serpentes), Mammalia: Primates (Non-cercopithecoid catarrhine, Hominoidea spp., Colobinae), Rodentia (Rhizomyidae, Thyronomyidae), Proboscidea (Deinotheriidae, Gomphotheriidae, Elephantidae), Hyracoidea (Procaviidae), Carnivora (Mustelidae, Hyaenidae), Perissodactyla (Equidae, Rhinocerotidae), Artiodactyla (Suidae, Hippopotamidae, Giraffidae, Bovidae). The faunal assemblage from the Nakali Formation is similar with the assemblage from the Namurungule Formation, and also correlative with the Fauna Set VI (10 to 8 Ma). Large hominoid fossils from the Nakali Fauna are new material from the late Miocene in age.

Friday 12:00

HORN MORPHOLOGY OF PACHYRHINOSAURUS AND HORN EVOLUTION IN CENTROSAURINE DINOSAURS

HIERONYMUS, Tobin, Ohio Univ., Athens, OH; TANKE, Darren, Royal Tyrrell Museum, Drumheller, AB, Canada; CURRIE, Philip, Univ. of Alberta, Edmonton, AB, Canada; WITMER, Lawrence, Ohio Univ., Athens, OH

The integument covering the rugose nasal and supraorbital bosses of the centrosaurine dinosaur *Pachyrhinosaurus* has been reconstructed with structures ranging from thin, unornamented skin to massive, rhino-like horns. Skin morphology has an impact on paleobiological inferences (e.g., behavior). As pachyrhinosaur bosses are novel structures, inferences regarding their soft-tissue morphology and function require a three step approach of testing (1) similarity by analogy to extant taxa, (2) transformational homology by congruence in the EPB, and (3) adaptation within the ingroup using phylogenetic comparative methods.

The nasal and supraorbital horn cores and surrounding bone of *Pachyrhinosaurus*, *Achelousaurus*, *Einosaurus*, and *Centrosaurus* were compared to the osteological correlates of extant amniote skin types to assess relative similarity of centrosaurine skin to modern analogs. Hypotheses of homology for the skin covering the skull roof were tested for congruence in extinct archosaurian taxa and extended to centrosaurines. Finally, hard- and soft-tissue character states were optimized onto a phylogeny of Centrosaurinae by parsimony.

The center of the horn bosses present on adult *Pachyrhinosaurus* and *Achelousaurus* shows bone texture most similar to that found beneath the horny frontal 'helmet' of muskoxen (*Ovibos*), and were most likely covered by a thick (2-10 cm) flat plate of papillary horn attached to an unspecialized, thin, tangentially-oriented dermis. The periphery of the horn bosses shows bone texture similar to that found beneath avian rhamphotheca and bovid cornuotheca, suggesting that the morphology of the base of the primitive centrosaurine epidermal horn was retained. Preliminary results indicate that ceratopsian nasal horns are transformational homologs of the frontal scale sequence in crocodylians and the frontonasal beak plate in birds, and that these structures initially arose by the tangential projection of a horny plate, similar to the derivation of the casque in hornbills.

Poster Session I

INSIGHTS INTO THE BIOLOGY OF LARGE, EXTINCT SOUTH AMERICAN UNGULATES

HIGGINS, Pennilyn, Univ. of Rochester, Rochester, NY

Several orders of ungulate mammals have arisen and become extinct on the continent of South America. The biology of these South American ungulate mammals is enigmatic, since there are obvious convergences in body form with many modern ungulates (including those that now live natively in South America), and yet no extant members of the South American ungulate orders exist. Most interpretations of the biology of South American ungulates are based upon the general morphology of teeth, skulls, and limbs. New advances in geochemistry allow for further investigation into the habitats of the animals. We have conducted isotopic analysis of 15 teeth or tooth fragments from members of the Notoungulata, Pyrotheria, and Litopterna, representing at least 11 individuals. Ten of the specimens were sampled serially, to examine annual variation in stable oxygen and carbon isotopes. The data provide insight into seasonal variation in climatic variables, such as temperature and rainfall, the approximate rate of growth of rootless molars, incisors, and tusks that are common in the large South American ungulates. Isotopes provide a means to study the advent and spread of C4 grasses in South America. Furthermore, isotopes from fossil teeth provide important information about the timing of uplift of the Bolivian Andes and the formation of the Altiplano.

Poster Session II

DYROSAURID (CROCODYLIFORMES) FOSSILS FROM THE CRETACEOUS AND PALEOGENE OF MALI

HILL, Robert, New York College of Osteopathic Medicine, Old Westbury, NY

Dyrosaurids are common components of late Mesozoic and early Cenozoic faunas in western Africa, yet their fossil record presents special challenges to the interpretation of their

phylogenetic relationships and biostratigraphy. Anatomically nonoverlapping specimens have frustrated attempts at species-level phylogeny, and whereas some species exhibit survivorship across the K-T boundary, others, ostensibly more primitive, are known only from temporally restricted Paleogene localities.

We describe new crocodyliform fossils from three separate localities in Mali, representing sediments of Maastrichtian, Paleocene, and Eocene ages. At least four distinct crocodyliform species are identified, two of which are unequivocally dyrosaurids. The crocodyliform material collected at the Maastrichtian locality includes two partial dyrosaurid braincases, along with numerous disarticulated cranial elements, vertebrae, limb bones, and osteoderms. The Paleocene locality produced a well-preserved posterior braincase of a medium-sized dyrosaurid, and the partial braincase of a much larger crocodyliform. Paired, articulated dentaries and splenials of a large dyrosaurid were discovered at the Eocene locality.

Morphological character data from these specimens are incorporated into existing phylogenetic analyses to test hypothesized relationships among dyrosaurid genera. The occipital region and osteoderms have recently been identified as two anatomical regions that may provide new data to refine crocodyliform phylogeny. Data from these regions are used to supplement more traditional morphological data that describe the postcranial skeleton, skull, and especially, the mandible. These new fossils provide additional insights into the apparent incongruence between phylogeny and stratigraphic data for dyrosaurids. A temporal range extension is indicated for at least one dyrosaurid taxon, based on its occurrence in Maastrichtian sediments.

Poster Session III

THE SISTER-GROUP OF ACIPENSERIFORMES: PAST PROBLEMS AND POTENTIAL POSSIBILITIES

HILTON, Eric, Chicago, IL

Acipenseriformes includes the sturgeons, paddlefishes, and their immediate fossil relatives, and consists of four families: Chondrosteidae; Peipiaosteidae; Polyodontidae; and Acipenseridae. This Holarctic order is known from the Early Jurassic to the present day from both marine and freshwater environments, and some modern sturgeons move between the two habitats. Many recent studies have focused on the interrelationships of fossil and living Acipenseriformes. The monophyly of Acipenseriformes has been well established, and Acipenseridae and Polyodontidae are considered to be sister-taxa. However, the basal relationships of Acipenseriformes are still unresolved and the closest fossil relatives of the Acipenseriformes as a whole are unknown. In this presentation, I will discuss taxa that have been hypothesized to be the sister-group of Acipenseriformes, such as *Birgeria* and *Saurichthys*. I will also identify the challenges and future directions of research related to the discovery of the acipenseriform sister-group. Specifically, the anatomy of *Chondrosteus* is insufficiently known to help resolve the basal relationships within Acipenseriformes, which will aid in understanding the relationships of Acipenseriformes within lower actinopterygians generally.

Wednesday 3:00

CORRELATION OF OSTEOLOGY AND LOCOMOTION: INFERRING SWIMMING MODES IN EXTINCT ORNITHURAE

HINIC-FRLOG, Sanja, MOTANI, Ryosuke, Univ. of California, Davis, CA

The anatomical features of extant Neornithes are expected to reflect physical constraints during locomotion. If identified, these properties may also be applicable to extinct birds for which direct ecological and behavioral observation is lacking. In order to infer locomotory attributes of fossil birds, it is necessary to show that osteology alone can be used to distinguish between different locomotor modes in extant birds.

We compiled data on locomotor preferences and anatomical features of 206 species of extant birds. Using a statistical approach we demonstrate that physical constraints of avian environments are reflected in osteological features. Principal component analysis (PCA) of living avians identified subsets of osteological features that are useful in separating diving, swimming, and flying species. When superimposing fossil species, *Hesperornis regalis* is placed within the distribution of foot-propelling underwater swimmers, whereas *Baptornis advenus* appeared among wing-propelled divers. This is the first quantitative test of underwater swimming ability of hesperornithiform birds.

We investigated the biomechanical significance of the width of the hip and the length of the cnemial process of the tibiotarsus. Previous workers already associated these features with swimming modes, but the reasons for the association have not been rigorously tested. The narrow hip was believed to contribute to a teardrop body shape that reduced drag forces while moving through the water. However, these divers spread the feet widely even when gliding through the water, eliminating the contribution of the narrow hip to reduce drag. Similarly, the long cnemial process has been associated with increased cross sectional area of the femoral muscles producing power for underwater propulsion; however, the femur is stationary throughout the swimming cycle. We argue alternatively that: relatively narrow hip increases force transmission efficiency by bringing the hip joint closer to the center of mass; enlarged cnemial process reduces the range of motion around the knee and increases propulsive power of the tarsometatarsus.

Student Poster Session

KINEMATICS OF THEROPOD RIB CAGES AND THEIR IMPLICATIONS FOR THE RESPIRATORY SYSTEMS

HIRASAWA, Tatsuya, The Univ. of Tokyo, Tokyo, Japan

Respiratory evolution is one of the major issues in vertebrate evolution, and theropods present an intriguing case for studying the evolution of respiratory systems because of their obligatory bipedal posture and their close phylogenetic relationship with extant Aves. While several aspects of respiratory systems in theropods have already been studied, the mode of their costal aspiration, an essential component of the amniote respiratory pump, remains mostly unknown.

The structures of costovertebral articulations in several theropods were examined. The main emphasis was on those in tyrannosaurids, for which both articulated and disarticulated skeletons were examined. The tyrannosaurid fossils exhibit that the tuberculum of each thoracic rib articulated with the posteroventral side of the distal tip of the vertebral transverse process. Diapophyseal facets articulating with costal tubercula are difficult to be identified, while parapophyseal facets for costal capitula are represented by distinct cup-like structures. Although clear facets for costal tubercula are lacking, the ventral sides of diapophyses, as well as corresponded regions of the ribs, are marked with rugosities, which most likely represent sites of attachments of ligamentum costotransversarium. In tyrannosaurids, therefore, this ligament would have suspended ribs from transverse processes, with their costovertebral articulations functioning as hinge joints.

The hinge axis of costal rotation can be defined as the line between two articular facets for capitulum and tuberculum respectively on vertebrae. Thus, the angles of hinge axis (AH) in theropods were measured and plotted in stereographic projections, and were then compared with those of extant crocodylians and birds. AH of crocodylians, theropods, and birds occupied different areas in stereographic projections. This result suggests that the kinematics of rib cages in non-avian theropods may have been different from those in crocodylians or birds, and will potentially provide novel insight into the respiratory evolution, especially the evolution of the flow-through ventilation seen in extant Aves.

Poster Session I

USING STABLE CARBON ISOTOPE, MICROWEAR, AND MESOWEAR ANALYSES TO DETERMINE THE PALEODIETS OF NEOGENE UNGULATES AND THE PRESENCE OF C4 OR C3 GRASSES IN NORTHERN AND CENTRAL FLORIDA

HOFFMAN, Jonathan, John Day Fossil Beds National Monument, Kimberly, OR

Traditionally, hypsodont (high-crowned) teeth in North American ungulates (hoofed mammals) were thought to have coevolved with grasses during the middle Miocene. Isotopic evidence has demonstrated that tropical C₄ grasses were not dominant and therefore not abundant enough to be responsible for this adaptive radiation. It has been proposed that high-altitude/high-latitude C₃ grasses were extensive throughout the Great Plains and were the dietary driving force behind the grazing adaptations. This study tests this hypothesis in the middle Miocene of the Southeastern United States. The $\delta^{13}\text{C}$ signatures from 24 specimens of 8 ungulate taxa from the Willacoochee Creek Fauna, an assemblage of middle Miocene animals from northern Florida and southern Georgia, are presented here to determine if there is a significant C₄ grass component in mammalian paleodiets. The $\delta^{13}\text{C}$ values indicate that all 8 taxa were consuming C₃ plant material, either browse or grass. Furthermore, microwear analyses conducted on 3 specimens of the most hypsodont taxon indicate that the equid was eating grass. Combined with the $\delta^{13}\text{C}$ data, this study concludes that C₃ grasses were predominant in the middle Miocene of northern Florida/southern Georgia and were being consumed by at least one hypsodont ungulate. This evidence supports a C₃ grass hypothesis for hypsodont radiations. This study also combines the mesowear paleodietary analysis with previously published isotopic data of 5 equid populations from 3 sites in central Florida, ranging in age from ~9.5 Ma to ~1.5 Ma, to trace the possible influence of C₃ grasses on ungulate diets. C₃ grasses were found to be the primary food source for these horses until approximately 7 Ma (the approximate age of C₄ grassland expansion). After that, equids fed on a mixed diet of C₃ and C₄ grasses until about 1.5 Ma. At that point in Florida, the abundance of C₃ grasses had diminished and grazers fed primarily on C₄ grasses.

Poster Session II

THE STRANGE AND INCREDIBLE JOURNEY OF THE HIGHGATE MASTODON

HOGANSON, John, North Dakota Geological Survey, Bismarck, ND

In 1992, restoration of the Highgate Mastodon skeleton was completed at the North Dakota Heritage Center, Bismarck. This ended the fossils incredible journey that began when collected in 1890 from the John Regcraft farm, Highgate, Ontario. William Hillhouse and John Jelly purchased the specimen as a commercial venture. The unmounted skeleton toured in Canadian and the US between 1890 and 1892. A handbill announced the coming of the "monster unearthed." In about 1893, the owners lost tract of the traveling exhibit, foul play was expected. The specimen surfaced again in dead storage at the Bibb Broom Corn Co. warehouse in Minneapolis. Harry Dickinson purchased the specimen for storage costs and sent it to his father in Barnesville, MN. In 1895, it went on tour again to towns in Minnesota, South Dakota, and North Dakota. James Grassick, from Buxton, ND, purchased the skeleton in 1898 for \$10, shipping by rail cost \$27.84. Grassick loaned the specimen to the U. of North Dakota in 1902, then sold it to them for \$100. A 1947 letter from Elwyn Robinson, historian at UND, to Russell Reid, State Historical Society of ND,

announced that a “a partial mastodon skeleton had been found in the attic of Macnie Hall” and would the Society want it. It was transferred to Bismarck in 1948 and fell into obscurity until 1991.

The unmineralized bones of the Highgate Mastodon were in remarkably good condition when restoration began in 1991, perhaps because the bones had been “sized” with white glue when collected. The skeleton is 80 to 85% complete. A tusk, left femur, left ulna, tooth, and several foot bones were missing and were fabricated for the restoration. The missing tooth was discovered by Regcraft’s granddaughter in an attic in 2006. Dental analysis indicates that this adult male mastodon was 40-45 years old when it died. The bones show no indication of disease. Several broken ribs on its left side may indicate cause of death, perhaps as a result of combat. A pebble size piece of entombing sediment recovered from a hole in the sternum indicates that the Highgate Mastodon inhabited a boreal forest dominated by spruce, probably between about 12,000 and 10,300 yrs BP.

Preparators Symposium, Thursday 8:30

PLASTIC DISPLAY JACKETS

HOGGIN, John, Wyoming Dinosaur Center, Thermopolis, WY

It was observed that large bones, such as those of the WDC supersaur specimen, suffered some breakage during transportation and arrangement in museum display situations. To rectify this situation a removable plastic jacket was proposed; this method proved to be effective in supporting and stabilizing large specimens (1-3 meters). Syn-air Por-a-kast TA, ‘mothermold’ is a spreadable putty polyurethane which produces a cost effective, durable, and strong form fitting platform. The strength-to-thickness ratio allows for a thin enough jacket to be hidden under the bones while maintaining competent support for display and repeated moving for research and storage. The inclusion of steel handles produces a more ergonomic grip and facilitates transportation and ease of use. The method devised for creating these display jackets involved covering the bone in a protective double layer of foil and spreading successive layers of ‘Mothermold’ infused burlap (similar to layers of plaster infused burlap for field jacketing). After a minimum of two layers, steel supports and handles may be inserted as needed for transportation and structural integrity. Once the plastic has hardened painting it flat black makes it unobtrusive when supporting the bone on display. A promoter spray is recommended to prevent flaking of paint over time. Several designs were instituted, though it was observed that a tripod mode of support was more stable than four or more points of contact with the floor. In addition to making cost effective transportation cradles, these jackets are also excellent storage solutions as the bones are well supported without drastically increasing their storage volume. Since the advent of this protocol repeated movements of large sauropod bones has produced no breakage.

Poster Session II

FUNCTIONAL MORPHOLOGY OF THE SHOULDER GIRDLE AND THE FORE-LIMBS IN SAUROPOD DINOSAURS UNDER CONSIDERATION OF 3-D FINITE-ELEMENT STRUCTURE SYNTHESIS (FESS)

HOHN, Bianca, Institute of functional morphology of the Ruhr-Universität Bochum, Bochum, Germany; DISTLER, Claudia, Institut für Zoology and Neurobiology Ruhr-Universität Bochum, Bochum, Germany; PREUSCHOF, Holger, Institut für functional morphology Ruhr-Universität Bochum, Bochum, Germany; WITZEL, Ulrich, Lehrstuhl für Maschinenelemente und Konstruktionslehre Biomechanics, Bochum, Germany

The functional morphology of the shoulder girdle, which includes the transmission of body weight to the forelimbs as well as the posture of themselves, is still poorly understood even in living animals. Basically there seem to be two widely different ways. One way is realized in amphibians, modern squamata and crocodiles as well as in birds and recent monotremes, the other in cursorial mammals. Our major aim is now to investigate which way was chosen by the sauropod dinosaurs.

Our 3-D FESS studies show that the stress pattern in the shoulder girdle and the trunk depends on mass distribution of the body’s stem and the position and posture of the supporting limbs. These factors were systematically analysed by means of FESS. Length of the neck and the tail were varied as well as the position of the supporting fore- and hindlimbs. The models were resting in symmetrical stance or in an important phase of walking. The results show a flow of compressive stresses in remarkable accordance with skeletal elements (vertebral column, ribs, shoulder girdle) in vertebrates like they were listed above. On the basis of this systematic survey we are now able to confirm our hypothesis by a more detailed model using the 3-D Finite-Element Structure Synthesis (FESS). The variation of different positions of the limbs and the inserting muscles will show diverse stress patterns. As mentioned before, the flow of the compressive stresses indicates the presence or absence of skeletal material in the model. So we can deduce which skeletal and cartilaginous elements are necessary and in which position they had to stand to each other for a successful transmission of body weight forces from the trunk to the forelimbs.

Poster Session III

CRANIAL AND POSTCRANIAL PERSPECTIVES ON THE AFFINITIES OF *PACHYNOLOPHUS* (MAMMALIA, PERISSODACTYLA)

HOLBROOK, Luke, Rowan Univ., Glassboro, NJ

Pachynolophus is a genus of perissodactyl known from the Eocene of Europe. Previous studies have allied this genus with a number of different perissodactyl groups, including the Equidae, Palaeotheriidae, and tapiromorphs. Most studies have addressed the question of the affinities of *Pachynolophus* with evidence from dental characters. Cranial material of

two different species of *Pachynolophus*, however, has been described, and the collection of the Faculty of Sciences of the Univ. of Lyon includes a number of isolated postcranial elements referred to *Pachynolophus*. Skulls and postcranial material referred to *Pachynolophus* were examined in an effort to identify characters relevant to the phylogenetic position of this genus. Overall, the morphology of *Pachynolophus* is similar to that of other primitive perissodactyls, and there are few derived features suggesting a relationship to a particular group. For instance, *Pachynolophus* lacks a preglenoid process characteristic of palaeotheriids, and its orbital foramina, as far as can be told, are not positioned in the derived manner characteristic of equids. There are, however, several interesting derived characters, including a few that suggest a relationship with palaeotheriids. *Pachynolophus* is similar to palaeotheriids in possessing deep pits for the cruciate ligaments, a distinct adductor tubercle on the distal femur, and a “J”-shaped sustentacular facet of the astragalus. In addition, the shape of the glenoid fossa of *Pachynolophus* is similar to that of ceratomorphs, and, perhaps most surprisingly, the fovea capitis of the femur is centrally located, a derived feature of chalicotheres and lophiodontids. Because the postcranial remains are not associated but merely referred to *Pachynolophus*, any phylogenetic conclusions based on postcranial characters are necessarily tentative, but these characters otherwise suggest a close relationship between *Pachynolophus* and palaeotheriids.

Saturday 12:15

A NEW ARRANGEMENT OF THE PALATAL ELEMENTS IN *TYRANNOSAURUS REX*

HOLLAND, Michael, Museum of the Rockies, Bozeman, MT

Previous descriptions of tyrannosaur palates place the posterior end of the vomer medial to and between the anterior pterygoid flanges. This vomeropterygoid complex is then positioned medial to and between the ascending processes of the palatines. This arrangement left an open space between the two posterior plates of the vomer. The recent assembly of two *Tyrannosaurus rex* skulls suggest a different arrangement of these palatal elements. The larger skull MOR 008, was collected from the Hell Creek formation in Montana during the late 1960’s, and was mostly articulated upon discovery. Since then, it has existed as largely a collection of broken fragments. Upon reassembly the skull was found to be the largest *Tyrannosaurus rex* skull ever collected. The smaller skull, MOR 1125, also from the Hell Creek formation, was collected in 2002. This exceptionally preserved skull is nearly complete and fully disarticulated. Both skulls were assembled for display in the new Late Cretaceous exhibit hall at the Museum of the Rockies. The MOR 008 mount displays the actual fossil material, the MOR 1125 mount is created with resin casts. Missing or incomplete elements were sculpted for each of the two mounts.

During the reconstruction process, further preparation of MOR 008 clearly revealed an alternate arrangement of the palatines, pterygoids, and vomer that is notably different from previous descriptions. A series of photographs taken during the process enabled comparison of relevant elements from both skulls. Images of MOR 1125 provide additional supporting evidence for the arrangement revealed by MOR 008. A computed tomography (CT) scan animation sequence of the vomeropterygoid complex of MOR 008 was used to assess the validity of the alternate arrangement without cutting the fossils. The resulting alternate palatal arrangement presented here places the anterior flanges of the pterygoids adjacent to and contacting each other at the midline of the skull. These closely appressed flanges then insert between the paired posterior plates of the vomer, and penetrate well into the middle of the vomer. This revised arrangement may have implications for tyrannosaur phylogeny, ontogeny and functional morphology.

Saturday 1:30

CRITICAL APPRAISAL OF CRANIAL KINESIS IN DINOSAURS

HOLLIDAY, Casey, WITMER, Lawrence, Ohio Univ., Athens, OH

Cranial kinesis (e.g., streptostyly, pleurokinesis, prokinesis) has been postulated to be common among some dinosaurs (e.g., theropods, ornithomorphs) but absent in others (e.g., ankylosaurs, sauropods). The presence of synovial cranial joints (e.g., otic and basal joints) typically has been the sole indicator of kinesis, whereas the protractor musculature, which supposedly powers these joints, has received little attention. Indeed, previous studies often are unclear as to whether a powered system (as in extant birds and squamates) or a passive system is envisioned. We reviewed the relevant musculoskeletal structures in extant diapsids and fossil taxa to assess the inference of cranial kinesis in dinosaurs. Synovial joints and protractor musculature are ubiquitous among dinosaurs including clearly akinetic taxa (ankylosaurs, ceratopsids). Most of the nonsynovial contacts postulated in dinosaurs are without extant analogs. Although these ubiquitous, plesiomorphic structures (e.g., key synovial joints, protractor musculature) may be necessary for powered kinesis, they are not sufficient for positive inferences of cranial kinesis, in that another critical requirement, the presence of kinematic linkages between bones that permit movement, is needed. Such permissive kinematic linkages are present in kinetic birds, snakes and many lizards, involving loss of bones, reduced palatal and temporal bars, and novel flexion zones. Any inference of powered (or even passive) cranial kinesis in dinosaurs must go beyond the mere presence of synovial cranial joints and address kinematic linkages, the vast majority of which appear non-permissive. Indeed, although many extant lizards bear all the “necessary and sufficient” morphological features suggestive of kinesis, they do not express *in vivo* cranial kinesis, which thus represents an important caveat for any fossil inferences. As an alternative hypothesis, we suggest that persistent synovial joints may represent growth sites that facilitate cranial growth and remodeling during ontogeny.

Wednesday 11:00

PHYLOGENETIC RELATIONSHIPS AMONG LATE MIDDLE EOCENE TO EARLY OLILOCENE OLD WORLD ANTHRACOTHERIIDS

HOLROYD, Patricia, Univ. of California, Berkeley, CA; CIOCHON, Russell, Univ. of Iowa, Iowa City, IA; GUNNELL, Gregg, Univ. of Michigan, Ann Arbor, MI

Recent phylogenetic analyses among Cetartiodactyla have highlighted the importance of anthracotheriids as the paraphyletic stem of the Hippopotamidae and as a potential sister taxon to Cetacea. However, relationships among Paleogene Anthracotheriidae have received less attention, and their relationships to other early Eocene artiodactyl groups considered to be possible sister taxa (e.g., Helohyidae, Dichobunidae) have not been well-explored. As part of ongoing systematic work on early anthracotheriids, we developed a matrix of dental characters which allow us to offer alternative hypotheses of anthracotheriid interrelationships and possible sister taxa to anthracotheriids. Using 13 ingroup taxa, and 7 outgroup taxa, we analyzed 40 unordered characters to examine dental evolution in the group.

Based on this analysis, anthracotheriids had already diversified into two distinct clades by their first appearance in the late middle Eocene. One clade comprises Eurasian *Anthracoherium*, SE Asian *Anthracotheuma*, *Siamotherium*, and new taxa from south China and are united by unreduced p1/P1, upper premolars that are wider than long, and upper molar protoloph incomplete with postprotocristae directed to the center of the molars. The other clade, comprising Asian *Anthracoheryx*, European *Elomeryx*, and the African genera *Bothriogenys* and *Qatraniodon*, are united by reduced p1/P1, P4 with antero-posteriorly oriented protocristae, and upper molars with lingual metaconule cristae lost and moderately developed and projecting para- and metastyles. In contrast to previous studies, helohyids do not appear to be the most closely related sister taxon to anthracotheriids. Instead, we recovered a clade including the raellid *Khirtharia*, the putative anthracotheriid *Pakkokuhys*, and the dichobunids *Diacodexis* and *Gujaratia* as sister to anthracotheriids.

These sets of relationships are consistent with an Asian origin of the Anthracotheriidae and suggest multiple dispersal events out of Asia by the beginning of the late Eocene: both *Anthracoherium* and *Elomeryx*-like forms into Europe and an African dispersal by a taxon similar to *Bothriogenys* or *Qatraniodon*. The fact that our earliest knowledge of anthracotheriids indicates a phyletic split by the late middle Eocene suggests there is an unsampled portion of their early history which would help illuminate their differentiation from other early artiodactyls.

Poster Session III

COMPARISON OF QUANTITATIVE AND QUALITATIVE PROXIES FOR FOSSORIALITY (DIGGING) FROM THE SKELETAL MORPHOLOGY OF MAMMALS

HOPKINS, Samantha, National Evolutionary Synthesis Center (NESCent), Durham, NC
Fossoriality, or digging, has evolved repeatedly in the history of mammals, and provides an ideal study system for processes driving convergent evolution, as well as the interaction between environmental change and community structure change. This evolutionary problem is best studied in a phylogenetic context. In order to make robust statements about the patterns and processes of fossoriality evolution, it is necessary to include fossil taxa, which creates a problem in describing fossorial behavior. Extinct taxa (except in rare cases, such as that of *Paleocastor*, excavator of *Daemoneelix* burrows) leave little evidence to reconstruct the precise nature of their fossorial behavior. To understand broad patterns of fossoriality, it is necessary to find robust proxies in skeletal morphology for fossoriality, preferably proxies which can indicate the degree of fossorial behavior. Here I consider a variety of suggested skeletal proxies for fossoriality from skull and dental morphology to shapes of limb bones and proportions of the manus and pes. These proxies are measured in modern mammal groups and compared with quantitative and qualitative descriptors of fossoriality. Preliminary results suggest that some measures are useful only in indicating certain types of fossorial behavior (i.e. chisel-tooth digging), while others seem to be consistently indicative of digging in general, regardless of the precise mode of excavation. There are also differences in performance of these measures in describing quantitatively the degree of fossoriality in a given organism. Finally, these measures differ in how successfully they discriminate fossoriality from swimming, a mode of life with some very similar functional constraints. This study emphasizes the importance of choosing the correct skeletal proxy for digging behavior to fit the group of organisms under study and the degree of precision required in identifying fossorial animals.

Poster Session II

NITROGEN ISOTOPES OF BISON BONE COLLAGEN: TEASING APART THE INFLUENCE OF BIOLOGY VERSUS ENVIRONMENTAL CHANGE

HOPPE, Kathryn, Univ. of Washington, Seattle, WA

Analyses of the stable isotope ratios of prehistoric animals can be used as a proxy for reconstructing biology and/or environmental conditions. The nitrogen isotope ratios of tissues from herbivores have been shown to vary both with metabolic processes and with variation in the nitrogen isotopes of dietary plants, which in turn vary with environmental conditions (e.g., amount of precipitation). Thus, it is often difficult to distinguish between environmental and biological factors when interpretation of the meaning of variations in the nitrogen isotopic values of prehistoric herbivores. However, comparison with corresponding analyses of modern herbivores from the same region can help clarify the factors that influence the nitrogen isotope ratios of fossil herbivores.

This study will present analyses of the nitrogen isotope ratios of modern bison and grassland plants from 11 locations across the United States that will serve as a baseline comparison for interpreting the nitrogen isotope ratios of prehistoric bison. Free ranging bison were sampled from locations in California, Kansas, Montana, Nebraska, North Dakota, Oklahoma, South Dakota, and Wyoming. Climatic conditions vary considerably between locations. Mean annual temperatures (MAT) range from 4.1 to 18.5°C. Mean annual precipitation (MAP) range from 390 to 1080 mm. The mean values of nitrogen isotope of collagen will be compared with climatic variations in MAT, MAP, and relative humidity. Bison isotopic values will also be compared with analyses of the nitrogen isotopes of dietary plants from the same location and with changes in grassland vegetation (i.e., C-3/C-4 ratios).

Poster Session II

COMMUNITY MEMBERSHIP OF MIDDLE MIOCENE PIKAS FROM NORTH-CENTRAL SPAIN

HORDIJK, Kees, VAN DER MEULEN, Albert, Utrecht Univ., Utrecht, Netherlands

Pikas (Lagomorpha, Mammalia) are commonly found in European Neogene small-mammal assemblages and represent an important component of the primary consumers of that time. Previous research has mainly been focused on rodents. The pikas studied here come from the rich small-mammal succession in the Calatayud-Daroca Basin (North-Central Spain). This well dated record consists of more than 100 localities, covering the time interval between 17 and 10 Ma. The pikas appear to be a quantitatively important group, show a separate signal with respect to the rodents and can, therefore, be considered as an important factor in paleoecological analysis. Recently, regularities in the assembly, composition and disassembly of the rodent community structure from this record have been demonstrated. The community membership times of the evolutionary lineages of the pikas confirm the presence of two successive communities in the succession.

Poster Session II

A GLOBAL VIEW OF THE CRETACEOUS DINOSAURS FROM SOUTH KOREA

HUH, Min, Gwangju, South Korea

Recently, abundant dinosaur fossils including dinosaur footprints, eggs and nests, bones and teeth have been found from the Cretaceous non-marine deposits of South Korea. In Korea, over 20 dinosaur localities have been discovered from the Cretaceous in several basins. The track sites (dinosaur, pterosaur, bird) comprise the majority of fossil localities in Korea. These unique and distinctive dinosaur tracksites are known as one of the world's most important dinosaur track localities. Mostly dinosaur footprints consist of various typed-ornithopod, theropod and sauropod. The variety of morphotypes and sizes of the footprints and the calculated body sizes indicate that different dinosaurs with various gaits inhabited in these areas during the Late Cretaceous. Abundant dinosaur eggs and clutches occur in seven dinosaur egg localities. Mostly the eggs are top-broken and filled with surrounding sediments, while some eggs at Boseong site show geoid-fill. Articulate subadult dinosaur bones assigned to a new hypsilophodontid dinosaur, turtle bones and turtle eggs were also found at Boseong. The pterosaur tracks are the most immense in the world. The longest pterosaur trackway yet known from any track sites suggests that pterosaurs were competent terrestrial locomotors. In the dinosaur localities of Korea, other fossils including turtles, crocodiles, fishes, fossil wood, plants, trace fossils and microfossils have also been discovered. The occurrences of Korean dinosaurs in diverse stratigraphic formations, sizes and morphotypes provide an opportunity to study the palaeoecologic and palaeoenvironmental conditions of the sites of the Late Cretaceous dinosaurs

Friday 11:30

EXCEPTIONAL PRESERVATION OF VERTEBRATES FROM HAILE 7G, A NEW LATE PLILOCENE SITE FROM FLORIDA

HULBERT, Richard, BLOCH, Jonathan, POYER, Arthur, Florida Museum of Natural History, Gainesville, FL

Over 50 fossil vertebrate localities have been discovered in limestone quarries near the former town of Haile in western Alachua County, north-central Florida. The newest Haile site, designated Haile 7G, is a former sinkhole about 30 m in diameter filled with clay, sand, and limestone boulders that was discovered in early 2005. Our first year's fieldwork yielded over 60 partial to nearly complete skeletons from only a small percentage of the total volume of the site, as well as hundreds of isolated bones and teeth representing 32 vertebrate taxa. The fossils show no evidence of pre-burial weathering, waterwear, or scavenging. Haile 7G likely formed as an alluvial sinkhole that was surrounded by a relatively dense forest. About half the fauna lived in freshwater habitats, including fish (e.g., *Amia*, *Ictalurus*, *Lepomis*), amphibians (e.g., *Rana*, *Siren*), reptiles (e.g., *Alligator*, *Chelydra*, *Trachemys*, *Chrysemys*, natricine snakes), and birds (teal-sized *Anas*). To date, 16 mammalian taxa have been found at Haile 7G. Surprisingly, the most abundant mammal is *Tapirus*, represented by about 30 skeletons, many with skulls and mandibles. They range in age from very young juveniles to full adults. Next in abundance, with about 10 individuals each, are two ground sloths, *Eremotherium eomigrans* and *Megalonyx leptostomus*. Although rarer, the most completely known skeletons of both the porcupine *Erethizon poyeri* and the pampather *Holmesina floridanus* were also found. Common smaller mammals include leporids and the biochronologically significant *Sigmodon curtisi*. Carnivorans are rare, but include the raccoon *Procyon* and the saber-toothed felid *Xenosmilus hodsonae*. A late Blancan age, ca. 2 Ma, is assigned to the Haile 7G fauna based on mammalian biochronol-

ogy. Haile 7G has already produced more mammalian skeletons than any other Florida vertebrate fossil locality, and the largest populations of *Tapirus* and *Eremotherium*. Ongoing fieldwork will add to these totals and recovery of the first-known skeletons of other poorly known Blancan taxa are likely.

Poster Session I

YESTERDAYS CAMEL: A PALEOPROTEOMIC COMPARISON OF EXTINCT AND MODERN CAMELIDS

HUMPULA, James, Michigan State Univ., East Lansing, MI; ANDREWS, Phillip, Univ. of Michigan, Ann Arbor, MI; GANDHI, Hasand, OSTROM, Peggy, Michigan State Univ., East Lansing, MI; VOORHIES, Michael, Univ. of Nebraska-Lincoln, Lincoln, NE

The extinct taxa *Camelops huerfanensis* and *Camelops hesternus* have been classified as separate species based on minor cranial differences, e.g. the location of the postpalatine foramen. Some paleobiologists argue that the morphological differences that define the two species may instead represent variation within a single species, and that *C. huerfanensis* and *C. hesternus* are conspecific. We are generating molecular data to supplement the morphological data and hope to clarify these otherwise uncertain species definitions. Here, we examine the relationship between fossil and extant camelid species using amino acid sequence data from the bone protein osteocalcin, derived from the bone of a 21,190±110 year-old *C. hesternus* from Isleta Cave, NM. Sequences were obtained using Edman and MALDI-MS (MS/MS and Peptide Mass Fingerprinting (PMF)) techniques and were then compared to the sequences of modern dromedary camels (*Camelus dromedarius*), bactrian camels (*Camelus bactrianus*), and llamas (*Lama glama*). The monoisotopic mass for the molecular ion from *C. bactrianus* was 5608 m/z, identical to that of *C. dromedarius* and *L. glama*. The monoisotopic mass of the *C. hesternus* molecular ion is 5663 m/z, which may indicate an important taxonomic difference between the modern and extinct camelids. We are currently investigating this possibility and plan to analyze fossil material from *C. huerfanensis*.

Poster Session III

A NEW PARADIGM FOR TETRAPOD ICHNOFACIES

HUNT, Adrian, LUCAS, Spencer, New Mexico Mus Nat Hist, Albuquerque, NM

There are three fundamental terms in ichnology relevant to ichnofacies: (1) ichnoassemblage, which is an assemblage of ichnofossils conceptually equivalent to an assemblage of body fossils; (2) ichnocoenosis, which is a trace fossil assemblage produced by a biological community that can be characterized by morphological criteria; and (3) ichnofacies, which refers to recurrent ichnocoenoses that represent a significant portion of Phanerozoic time.

There are two distinct traditions can be identified in ichnology which we term the ethological and the biotaxonomic. Invertebrate ichnologists mostly use an ethological approach to ichnology by describing and naming behavioral interactions between an organism and the substrate. In contrast, vertebrate ichnologists have principally applied a biotaxonomic approach by attempting to relate tracks and traces to the taxonomy of the producer (e. g., ichnotaxa as proxies of biotaxa). Thus, there are two types of ichnofacies, ethoichnofacies (mostly invertebrate ichnofacies) and biotaxoichnofacies (mostly tetrapod ichnofacies). Nonmarine invertebrate ichnologists now recognize five archetypal ichnofacies (*Mermia*, *Skolithos*, *Scoyenia*, *Copriniisphaera*, *Psilonichnus*) to which we have added the *Octopodichnus* ichnofacies. We have proposed a coherent and consistent classification and nomenclature for tetrapod ichnofacies. We recognize five archetypal vertebrate ichnofacies for nonmarine environments: *Chelichnus*, *Grallator*, *Brontopodus*, *Batrachichnus* and *Characichichnus* ichnofacies.

Poster Session II

PACKING AND TRANSPORTING VERTEBRATE FOSSILS OVERSEAS

HUNT, Rebecca, Augustana College, Rock Island, IL

In the summer of 2006, Augustana College shipped vertebrate remains of the holotype specimen *Cryolophosaurus*, a prosauropod, and capitosaur, along with plant material, to Japan. This fauna will be the focus of an Antarctic exposition at the National Science Museum in Tokyo. Therefore, the safe packing of these vertebrate fossils for overseas transport is vital for the future study of these remains and for the success of the exhibit.

The wrapping of small to medium sized material in foil insures that any breakage will be held in place during shipping, while the use of styrofoam, bubble wrap, clamshell jackets and sturdy boxes will also ensure stability during shipping. Large and more delicate remains will require more precise packing. Expanding liquid foam that sets up rigidly will be used to contour and hold the individual remains. This foam must be kept away from the fossil, so it will first be wrapped in plastic to serve as a separation layer. The foam mold for each specimen can be used repeatedly, if handled correctly and undamaged in shipping.

The fabrication of crates for overseas importation must adhere to set guidelines by the National Plant Protection Organization and the USDA. There are two official export treatment and marking programs used to meet the requirements of countries with import requirements based on the International Standards for Phytosanitary Measures—Guidelines for Regulating Wood Packaging Materials in International Trade (ISPM15). These treatments must have been applied to the wood products, and include Heat Treatment (HT) and the Methyl Bromide (MB) Fumigation Programs and will be marked by a certified inspection agency. This can be both a costly and time consuming venture, though there are several ways to avert these issues. One would be to have crates constructed by a certified shipping

agency which can fabricate and treat these crates at a reduced cost. Other methods included fabricating your containers from a non-wood product.

Poster Session I

RELATIVE BRAIN SIZE OF SMALL THEROPOD DINOSAURS INDICATES PROBABLE OBLIGATE ENDOTHERMY

HURLBURT, Grant, Dallas, PA

The large relative brain sizes of small theropod Cretaceous dinosaurs (*Troodon*, *Ornithomimus*, and *Bambiraptor*) probably required them to be visceral endotherms, defined as endotherms whose high resting metabolic rate (BMR) depends on visceral organ metabolism. Their relative brain sizes were well within the relative brain size range of Recent endothermic amniotes (birds) and well above the range of Recent (nonavian) reptiles. This proposal rests on the hypothesis that the relatively large brains of Recent visceral endotherms require both a high and controlled BMR. In all known ecto- and endothermic vertebrates, the central nervous system (CNS) uses 2-8% of basal metabolism, excepting 20% in *Homo*, and 11-13% in other primates. Although some elasmobranchs have large brains, the low metabolic rate of elasmobranch brains makes them metabolic equivalents of bony fish brains one-third their size, meaning their large relative brain size does not invalidate this hypothesis. Dinosaur brain mass was estimated from endocasts, using brain-endocast ratios of adult alligators. Dinosaur relative brain sizes were calculated as EQs, which were based on brain-body equations of reptiles (REQ) and birds (BEQs). Ranges of reptile log (log₁₀) REQs and bird log BEQs, were used because, unlike the corresponding EQs, they were normally distributed, validating use of Standard Deviations (SDs). Other than small theropods, dinosaur log REQs (-0.60 to 0.380; -3.0 to 2.0 SDs of the mean) were within both the actual range and two SDs of the mean of reptile log REQs (-0.41 to 0.39; -2.0 to +1.9 SDs of the mean). Small theropod log BEQs of -0.17 to -0.09 (1.05 to 0.58 SDs below the mean) were well within the range of bird log BEQs (-0.40 to 0.50; -2.33 to +2 SDs of the mean); and within 1 SD of the bird log BEQ mean. The only ectothermic vertebrate even 3 SDs above the reptile log REQ mean is the elephant-nosed fish, (*Gnathonemus*, log REQ 0.64), at 3.3 SDs above the reptile mean. It devotes 60% of total body metabolism to the brain, an amount unknown and unlikely in terrestrial amniotes. Log REQs (-0.45 to 0.48) of other bony fish are -2.2 to +2.5 SDs of the reptile REQ mean.

Poster Session I

A COMPARATIVE STUDY OF FORELIMB RANGE OF MOTION IN REPORTED BIPEDAL AND QUADRUPEDAL BASAL ARCHOSAURS

HUTSON, Joel, Northern Illinois Univ., DeKalb, IL

Digital animation technology offers a powerful tool for recreating and analyzing functional morphology. Software can be used to articulate or reconstruct skeletal morphology in three dimensions, and then to portray motion graphically. Maya animation software is used to estimate the range of motion of the forelimb of the basal archosaur *Postosuchus kirkpatricki* with the goal of finding evidence for or against bipedalism. Basal archosaurs are an important example of tetrapods that had a diverse array of postures and gaits. Postural features are one of the primary characters used to differentiate among archosauriforms, although researchers debate the presence and/or extent of bipedalism in several taxa, including *Postosuchus*. Previous hypotheses for bipedalism in extinct archosaurs have rested mainly on observations of fore and hindlimb disparity. Most studies on posture and gait have focused on analyses of the hindlimb and pelvis, not on the shoulder girdle and forelimb. Few attempts have been made, likely because of a lack of well-preserved forelimb material. However, as shown here, forelimb evidence can be important in interpreting posture in basal archosaurs. To consider the range of motion in *Postosuchus* within a phylogenetic context, its forelimb elements were compared with those of two quadrupedal basal archosaurs, the aetosaur *Desmatosuchus haplocerus* and the phytosaur *Pseudopalatus pristinus*, and the extant phylogenetic bracket of the crocodylian *Alligator mississippiensis* and the bird *Opisthocomus cristatus*. All forelimb element ranges of motion were measured and all material was digitized three dimensionally with a MicroScribe and Rhinoceros software. The completed elements were then imported into Maya to be articulated and to build up range of motion animations. Inferences as to the posture and degree of mobility of the forelimbs of *Postosuchus* were then made with these comparisons and animations. Results indicate that *Postosuchus* was well-adapted for quadrupedalism, although facultative bipedalism can not be ruled out.

Saturday 2:15

OSTEOHISTOLOGY OF *SPHENACODON* (SYNAPSIDA: SPHENACODONTIDAE) AND THE HIDDEN DIVERSITY OF GROWTH PATTERNS IN BASAL SYNAPSIDS

HUTTENLOCKER, Adam, California State Univ., San Bernardino, San Bernardino, CA; ANGIELCZYK, Kenneth, Univ. of Bristol, Bristol, United Kingdom; LEE, Andrew, Univ. of California, Berkeley, Berkeley, CA

Recent histological investigations of bone microstructure in nonmammalian therapsids have documented an abundance of fibrolamellar bone tissue in numerous genera. Although some instances of this tissue type have been reported in neural spines of *Dimetrodon*, fibrolamellar bone never has been described in the long bones of "pelycosaur." Here we provide a preliminary description of bone microstructure in the closely related *Sphenacodon* and highlight its utility in elucidating the origins of therapsid-like growth patterns in the synapsid lineage.

Sphenacodon humeri and femora from the Lower Permian Anderson Quarry in New Mexico (Cutler Formation) were separated into five age classes and were serially sectioned for histological analysis. In general, the cortical bone is well vascularized and the bone matrix is woven-fibered with some alternating sheets of lamellar bone, forming an overall fibrolamellar structure in conjunction with the primary osteons. Early growth stages in *Sphenacodon* are diagnosed by thick growth zones in the cortex lacking LAGs or annuli in the smallest individuals, densely packed radial primary osteons, and an irregular gradation between the cancellous medulla and the compact cortex. Later growth stages display several LAGs and annuli, fibrolamellar bone tissue with abundant radial canals and primary osteons, and an abrupt transition from the cortex to the medullary region with some secondary osteons forming along the endosteal surface. The basic organization of the bone tissue closely resembles that of some gorgonopsian therapsids (e.g., *Scylacops*), but the overall growth pattern reflects that which has been described for some thercephalians and basal cynodonts, with evidence for rapid sustained growth in juveniles, and cyclical but decreasing rates of periosteal deposition in some of the largest (presumably older) individuals. The possibility of such growth strategies in an early synapsid, which pre-dates those therapsid forms by at least 20 million years, challenges the conventional views, instead suggesting that this condition arose early and perhaps multiple times in synapsid evolution.

Romer Prize Session, Thursday 9:15

PHYLOGENETIC ANALYSIS OF ENAMEL MICROSTRUCTURE CHARACTERISTICS IN DINOSAUR TEETH

HWANG, Sunny, New York College of Osteopathic Medicine, Old Westbury, NY

Most studies of enamel evolution only involve mapping characters onto an independently constructed cladogram. Very few studies actually include discrete enamel characters in a phylogenetic data matrix and attempt to integrate enamel characters into a larger morphological dataset, and all of these few studies have included only mammalian taxa. Non-mammalian amniote ("reptile") enamel remains tremendously understudied in comparison to mammalian enamel, because its aprismatic structure renders it difficult to characterize.

Enamel characters of 54 saurischian and ornithischian dinosaur taxa were first mapped onto independently generated reference phylogenies to determine their evolutionary trends. Within many monophyletic dinosaur clades, the combination of enamel types and enamel features within a tooth — the schmelzmuster — is the same in all the taxa due to their common ancestry, and their schmelzmusters are diagnostic of their respective clades. However, the enamel complexity of a taxon does not necessarily coincide with the position of the taxon on a phylogenetic tree; more derived taxa do not necessarily have more derived enamel and more primitive taxa do not necessarily have more primitive enamel. Therefore, there is no overall trend in enamel evolution within Dinosauria.

Second, features observed in dinosaur enamel microstructure were parsed into phylogenetic characters. These enamel characters were analyzed separately as well as added to datasets of skeletal characters for theropod and ornithischian dinosaurs. Tests for phylogenetic signal in enamel type were also performed. Phylogenetic analysis of enamel characters and tests for phylogenetic signal in enamel type confirm the pattern observed via character mapping, namely that there are enamel characters that diagnose different clades within Dinosauria, but that there is not an overall trend in enamel evolution within Dinosauria. Enamel characters alone are not enough to recover the traditional groups obtained via skeletal character analysis, but they can improve resolution within strict consensus trees when added to a skeletal character matrix.

Student Poster Session

THE EVOLUTION OF THE GROOMING CLAW IN CASTORIDAE

HYNES, Kristin, Carleton Univ., Ottawa, ON, Canada

Extant beavers (*Castor*) possess a grooming claw, which can function as a comb or a pincer. The grooming claw has been described as a secondary adaptation to the beaver's semi-aquatic lifestyle. It is held in a semi-retracted position, on the second digit of the hind foot. This specialized posture is associated with skeletal modification of the distal and middle phalanges of this digit, allowing the presence of a specialized claw to be identified in fossil taxa. Dissections of *Castor canadensis* and *Felis silvestris catus* feet were performed to investigate how the grooming claw works (opens and closes) and to compare hind foot anatomy. The *Castor* and *Felis* phalange bones were also examined for comparison and to identify characters associated with the grooming claw as well as those associated with claw retraction. This project also tested the hypothesis that the grooming claw evolved secondarily to swimming in Castoridae by looking for evidence of the claw in a fossorial genus (*Palaocastor*) of Castoridae. The phalanges of *Palaocastor fossor* were examined for evidence of a grooming claw on their second digit. Results suggest that the opening and closing of the grooming claw may be primarily controlled by the tension of the webbing on the medial and lateral sides of the claw. While *P. fossor* had skeletal characteristics which are similar to those observed in *Castor*'s second phalange, these are likely associated with the retracted position of the claw and not necessarily characteristic of a pincer claw. Since it is unlikely that *P. fossor* had webbed feet, their grooming claw may not have been able to function as a pincer but perhaps served as a comb prototype which was later co-opted into the modern claw. It appears that the modern Castoridae grooming claw most likely evolved after the acquisition of webbed feet in the semiaquatic clade, suggesting that a pincer-type grooming claw (but not the comb-type grooming claw) arose as a secondary adaptation to swimming.

Neoceti Symposium, Saturday 10:45

A NEW *SQUALOZIPHIUS*-LIKE ODONTOCETE CETACEAN FROM THE LATE OLIGOCENE OF HOKKAIDO, JAPAN

ICHISHIMA, Hiroto, Fukui Dinosaur Museum, Katsuyama, Japan; SAWAMURA, Hiroshi, Ashoro Museum of Paleontology, Ashoro, Japan

The early Miocene *Squaloziphius emlongi* Muizon (Washington) is known from an incomplete skull, originally attributed to the living family Ziphiidae (beaked whales). Alternatively, some authors have suggested that *Squaloziphius* is related to the Eurhinodelphinidae. Both options raise questions about the identity of odontocete families, although the original specimen is probably too incomplete to judge which option is best. Here we record a new skull (AMP 19) of late Oligocene age, which is similar both in size and in morphology to *Squaloziphius emlongi*. The new skull, which lacks most of the rostrum and some ventral structures, is markedly similar to *S. emlongi* in overall topography and in: a well-developed postglenoid process of the squamosal; an elevated synvertex, comprising the fronto-nasal platform, the maxilla, and the posteromedial splint of premaxilla; and a wide, dorsally-opened mesorostral groove just anterior to the bony nares. The skull differs from *S. emlongi* in its more elevated synvertex and the laterally and anteriorly more inflated nasals, and thus probably represents a new species.

The relationships of *Squaloziphius* with other odontocete groups—Ziphiidae, Eurhinodelphinidae, or other—have been controversial. It is now known that ziphiid-like features have arisen in separate odontocete lineages as a result of convergence, exemplified by *Australodelphis* from the early Pliocene of Antarctica. *Australodelphis* shows surprising resemblances with ziphiid odontocetes, including an elevated synvertex, despite its clear allocation to the dolphin family Delphinidae. In the case of *Australodelphis*, tympanoperiotics are potentially powerful tools to reveal relationships; for *Squaloziphius*, the lack of ear bones in AMP 19 and *S. emlongi* hampers comparisons. We have found it difficult to justify placing *Squaloziphius* with Eurhinodelphinidae or Ziphiidae, and expect that supposed early eurhinodelphinids such as *Argyrocetus* must be reviewed before *Squaloziphius* relationships can be finalized. Revision of early eurhinodelphinids has implications for definition and recognition of early clades of Odontoceti.

Wednesday 10:15

A NEW UPPER TRIASSIC VERTEBRATE QUARRY FROM THE CHINLE FORMATION OF NORTHERN NEW MEXICO WITH A UNIQUE AND EXCEPTIONALLY DIVERSE TETRAPOD FAUNA

IRMIS, Randall, Univ. of California, Berkeley, Berkeley, CA; NESBITT, Sterling, American Museum of Natural History, New York, NY; DOWNS, Alex, Ghost Ranch Conference Center, Abiquiu, NM

Large, multi-taxic tetrapod assemblages are rare in the Upper Triassic Chinle Formation of southwestern North America. Only the *Placerias* Quarry in Arizona and the Snyder and *Coelophysis* quarries in northern New Mexico preserve a wide variety of taxa and a large number of specimens. Thus, any similar new locality will increase our understanding of Late Triassic tetrapod diversity patterns in North America. The Hayden Quarry, a recently discovered locality from the Petrified Forest Member of the Upper Triassic Chinle Formation in northern New Mexico, at Ghost Ranch, preserves an abundant tetrapod fauna comparable in diversity to these three previously known localities. Taxa known from the Hayden Quarry include metoposaurid temnospondyls, the diapsid *Vancleavea*, pseudopalatine phytosaurs, the aetosaurs *Typhorax* and "*Desmatosuchus*" *chamaensis*, a tooth-bearing jaw fragment similar to *Revueltosaurus callenderi*, an unidentified 'rauisuchian', the basal dinosauriform *Eucoelophysis*, associated material of a new basal dinosaur with an ilium similar to *Chindesaurus* and *Caseosaurus*, and several individuals of a large coelophysoid theropod.

Beyond its raw diversity of taxa, the Hayden Quarry is important because it represents the first confirmed co-occurrence of a basal dinosauriform, basal dinosaur, and basal theropod, suggesting a greater range of contemporaneous early dinosauriform taxa from North America than previously realized. Put in context with other geographically proximate localities from the Chinle Formation of northern New Mexico (e.g., Snyder, Canjilon, and *Coelophysis* quarries), the Hayden Quarry provides a detailed view of changes in tetrapod assemblage diversity and composition through time in one geographic space. Such a refined study is currently not possible anywhere else in the Late Triassic of North America.

Poster Session I

NEW INFORMATION ON THE PECTORAL FIN IN PLACODERMI FROM THE LATE DEVONIAN CLEVELAND SHALE FAUNA (FRASNIAN OF NORTHERN OHIO)

JACKSON, Gary, Cleveland Museum of Natural History, Cleveland, OH; CARR, Robert, Ohio Univ., Athens, OH

Placoderms have been characterized as either obligate benthic organisms or that they were limited to life just off the bottom. These interpretations are a consequence of our lack of understanding of the locomotor structures in these fishes. Preservation in most taxa is limited to perichondrally ossified pectoral girdle and basal fin elements. An exception to this pattern is the ray-like rhenanid, *Gemuendina*, with a pectoral fin consisting of a single proximal element with up to three rows of radials. Other than this rare example, little is known of the fin distal to the proximal basals.

Four placoderm specimens from the Cleveland Shale provide new information on the pectoral fin. A large *Dunkleosteus terrelli* specimen documents the first recognized occur-

rence of radials among the arthrodires. A second specimen of *D. terrelli* possesses numerous basals with a carbon film representing the distal fin (no ossified radials are seen in this specimen suggesting radial ossification may represent an age-related phenomenon). Two specimens of unidentified selenosetoid arthrodires also demonstrate the presence of organic films. The importance of these specimens is the information they provide on estimates for the aspect ratio of the pectoral fin. In comparison to the chondrichthyan *Cladoselache* (a recognized active swimmer in the pelagic realm), the pectoral fin in arthrodires appears to have a comparable aspect ratio (standardized for size and thus suggesting equivalent lift capabilities). In the arthrodire *Heintzichthys*, the presence of potential muscle attachments on the basal elements suggests the possibility of active fin retraction or alteration of fin camber further adding to controlled maneuverability.

A proposed explanation for the extinction of placoderms is thought to be through the process of competitive displacement by the contemporaneous chondrichthyans and osteichthyans. This has been related, in part, to relative differences in effective locomotion (based on incomplete evidence among placoderms). The recognition of comparable locomotor structures in arthrodires and sharks of the Late Devonian necessitates our reevaluation of placoderm extinction at the close of the Devonian.

Marine Reptiles Symposium, Wednesday 4:45

SYSTEMATIC POSITION AND GEOLOGICAL CONTEXT OF *ANGOLASAURUS* (MOSASAURIDAE) AND A NEW SEA TURTLE FROM THE CRETACEOUS OF ANGOLA

JACOBS, Louis, SMU, Dallas, TX; MORAIS, Maria, Geologia, Luanda, Angola; SCHULP, Anne, Natuurhistorisch Museum Maastricht, Maastricht, Netherlands; MATEUS, Octávio, Museu da Lourinhã, Lourinhã, Portugal; POLCYN, Michael, SMU, Dallas, TX
Results of recent fieldwork in Angola after a hiatus of nearly fifty years include discovery of the skull of a new taxon of turtle, new and higher quality mosasaur material (including the second skull of the mosasaur *Angolasaurus*), and a number of plesiosaur specimens. The *Angolasaurus* material allows evaluation of alternative hypotheses of its placement within and composition of Plioplatecarpinae. The new turtle has a derived palate and closed incisura columella similar to Aptian *Sandownia* from the Isle of Wight and an unnamed late Aptian taxon from Texas. Turtles and plesiosaurs have longer marine records than do mosasaurs, but together their history must reflect the biogeographic evolution of the Cretaceous South Atlantic and its Albian connection with the North Atlantic. The completion of the Atlantic Ocean allowed mixing of low latitude marine faunas through the tropical Atlantic, but it also completed the breakup of western Gondwana and contradicts hypotheses of dinosaur dispersal between Africa and South America after 100 Ma.

Romer Prize Session, Thursday 9:30

EVOLUTIONARY INSIGHT FROM CHARACTER ANALYSIS: TESTUDINATA AS A CASE STUDY

JAMNICZKY, Heather, Univ. of Calgary, Calgary, AB, Canada

Treating phylogenetic characters as hypotheses has long been advocated. The process of character analysis, however, whereby potential characters are evaluated using multiple sources of data, prior to being inserted into phylogenetic analyses for congruence testing, has received less attention. Herein I demonstrate the utility of an integrative approach to character analysis, both as a means of positing more robust phylogenetic characters, and as a source of insight into the evolutionary trajectory of complex morphological traits. Multiple lines of evidence, provided by soft-tissue and developmental studies of extant taxa, provide new insight into homology relations among parts of organisms, and allow more robust inferences of morphology in fossil taxa. I show that the use of such techniques, in combination with an "overall pattern" approach to homology definition, reveals that the cranial arterial circulation of Trionychia is paedomorphic. Further, this approach allows the postulation of new hypotheses of evolutionary transformation of this character complex among members of Testudinata. Previous hypotheses of relationship within Testudinata are called into question by these results, emphasizing the importance of robustly investigated morphological characters in instances where such data are the only source of information available to systematists. The use of character analysis will help to ensure that morphological systematics remains at the forefront of evolutionary research, representing a unique means by which the anatomy and evolution of complex morphological features may be better understood.

Poster Session III

LOCOMOTOR SPECIALIZATIONS IN STHENURINE KANGAROOS

JANIS, Christine, KUCHENBECKER, Karalyn, BERGLAND, Alan, CLIFFORD, Andrew, Brown Univ., Providence, RI

Sthenurines, popularly known as "giant browsing kangaroos", are commonly assumed to have a similar mode of ricochet locomotion as large macropodines (e.g., gray and red kangaroos), perhaps being even more cursorially specialized as their pes is monodactyl. However, modern macropodines appear to be at the size limit for strain on the Achilles tendon, the determining feature in hopping, and some sthenurines were twice the mass of large extant kangaroos (i.e., around 200 kg). This preliminary investigation into sthenurine postcranial morphology reveals some interesting differences from macropodines, and suggests that sthenurines were not as specialized for hopping.

We obtained measurements from 27 species of extant macropodoids (4 potoroids, or rat kangaroos, and 23 macropodids), and 23 individuals of *Sthenurus* (of varying sizes and

degrees of completeness). Bivariate plots and ternary diagrams show that, while the limb proportions are broadly similar, sthenurines have a relatively shorter fourth metatarsal than macropodines (and thus a shorter foot, resembling dendrolagines [tree kangaroos] in this regard), and are also considerably more robust in their femur and tibia. PCA analysis revealed differences in the shape of certain bones between sthenurines and macropodines, and also similarities between sthenurines and dendrolagines. The sthenurines differ from macropodines (and resemble dendrolagines) as follows: the pelvis is broader mediolaterally and the ilium is longer, but the ischium is shorter and the pubic symphysis less elongated; the femur has broader proximal and distal articulations, and a longer greater trochanter; the calcaneum has a shorter and thicker heel. Additionally, the sthenurine astragalus has a broader tibial facet but a narrower fibular facet than the macropodine one. These differences relate to a postcranial skeleton that is built for power rather than for speed, suggesting a different locomotor focus from the derived hopping of macropodines. The similarities to dendrolagines, the only macropodids to move their hindlimbs independently of each other, raises questions as to whether this mode of locomotion was also seen in sthenurines.

Poster Session II

EFFECTS OF HEAT ON AVIAN DINOSAUR EGG SHELL FRAGMENTS

JANSSEN, Jennifer, Georgia Aquarium, Atlanta, GA; HAYWARD, James, Andrews Univ., Berrien Springs, MI

The taphonomic effects of heat and/or fire on bones, conodonts, and plant tissues have received significant attention among paleontologists and geologists, but to our knowledge an examination of the effects of high temperatures on amniote eggshell has not been made. We compared the effects of heat on extant avian dinosaur eggshell, which, like non-avian dinosaur eggshell, is constructed primarily of CaCO₃ deposited within a protein matrix. Ostrich and glaucous-winged gull eggshell fragments were heated to temperatures up to 850°C for various lengths of time. A series of dramatic color changes, similar to those reported for conodonts, began to occur at about 200°C, especially in ostrich eggshell. Reverse curling of eggshell was observed at temperatures above 600°C. Thermogravimetric analysis showed a negligible decrease in mass below 200°C, which was attributable to water loss. Sharp decreases in mass occurred at about 710°C for both eggshell types. The remaining CaO residue represented 55% of the original mass. Heat should not be overlooked as a factor contributing to the variability of fossil eggshell, including color differences and reverse curling. Existence of these features, in turn, may provide important clues toward an understanding of environmental conditions and events preceding or accompanying fossilization.

Poster Session III

A PRELIMINARY ANALYSIS OF STOMACH CONTENTS FROM A NEW POLYCYOTYLID PLESIOSAUR

JANZIC, Anita-Maria, Canadian Fossil Discovery Centre, Morden, MB, Canada

The Pembina Hills of the Manitoba Escarpment of Southwestern Manitoba has produced many marine reptile specimens with the co-operation of mining companies. The mining has ceased but the quarries remain and a new discovery of a polycotyloid plesiosaur was discovered in 2004. The remains were located within the Pembina Member of the Pierre Shale Formation (Campanian) deposits from the Western Interior Seaway. This new polycotyloid and only two other plesiosaur specimens from the Pierre Shale Formation in Manitoba are associated with stomach contents.

The stomach contents were conglomerated into a solid layer beneath the specimen resulting in a gastric residue, spanning an area of 2.5 square metres. Preliminary dissociation of fragments from the residue yielded teleost teeth and vertebrae. These stomach contents are not unusual for polycotyloid plesiosaurs, however the dimensions and quantity are. This preliminary analysis indicates teeth lengths between 1.0mm and 5.0mm representing only the tips or apex of the crown. Samples that have been analysed yielded over 100 teleost teeth.

Wednesday 9:45

NEW PODOCNEMIDIDAE FOSSIL TURTLES FROM THE UPPER PALEOCENE CERREJON FORMATION, GUAJIRA PENINSULA, COLOMBIA

JARAMILLO, Carlos, CADENA RUEDA, Edwin, Smithsonian Tropical Research Institute, Panama

Six fossil turtles represented by nearly complete carapaces, plastrons, pelvic bones and an excellently preserved lower jaw, were collected during 2005 in the middle part of the upper Paleocene Cerrejón Formation, at the Cerrejón Coal Mine, Guajira Peninsula, Colombia. The fossils belong to the Podocnemididae Family and are useful to understand the origin of the extant fauna of South American podocnemid turtles. Indicative characters on the carapaces, are the absence of neural bones specially in three small turtles (<25cm long axis). This absence indicates an earlier tendency to reduction of neural bones in podocnemids, and also has been seen in some turtles from the Urumaco Formation (late Miocene, Venezuela). The absence of cervical scute, the first neural bone subrectangular and more elongated compared to the following ones, are additional characters that suggest a podocnemid affinity. Other characters as shape and position of pubis and ischial scars on plastron, ilium scar on carapace, axillary and inguinal process attachment and shell bones-scutes configuration are being analyzed and integrated into a matrix character for cladistic analysis. We also found a lower jaw that present a labial ridge curved acute, processus coronoideus less prominent than in *Shweboemys* group, fossa meckelli more narrow than in *Bairdemys*, low angle of

lower jaw rami at symphysis and labial ridge sharp as in *Erymnochelys* and *Podocnemis*. Although, its systematics is actually under determination, all characteristics indicate its close relation to *Podocnemis*, being the oldest record of this genus. The fossil were found in the oldest neotropical rainforest known so far (the late Paleocene Cerrejon Flora) suggesting that relationships between freshwater South American turtles and rainforest go back a long period of time.

Saturday 1:45

GREAT BASIN BIOGEOGRAPHY: A NEW PERSPECTIVE IN TIME

JASS, Christopher, Austin, TX

A considerable amount of research has been dedicated to understanding late Pleistocene to Recent biogeographic patterns in the Great Basin of the western United States. Numerous studies support the hypothesis that the modern, disjunct distribution of several montane mammals within the Great Basin arose as a direct result of climatic change from the late Pleistocene to Recent. Presently, our understanding of this biogeographic model is chronologically restricted to that time frame.

An improved understanding of the chronology at Cathedral Cave, Nevada, provided an opportunity to test for similar patterns in the fossil record prior to the terminal Pleistocene. Climatic perturbations were common throughout the Pleistocene and as such it is possible that biogeographic patterns documented for the latest Pleistocene-Recent in the Great Basin also occurred prior to that time. Data from Cathedral Cave provide preliminary support for this hypothesis.

Faunal remains from Cathedral Cave provide evidence of: (1) extinct taxa that pre-date any late Pleistocene extinction, (2) possible unique extirpation events with respect to the late Pleistocene, and (3) possible population-level response to changing climate. Four arvicoline rodent taxa (*Allophaiomys pliocaenicus*, *Microtus meadensis*, *Microtus paroperarius*, and *Phenacomys gryci*) represent unique extinctions events with respect to the late Pleistocene. The presence of *Aztlanolagus* sp. may represent a unique extirpation event in the Great Basin prior to succumbing to extinction in the late Pleistocene. Abundance data for *Microtus* versus *Lemmiscus* throughout the excavated sediment levels show an inverse relationship. Episodes of increasing abundance in *Microtus* correspond to decreasing abundance in *Lemmiscus* whereas increases in the abundance of *Lemmiscus* correspond to decreases in the abundance of *Microtus*. These changes in relative abundance may reflect changes in climate, given the habitat tolerances of these taxa today.

Vertebrate Development Symposium, Wednesday 12:15

MAMMALIAN DENTITION: FROM DEVELOPMENT AND GENES TO FOSSILS

JERNVALL, Jukka, Institute of Biotechnology, U. Helsinki, Helsinki, Finland

To help identify species in the fossil record, the typical range of dental variation found in living taxa and populations has attracted continuing research interest. While developmental biology studies of mice are uncovering details about molecular signaling and morphogenesis, present day knowledge about development is often too crude to address questions about population level variation. New avenues to study detailed changes in morphology include 'modulatory' signaling molecules which seem to fine tune the overall effects of gene networks. Mice with dental phenotypes that lack functional copies of these modulatory molecules still have teeth but with altered cusp morphologies. One example of the effects of modulatory signaling on tooth morphology is the ectodysplasin gene. Total inactivation of, or increase in, ectodysplasin production changes several dental characters without the loss of occlusion. The effects of ectodysplasin and other modulatory genes indicate that even large morphological changes in dental form could have simple genetic underpinnings. Furthermore, character state analysis of transgenic mice, quantitative alterations of molecular signaling during mouse tooth development, and mathematical modeling suggest that certain tooth shape variants are more likely to be present in populations than others. The developmentally decomposed morphological variation can be used to identify variation delineating fossil taxa and to also test at what point mammalian ancestors can be interpreted to have evolved their modern mode of tooth development.

Student Poster Session

CT-SCAN-BASED ANALYSIS OF MORPHOLOGICAL FEATURES OF THE OTIC REGION IN MIOCENE LAMNID SHARKS

JERVE, Anna, Michigan State Univ., East Lansing, MI

Fossil sharks, particularly from the Cenozoic, are primarily known from isolated teeth, which are often difficult to use in systematic and functional studies due to problems of heterodonty and convergence. Shark prismatic cartilage has a low preservation potential in comparison to teeth, and is thus relatively rare in the fossil record. However, in some exceptional cases, delicate cartilaginous structures do preserve, and can serve as a potentially rich source of data for systematic and functional interpretations. This study reports on morphological features from two well-preserved shark otic capsules collected from the Miocene Calvert Formation of Maryland.

The otic capsules are composed of prismatic cartilage and preserve portions of the skeletal labyrinth that enclosed soft structures of the membranous labyrinth. The overall size of the structures, as well as the proportions of the sacculus and utriculus, suggest that the fossils should be assigned to the Family Lamnidae (mackerel sharks). High-resolution CT-scans of the specimens reveal exceptional images of the labyrinth and show the exact positioning of their morphological components. Resolved structures include the size and shape of the semi-circular canals (anterior, posterior and lateral), the position of the endolymphat-

ic duct, and the size and positional relationships of the sacculus, utriculus and ampullae. These are homologous to the corresponding structures seen in the labyrinth of extant lamnid shark species. Therefore, the morphology of the otic capsules will prove useful for future phylogenetic studies of this group, and provide complementary data to often ambiguous tooth-based studies. Moreover, understanding this region of the chondrocranium is valuable for investigating the intricacies of otic function and associated aspects of sensory biology in fossil sharks.

Marine Reptiles Symposium, Wednesday 2:45

FIRST RECORD OF PLACODONTOIDEA (REPTILIA, SAUROPTERYGIA, PLACODONTIA) FROM THE EASTERN TETHYS

JIANG, Da-yong, HAO, Wei-cheng, SUN, Yuan-lin, Peking Univ., Beijing, China; MOTANI, Ryosuke, SCHMITZ, Lars, Univ. of California, Davis, CA

The Order Placodontia comprises the unarmored placodontoids and the armored cyamodontids. Placodontoids are known only from the Middle Triassic whereas cyamodontoids range from the Middle to Upper Triassic. Traditionally, the group was known only from western Tethyan province, but more recently, two cyamodontoid placodonts have been reported from the Upper Triassic of Guizhou Province, China. Unarmored placodonts, however, have been thought to be endemic to Europe.

We report the first record of the unarmored placodont from outside Europe. The specimen was collected from the Pelsonian (middle Anisian) of the Middle Triassic in Panxian County, Guizhou Province, China. As we reported last year, abundant vertebrate fossils have been excavated from the horizon. The specimen is a complete skeleton that spans 205 cm. The skull, which is 18 cm long, is deep, carrying three procumbent and chisel-shaped premaxillary teeth and four flat to rounded maxillary teeth. There are one anterior procumbent tooth and four posterior flat teeth presented in the dentary. The verticle oriented external naris results in a distinct step of the preorbital region. A single row of osteoderms caps the expanded dorsal tips of the high neural spines. These and other characters enable us to assign the specimen to the genus *Placodus*, which is monotypic. Our specimen exhibits some differences from the type species, *P. gigas*. For example, the ventral process of the nasal is absent, allowing the prefrontal to enter the posterior margin of the external naris. Also, the distinct postorbital process projecting into the orbit is lacking. It is possibly a second species of the genus for this reason. Our study shows that unarmored placodonts, against conventional wisdom, had a wide geographical distribution within the Tethyan realm in the Middle Triassic. It further enforces the similarity between Middle Triassic marine reptile faunas of China and Europe that we discussed last year.

Poster Session III

THE EARLY BLANCAN CAMELIDS FROM SAN MIGUEL DE ALLENDE, GUANAJUATO, CENTRAL MÉXICO

JIMENEZ-HIDALGO, Eduardo, Universidad del Mar, Campus Puerto Escondido, Puerto Escondido, Oaxaca, Mexico; CARRANZA-CASTAÑEDA, Oscar, Centro de Geociencias, UNAM, Querétaro, Mexico

The examination of cranial and limb material collected from several localities allowed us to significantly increase the knowledge of the camelid species present in the area. Previously, only *Camelops* sp. was tentatively recognized. The fossil material was recovered from sandy and silty clay with some lenses of volcanic ash and sand that have been interpreted as flood-plain deposits. The associated fauna, magnetostratigraphic studies and radiometric dates of 4.6 Ma, 3.6 Ma and 3.3 Ma available for some of the localities, allowed to establish an early Blancan age for the bearing beds.

Identified taxa include *Hemiauchenia blancoensis*, a small species of *Hemiauchenia*, *Blancocamelus meadei*, *Camelops* sp. and *Megatylopus*(?) sp. The lamini *H. blancoensis* and *B. meadei* represent the first Mexican records of the species; also the record of *B. meadei* is the oldest in North America, since previously it was only identified in the late Blancan faunas of USA. The small species of *Hemiauchenia* is also present in the Hemphillian deposits of the studied area. The record of *Megatylopus*(?) sp. is the first one in the Blancan of Mexico. The early Blancan camelid species richness observed in San Miguel is higher than the one from USA faunas of the same age, where three or four taxa are associated.

Previous studies on their probable feeding strategies indicate that *H. blancoensis* and the small species of *Hemiauchenia* were browser-like intermediate feeders or browsers, while *Camelops* was an intermediate feeder and *B. meadei* and *Megatylopus*(?) sp. were browsers. This suggests an important component of trees and shrubs besides of grasses in the studied area during the early Blancan. The records of these camelid species in San Miguel de Allende are at present the southernmost in North America.

Poster Session III

PHYLOGENETIC POSITION OF SOUTHWESTERN NORTH AMERICAN TORTOISES (TESTUDINIDAE)

JONES, Cory, San Diego State Univ., San Diego, CA

Gopherus is part of a clade of tortoises restricted to North America. *Gopherus* is represented by four extant taxa, *Gopherus agassizii* (Desert tortoise), *G. berlandieri* (Texas tortoise), *G. flavomarginatus* (Bolson tortoise), and *G. polyphemus* (Gopher tortoise). In the Tertiary, three other genera of tortoises inhabited North America. The earliest known, *Hadrianus*, is thought to have given rise to *Gopherus* and *Styemys*+*Hesperotestudo*. The earliest *Gopherus*, *Gopherus laticuneus*, is known from the White River Formation in the central United States. Interestingly, from the understudied Eocene and Oligocene sedi-

ments of Southern California, gopher tortoises have been reported and are thought to belong to *G. laticuneus* or perhaps an undescribed species. These taxa have yet to be examined in depth and will provide much insight to the zoogeography and the evolution of *Gopherus* and North American tortoises as a whole. Preliminary results on the southern California fossil tortoises indicate that these fossils do indeed belong within *Gopherus*, but they appear to be morphologically distinct from the other Oligocene *Gopherus*, *G. laticuneus* and the Eocene *Hadrianus uintensis*.

To this point most systematic analyses of North American tortoises have coded *Hadrianus*, *Stylemys*, and *Hesperotestudo* only at the generic level rather than examining individual species. This project includes species within these three genera. This analysis aids in understanding the relationships between the early diverging *Hadrianus* and the later diverging taxa.

This study builds on previous work on North American tortoises especially with the addition of postcranial characters. This increases the number of characters that are coded for fossil specimens from which only postcranial elements are found. This study will result in greater phylogenetic resolution within the North American *Gopherus* clade.

Friday 1:30

A NEARLY COMPLETE SKELETON OF *POPOSAURUS GRACILIS* FROM THE LATE TRIASSIC OF UTAH

JOYCE, Walter, GAUTHIER, Jacques, Yale Univ., New Haven, CT

The Yale Peabody Museum has been conducting fieldwork in the Chinle Formation of southern Utah since 2002. In the course of four field seasons, a significant amount of vertebrate fossil material was recovered, that consists primarily of fragmentary basal archosaur and temnospondyl remains of limited diagnostic value. This situation contrasts with the find of a skeleton in 2003 along the western rim of Circle Cliffs in the newly established Grand Staircase-Escalante National Monument in Garfield County. That find appears to represent one of the most complete bipedal stem-crocodylian found to date worldwide. The specimen likely once consisted of a single, fully preserved individual that eroded headfirst down to the base of the neck. The rest of the specimen is largely preserved in full articulation with little post-mortem distortion. Comparison with the holotype of *Poposaurus gracilis*, which consists of a partial pelvis and femur from the Upper Triassic Popo Agie Formation of Wyoming, reveals only minor differences in size and degree of ossification at muscle attachment sites and the specimens is thus interpreted as a less mature individual of that species.

The postcranium reveals clear evidence that corroborates the hypothesis that *Poposaurus gracilis* possessed a bipedal stance and gait. Anatomical traits that favor this interpretation include a forelimb to hindlimb ratio of 1:2.2, a hind limb to presacral column ratio of approximately 1:1, the presence of a long tail (approximately 65 percent of the total vertebral column length) that placed the center of gravity at the hip joint, restriction of lateral movement in the thoracic vertebrae, a narrow pelvic girdle, a modest lesser trochanter and prominently overhanging supracetabular buttress, and the presence of a prominent anterior iliac spine. Although the pes exhibits four well-developed digits, *Poposaurus gracilis* walked digitigrade on the median three, and may have left only tridactyl imprints. Overall, the postcranial skeleton of *Poposaurus gracilis* resembles that of the contemporaneous *Coelophysis bauri* in gestalt, although the body is estimated to somewhat larger.

Wednesday 8:45

RODENT INCISORS AS BIONIC MODELS

KALTHOFF, Daniela, KOENIGSWALD, Wighart, Univ. of Bonn, Bonn, Germany

Rodent incisors are (almost) all purpose tools. They are used for gnawing, chopping, slicing, digging, cutting down trees, or as tweezers and many other applications. This wide suitability is guaranteed by three factors: firstly, the combination of a hard tissue (enamel) with a softer tissue (dentin) provides a self-sharpening construction; secondly, the stability of the thin cutting edge is maintained by a crack preventing microstructure of the enamel; and thirdly, heavy abrasion is allowed and compensated by continuous growth. This mechanical principle of self-sharpening incisors evolved in several mammalian lineages independently. The self-sharpening abilities are fascinating for bionic engineers. Industrial knives, which are used e.g. for cutting plastic garbage, have to be replaced currently on a daily basis. The service life of these knives could be significantly extended if the self-sharpening feature of rodent incisors could be imitated. Engineers of the Fraunhofer-Gesellschaft and paleontologists of the Institute of Paleontology at Bonn Univ. are working together to simulate this two-layered composite structure in technical materials. Bionic engineers tend to assume that natural constructions are always optimised and attempt to replicate all details. Paleontologists know that these constructions are a temporal stage in the course of evolution. The many solutions provided by parallel evolution indicate the framework in which those constructions are possible. Thus the specific contribution of paleontologists is to identify the principles upon which technical applications can be developed.

Poster Session III

PRELIMINARY RESULTS ON INTERPRETING THEROPOD BEHAVIOR USING PEDAL PHALANGEAL MORPHOLOGY

KAMBIC, Robert, Montana State Univ., Bozeman, MT

Studies of pedal phalangeal morphology in theropods have important implications for areas such as locomotion, the evolution of modern birds, track-maker identification, paleoecology,

and behavior. Previous morphologic analysis on modern birds has found correlations between phalangeal proportions and cursorial or arboreal behavior. This study expands on the morphometric analysis of previous work in order to develop more specific behavioral interpretations for non-avian theropods.

This study uses modern birds as analogues to non-avian theropods to define categories of behavior on the basis of linear measurements of pedal phalanges taken with digital calipers. Measurements include not only length and width of the phalanx, but also measurements of height and relative lengths of different structures. Taxa of varying behavior, phylogenetic position, and body size are chosen to control for confounding factors. Groups of birds measured include ratites, tinamous, galliformes, cuculiformes, falconiformes, and coraciiformes. Principal component analysis, which has been used in similar studies, will be used to determine the metrics most responsible for morphological variation across taxa with an emphasis on the metrics added for this study. Non-avian theropods will then be plotted with modern birds on a diagram representing these "principal components" to ascertain whether behavioral inferences are possible. An emphasis will be placed on groups closely related to birds such as dromaeosaurs and troodontids.

Preliminary results of this study are reported here. Phalangeal proportions are supported as being correlated with cursorial or grasping behaviors. Additionally, shape of the trochleas appears to vary independently of size. These results support the utility of examining these metrics as part of a single data set.

Saturday 2:00

ANALYSIS OF CRANIAL DISPARITY IN THE THEROCEPHALIA USING GEOMETRIC MORPHOMETRICS

KAMMERER, Christian, Univ. of Chicago, Chicago, IL

The Therocephalia represents one of the major subclades of Permo-Triassic therapsids. Therocephalians are known from the earliest therapsid-bearing strata of the Late Permian South African Karoo Basin and persist until the Middle Triassic. The group attained a high level of morphological diversity compared to coeval clades, and included herbivorous and probably venomous forms. Here I present the results of an investigation into patterns of therocephalian disparity over time. I undertook a geometric morphometric analysis of therocephalian specimens using 10 lateral and 8 dorsal cranial landmarks taken from digitized images. Shape-based variance in the data was summarized using relative warps. Specimens were binned into eight Karoo biozones, with differences in extent of morphospace occupation between the bins quantified using variance and range metrics.

Therocephalians remain highly conservative in cranial morphology through the first three biozones, followed by expansion into new morphospace but loss of old in the *Tropidostoma* Zone. The major burst of therocephalian morphospace expansion does not occur until the end-Permian *Dicynodon* Zone. Therocephalians parallel cynodonts and anomodonts in their evolution towards broad-headed forms with large temporal openings over the course of clade history. These features have been associated with the independent evolution of herbivory in therapsid groups. However, some of the stratigraphically earliest members of the therocephalians in question display the "herbivore skull" morphology but retain carnivore dentition, so this cranial form may have been exaptive within the clade. Therocephalians suffer a major contraction in morphospace occupation across the Permo-Triassic boundary, and continue to lose morphological diversity through the Early Triassic (*Lystrosaurus* Zone). Although therocephalians go on to diversify taxonomically in the Triassic, they do not regain lost morphospace. Triassic cynodonts, on the other hand, expand into areas of morphospace occupied by therocephalians in the Permian.

Saturday 2:30

BRAIN SIZE, ACTIVITY PATTERN, AND VISUAL ACUITY IN *HOMUNCULUS PATAGONICUS*, AN EARLY MIOCENE STEM PLATYRRHINE: THE MOSAIC EVOLUTION OF BRAIN SIZE AND VISUAL ACUITY IN ANTHROPOIDEA

KAY, Richard, Duke Univ., Durham, NC; LINCOLN, Abraham, Washington, DC; COLBERT, Matthew, Univ. of Texas, Austin, TX; MALINZAK, Michael, Duke Univ., Durham, NC; KIRK, E., Univ. of Texas, Austin, TX

A nearly complete and undistorted skull of *Homunculus patagonicus*, an early Miocene stem platyrrhine collected in 2004, was scanned by high-resolution CT. The skull provides the oldest record of orbit size, optic canal size, and endocranial volume (ECV) in a platyrrhine, allowing reconstruction of adaptive parameters of the visual system and a broader consideration of anthropoid brain size and visual system evolution.

The relative orbital aperture size of *Homunculus* suggests diurnal habits and is smaller than expected for a nocturnal monkey. The optic canal, and by inference the optic nerve, is anthropoid-like and larger than in strepsirrhines. This feature is related to the amount of visual information transmitted from the retina to the brain. It suggests that *Homunculus* had highly refined visual acuity, a hallmark of living anthropoids not found in strepsirrhines. The African Oligocene stem anthropoid *Simonsius* and the stem catarrhine *Aegyptopithecus* also resemble living anthropoids in having a high level of visual acuity. *Simonsius* has a large optic canal. The canal is not preserved in *Aegyptopithecus* but the rostrally positioned lunule sulcus on its endocranium, suggests that visual areas in the occipital lobe were relatively large as in living anthropoids. The more caudal position of the lunule sulcus in strepsirrhines reflects reduced cortical visual processing.

In spite of the increased visual inputs and a proportionately enlarged visual cortex, it is clear that relative ECV was small and strepsirrhine-like in stem anthropoids (*Simonsius*) and stem catarrhines (*Aegyptopithecus*). The relative ECV of *Homunculus* likewise is small-

er than in any living platyrrhine or catarrhine and falls near the mean for living strepsirrhines. These findings suggest that the very high encephalization of living anthropoids evolved independently in platyrrhines and catarrhines and not in concert with the more ancient initiation of increased visual acuity. Once initiated, additional selection for increased visual processing to meet socioecological demands led to further increases in relative brain size among anthropoids.

Poster Session II

SOFT TISSUE SURROGATES FROM AN SEM SURVEY OF FOSSIL MATERIAL FROM THE LANCE AND HELL CREEK FORMATIONS

KAYE, Thomas, Prospect Heights, IL; SAWLOWICZ, Zbigniew, Jagiellonian Univ., Krakow, Poland; GAUGLER, Gary, Microtechnics Inc., Granite Bay, CA; STIPANOVIC, Bozidar, APL Biopurification Technologies, Highland Park, IL

Prompted by recent excitement in the scientific community surrounding the discovery of soft tissues in *Tyrannosaurus rex* bone, a survey was undertaken in an attempt to discover these tissues in situ. A variety of Lance and Hell Creek specimens including *triceratops*, *hadrosaur*, *ankylosaur*, *champtosaur* and well-preserved small bones were examined under the scanning electron microscope (SEM) and energy dispersive spectroscopy (EDS). Many likely structures were identified and found in surprisingly common numbers. Micron-sized spheres containing iron and oxygen were identified as an oxidized sub-group of common sulfur-iron framboids. Filamentous mats and non-bone coatings were imaged in the open vascular canals showing evidence of microbial movement through a viscous film. Characteristic micron size pores on both the canal walls and the framboid surfaces, suggested the presence of desiccated biofilms. Quartz crystals with attached framboids suggested a prolonged time line for framboid and biofilm development. Further analysis after digestion in acid, showed that these structures resembled presumed dinosaurian soft tissues but this study suggested that they were in fact microbiologic and mineral in origin with a morphology that could allow for multiple interpretations. Additional surveys of ammonoids from the Pierre Shale and bone from the White River Group also contained these same structures indicating that morphology alone is not a reliable identification method for soft tissues. Consequently, this survey suggests, that a biologic testing regimen is required to determine affinities and ages of biomolecules.

Poster Session II

A DIVERSE MARINE REPTILE ASSEMBLAGE FROM THE LOWER CRETACEOUS HIGH LATITUDE DEPOSITS OF SOUTHERN AUSTRALIA

KEAR, Benjamin, Univ. of Adelaide/South Australian Museum, Adelaide, Australia

The Lower Cretaceous (Aptian-Albian) high latitude deposits of southern Australia have yielded a diverse range of marine reptile fossils. Identifiable taxa include the ubiquitous Cretaceous ichthyosaur *Platypterygius* and at least five distinct kinds of plesiosaur—an archaic rhomaleosaurid, the large pliosaurid *Kronosaurus*, indeterminate elasmosaurids, polycotyliids, and an enigmatic cryptocleidoid morphologically intermediate between Late Jurassic and Late Cretaceous forms. Notably, the polycotyliid material is amongst the oldest from anywhere in the world, and together with the unusual occurrence of a relict rhomaleosaurid, might suggest that the Early Cretaceous austral high latitude region was both a centre of origin and refuge for many groups. The southern Australian high latitude marine reptile fossils are derived mainly from the lower Aptian to lower Albian Bulldog Shale and laterally equivalent Wallumbilla Formation. These units are famous for producing opal and represent shallow epicontinental marine environments. Estimates of palaeolatitude place most of southern Australia at around 60° to 85° south during the late Early Cretaceous. Sedimentary structures (including glacial erratics, glendonites, cryoturbated terrestrial sediments and tillites), densely growth-banded fossil wood, isotope data and climatic modelling indicate highly seasonal, cool to very cold conditions possibly with winter freezing. This contrasts markedly with climate regimes typically tolerated by modern aquatic reptiles but suggests that some Mesozoic forms might have possessed adaptations (e.g., elevated metabolic levels and/or annual migration) to cope with low average water temperatures.

Preparators Symposium, Thursday 8:45

RECONSTRUCTING NIGERSAURUS TAQUETI

KEILLOR, Tyler, Brookfield, IL

The reconstruction of the bizarre African sauropod, *Nigersaurus taqueti*, required a melding of old and new materials and techniques. Careful preparation freed the fossils from a sandy matrix. The impossibly delicate, disarticulated skull bones could not be molded; but were CT scanned and prototyped. The scan data yielded reversed bones, as well, where only one side was preserved. The prototyped bones were fitted together, and missing bones were sculpted with plasticene clay to fill the gaps. The reconstructed skull model was molded with silicone; skulls were cast with polyurethane resin. Over a cast of the skeletal elements, a flesh reconstruction was sculpted. Care was taken to follow the bony landmarks for clues to soft tissue, and diverse extant taxa were observed for comparison and inspiration. Skin impressions and sclerotic rings from other types of sauropods were the reference for scales and eye size; while details like the skin color, and bits of green plant material mixed with saliva were speculative artistic decisions. A truly unique and unusual dinosaur like *Nigersaurus* could not have been reconstructed for public exhibition without the full spectrum of materials and techniques available to skilled preparators today.

Thursday 1:45

THE SMALLEST PTEROSAUR FROM THE EARLY CRETACEOUS JEHOL BIOTA, CHINA

KELLNER, Alexander, Museu Nacional/UFRJ, Rio de Janeiro, Brazil; CAMPOS, Diogenes, Museu de Ciências da Terra/DNPM, Rio de Janeiro, Brazil; WANG, Xiaolin, ZHOU, Zhonghe, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, China

A new pterosaur from the Liaoning deposits, northeastern China is reported. The specimen (IVPP V-14377) consists of an almost complete skeleton that was collected in the Jiufotang Formation (~120 Ma), close to Jianchang, western part of Liaoning. The maximum length of the skull is 39.6 mm (sq-pm: 37.8 mm). The posterior region of the skull is expanded and the articulation with the mandible is positioned under the anterior half of the orbit. The orbit is sub-oval and comparatively large. The nasoantorbital fenestra is comparatively small, occupying about 25% of the sp-pm length. The confluent naris and antorbital fenestra, the absence of ribs in the mid-cervicals, and the reduced fifth pedal digit indicates that IVPP V-14377 is a member of the Pterodactyloidea. The new specimen further lacks any synapomorphy of the Archaeopterodactyloidea and the toothless condition suggests that it is a member of the Dsungaripteroidea. The humerus has a proximally placed and slightly curving deltopectoral crest, differing from the hatched-shaped or warped condition of, respectively, the Nyctosauridae and the Pteranodontoidea. The short mid-cervical vertebrae are distinct from the Azhdarchidae and the small size of the nasoantorbital fenestra from the Tapejaridae. The absence of a premaxillary sagittal crest is another character that distinguishes it from all known clades of the Dsungaripteroidea. IVPP V-14377 further shows some unique features (e.g., high caudals, distinct medial process on femur, curved phalanx of first pedal digit) suggesting that it belongs to a new taxon, and expands the diversity of the Jehol pterosaur fauna. The estimated wingspan of IVPP V-14377 is around 20 cm, making it one of the smallest pterosaur ever found. Several bones are unfused (e.g., scapula and coracoid, cranial bones), but the tarsals are ossified, suggesting that it was a juvenile but probably not a hatchling.

Wednesday 1:30

AN ASSESSMENT OF HEARING FUNCTION IN A NONMAMMALIAN EUCYNODONT

KEMP, Tom, Oxford Univ., Oxford, United Kingdom

Allin's theory that the postdentary bones and quadrate of cynodonts were not only the homologues of the mammalian ectotympanic and accessory ear ossicles, but also functioned in essentially the same way in sound reception is assessed in the light of an exceptionally well-preserved and completely prepared specimen of *Chiniquodon* (= *Probesodon*). The sound reception function was compromised by the design requirements for a persistent, though reduced mechanical function of stress transmission during jaw muscle function, and in particular during jaw-opening. However there were also adaptations specifically to improve the sound-conduction function, notably in nature of the attachment of the postdentary rod to the dentary and skull. There was an acoustic transformer ratio of about 30, which is within the range of modern mammals. But the estimated masses of the bones, and a subjective assessment of the compliances lead to the conclusion that only low frequency sound up to 1-2KHz could be detected. No reptile-like postquadrate tympanum was present. Nor is there either evidence for, or functional expectation of an air-filled tympanic cavity and specialised tympanic membrane at this stage of evolution of the ear. The mechanism for hearing was more analogous in some respects to that of modern squamates that have lost the tympanic cavity than to modern mammals.

Poster Session I

ONTOGENETIC ALLOMETRY IN THE LIMB BONES OF DINOSAURS WITH IMPLICATIONS FOR ORNITHISCHIAN BIOMECHANICS

KILBOURNE, Brandon, Univ. of Chicago, Chicago, IL

For the study of locomotor biomechanics during ontogeny two important sources of information are bone dimensions and body mass. As body mass increases the skeleton has to cope with the increased loading during support and locomotion. Two methods for studying the response of the skeleton to increasing body mass are through limb bone scaling and testing for mechanical similarity in limb bones.

For ontogenetic scaling, departures from isometry could indicate selective pressures and adaptations. Allometry for the supporting limb bones (i.e. hindlimb bones for bipeds and both fore- and hindlimb bones for quadrupeds) were assessed to determine if departures from isometry are characteristic of Dinosauria as a whole, or to particular taxonomic groups. Theropod dinosaurs show negative allometry while some ornithischians exhibit either isometry or slightly positive allometry (i.e., bones grow more gracile). A correlation between adult body mass and ontogenetic allometry has been tested by a regression of adult body mass to the allometric exponent. For taxa that have estimated growth rates, maximum growth rate is compared to the allometric exponent of limb bones to determine if increasingly robust limb bones are associated with maximum growth rate. Body mass increases much faster than limb bone cross-sectional area during growth, implying decreased safety factors for limb bones that grow either isometrically or with moderate allometry. For taxa that exhibit such growth, potential compensatory mechanisms in the form of changes in cross sectional properties, or altered posture and kinematics during ontogeny, will be identified. Preliminary results show that for at least one taxon, *Dryosaurus lettowvorbecki*, compensatory effects come in the form of changing cross-sectional properties.

Poster Session I

UNDER THE FEET OF GIANTS: AN INVESTIGATION OF THE SMALL VERTEBRATES AT THE MYGATT-MOORE QUARRY, MORRISON FORMATION, WESTERN COLORADO

KING, Lorin, Dinosaur Depot Museum, Cañon City, CO; FOSTER, John, Museum of Western Colorado, Grand Junction, CO

For over 25 years, the Mygatt-Moore Quarry has been producing abundant remains of large dinosaurs represented mainly by *Apatosaurus* and *Allosaurus* with some camarasaurid, diplodocid, and ceratosaurid material. The ephemeral shallow lacustrine paleoenvironmental setting is generally devoid of smaller vertebrates. However, the quarry has produced some identifiable, albeit fragmented, small vertebrate remains. The rare, smaller non-dinosaurian vertebrates include the first pterosaur and turtle material ever found at the quarry, a sphenodontian, a small primitive crocodylomorph, and a goniopholidid crocodyliform. These remains are represented mainly by limb bones, vertebrae, and teeth. The one goniopholidid tooth known from the quarry is in stark contrast to the more than 300 shed teeth of theropods. Several fish (*Morrolepis*, cf. *Leptolepis*, and "*Hulettia*") are known from the quarry, but these remains are found in a different lithology approximately 2m stratigraphically above the dinosaur bone bed. The Mygatt-Moore Quarry is similar to the Cleveland-Lloyd Quarry and several sites at the eastern end of Como Bluff in the paucity of aquatic vertebrates such as turtles and crocodylians and the high ratio of shed theropod teeth to those of crocodylians. Other sites such as Quarry 9, the Small Quarry, and Ninemile Hill have abundant fish, turtles, and crocodylians and differ substantially from the Mygatt-Moore, Cleveland-Lloyd, and Como Bluff sites. Although the scarcity of fish, turtle, and crocodile material in the main bone bed at Mygatt-Moore suggests that standing water was infrequent, the abundance of plant material in the bone bed mudstone indicates an often wet substrate and likely a high local water table.

Friday 8:30

REASSESSING THE PALEOECOLOGY OF THE PLIOCENE SITE OF LAETOLI, NORTHERN TANZANIA, UTILIZING ISOTOPIC ANALYSIS OF FOSSIL HERBIVORE ENAMEL

KINGSTON, John, Emory Univ., Atlanta, GA; HARRISON, Terry, New York Univ., New York, NY

Interpretations of paleoenvironments at the Pliocene locality of Laetoli have figured prominently in discussions of human evolution, primarily because early hominins recovered from Laetoli are generally inferred to be associated with grassland, savanna or open woodland habitats. These reconstructions effectively extend the range of habitat preferences for Pliocene hominins and contrast with interpretations of predominantly woodland and forested ecosystems at other early hominin sites. Here we reevaluate the paleoecology at Laetoli utilizing isotopic analyses of the enamel of twenty-one extinct mammalian herbivore species from the Laetoli Beds (~4.3-3.5 Ma) and Upper Ndolanya Beds (~2.7-2.6 Ma) to develop a consensus reconstruction of available forage and by inference habitat types within the succession. Dietary patterns of the various herbivore guilds represented in the Laetoli and Upper Ndolanya Beds indicate eclectic, mixed C3/C4 diets for all herbivore families other than the obligate browsing giraffids. The almost complete absence of specialized grazing guilds and the heavy reliance on browse by most fossil herbivores does not support earlier interpretations of grassland-savanna habitats dominating the landscape, but rather a more heterogeneous woodland biome. Evidence of a variable C4 grazing component in most lineages, however, does indicate that grasses were ubiquitous, consistent with habitats dominated by closed woodlands with a substratum of C4 grasses or open woodland interspersed with grassy patches. Relative to other Pliocene African fossil localities where enamel has been extensively analyzed, Laetoli isotopic values generally indicate similar dietary patterns for specific taxonomic groups, although there is a consistent bias towards a greater C3 browsing component among Laetoli herbivores. Compared to modern African herbivore isotopic profiles, the Laetoli cumulative dietary spectrum is heavily weighted towards mixed C3/C4 foraging patterns with limited evidence for specialized grazing or browsing strategies that characterize modern descendants. These data suggest that modern African ecologies may not provide appropriate analogs, specifically in the foraging behavior of the herbivore community, but perhaps also in the overall physiognomy and composition of the vegetation.

Poster Session II

APPLICATION OF GEOGRAPHIC INFORMATION SYSTEMS (GIS) TO MODEL THE KOOBI FORA

KIRERA, Francis, Univ. of Arkansas, Fayetteville, AR

This study examines the application of GIS technology in combination with faunal ecomorphological analysis to model the paleoenvironment of the Plio-Pleistocene Koobi Fora Hominin sites. Several researchers have used ecomorphology to reconstruct aspects of early Hominin paleoenvironments in East Africa. Such studies have been based on the notion that morphological adaptations evinced by herbivorous mammals reflect specific aspects of environment. The current study adds to our knowledge of the paleoenvironment dynamics of Koobi Fora, by bringing data into a platform that can be clearly visualized using a Geographic Information Systems (GIS) model.

We present some of the technical aspects of incorporating GIS into the analysis of the spatial and temporal dynamics of adaptations inferred from fossil bone morphology. Fossil elements of bovids are transformed into the GIS model using geo-referenced data

points collected with the aid of GPS survey in the field and on-table digitizing of previously marked locations on maps.

This study is divided into two parts; First, traditional multivariate analyses are used to gather ecomorphological data on fossil elements (based on relationships between environment and ecomorphology of extant fauna) Second, these data are incorporated into a GIS environment for spatial modeling and geostatistics. Results from this study clearly indicate both general shifts and the variability of Koobi Fora paleoenvironment with open environments dominating the entire epoch intermittent with closed and intermediate habitats.

Friday 11:45

A NEW GENUS OF ORNATE LONG-HORNED CENTROSAURINE CERATOPSIAN FROM THE MIDDLE CAMPANIAN (CRETACEOUS) WAHWEAP FORMATION, GRAND STAIRCASE-ESCALANTE NATIONAL MONUMENT, SOUTHERN UTAH

KIRKLAND, James, DEBLIEUX, Donald, Utah Geological Survey, Salt Lake City, UT
An isolated, well-preserved skull (~1 m long less parietal spines) of a ceratopsian dinosaur from the "middle mudstone member" of the middle Campanian Wahweap Formation may be the oldest, and is the first diagnosable, centrosaurine recovered south of Montana. It shares with more derived centrosaurines the stepped squamosal and a nasal-premaxillary process along the caudal border of the naris. The preorbital skull is deep and shorter than other known centrosaurines. Rostral to a low, subconical narial horn is a smaller "epinasal" suggesting the presence of a second smaller narial horn. Long, erect postorbital horns extend over the nasal horns. Large, vertically oriented, blade-like epijugals extend laterally from skull. The erect frill is subequal in length to the skull, and is widest at the laterally directed squamosals, tapering to half its width at the base of a pair of caudal parietal spines separated by a medial notch. The parietal fenestrae are caudo-rostrally elongate. The parietal bar preserves weak undulations, but no distinct ornamentation. The squamosals each bear four epoccipitals. Laterally, the parietal bears five triangular epoccipitals with the largest near its suture with the squamosal. The epoccipitals are progressively smaller caudally such that, at the base of the elongate caudal parietal spine, the epoccipital is less than one square centimeter in size. The narrow caudal parietal margin is dominated by a pair of robust spines as long as the entire frill, which extend caudally and then gradually sweep laterally beyond the widest portion of frill. The long postorbital horns and small narial horn are primitive character states as indicated by the ceratopsid sister taxon *Zuniceratops*. Autapomorphies include a separate narial horn and rostral "epinasal," short muzzle, large blade-like epijugals, and a caudally-tapering frill with long sweeping spines.

Saturday 9:45

AN UNUSUAL BONE HISTOLOGY AND GROWTH PATTERN IN AMPELOSOSAURUS ATACIS, A TITANOSAURID SAUROPOD FROM SOUTH FRANCE

KLEIN, Nicole, SANDER, Martin, Institute of Paleontology, Bonn, Germany; LELOEFF, Jean, Musée des Dinosauriens, Esperaza, France

Several humeri and femora of the titanosaur sauropod *Ampelosaurus atacis* from the Maastrichtian of South France were sampled by core drilling and cross sectioning for paleohistological study. The material was collected within the scope of a large project about sauropod bone histology. The comparison with other sampled sauropods (Neosauropoda including several Diplodocoidea and Macronaria) or any other dinosaur currently studied by bone histology, shows that *Ampelosaurus atacis* is clearly different/unique in its bone histology. Whereas all studied sauropods and even closer relatives like *Alamosaurus* and *Phuwiangosaurus* show the laminar fibro-lamellar bone typical for most dinosaurs, *Ampelosaurus* *atacis* indeed retains the laminar vascular organization, but completely lacks the fibrous bone tissue component, even in early ontogenetic stages. The dominant bone tissue here is the parallel-fibered bone and lamellar bone. However, contrary to e.g. reptiles which also grew with parallel-fibered or lamellar bone, *A. atacis* growth was not cyclically interrupted by LAGs or other growth marks, except in the outer cortex of some ontogenetically old specimens. Furthermore, *A. atacis* long bones are characterized by remodelling (secondary osteons) starting very early in ontogeny. Current phylogenetic hypothesis place *Ampelosaurus* as a derived titanosaur. Thus, its unique bone histology must have evolved from the standard sauropod long bone histology that always indicates high growth rates. The lack of the fibrous component in the laminar bone of *A. atacis* suggests a greatly reduced bone apposition rate, which in turn would implicate an clearly decreased growth rate and delayed maturity relative to other sauropod dinosaurs. Such a delayed maturity is sometimes seen in insular forms such as the extinct moa (*Dinornis*) of New Zealand, although the bone histology of moa is different from *Ampelosaurus*. This is consistent with the Maastrichtian paleogeography of southwestern Europe, which indicates that *A. atacis* inhabited large islands.

Student Poster Session

NEW SKELETAL REMAINS OF PALAEOSPINACID SHARKS—KEY-TAXA FOR UNDERSTANDING THE INTERRELATIONSHIPS OF SYNECHODONTIFORMES (NEOSELACHII)

KLUG, Stefanie, Berlin, Germany

Palaeospinacid sharks ranging from the Late Triassic to the Eocene are the most diverse family (>30 species) of Synchodontiformes, which are supposed to be a monophyletic group of basal galeomorphs (Neoselachii). Most palaeospinacids are represented by isolat-

ed teeth, placoid scales, and fin spines. Currently, there is a major controversy concerning the value of diagnostic characters for distinguishing palaeospinacid genera, because of very similar dental morphologies and the scarcity of articulated skeletal material, which is only known from the Lower Jurassic of Lyme Regis (England) and Holzmaden (southern Germany), from the Upper Jurassic of southern Germany, and the Late Cretaceous of England.

So far, two genera are considered valid within this family: *Paraorthacodus* being represented by one partial and *Synechodus* by several skeletal remains. All specimens from the Lower Jurassic bear two fin spines, whereas all other material known up to date lacks most postcranial portions.

A re-examination of all articulated selachians from the Upper Jurassic Lithographic Limestones of southern Germany yielded several complete palaeospinacid individuals displaying abundant dental, cranial, and postcranial characters. One new species of *Paraorthacodus* is represented by very well-preserved adult and juvenile individuals. In addition, skeletal remains of two different species of *Synechodus* including one new taxon are reported here. This new material proves to include key-taxa for solving taxonomic problems and reconstructing the phylogeny and biogeography of synchodontiform sharks. Important characters are the number of dorsal fins, the distribution of fin spines, and the position of paired and unpaired fins. Based on this material, it is possible to define apomorphic dental characters for distinguishing *Paraorthacodus* and *Synechodus*, and additionally, to transfer all Early Jurassic palaeospinacids possessing dorsal fin spines to a new genus.

Poster Session II

DOES *PROCOMPSOGNATHUS* HAVE A HEAD? SYSTEMATICS OF AN ENIGMATIC TRIASSIC TAXON

KNOLL, Fabien, SCHOCH, Rainer, Staatliches Museum für Naturkunde, Stuttgart, Germany

Procompsognathus triassicus is a taxon from the Stubensandstein of Pfaffenhofen, near Heilbronn (Baden-Württemberg, Germany), which has been the subject of persistent controversies. In order to provide clarification of the status of SMNS material ascribed to this enigmatic archosaur (SMNS 12591, 12591a, 12352, and 12352a), additional preparing as well as high-resolution X-ray CT analyses have been conducted. From a global morphological point of view, the type material, SMNS 12591, shows strong similarities with *Coelophysis*. A supertree analysis suggests that *Dilophosaurus*, *Liliensternus*, *Coelophysis*, and *Segisaurus* may be successively closer sister-taxa to *Procompsognathus*. SMNS 12591a shows a mosaic of characters difficult to decipher in terms of phylogenetic affinities, but it is tentatively suggested that it is from an early and very plesiomorphic tetanuran based on the presence of an assumed maxillary fenestra. SMNS 12352 likely pertains to a crocodylomorph in part due to the separation between the nasal and the antorbital fossa. SMNS 12352 has been attributed to *Saltosuchus connectens* but there are some differences between SMNS 12352 and 12596 (regarding the outline of the antorbital fenestra and the depth of the maxilla at the level of the rostral part of the antorbital fenestra) that cast serious doubt on this identification. Finally, SMNS 12352a shows a definitive primitive *Bauplan* in being pentadactyl with no obvious differential development of the digit II. Yet, a long and powerful three-fingered hand arose in the earliest theropods whereas the hand of "thecodonts" is generally crocodile-like. Therefore, though it cannot be definitely attested so far, the pertaining of SMNS 12352a to a crocodylomorph is substantiated. The carnivorous guild that dwelled southern Germany prior to the Tr-J boundary events was remarkably diverse and strengthens the hypothesis according to which fundamental evolution within the clade Theropoda was under way well before the Tr-J boundary events.

Saturday 11:00

ORNITHOMIMIDS (THEROPODA: DINOSAURIA) FROM THE LATE CRETACEOUS OF ALBERTA, CANADA

KOBAYASHI, Yoshitsugu, Hokkaido Univ., Sapporo, Japan; MAKOVICKY, Peter, Field Museum of Natural History, Chicago, IL; CURRIE, Philip, Univ. of Alberta, Edmonton, AB. Ornithomimid dinosaurs are common in Upper Cretaceous sediments of North America, but most are fragmentary and crushed. In the 1990's, beautifully preserved skeletons of two ornithomimids (*Struthiomimus altus* (TMP 90.26.1) from the Horseshoe Canyon Formation and *Ornithomimus edmontonicus* (TMP 95.110.1) from the Dinosaur Park Formation) were discovered in Alberta, providing a better understanding of North American ornithomimids.

Comparisons of these two skeletons with other North American ornithomimid specimens clarify differences between *Struthiomimus* and *Ornithomimus*. These differences are mainly seen in the structures of skull (e.g., skull size relative to femur length, shapes of anterior ramus of the postorbital, dorsal ramus of the quadratojugal, and paraquadratic foramen), arm (e.g., robustness of humerus and relative length of metacarpals and manual unguals), and posterior caudal vertebrae. The unique features of *Struthiomimus* are a small skull relative to femur length and long manual unguals. *Ornithomimus* is diagnosed by an accessory process of the anterior ramus of the postorbital, bifurcated dorsal ramus of the quadratojugal, deep embayment along the posterior border of the quadratojugal for the paraquadratic foramen, and ridge and groove articulation between pre- and postzygapophyses of the posterior caudal vertebrae.

Dromiceiomimus, another ornithomimid genus from North America, was originally diagnosed by proportions of selected elements, but some previous studies suggested that those ratios are not statistically supported and that *Dromiceiomimus* is a junior synonym to *Ornithomimus*. A partial skull of *Dromiceiomimus breviterius* (CMN 12228) shows

Ornithomimus characters (shapes of anterior ramus of the postorbital, dorsal ramus of the quadratojugal and paraquadratic foramen), confirming that *Dromiceiomimus* is synonymous with *Ornithomimus*.

Wednesday 10:15

ENAMEL MICROSTRUCTURE IN *CORYPHODON* AND THE POSSIBLE CORRELATION OF BODY SIZE AND SCHMELZMUSTER

KOENIGSWALD, Wighart, Univ. of Bonn, Bonn, Germany; ROSE, Kenneth, Johns Hopkins Univ., Baltimore, MD; GINGERICH, Philip, Univ. of Michigan, Ann Arbor, MI. Most small mammals (e.g., Lipotyphla, Chiroptera, Apatotheria, and small primates) have only radial enamel. In this body size group, Glires are a remarkable exception, having a modified schmelzmuster in their ever-growing incisors. During the Paleocene and Eocene, most placental lineages independently evolved transversely oriented Hunter Schreger-bands (HSB) as body size increased: e.g., Primates [*Plesiadapis*], Perissodactyla [*Hyracotherium*], Artiodactyla [*Diacodexis*], and Notoungulata [*Colbertia*]. Prism decussation of the HSB protects the enamel from cracking. In the lower Eocene the pantodont *Coryphodon* is by far the largest herbivore, surpassing contemporary *Hyracotherium* and *Diacodexis* by more than two orders of magnitude. The dentition of *Coryphodon* differs from that of the small herbivores in two ways: (1) the molars have better developed high cutting edges; and (2) the enamel microstructure is modified in a very specific way. There is intensive decussation of prisms, but no transverse HSB. It is striking that extant African rhinos and elephants have modified enamel too, showing the 3D-enamel and a vertical arrangement of HSB. This is in contrast to the smaller herbivorous zebras and antelopes. Similar modifications in enamel microstructure have been observed in the giant South American ungulates *Pyrotherium* and *Astrapotherium*, and in the North American brontotheres, chalicotheres, and *Uintatherium*. Most herbivores of smaller body size have transverse HSB.

Certainly body size and enamel microstructure are only weakly correlated, but three size classes may be differentiated: (1) small mammals with radial enamel; (2) mid-sized mammals with transverse HSB; and (3) giants with strongly modified prism decussation. This seems to apply generally to placental mammals, whereas marsupials developed HSB only occasionally.

Friday 9:00

RECONSIDERATION OF TECTONICS-REGIONAL CLIMATE FORCING OF MIOCENE FAUNAL DIVERSITIES IN THE WESTERN UNITED STATES

KOHN, Matthew, Univ. of South Carolina, Columbia, SC; FREMD, Theodore, National Park Service, Kimberly, OR

Reconsideration of the temporal patterns in mammal alpha diversities confirms a correlation we suggested earlier with respect to regional tectonics and climate change. In this study we: 1) consider faunal diversity patterns in four provinces: Great Plains, Pacific Northwest, Mojave, and Rockies, 2) screen for taphonomic and area biases to better characterize alpha-diversities, 3) include ungulates, carnivores and rodents to investigate different correlations with climate parameters, and 4) consider global climate and tectonic drivers of regional climate.

Ungulate diversity increases much more abruptly at ~17.5 Ma than previously recognized (<1 Myr, and possibly not resolvable chronologically); diversity then gradually decreases between 15 and 11.25 Ma and remains static thereafter in the Pacific Northwest. Carnivore diversity essentially tracks herbivore diversity, but with a 0.5 Myr time lag at 17.5 Ma. Rodent diversity remains low until 15.6 Ma, then increases 3-fold by 14.7 Ma and remains high until the present.

At 17.5 Ma, abrupt, widespread extensional tectonism increased topographic diversity and best explains near-coincident increases in ungulate and carnivore diversities. The other trends mainly reflect global influences on regional climate. Atmospheric and ocean circulation patterns shifted to quasi-modern conditions, initiating ~15 Ma with narrowing of Tethys, and strengthening at 11 and 8 Ma with growth of the Tibetan Plateau. These changes yielded a new, progressively intensifying climate regime in western North America—drier conditions overall, greater precipitation seasonality, and warmer winters along the west coast. Correlations between modern faunal diversities and climate show that these changes should yield decreased diversities in large mammals (ungulates) and carnivores, but increased diversities of small mammals (rodents), as observed. Miocene extensional tectonics and plateau formation were main driving forces for faunal diversification, both directly through the generation of topography (17.5 Ma), and indirectly through climate and climate seasonality intermediaries (15-8 Ma).

Poster Session III

NEW MAMMALIAN FAUNA FROM THE EARLY PLIOCENE OF MONGOLIA

KONDRASHOV, Peter, Northwest Missouri State Univ., Maryville, MO; AGADZHANYAN, Alexandre, Paleontological Institute RAS, Moscow, Russia

Significant mammalian specimens were obtained from the Chono-Khariakh locality in northwestern Mongolia during an expedition of the Russian Academy of Sciences in 1997. The fossil-bearing horizons correspond to the upper Khirgis-Nur member, long thought to be of middle-late Pliocene in age, but recently redefined as early Pliocene. Most bones were found in the sand-argillaceous horizon, overlain with a large amount of pebbles. The following mammals were identified: *Sinotherium lagrelii* Ringstrom, 1922; *Gazella* sp.; *Vulpes* sp. nov.; Mustelidae gen. indet.; *Trogontherium cuvieri* Fischer von Waldheim, 1809; *Aratomys multifidus* Zazhigin, 1977; *Trischizolagus* sp.; *Ochotona* ex gr. *O. gigas*

Argyropulo et Pidoplishka, 1939. The newly found *Sinootherium* is of great interest, because it represents the first complete lower jaw of a representative of this genus. The Mongolian *Sinootherium* bears a close resemblance to *S. lagrelii*, previously known only from the early Pliocene in China. Differences include: slightly larger size of the Mongolian specimen and better developed m2-3 hypoconid. Based on the structure of the lower teeth and the jaw we conclude that *S. zaisanense* Bayshashov is a junior subjective synonym of *S. lagrelii* Ringstrom. Apparently *Sinootherium* was rather widely distributed in Asia in early Pliocene ranging from China and Mongolia to Kazakhstan.

Trischizolagus is a rare lagomorph with an advanced p3 structure that is known from the Pliocene of Romania and the Narnus hipparion fauna from Armenia and represents the first occurrence of the genus in Mongolia. Of additional interest is occurrences of a poorly known archaic vole—*Aratomys*, known only from the Chono-Khariah locality. *Aratomys* does not have tooth cement and retains tooth roots. The lower incisor in this species passes ventral to the anterior m3 root and its root emerges posteriorly behind the latter. *Aratomys* shows some resemblance to North American *Ogmodontomys*. Taken together the faunal composition indicates the age of the deposits to be late early Pliocene.

Marine Reptiles Symposium, Wednesday 5:45

RE-DIAGNOSIS OF *PLATECARPUS PLANIFRONS* (COPE, 1874) (SQUAMATA: MOSASAURIDAE) AND A REVISED TAXONOMY OF THE GENUS

KONISHI, Takuya, CALDWELL, Michael, Univ. of Alberta, Edmonton, AB, Canada

One of the most enigmatic species of *Platecarpus* from the Western Interior Seaway of North America (Upper Santonian-Lower Campanian), *P. planifrons*, has been re-diagnosed based on the one of the most completely-preserved cranial specimens of the genus, UALVP 24240, along with the other less complete specimens that are assignable to the species. The species is definitively distinguishable from any other congener from North America according to the following diagnosis: clear separation of prefrontal and postorbitofrontal on ventral surface of frontal, transverse distance of preorbital region of frontal greater than interorbital distance, dorsal surface frontal planar lacking mid-sagittal keel, presence of paired posteromedian flanges on frontal, anterodorsal border of quadrate distinctly notched posteriorly, and stapedial pit narrow and keyhole shaped. In addition, UALVP 24240 provides the first evidence of the presence of a pair of septomaxillae in the genus, posteriorly forming the floor of the nasal cavity.

Once considered *nomen vanum*, the newly gained osteological data based on these specimens of *P. planifrons* not only re-establish the validity of the taxon, but also provides some opportunity to re-examine the current taxonomy of the genus found in the seaway. Based on our data, we support the synonymization of *P. coryphaeus* with *P. ictericus*, while retaining the latter taxon as a distinct species from the generic type, *P. tympaniticus*, which lacks a significant amount of diagnosable characters to the species level. *Platecarpus* cf. *P. somenensis* from the Pierre Shale Formation is tentatively retained for its taxonomical recognition; in consequence, we recognize four species of *Platecarpus* in North America.

Poster Session I

SHED TEETH AS INDICATORS OF AGE DEMOGRAPHICS IN POPULATIONS OF HADROSAURS

KRAUSS, David, CUNY, New York, NY; RESHANOV, Alexandra, Borough of Manhattan Community College, New York, NY

A persistent question in dinosaur paleobiology is that of the age structure of dinosaur populations. Rare finds of dinosaur herds provide some insight to this issue. Here we present a statistical method that can provide more insight across a wider spectrum of area and species. It is well established that hadrosaurs shed their teeth as they are worn down and that shed teeth are frequently encountered in appropriate sediments. By analyzing the size distribution of teeth found in sediment samples it is possible to gain information about the age structure of hadrosaur populations. Analysis of hadrosaur tooth-bearing bones in museum collections established that larger individuals have larger teeth and shed them at a larger size ($p < .0001$ in linear regression analysis). This correlation is empirical, but was not established in the literature. By measuring teeth still in place and gaps in tooth rows from shed teeth we established that this relationship exists both within and across hadrosaur species. The size distribution of hadrosaur teeth collected from sediment samples was significantly different from that of hadrosaur jaws of any specific size range in museum collections. These data indicate that the shed teeth in the sediments reflected the population as a whole. Size fractionation does not appear to be a problem as all sizes were collected within the same sites and collection methods were designed to accommodate all size categories of shed tooth. Our results suggest a preponderance of mid-size to large individuals and relatively few very large and small individuals. Such an age distribution suggests a stable population with a low replacement rate typical of k-selected species. A possible confounding factor is that larger animals have more teeth and thus should shed teeth more frequently. This pattern would produce a preservation bias towards older individuals and so the population may be younger than our results indicate. Nonetheless we feel that this analysis provides important insights into the population dynamics of hadrosaurid dinosaurs and may be applicable across a wider taxonomic range.

Poster Session III

DIVERSITY AND BIOGEOGRAPHY PATTERNS OF LATE JURASSIC NEOSELACHIANS (CHONDRICHTHYSES, ELASMOBRANCHII)

KRIWET, Juergen, KLUG, Stefanie, Palaeontology, Berlin, Germany

The regional diversity and biogeographic patterns of Late Jurassic neoselachians at genus level in Europe were analysed. The fossil record of neoselachians, as expressed by the simple completeness metric (SCM), is quite good in the Late Jurassic with a peak in the Kimmeridgian. We also calculated origination, extinction, diversification, and turnover rates. The observed diversity fluctuations are related to normal background originations (Oxfordian, Kimmeridgian) and background extinctions (Tithonian). The decline in diversity at the end of the Jurassic is not related to an extinction event but is the expression of missing sediments; the latest Jurassic to Berrisian was a time of major regressions.

During the Late Jurassic, an obvious reduction of biogeographic diversification is apparent from the Oxfordian to Tithonian. The more or less uniform faunal compositions, especially in the Kimmeridgian, are related to uniform palaeoclimatic conditions, which were warm and humid, sea level high stands, and absence of important physical barriers in central and northern Europe. The opening of the Bay of Biscaya Rift had a great influence on the ocean currents and acted as a physical barrier reducing the possibilities of faunal exchanges.

The degree of endemism is highest in the Oxfordian and decreases continuously towards the Tithonian. Our analyses indicate that the distribution of Late Jurassic neoselachians is the result of vicariance and subsequent endemisms but also of dispersal events. Consequently, parsimony analyses of endemism, which assume vicariance being the predominant process for organism distributions fails to provide an accurate sketch of faunal and area relationships.

The results indicate that (1) neoselachians in the Late Jurassic are still underexplored and their true diversity is far from being completely known and (2) neoselachian occurrences are usually reported on rather large spatial and temporal scales. The limited data sets and inaccurate faunal descriptions continue to form a serious problem in analysing past diversity and biogeographic patterns of sharks.

Poster Session II

A VARIATION ON THE PADDED PLASTER JACKET FOR HOUSING VERTEBRATE FOSSILS

KROEHLER, Peter, Smithsonian Institution, Washington, DC

The Smithsonian Institution's Vertebrate Paleontology Lab has been constructing housing for its large fragile vertebrate fossils using a method described by Jabo, et al. for a number of years. This method has worked well and hundreds, if not thousands, of jackets have been constructed in this manner. This poster will show another now acceptable method of construction using polyethylene felt as the padding/lining instead of the polyethylene foam previously described. The new method eliminates a few of the time consuming gluing and clay rolling steps. Samples of the new lining material will be shown at the poster and a limited number of samples will be available. Suppliers names will be provided (though not endorsed) by the author.

Student Poster Session

ORNITHOPODS OF THE WAYAN FORMATION (ALBIAN) OF EAST IDAHO: A RE-EVALUATION OF THE DINOSAURIAN FAUNA

KRUMENACKER, L.J., Idaho Museum of Natural History, Pocatello, ID

The dinosaurian fauna of the middle Albian Wayan Formation of east Idaho appears to be somewhat different from other Albian faunas of North America. As is typical for the Cretaceous, this fauna is ornithopod dominated; but by smaller ornithopods (possibly representing two taxa), rather than larger ones.

Despite previous reports, there is no postcranial evidence for a *Tenontosaurus*-like iguanodont in the Wayan fauna. The associated skeleton previously reported as such belongs to an armored ornithischian. The only evidence for a *Tenontosaurus*-like animal comes from a single worm tooth recovered in the 1980's.

The vast majority of ornithopod fossils come from small, long tailed, gracile animals similar to *Hypsilophodon*, *Orodromeus*, and *Zephyrosaurus*. Remains commonly occur as very fragmentary appendicular skeletal elements associated with partially articulated or associated vertebrae. Elongate caudal vertebrae have ventral grooves, lateral ridges, and distinct hexagonal articulations. Caudals are commonly associated with or encased in hypaxial and epaxial tendons. Previous reports suggested the presence of abundant dromaeosaurids in the Wayan, but it now appears more probable that the reputed dromaeosaur material belongs to these small ornithopods.

An enigmatic collection of associated caudal vertebrae may represent a second ornithopod type. These vertebrae come from an animal somewhat larger than the more common smaller ornithopod type. Caudals have circular articulations with tall, thin neural spines. Distinct lateral grooves are present on the mid-caudals. Ossified tendons entirely encase the vertebrae and neural spines. This animal is the largest probable ornithopod for which there is postcranial evidence from the Wayan.

Wednesday 3:45

THE PHYLOGENY OF LIVING AND FOSSIL SPHENISCIFORMES (PENGUINS)

KSEPKA, Daniel, Division of Paleontology, American Museum of Natural History, New York, NY; BERTELLI, Sara, Natural History Museum of Los Angeles County, Los Angeles, CA; NORBERTO, Giannini, Dept. of Mammalogy, New York, NY; CLARKE, Julia, Dept. of Marine, Earth and Atmospheric Sciences, Raleigh, NC

The Sphenisciformes have an exceptional fossil record by avian standards. Fossil penguins offer insight into the transition from aerial to underwater flight, gigantism in birds and the interplay between avian distribution and Gondwanan break-up. We compiled a matrix of 210 morphological characters as well as sequence fragments from 5 genes (12S, 16S, COI, cytochrome b, RAG-1) and sampled 20 fossil and 17 living ingroup taxa to reconstruct the evolutionary relationships of penguins. Despite large percentages of missing data in several fossil taxa, combined analysis using POY 3.11 yielded a largely resolved strict consensus cladogram.

Our results place *Waimanu* as the most basal penguin genus. Three small fossil penguins and two clades including the giant fossil penguins *Anthropornis* and *Pachydyptes* occupy other basal branches of the penguin tree. The interrelationships of these taxa indicate major shifts in body size occurred during early penguin evolution. Further up in the tree, an alternating pectinate arrangement of fossil taxa from the South American and Australian quadrants of the Southern Hemisphere reveals dispersal between these areas was common throughout the Tertiary. Nearly all included fossil taxa fall outside of the crown clade Spheniscidae, suggesting the modern penguin fauna is the result of a successful radiation of derived forms rather than an assemblage of survivors from numerous lineages. Many derived cranial features correlated with diet in living penguins are restricted to the Spheniscidae. *Aptenodytes* is the basal extant genus in the combined result, but *Eudyptula*+*Spheniscus* form the basal divergence within Spheniscidae when only morphology is considered. This is largely the effect of different rootings the extant penguin subtree supported by molecular vs. morphological data. Our results do not support an expansion of crown penguins out of a deteriorating Antarctica, but instead suggest that penguins currently breeding on Continental Antarctica have recolonized the area.

Poster Session II

REEXAMINATION OF *ADASAURUS MONGOLIENSIS* (DINOSAURIA: THEROPODA) FROM THE UPPER CRETACEOUS NEMEGT FORMATION OF MONGOLIA

KUBOTA, Katsuhiko, Graduate School of Life and Environmental Sciences, Univ. of Tsukuba, Tsukuba, Ibaraki, Japan; RINCHEN, Barsbold, Geological Institute, Mongolian Academy of Science, Ulaan Baatar, Mongolia

Adasaurus mongoliensis from the Upper Cretaceous Nemegt Formation of Bugin Tsav, southwestern Mongolia, was described based mainly on pelvic and pedal elements in 1983 and was originally diagnosed by highly reduced pedal ungual II-3. *Adasaurus mongoliensis* has been referred as a member of dromaeosaurids, but its phylogenetic position within Dromaeosauridae remains unresolved. In this study, its holotype (MPD 100/20, a posterior portion of skull and postcranial skeleton, missing dorsal ribs, forelimbs, and some pedal phalanges) and referred specimens (MPD 100/21, two caudal vertebrae and right foot) are reexamined and compared with other dromaeosaurids.

Preliminary phylogenetic analysis in our study indicates that *Adasaurus mongoliensis* shows affinities with another Mongolian dromaeosaurid, *Velociraptor mongoliensis*, in having fused scapulocoracoid and distal tarsals fused with metatarsals. Differences between *Adasaurus mongoliensis* and *Velociraptor mongoliensis* are expanded maxillary process of jugal, paroccipital process with straight dorsal edge, and pleurocoels on only anterior sacra. *Adasaurus mongoliensis* can be distinguished from other dromaeosaurids in having a low dorsal ridge on median frontals (continuous with sagittal crest on parietals), large surangular foramen, and notched anterior margin of preacetabular process as well as reduced ungual of pedal digit II. Our study suggests that a ventral surface of proximovertebral heel on the penultimate phalanx has no asymmetrical ridges like other dromaeosaurids and troodontids (Deinonychosauria), supporting that the use of pedal ungual II-3 is different from that of other deinonychosaur theropods.

Vertebrate Development Symposium, Wednesday 8:15

DEVELOPMENTAL FACTORS BEHIND THE EVOLUTIONARY NOVELTIES OF VERTEBRATES

KURATANI, Shigeru, Center for Developmental Biology, RIKEN, Kobe, Japan

Genes involved in specification and patterning of global structures such as pharyngeal arches and neuromeric compartments in the vertebrate pharyngula tend to be upregulated in conserved spatiotemporal patterns: homologous genes are often associated with morphologically homologous cell populations and primordia as typically seen in the Hox code. Emergence of evolutionary innovations, on the other hand, can be viewed as changes introduced into the developmental program, resulting in acquisition of new developmental patterns that never existed in ancestors. It does not necessarily mean, however, that generation of novel genes is a prerequisite for the novel structures. Instead, homologous sets of regulatory genes can be recruited to different sites of developmental stages. Thus homologies of genes and morphological patterns are primarily uncoupled. Thus, evolutionary novelty is often obtained by heterotopic and heterochronic shift of gene regulations or tissue interactions that lead to loss of morphological novelties. I will use the acquisition of the jaw in gnathostomes and shells in turtles as examples of evolutionary novelties in verte-

brates, and will show how these phenomena can be explained as result of shift of tissue interactions and folding of tissues.

Romer Prize Session, Thursday 9:45

QUANTIFICATION OF THE EXTENT OF DIAGENESIS IN BIOGENIC APATITE OF CENOZOIC SHARK CENTRA

LABS HOCHSTEIN, Joann, Florida Museum of Natural History, Gainesville, FL

Diagenesis of bone during fossilization is pervasive, however, the extent of this process varies with depositional environment. This study quantifies diagenesis of shark vertebral centra through analysis of a suite of physical and chemical characters. Although shark skeletons are initially cartilaginous, the soft cartilage of the vertebral centra is replaced with carbonate hydroxyapatite during the growth of the individual. Nine vertebral centra are analyzed from Lamnoidea ranging in age from the Cretaceous to Recent using Fourier Transform Infrared Spectroscopy (FT-IR) and Inductively Coupled Plasma Mass Spectrometry (ICPMS). The variables Cl, carbonate content, rare earth element (REE) concentrations, (La/Yb)_N vs. (La/Sm)_N, La/Yb, and Ce anomalies, elucidate the diagenetic and depositional environments of the seven fossil vertebral centra. The two extant centra demonstrate the initial, unaltered end-member conditions for these variables. Two fossil vertebral centra (*C. megalodon* and *I. hastalis*) demonstrate a strong terrestrial influence during diagenesis (distinctive flattening of shale-normalized REE patterns) that masked the seawater signal. Three centra (*C. auriculatus*, *C. angustidens*, and *C. mantelli*) have indications of some terrestrial influx evident by some flattening of the REE patterns relative to seawater. The terrestrial influence in these five shark centra (*C. megalodon*, *I. hastalis*, *C. auriculatus*, *C. angustidens* and *C. mantelli*) are interpreted to represent a primarily nearshore habitat for these species. In contrast, the two *O. obliquus* centra have REE patterns that represent the original seawater signal and have no indications of terrigenous input. These results indicate that fossil shark vertebral centra have the potential to understand diagenesis and reconstruct paleoceanographic environments.

Wednesday 1:45

AN EMERGING FOSSIL BIOTA FROM THE EARLY CRETACEOUS OF NORTH-WESTERN CHINA

LAMANNA, Matthew, Carnegie Museum of Natural History, Pittsburgh, PA; LI, Da-Qing, Third Geology and Mineral Resources Exploration Academy of Gansu Province, Lanzhou, China; YOU, Hai-Lu, Ji, Qiang, Chinese Academy of Geological Sciences, Beijing, China; HARRIS, Jerald, Dixie State College, St. George, UT

In 2004 and 2005, cooperative Chinese-American field efforts recovered abundant and often beautifully preserved plant, invertebrate, and vertebrate fossils from lacustrine deposits of the Lower Cretaceous Xiagou Formation exposed near the town of Changma in Gansu Province, northwestern China. Although the precise age of the Xiagou Formation is presently unresolved, it is probably slightly younger than the early Aptian Jiufotang Formation of northeastern China, as it contains several forms characteristic of the Jehol Biota (e.g., the insect *Ephemeropsis trisetalis*) but lacks others (e.g., the fish *Lycoptera*). Moreover, the Xiagou Formation overlies the Chijinpu Formation, which yields *Lycoptera* as well as other representative Jehol Biota taxa.

Megafloral remains recently recovered from the Xiagou Formation have not yet been studied in detail, but most appear to pertain to ferns and conifers. Invertebrate fossils include ostracods, conchostracans, and a diversity of insects. Vertebrate material from the Xiagou Formation includes numerous osteichthyans, a salamander and turtle each represented by a nearly complete skeleton, and dozens of avian specimens, many preserving soft tissues (feathers or skin impressions). Bird specimens prepared to date include several enantiornithine partial skeletons and over 30 fragmentary to nearly complete ornithuromorphs. The overwhelming majority of the latter are referable to the basal ornithuran *Gansus yumenensis*, and collectively represent all parts of its skeleton except for the skull, yielding significant new insight into the anatomy of this taxon.

Analyses of many of these new fossils from the Xiagou Formation are still in their initial stages. However, as the Changma assemblage becomes better characterized, it will enable comparisons with the celebrated, nearly coeval Jehol Biota, and greatly improve our understanding of Early Cretaceous paleoecosystems in central Asia.

Friday 1:45

A RELATIVE OF THE BELUGA AND NARWHAL (ODONTOCETI, MONODONTIDAE) FROM THE EARLY PLIOCENE OF THE NORTH SEA

LAMBERT, Olivier, Institut royal des Sciences naturelles de Belgique, Brussels, Belgium; GIGASE, Pierre, Antwerp, Belgium

The odontocete family Monodontidae includes two modern species: the beluga *Delphinapterus leucas* and the narwhal *Monodon monoceros*; both species are geographically limited to the cold Arctic Ocean and adjoining seas. The fossil record of the family is poor: one species *Denebola brachycephala* from the latest Miocene of Mexico, monodontid ear bones from the early Pliocene of Peru, and an undescribed skull and ear bones referred to *Delphinapterus* sp. from the early Pliocene of the east coast of USA.

A fragmentary skull with atlas and axis discovered in the early Pliocene (5.0-4.4 Ma) of Antwerp (North of Belgium, southern margin of the North Sea Basin) clearly belongs to a Monodontidae, based a. o. on the dorsal exposition of the maxilla along the bony naris, the anterior position of the supraorbital process of the frontal and the related longitudinally elongated temporal fossa. The skull, with a size somewhat smaller than the adult beluga,

bears predation/scavenging marks likely inflicted to the animal by a large shark.

From an ecological point of view, this new record indicates a much wider latitudinal distribution for the early Pliocene Monodontidae (from the warm tropical waters off Peru to the cool-temperate North Sea) than for the Arctic to sub-Arctic modern beluga and narwhal. The shift to the North Sea was achieved before or during the first steps of the strengthening of the Gulf Stream related to the progressive closure of the Isthmus of Panama (from ca. 4.7 Ma). More generally, the oldest reliable records of crown-Delphinoidea (Delphinidae + Monodontidae + Phocoenidae) date from the late to latest Miocene in the east Pacific Ocean, while crown-Delphinoidea are first discovered in the North Atlantic realm during the Early Pliocene. This chronological gap suggests an origin of the group in the Pacific Ocean and a subsequent migration across the Panama Seaway, a hypothesis that should be tested with a more detailed late Miocene odontocete record in the North Atlantic.

Poster Session III

BOOTSTRAP RESAMPLING AND THE STATUS OF THE FOSSIL PENGUINS *PALAEOSPHEINISCUS GRACILIS*, *P. PATAGONICUS* AND *P. WIMANI*

LAMM, Kristin, KSEPKA, Daniel, American Museum of Natural History, New York, NY
The fossil penguins *Palaeospheniscus gracilis*, *P. patagonicus* and *P. wimani* are known from the Miocene of Patagonia. Relative size alone distinguishes these three taxa from one another—*P. gracilis* is the smallest, *P. patagonicus* is intermediate and *P. wimani* is the largest. This diagnostic criterion assumes that the size variation between any two of these fossil species exceeds the range of size variation within any extant penguin species. However, this assumption has not been adequately explored using quantitative methods. We assess the probability of sampling a set of *n* individuals from a given extant penguin species whose size variation is greater than that in a sample of *n* individuals from these fossil taxa. If the fossil record represents a random and independent sample, then these random samples approximate potential “fossil samples” for the extant penguins. The humerus, radius, ulna and tarsometatarsus are used to examine size variation, and the geometric mean is taken as the size variable for each skeletal element. For each element, 1000 samples of *n* geometric means are randomly selected with replacement from each of the extant penguin species considered. Coefficients of variation (CVs) and max/min ratios are calculated for each sample. For each element and each extant species, we assess the probability of obtaining a CV or max/min ratio equal to or greater than that of each pair of fossil species. If the size variation between the extinct species does not significantly exceed that within the extant reference group ($p > 0.05$), then variation in size alone is not a sufficient criterion for assigning these specimens to different species.

Vertebrate Development Symposium, Wednesday 11:15

DEVELOPMENTAL MECHANISMS IMPLICATED IN THE EVOLUTION OF THEROPOD-AVIAN TAIL REDUCTION

LARSSON, Hans, EBN-AL-NASSIR, Ardeshir, MORISON, Stephen, BURE, Lionel, McGill Univ., Montreal, QB, Canada

The evolution of the short tail skeleton of birds was achieved during the evolution of their dinosaurian ancestors and throughout basal birds. Tails were reduced from over fifty vertebrae to only five to eight free vertebrae in modern birds. Modern bird embryos were examined to illuminate the early patterning of the tail skeleton. Mesenchymal condensations that establish initial endoskeleton patterns were visualized in early developing chick embryos. These condensations indicate that a large number of vertebrae are present initially but only some later chondrify and even less ossify. Some of the developmental mechanisms responsible for vertebrate tail development were examined in developing chickens and alligators and compared to those acting in known model species. A model of the evolution of developmental mechanisms that may be responsible for theropod tail reduction is presented based on the fossil record of theropods and the development of modern birds.

Poster Session II

REVIEW OF THE BRAZILIAN ICHTHYODECTIFORMES

LEAL, Maria Eduarda, ALVARADO-ORTEGA, Jesús, BRITO, Paulo, Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil

In Brazil the Order Ichthyodectiformes is well represented in Lower Cretaceous sediments and they start to be described since 1841. Today, at least three genera belonging to the sub-order Ichthyodectoidei are recognized in the country: *Saurocephalus*, *Cladocyclus*, and *Chiomystus*. The validity of a fourth genus, *Itaparica*, is now under study. Once *Chiomystus* and *Itaparica* were located as synonymus of *Cladocyclus*; however, recent phylogenetic analysis shows that the latter is a basal form of the most derived Ichthyodectiformes including *Saurocephalus*, among others. *Chiomystus* and probably *Itaparica*, characterized by a low amount of vertebrae (40-50), are located among the most primitive ichthyodectoids. The review *Cladocyclus* is Brazilian ichthyodectiform and it has been described from many localities by diverse authors. The review of this record of *Cladocyclus* into the collection of the DNPM allows recognizing the presence of a new species (and probably new genus) related to *Chiomystus*. This new species differs from *Chiomystus* because it has about 60 vertebrae but both shares the position of the pelvic fin in the middle of the body, a primitive feature does not present in *Cladocyclus*.

Friday 11:30

EVOLUTION OF RAPID LIMB GROWTH AND VASCULAR CANAL ORGANIZATION IN CERATOPSIDAN DINOSAURS

LEE, Andrew, Univ. California, Berkeley, Berkeley, CA

Ceratopsian dinosaurs are common in the Late Cretaceous deposits of Asia and North America, yet relatively little is known about their skeletal growth dynamics. To assess how rapidly ceratopsians achieved skeletal maturity as well as to understand the relative importance of phylogeny, ontogeny, and mechanics on bone microstructure, a histological analysis of the limb bones of *Psittacosaurus*, *Protoceratops*, and *Centrosaurus* was performed. Skeletal maturity required 8 to 13 years in *Psittacosaurus*, about 7 years in *Protoceratops*, and 6 years in *Centrosaurus*. In those ceratopsians, the presence of cyclical annuli suggests that limb bone growth did not abruptly stop but slowed towards the end of each growth cycle. Vascular canal organization also provides evidence of rapid growth. Radial vascular canals, which are found in some rapidly growing amniote bones, are common in the limbs of yearling *Psittacosaurus* and *Protoceratops* but are replaced by reticular or longitudinal canals during subsequent years of growth. In *Centrosaurus*, radial canals dominate the beginning of each growth cycle, and that pattern continues through the third year of growth after which canals are generally longitudinal. Repeated deposition of radial vascular canals correlates with accelerated limb growth in ceratopsians and suggests the relative importance of ontogeny over mechanics in vascular canal organization.

Poster Session II

NEW PTEROSAUR TRACKS FROM THE HASANDONG FORMATION (LOWER CRETACEOUS) OF HADONG COUNTY, SOUTH KOREA

LEE, Yuong-Nam, LEE, Hang-Jae, Korea Institute of Geoscience and Mineral Resources, Daejeon, South Korea

New pterosaur tracks were discovered in the Hasandong Formation (Aptian) at an abandoned quarry of Hadong County in 2004. A total of 50 pterosaur footprints are preserved as natural casts on a big black shale slab (70 x 50 cm). Footprints consist of isolated 25 manus and 25 pes prints, indicating the quadrupedal locomotion. The average manus length and width are 25.6 mm and 12.3 mm, respectively. The manus prints are asymmetric, with three digit imprints. The first digit imprint is anterolaterally oriented and is the shortest. The second and third digit imprints are posterolaterally orientated. The average pes length and width are 25.7 mm and 12.8 mm, respectively. The pes prints are triangular, elongate and fully plantigrade. They are tetradactyl with anterior claw marks. The first digit impression (average 8.9 mm) is shorter than digits II-IV, subequal in length. The metatarsals are long and elongate which are always longer than digits. It is difficult to trace complete trackways due to lack of consecutive manus-pes footprints. Nevertheless, in a complete manus-pes set, the pes print is anterior to the manus print and the latter is located further from the mid-line than the former. Hadong pterosaur tracks are distinguished from *Haenamichnus uhangriensis* reported in the Uhangri Formation (Upper Cretaceous) of Haenam County, Korea in terms of the size and morphology.

Student Poster Session

DETERMINING CURSORIALITY OF MID-TERTIARY MAMMALS THROUGH DISTAL/PROXIMAL LIMB BONE RATIOS

LEVERING, David, Univ. of Oregon, Eugene, OR

The ratio between proximal long bones (humerus or femur) and distal long bones (ulna or tibia) is a measure of running ability (cursoriality). In increasingly open and grassy habitats of the mid-Tertiary, cursoriality has been considered an adaptation to running escape from increasingly fleet-footed predators, and increasing locomotor efficiency at distance. Limb long bones of fossils and some living mammals were measured in the collections of the Condon Collection of the Univ. of Oregon, Univ. of California Museum of Paleontology in Berkeley and John Day Fossil Beds National Monument at the Condon Center. These data were supplemented with an array of published data for living and fossil mammals, where living mammal data were used as a scale for determining cursorial capacity in fossil taxa. Measurements of mid-Tertiary fossil sabertooths (Nimravidae), oreodonts (Oreodontidae), and horses (Equidae) show that predators showed less elongation in the distal portion of the forelimb than prey, regardless of size. Hindlimbs display markedly less distal long bone lengthening than forelimbs in both predator and prey. This difference between hindlimb and forelimb ratios gave some mammals much greater running stride than others, and may be due to biomechanical advantage of keeping the back straight while running, which is reflected also in adaptations of vertebrae of modern running mammals.

Marine Reptiles Symposium, Wednesday 4:00

AN UNUSUAL ARCHOSAURIAN FROM THE MARINE TRIASSIC OF CHINA

LI, Chun, Institute of Vertebrate paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, China; WU, Xiao-chun, Canadian Museum of Nature, Ottawa, ON, Canada; WANG, Liting, Guizhou Geological Survey, Guiyang, China; SATO, Tamaki, National Science Museum, Tokyo, Japan; CHENG, Yen-nien, National Museum of Natural Science, Taichung, Taiwan, ROC

Archosauria (=Archosauriformes in some publications) originated in the Late Permian and later gave rise to dinosaurs (including birds), pterosaurs, and crocodylomorphs (including extant crocodylians). Its early members, traditionally called “thecondons”, flourished worldwide during the Triassic, and have been long considered terrestrial. Archosaurian remains have been reported from Triassic marine strata before but most are believed to be the

remains of terrestrial animals washed out to sea. *Sikannisuchus* and a few of European phytosaurs (such as *Mystrisuchus*) from the marine Upper Triassic are considered to be specialized toward marine life. Here we report a new Triassic archosaurian which, together with fishes, nothosaurs, protosaurs and ichthyosaurs, has been collected recently from the Middle Triassic marine limestone in west Guizhou, China. The new archosaurian is well represented by articulated skeletons with skulls.

The new archosaurian shows a number of aquatic specializations, of which the most striking is the extreme lateral compression of the long tail. Others that may also reflect aquatic adaptations include plate-like scapula and coracoid, elongate neck with extremely long and slender ribs, and reduction of osteoderms. These indicate that the new form was more aquatic than any of other known taxa among the Triassic archosaurians. In contrast, its pelvic girdle and hindlimb of the new archosaurian have no aquatic modifications. Anatomic features, taphonomy and local geological data suggest that the new form may have lived in a coastal-island environment. This life style, convergent with some Jurassic marine crocodyliforms that lived at least 40 million years later and the saltwater species of extant *Crocodylus*, contradicts with the prevailing view that Triassic archosaurians were restricted to non-marine ecosystems. Its mosaic anatomy represents a previously unknown ecomorph within primitive archosaurians.

Poster Session II

AN OVERVIEW OF VERTEBRATE PALEONTOLOGY IN NORTHERN CALIFORNIA: KNOWN LOCALITIES, TAXA, AND FUTURE POTENTIAL

LIGGETT, Gregory, Northern California Natural History Museum, Chico, CA

Northern California contains relatively few fossiliferous outcrops. Those that exist are interspersed among the remote and rugged igneous and metamorphic landscape that rings the Sacramento Valley. Northern California is arbitrarily defined here as the northern-most 28 counties of the state, the roughly 55,000 square miles north of Sacramento, approximately equal to the state of New York. Most of the organized collecting activity in northern California has taken place during the late 19th and the first half of the 20th centuries. In more recent decades only a handful of collectors have scoured the region for vertebrate fossils.

Despite its intermittent history of collecting, the region has produced many significant vertebrate paleontology localities covering a wide geologic time span: Triassic, Jurassic, Cretaceous, Eocene, Miocene, Pliocene, and Pleistocene aged localities are known. Some notable holotypes from the region include the enigmatic *Thalattosaurus alexandrae* and the ichthyosaur *Shastasaurus pacificus* from the Triassic; the Jurassic ichthyosaur *Ichthyosaurus franciscus*; and the Quaternary bear *Arctodus simus*.

A compilation of the vertebrate sites of northern California was produced as a preliminary step in developing a deeper understanding and characterization of the vertebrate paleontology resources of the region. Vertebrate fossil localities were compiled primarily using the University of California Museum of Paleontology Web site and a detailed literature review. A Geographic Information System (GIS) database focusing on northern California was initiated. The locality data layer helps to clarify the spatial relationships between localities, and will be used in conjunction with additional data layers to create a paleontology potential map to target areas for future exploration.

Student Poster Session

FOSSIL SPEAK: CONTROVERSIAL CONCEPTS OF DEEP TIME AND CHANGE THROUGH TIME PRESENTED TO STUDENTS THROUGH THE STRONG EVIDENCE OF THE FOSSIL RECORD

LINDSAY, Thomas, Portland State Univ., Portland, OR

"Life of the Past" is a survey of life as evidenced by the fossil and rock record. It is used for upper division and graduate students to meet a general science with a lab requirement for non-BS geology majors. The major themes of the class are the evidence for the advent and evolution of life, transitional species, conceptualization of deep time, the correlation of climatic, volcanic and other conditions at times of major extinctions, and the geological concepts which support the occurrence and distribution of the fossil record. According to NSF, 44% of people surveyed on biological evolution and the "big bang" accepted these concepts. This class has the opportunity to present strong evidence in the rock and fossil record of these scientific concepts to students. I have conducted two of three proposed treatments to examine student conceptualization of the themes listed above to evaluate which factors are most conducive to student learning. Treatment one is a condensed summer class with 16 participants in 2005 and an unknown number of students in 2006, in which the lecture and lab times are reduced, and in their stead, students participate in two on-site fossil locations found in Oregon. The second treatment is a full lecture and lab with 56 students from both winter and spring terms of 2005/2006, but the course does not include fieldtrips. Dodick and Orion developed the GeoTAT assessment, which has correlated geologic skill and cognitive skill in a series of questions. The GeoTAT questions were linked to the pedagogy that addressed that particular question. Students took a pre-assessment the first week of class, and a post-assessment on the last day of class. Paired Student-*t* test was used to evaluate the pre- and post-assessments by student. The results were then compared to the geologic skill, cognitive skill and the pedagogy that addressed those concepts to elucidate what combination of pedagogical approaches gained significant results. This approach also revealed concepts that were most difficult for student comprehension, as revealed by non-significant results.

Student Poster Session

LIMB BONE SCALING IN DINOSAURS

LINTON, Deborah, The Natural History Museum, London, United Kingdom

Previous work by Carrano compared scaling in the long bones of dinosaurs with those of mammals, to look for describe and explain scaling patterns relating to body size and posture. No attempt was made in that paper to separate the major divisions within the Dinosauria, which could cloud the possible causes of any observed differences with mammalian scaling.

In order to establish whether the posture has a different effect on limb bone scaling within the Dinosauria, Reduced Major Axis regression analysis was performed a dataset consisting of this same data and supplemental measurements obtained separately. Length was regressed against diameter for humeri and femora for the Theropoda, Sauropoda, and three postural groups within the Ornithischia.

Forelimbs tended to scale more negatively for bipedal forms than quadrupedal: lengths increase at a faster rate compared to diameter in bipeds and semi-bipeds than in quadrupeds. This is in accordance with Carrano's observation of the same, but the tendency is more pronounced in theropods than ornithischians.

In the hindlimb, however, the greatest distinction was between the taxonomic groups: saurischian hindlimbs scale more negatively than ornithischian of any posture, implying that there is some sort of taxonomic constraint having a greater effect on the rate of hind limb scaling than posture alone.

Friday 8:30

A NEW DINOSAUR SUPERTREE AND THE UTILITY OF LARGE TREES IN MACROEVOLUTION

LLOYD, Graeme, Univ. of Bristol, Bristol, United Kingdom; DAVIS, Katie, Univ. of Glasgow, Glasgow, United Kingdom; BENTON, Michael, Univ. of Bristol, Bristol, United Kingdom; PISANI, Davide, National Univ. of Ireland, Co. Kildare, Ireland

Evolution occurs along the branches (not across the tips) of a phylogenetic tree, but that tree must be as comprehensive as possible in order to provide an adequate framework to answer macroevolutionary questions. Here a 'supertree' approach (which combines the information contained in source trees that have overlapping taxon sets) is applied to the Dinosauria. Supertree methodology has gained greater sophistication since its inception and new methods applied here included filtering criteria (which removed redundant source trees), node-based higher taxon substitution and multiple supertree construction algorithms (e.g. MRP/F, triplet/quartet fit). In total 147 source trees (after filtering) were used, spanning over half (377) of all valid non-avian dinosaur species. Due to the size of the dataset analyses were performed on a supercomputer array.

Lack of resolution in the resulting supertrees was attributed in part to problematic taxa, which provided insufficient information concerning their placement. Remaining uncertainty was due to conflict between source trees and was concentrated amongst maniraptoran theropods, a historically problematic group. An objective criterion (stratigraphic fit) was used to select a fully resolved tree for subsequent analyses. These included palaeobiogeographic, body size, diversification rate and ghost range analyses. Overall the various dinosaur clades show divergent trends of dispersal ability, body size change and speciation rate, but are all similarly constrained by the fossil record.

An alternative approach to constructing large phylogenies is the 'supermatrix' method, where source matrices rather than their resulting trees are combined. Here such an approach was applied to maniraptorans in an attempt to better resolve their interrelationships. Additionally the use of morphological characters enabled analysis of character acquisition along the branch leading to birds. Here a 'ground-up' rather than a 'trees-down' model is more parsimonious.

Poster Session III

THE LATE EOCENE MAMMALIAN FAUNA OF THE FLORISSANT FORMATION, CENTRAL COLORADO, INCLUDING THE DISCOVERY OF A NEW INSECTIVORAN

LLOYD, Karen, EBERLE, Jaelyn, Univ. of Colorado at Boulder, Boulder, CO

Renewed collecting of fossil vertebrates in the Upper Eocene Florissant Formation in Florissant Fossil Beds National Monument, central Colorado, has nearly tripled the number of mammalian taxa from this rock unit. Here we report the eomyid rodent *Paradjidaumo trilophus*, the lagomorph *Palaeolagus*, and the rare artiodactyl *Pseudoprotoceras longinarius*. The Florissant mammalian fauna corroborates the Chadronian (latest Eocene) age determined by others, with many occurrences representing southwestward geographic range extensions.

We also report the discovery of an insectivoran that appears most similar to Miocene-aged *Mystipterus* (Uropsalinae; Talpidae; shrew-moles). The miniscule (approximately 7 mm long) incomplete right dentary with m1-m3 shares the following characters with *Mystipterus*: posterior mental foramen positioned under m1; cristid obliqua long and extends lingually, intersecting the posterior wall of the protolophid below the metaconid; labial cingulids interrupted by hypoconid; and a prominent posterior accessory cuspid (hypoconulid) directly posterior to the entoconid. The Florissant insectivoran seems a plausible ancestor to Miocene *Mystipterus* (also known from Colorado), and extends the known temporal range of New World moles back several million years.

A NEW MAP AND ANALYSIS OF AMERICAS MOST FAMOUS HOMINID FOOT-PRINT SITE: ACAHUALINCA, NICARAGUA

LOCKLEY, Martin, Univ. of Colorado at Denver, Denver, CO; GARCIA-VASQUEZ, Ramiro, Museo Nacional, Managua, Managua, Nicaragua; ESPINOZA, Edgar, Departamento de Investigaciones Antropológicas, Managua, Nicaragua; LUCAS, Spencer, New Mexico Museum of Natural History and Science, Albuquerque, NM
6000-year-old hominid (*H. sapiens*) tracks from the Acahualinca Footprint Museum, Nicaragua, known since 1874, have never been mapped or described detail. We report the results of mapping about 350 tracks attributed to at least 15 human, two ungulates, a 'raccoon' and a bird. The tracks occur in volcanic ash containing plant remains, on two exposures of the same surface separated by an area still buried for future study. More than 1000 tracks are estimated for the whole area. The human trackways are all parallel, ranging in size (track length) from 18.5 to 22.0 cm, suggesting individuals between 1.32 and 1.57m tall (estimated foot length/height =14%). It is possible to identify some individuals on the basis of track depth and differential toe impression configurations. Most literature on the site promotes anecdotal ideas about trackmaker identity and behavior. For example, there is debate about whether the humans were fleeing as a group from an eruption and ashfall. Human trackway step and depth indicates normal walking at different times. Trackways run to the NW perpendicular to small 'channels' that erode some tracks. Reports of tapir and otter tracks have not been confirmed, but the museum preserves a pair of bovine tracks from another nearby site (El Recreo) that is no longer accessible.

With the exception of one track from Chile dated at about 12,500 years, the well-preserved human tracks from Nicaragua are as old as any reliably dated from elsewhere in the Americas: e.g., Californian and Argentinian footprints dated to about 6-7,000 years BP. Early human tracks are also reported from several Mexican sites, but dates are problematic.

Saturday 10:45

ORDERING THE SEMIONOTIDS 1: INCORPORATING THE RECENTLY DESCRIBED AND REVISED TAXA IN A CLADISTIC STUDY

LOPEZ-ARBARELLO, Adriana, Bayerische Staatssammlung für Paläontologie und Geologie, Munich, Germany

Semionotus bergeri (type species of the genus) from the Sandsteinkeuper (Coburgersandstein) of the German Triassic was revised and incorporated in several cladistic analyses. The analyses also include the type species of *Lepidotes* (Jurassic, France and Germany), the monospecific *Araripelepidotes* (Cretaceous, Brazil), *Paralepidotes* (Triassic, Italy), and *Pliodetes* (Cretaceous, Niger), the recently described *Lepidotes tendaguruensis* (Jurassic, Tanzania), *L. buddhabutrensis* (Jurassic-Cretaceous, Thailand), and *L. microrhis* and *L. tanyrhis* (Cretaceous, Spain), the recently revised *Neosemionotus* (Cretaceous, Argentina), and *Semionotus elegans* and *S. kanabensis* (Triassic-Jurassic). *Dapedium*, Lepisosteidae, Macrosemiidae, and the recently described *Isanichthys* were alternatively used as outgroup taxa. The results largely depend on the selection of the outgroup. In that respect, *Isanichthys* seems to be a better option than the very specialized lepisosteids or macrosemiids.

The analyses show that several characters that have been traditionally consider in semionotid taxonomy should be reevaluated in the light of their homoplastic distribution (e.g. number and arrangement of suborbital plates, the presence of a dorsal ridge of scales). On the other hand, the systematic value of other characters has been underestimated (characteristics of the circumorbital ring, the shape of the parietals [= frontals], etc.). Despite the differences depending on the choice of outgroup, several reoccurring patterns are found. Whereas *Lepidotes* is polyphyletic in all topologies found, the genus *Semionotus* always results as monophyletic. For example, *L. tendaguruensis* and *L. buddhabutrensis* do not appear referable to *Lepidotes*. Thus, a thorough taxonomic revision of *Lepidotes* is needed and should be based on a phylogenetic analysis.

Poster Session II

AN ARTICULATED PARTIAL POSTCRANIAL SKELETON OF A SMALL ORNITHOPOD (C.F. OTHNIELIA) DINOSAUR (MORRISON FORMATION; ALCOVA, WYOMING)

LOVELACE, David, Big Horn Basin Foundation, Thermopolis, WY

UW24823, a small articulated ornithopod skeleton was discovered in 1991 by a summer high school field-science outing at Alcovia Lake in Natrona County, Wyoming. The skeleton was partially prepared and displayed at the Tate Museum, with recent completion of preparation carried out at the Univ. of Wyoming in 2005. The skeleton is lacking a skull but exhibits a well-preserved forearm, manus, pelvis, both hindlegs sans pes, 3-dimensionally preserved rib cage, and several novel structures preserved along the costal midline.

UW24823 was found in a medium-coarse-grained sandstone channel in the upper Morrison Formation. The high-energy fluvial environment provided a rapid mode of burial, allowing 3-dimensional preservation of the body cavity. The dorsal neural spines were facing the recent erosional surface and are only present as casts of the centra and transverse processes.

Thin structures adjacent to the rib cage were initially interpreted to be skin impressions; upon further preparation these structures appear to be bone or partially ossified cartilaginous elements. The structures, found along the midline of the ribcage, are tentatively identified as uncinat processes. Each structure originates from one rib and overlaps the fol-

lowing posterior rib resulting in a more ridged ribcage. Stiffening of the ribcage may have played a role in locomotion or respiration. Similar structures have been observed in the ornithopod *Hypsilophodon*.

The rib cage clearly demonstrates posterior deflection of the anterior and mid ribs grading into a more vertical alignment of the posterior most ribs. The forearm and manus are well preserved and fully articulated from phalanges to distal humerus. Compared to other *Othnielia* specimens UW24823 shows few skeletal differences. UW24823 has a less pronounced brevis shelf, and the skeleton is 35-40% larger than other reported specimens of this genus.

Wednesday 10:30

FOSSIL VERTEBRATES AND THE POSITION OF THE TRIASSIC-JURASSIC BOUNDARY

LUCAS, Spencer, New Mexico Museum of Natural History, Albuquerque, NM; TANNER, Lawrence, Le Moyne College, Syracuse, NY

The working definition of the Triassic-Jurassic boundary (TJB) has long been taken as the LO (lowest occurrence) of the ammonite *Psiloceras* (usually *P. planorbis*). But, there is no direct way to relate the LO of *P. planorbis* to the fossil vertebrate record across the TJB. In the nonmarine Newark Supergroup of eastern North America, the TJB has been placed just below the oldest basalts of the Central Atlantic Magmatic Province (CAMP) based on palynostratigraphy, and most vertebrate paleontologists have long relied on this placement of the TJB. This boundary, however, is demonstrably older than the TJB defined in marine strata.

The palynological turnover cited as the TJB in the Newark most resembles a late Norian change in the European sections and does not correspond to any palynological event at the marine-defined TJB. Vertebrate footprint evidence (LO of *Eubrontes*) used to support the palynostratigraphic placement of the TJB in the Newark Supergroup is undermined by occurrences of *Eubrontes* in the Triassic of Europe and Australia and of bones of potential *Eubrontes* trackmakers in Triassic strata. Radioisotopic ages indicate the marine TJB is no older than 200 Ma, but the palynostratigraphically-defined TJB in the Newark Supergroup is older than 201 Ma, based on isotopic dates of the oldest CAMP basalts. Magnetostratigraphic correlation to European marine sections also suggests that the palynostratigraphically-defined TJB in the Newark Supergroup is older than the marine TJB. Thus, all data indicate that the TJB in the Newark Supergroup is above the lowest CAMP basalt, probably in the extrusive zone or just above it. Therefore, the position of the TJB in nonmarine strata is actually higher than generally thought, and does not obviously correspond exactly to any bioevent in the fossil record of vertebrates.

Wednesday 10:30

A SYSTEMATIC REVISION OF THE "AGRIOCHOERIDAE" (CETARTIODACTYLA: OREODONTA)

LUDTKE, Joshua, San Diego State Univ., San Diego, CA

Oreodonta, despite being a common group of extinct North American ungulates, has a highly contentious placement within Cetartiodactyla. Most workers agree that it is an early diverging group, but disagreement exists as to whether oreodonts are more closely related to Tylopoda, Ruminantia, or Suina. The earliest appearing branch of Oreodonta is the clade Agriocheridae, which is defined by the retention of several ancestral character states, such as an incomplete postorbital bar and a lack of lacrimal fossae. The clade is represented by the ubiquitous middle and late Eocene genus *Protoreodon*, the less common *Diplobunops* from the same time period, and the unusual, clawed Eocene-Oligocene genus *Agriocheris*. "*Protoreodon*", "*Agriocheris*" and "Agriocheridae" are, as currently defined, paraphyletic, with the genera consisting of various ill-defined species and the clade containing basal oreodonts, true agriocherid oreodonts, and basal members of the merycoidodont oreodonts. These over-generalized definitions add nothing to the studies of the position of oreodonts within Cetartiodactyla and the phylogenetic relationships within Oreodonta.

Reorganization of the species and supra-species level systematics of the "Agriocheridae" is necessary to allow the proper placement of Oreodonta in cetartiodactylan systematics. This investigation uses measurements and observations of dental, cranial, and postcranial morphology to diagnose and describe "agriocherid" oreodonts at the species level. At least twenty species in this clade can be distinguished, mostly by a combination of dental row size and the cusp development of the upper and lower fourth premolar. These characters are used to place the "agriocherid" species into a phylogenetic taxonomy. Using this approach, the existence of the three described genera, *Protoreodon*, *Diplobunops*, and *Agriocheris*, as monophyletic taxa is supported, along with the existence of unnamed genera currently lumped into *Protoreodon* and *Agriocheris*. This information will be used to further refine the placement of "Agriocheridae" and Oreodonta within Cetartiodactyla.

Preparators Symposium, Thursday 10:45

THE SOFTER SIDE OF PREPARATION: DEALING WITH NONMINERALIZED VERTEBRATE TISSUES

LUND, Eric, Utah Museum of Natural History, Salt Lake City, UT

Nonmineralized vertebrate tissues are relatively rare occurrences in the fossil record. In addition to being a rich source of nutrients for predators, scavengers, and microbes, such soft tissues do not tend to survive the process of fossilization. Nevertheless, a range of non-mineralized tissues have been preserved in the fossil record, including (but are not limited to) skin, muscle, gut contents, blood vessels, and keratinous sheaths. Over the past six years,

a team from the Univ. of Utah working in Grand Staircase-Escalante National Monument, southern Utah, has recorded 11 vertebrate localities preserving soft-tissue structures. Three of these sites are associated with dinosaur specimens: 1) a small ornithomimid; 2) a 60% complete hadrosaur skeleton; and 3) a hadrosaur skull. Recovery and subsequent preparation of these specimens has resulted in a number of insights relating to the handling of fossilized vertebrate soft tissues both in the field and the laboratory. Dealing with soft tissue remains in the field and in the preparation lab is often problematic, since these remains—like vertebrate hard tissues—vary greatly in quality and preservational durability. One of the first obstacles is deciding what to preserve in situ, what to remove and retain from the specimen, and what to destroy in order to carry out collection or preparation. As a general rule of thumb, it is best to delay this decision as much as possible until the specimen is in the lab, where preparation can occur in a more controlled setting. During field collection, wrapping smaller specimens in paper or cloth is usually sufficient for transport, but those specimens that are too large to pack out, or are associated with vertebrate fossils, should be encased within a protective plaster jacket. In some cases a consolidant may need to be applied, but use of adhesives should be minimal. Once back in the lab, abundant photographs should be taken before removal or destruction of any soft-tissue remains. Where possible, soft-tissues should also be molded with latex or silicon in order to preserve maximal information and enable placement of soft and hard tissues relative to each other at a later date.

Thursday 10:45

THE MORPHOLOGY OF *THRINACODUS* ST. JOHN AND WORTHEN, AN ELASMOBRANCH FROM THE SERPUKHOVIAN HEATH FM. OF MONTANA

LUND, Richard, Carnegie Museum, Mount Holly, NJ; GROGAN, Eileen, Saint Joseph's Univ., Philadelphia, PA

Isolated teeth of several species in the genus *Thrinacodus* have been described from the Fammenian through Chesterian of Europe and North America. The type species is *T. namus* St. John and Worthen 1875, from the Kimmeridgian of Kinderhook, Iowa, and the genus has been assigned to the elasmobranchian Family Phoeboodontidae. One complete and two partial specimens have emerged from the Upper Chesterian Bear Gulch Limestone, Heath Formation of Montana. The dentitions of the Montana *Thrinacodus* specimens are homodont, and differ significantly from previously described species in the genus. The dentition is homodont, consisting of tricuspid teeth on long, narrow, thick lingual bases. The cusps are subequal in length, elliptical in frontal section, strongly costate, widely divergently curving in anterior view, and posteriorly recurved. Bases of successional teeth are tightly overlapped and tooth families are closely packed together on the jaws. These observations together with data on gut contents present evidence of this dentition as a formidable piscivorous mill. The suspensorium is amphistylic, and the gape is as long as the head. Squamation is densely packed placoid scales that cover the body and caudal fin; cranial squamation is highly specialized. The caudal axis is horizontal, in line with the body axis, and the caudal fin is supported only by hypochordal elements. Neither dorsal fins nor dorsal fin spines can be seen. With respect to other chondrichthyans, the body proportions of the Bear Gulch *Thrinacodus* are unique. A long, sturdy ethmoid, and lower jaws that project posterior to the occiput, delineate a gar-like head which occupies only 9% of the total length of the fish. The branchial basket, which is situated posterior to the head, is 50% of the head length. Precaudal length is about 35% of total length; thus the caudal portion of *Thrinacodus* is 65% of the fish.

Wednesday 1:45

PHYLOGENETIC AND ECOLOGICAL DIVERSITIES OF DOCODONTAN MAMMALIAFORMS, AND THEIR PALEOBIOGEOGRAPHIC PATTERNS

LUO, Zhe-Xi, Carnegie Museum of Natural History, Pittsburgh, PA; JI, Qiang, YUAN, Chong-Xi, Chinese Academy of Geological Sciences, Beijing, China; TABRUM, Alan, Carnegie Museum of Natural History, Pittsburgh, PA

Docodontans are a Mesozoic mammaliaform group with a fossil record from the Middle Jurassic to the late Early Cretaceous. They are the most primitive mammaliaforms with mammalian integument structure and physiological functions, and offer the earliest-known evidence of mammalian swimming adaptation. With a wide range of body mass from 30 to 800 grams and distinctive molars capable of both shearing and grinding functions, docodontans developed diverse dietary and feeding adaptations. Most docodontans are mostly insectivorous and omnivorous, although larger species were carnivorous. At least two docodontans are inferred to have occupied the semi-aquatic niches, as in modern platypus. The currently known docodontans can be grouped into a Middle Jurassic clade (*Castorocauda*, *Krusatodon*, *Simpsonodon*), a Late Jurassic Euramerican clade (*Docodon* and *Haldanodon*) and an Early Cretaceous Asiatic clade (*Sibirotherium* and *Tegotherium*). Most docodontans with plesiomorphic features are from the Middle Jurassic of Eurasia, which was likely the ancestral area for the early diversification of this group, although a putative docodontan from the Kota Formation of India suggests a dispersal to the Gondwana during the Middle Jurassic. Among several putative relatives of docodontans, *Tikitherium* from the Upper Triassic of India appears to be more closely related to *Docodonta*, than the European mammaliaforms *Woutersia* and *Delsatia*.

Poster Session II

TWO NEW EUBAENINE (BAENIDAE: TESTUDINES) TURTLE TAXA FROM THE LATEST CRETACEOUS OF NORTH DAKOTA

LYSON, Tyler, Yale Univ., New Haven, CT; SCHACHNER, Emma, Univ. of Pennsylvania,

Philadelphia, PA; HANKS, Harold, Marmarth Research Foundation, Marmarth, ND; TREMAIN, Emily, Kansas Univ., Lawrence, KS

Two new taxa of baenid turtle are described based on well-preserved skull material found in the Hell Creek Formation (latest Maastrichtian) of North Dakota. *Gamerabaena sonsallai*, gen. et sp. no., and *Stygiochelys gilberti*, sp. no., are placed in the Eubaenina of the Baenidae based on the presence of a medially expanding triturating surface and deep temporal emargination exhibited by both taxa. *G. sonsallai* differs from other baenids in having a large prefrontal with a medially expanded dorsal lappet that excludes the frontal from the orbital margin and forms a relatively large portion of the skull roof. *G. sonsallai* shares two weak apomorphies with *Stygiochelys* and *Palatobaena*. The triturating surface and overall shape and robust nature of the skull of *S. gilberti* most closely resembles that of *Stygiochelys estesi*. *S. gilberti* differs from *S. estesi* in having frontals that laterally enter the orbital openings, small jugals that are restricted from the orbital margin, and the presence of a well-developed midline contact between the pterygoids.

A high-resolution phylogenetic analysis of the Baenidae supports the general phylogenetic framework of Gaffney and Meylan. The analysis supports the placement of both new taxa in the Eubaenina. The analysis regards *G. sonsallai* as the sister taxon to both *S. estesi* and *S. gilberti*. The placement of the two new taxa within Eubaenina increases the group to eight taxa, with all but two of the taxa found in the Hell Creek formation. The addition of these taxa to the Eubaenina indicates that this group was more diverse during the late Cretaceous than previously thought.

Wednesday 4:00

REFINED AGE OF THE LATE NEOGENE TERROR BIRD (*TITANIS*) FROM FLORIDA AND TEXAS USING RARE EARTH ELEMENTS

MacFADDEN, Bruce, LABS-HOCHSTEIN, Joann, HULBERT, Richard, Univ. of Florida, Gainesville, FL; BASKIN, Jon, Texas A & M Univ., Kingsville, TX

The giant flightless bird *Titanis walleri* (†Phorusrhacidae) is known from three localities in Florida and one in Texas. At two FL sites (Port Charlotte and Inglis) the age of *Titanis* is constrained by associated late Blancan mammals. The age of *Titanis* at the other two sites, however, is problematical because this taxon co-occurs with temporally mixed faunas. Thus, prior to the current study, *T. walleri* from the Santa Fe River, FL (type locality) was either as old as late Blancan (~2.4 to 2.0 Ma) or as young as latest Rancholabrean (RLB, ~15 ka). Likewise, *Titanis* from a gravel pit along the Nueces River, TX was either as old as late Hemphillian (~5 Ma) or as young as latest RLB (~15 ka). This study uses Rare Earth Elements ("REEs") to refine the age of *Titanis* from the two problematic sites.

REEs occur in low abundances in living vertebrate skeletons, but are rapidly taken up during early diagenesis. Thereafter, REEs in fossil bones and teeth are characteristically "locked in" As such, REEs preserve a distinctive signature of local geochemistry and environmental conditions for a short period of geological time. The REEs of *Titanis* [N = 6] from the Santa Fe River, FL were compared to two biochronologically unambiguously groups (Blancan [N = 17] versus RLB [N = 12]) of fossil mammals from the same locality. Similarly, the REEs of *Titanis* (N = 1, only specimen known) from the Nueces River, TX were compared to two groups (Hemphillian [N = 9] versus RLB [N = 10]) of fossil mammals from the same locality. The REE signatures of *Titanis* from FL are indistinguishable from those of the Blancan mammals of FL. Likewise, the REE signature of *Titanis* from TX is indistinguishable from those of the Hemphillian mammals from TX.

Given these REE constraints, the refined age of *Titanis* is late Hemphillian in Texas (~5 Ma) and late Blancan (~2.4 to 2.0 Ma) in Florida. No evidence currently exists for latest RLB *Titanis* in North America. As such, *Titanis* was an early immigrant during the Great American Interchange. Analyses of REEs preserved in vertebrate fossils have the potential to elucidate a broad range of aged-related questions in Deep Time.

Poster Session II

REDESCRIPTION OF *IEMANJA PALMA* (ACTINOPTERYGII: PYCNOdontIFORMES) FROM THE ALBIAN OF THE SANTANA FORMATION, NORTHEAST BRAZIL

MACHADO, Lúcio Paulo, BRITO, Paulo, Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil

Pycnodonts are a neopterygian fossil fish clade considered to be sister group to teleosts. Specimens of *Iemanja palma* from the Santana Formation are among the best preserved pycnodont specimens in the world, however much of its anatomy remains to be described. All anatomical knowledge on *I. palma* in the literature is based on three specimens, one of them acid-prepared. Recent discovery and acid-preparation of new specimens of *I. palma* revealed new anatomical features and allowed a better appreciation of its phylogenetic position. A series of previously heretofore undescribed characters were discovered in the new specimens, such as contour scales showing large spines, a ventral lateral line (previously reported only in *Akromystax tilmachiton* from the Late Cretaceous of Lebanon, among pycnodonts), and the correct estimation of the body shape as discoid. Even more interesting is the discovery of preserved endocranial elements, very rare in pycnodont specimens, such as prootics, exoccipitals, and a very large "supraotic". Some cranial features of *I. palma* are unknown in other pycnodonts, as for example the way in which the efferent pseudo-brachial arteries and the internal carotids pass through the parasphenoid, the "supraotic" articulating with the exoccipitals, and the posterior semicircular canal extending into the occipital region. The revision of a series of characters indicate a more basal position for *Iemanja palma* among the family Pycnodontidae.

Student Poster Session

MORPHOLOGY AND HISTOLOGY OF TOOTH WHORLS IN EARLY GNATHOSTOMES FROM M.O.T.H., NORTHWEST TERRITORIES

MACKENZIE, Lindsay, Univ. of Alberta, Edmonton, AB, Canada

Tooth whorls are often spoken about in the literature but are rarely discussed further. Some examples of tooth whorls are seen in Carboniferous sharks such as *Helicoprion*, as well as in the onychodontiform sarcopterygians *Onychodus* and *Strunius*. What exactly is a tooth whorl? Is it a curved tooth base with multiple cusps, or is it multiple teeth fused together at the roots, or both? In an attempt to answer this question, I plan to study the morphology and histology of several different kinds of tooth whorls of early gnathostomes in order to identify any similarities or differences in the structure and possible growth patterns of the teeth. I will be looking at in situ, isolated, and extracted whorls in a variety of putative chondrichthyans and acanthodians.

The specimens being studied are all from the M.O.T.H. ("Man on the Hill") locality in the Northwest Territories, Canada. These are early Devonian fishes that show excellent preservation of the body and oral regions. For this study, I will be focusing on some putative chondrichthyans, including *Aethelamia elusa*, and several acanthodians, including *Brochoadmones milesi* and several species of *Ischnacanthus*. These fishes show great diversity in tooth whorl morphology as well as location in the mouth. In some cases, the whorls line the entire upper and lower jaws, and in others, they are restricted to the front or back part of the oral region.

Based on the morphological and histological observations and on the pattern of occurrence of the different types of tooth whorls, it should be possible to identify different types of whorls to individual species. By mapping these types of whorls onto the phylogeny of early gnathostomes, the evolution and homologies of these fishes and their teeth should be clarified.

Preparators Symposium, Thursday 11:30

TECHNIQUES AND MATERIALS USED IN DISMANTLING, CLEANING, CONSERVING, AND REMOUNTING THE MUSEUM FÜR NATURKUNDE'S DINOSAUR SKELETONS

MACKIE, Carla, MAY, Amelia, MAY, Peter, FAIR, Matt, KRUDWIG, Kevin, Research Casting International, Beamsville, ON, Canada

In May 2005, Research Casting International dismantled the dinosaur skeletons in the main hall of the Museum für Naturkunde in Berlin, Germany. Research Casting returned to Berlin in January 2006 to clean, conserve and remount these skeletons. This presentation will review the techniques and materials used in dismantling, cleaning, conserving and remounting the Museum für Naturkunde's dinosaur skeletons.

Poster Session III

SCANNING FOR PALEONTOLOGY: ESTABLISHING WORKFLOW FOR ACCURACY AND EFFICIENCY

MACKIE, Dave, Research Casting International, Beamsville, ON, Canada

Research Casting International has been using 3D laser scanners and rapid prototype printing to compliment traditional molding and casting for over a year. RCI has also provided portable, permanent and highly detailed scans to several museums as accurate curatorial records. This presentation will discuss issues that are of particular interest to the application of scanning technology to paleontology. Topics will include: capturing color, controlling compound error, establishing an effective and efficient workflow, and the management of large data volumes. Several case studies will be presented, including the scanning of the Berlin Brachiosaur skull at the Museum für Naturkunde.

Poster Session III

AN UPDATED CHRONOLOGY FOR THE EARLY MIOCENE OF NE UGANDA

MACLATCHY, Laura, Univ. of Michigan, Ann Arbor, MI; DEINO, Alan, Berkeley, Berkeley, CA; KINGSTON, John, Emory Univ., Atlanta, GA

Lower Miocene fossil localities on the flanks of the extinct Moroto, Mt. Elgon and Napak volcanoes in Uganda chronicle the evolution of the oldest known hominoids and cercopithecoids, as well as many other mammal groups. The localities were radiometrically dated in the 1960's: the Mt. Elgon site of Bukwa II was thought to be oldest (22 Ma), followed by the Napak localities (~19 Ma), with the Moroto sites considered youngest. However, when we reassessed the age of the Moroto I and II localities using the $^{40}\text{Ar}/^{39}\text{Ar}$ incremental heating technique, we found capping basaltic lavas to be >20.6 Ma, 6-8 Ma older than previously reported conventional K/Ar dates. This spurred a reexamination of the Bukwa II and Napak localities.

We conducted 2-3 step-heating $^{40}\text{Ar}/^{39}\text{Ar}$ age experiments on groundmass extracted from each of 3 samples from Bukwa. A nephelinite lava overlying the fossiliferous sediments yielded broad apparent-age plateaus with weighted-mean isochron ages of 18.99 +/- 0.17 Ma and 19.27 +/- 0.20 from two samples, for an overall age of 19.11 +/- 0.13 Ma. An aphanitic lava at the base of the Bukwa II section yielded poorer results with narrow plateaus, suggesting an age of approximately 19.5 +/- 0.3 Ma. The new age range for this sequence of 19.5-19.1 Ma is ~3 Ma younger than previous estimates.

Previous radiometric dates on volcanic rocks from the Napak localities range from 6.7 to 30+ Ma, but an age of ~19 Ma was always strongly supported faunally, and the site has been assumed to be penecontemporaneous with Songhor in Kenya (19.5 Ma). Unfortunately, Napak lava samples evidenced extensive isotopic disturbance during incre-

mental-heating analysis and did not yield plateaus. Integrated ages cluster around 20 Ma, however, lending provisional support to the faunal age.

Our current understanding of the chronology of these sites indicates that 1) all are Early Miocene, 2) Moroto sites are oldest, and 3) Bukwa and Napak sites are approximately contemporaneous. This improved framework can now be used to evaluate phylogenetic and ecological scenarios and facilitate faunal comparisons with other East African sites.

Poster Session III

DIGITAL CRANIAL ENDOCAST FROM *PUCADELPHYS ANDINUS*, A PALEOCENE METATHERIAN

MACRINI, Thomas, Univ. of Texas, Austin, TX; MUIZON, Christian, Muséum national d'Histoire naturelle, Paris, France; CIFELLI, Richard, Oklahoma Museum of Natural History, Norman, OK; ROWE, Timothy, Univ. of Texas, Austin, TX

A digital cranial endocast of *Pucadelphys andinus* was extracted from high-resolution X-ray computed tomography scans of a single skull. *Pucadelphys*, known from the Paleocene of Bolivia, is arguably the best preserved stem marsupial (e.g., non-marsupial metatherian), represented by multiple, nearly complete, three-dimensional skulls and skeletons. The *Pucadelphys* endocast examined here is the only cranial endocast known from a stem marsupial and thus provides a unique opportunity to polarize endocranial characters with respect to crown Marsupialia. To this end, the *Pucadelphys* endocast is compared with other endocasts generated from skulls of the following extant marsupials: *Monodelphis domestica*, *Didelphis virginiana*, *Dasyurus hallucatus*, *Vombatus ursinus*, *Phascogale carterensis*, and *Dromiciops australis*.

The *Pucadelphys* endocast is generally similar to that of the didelphid marsupial *Monodelphis*. However, the olfactory bulb casts and the cerebellar space (approximated using vermis cast length) of *Pucadelphys* are relatively large in comparison to those of these extant marsupials. The cast of the vermis of *Pucadelphys* extends anterior to the casts of the parafloccular lobes of the cerebellum, in contrast to the condition seen in *Monodelphis*, *Didelphis*, *Dasyurus*, and *Dromiciops*. The cerebral hemisphere casts of *Pucadelphys* are dorsoventrally thin in comparison to those of the extant marsupials examined here. Other dimensions of the cerebral hemisphere casts are comparable between *Pucadelphys* and extant marsupials, suggesting that the overall volume of the cerebral hemispheres was smaller in *Pucadelphys*. Thus, two possible synapomorphies for crown Marsupialia are a decrease in size of the cerebellar space and an increase in cerebral hemisphere volume. These changes might represent adaptations for increased sensory acquisition associated with the radiation of marsupials into a variety of different habitats (e.g., arboreal, scansorial).

Saturday 12:15

THE EVOLUTIONARY HISTORY OF CASEIDAE

MADDIN, Hillary, REISZ, Robert, Univ. of Toronto at Mississauga, Mississauga, ON, Canada; SIDOR, Christian, Burke Museum of Natural History and Culture, Seattle, WA

Caseids, along with eothyridids, form the clade Caseasauria, which is the sister taxon to all other synapsid amniotes. Caseids appear only during the late Cisuralian (Early Permian), much later than other basal synapsid clades (Middle and Late Pennsylvanian). This results in a long ghost lineage (~20 m.y.) indicating that little is known about the origin and early evolutionary radiation of this group. However, Caseidae is a long-lived lineage, extending well into the therapsid-dominated Guadalupian (Middle Permian). Ecologically, caseids were the earliest herbivores with non-occluding dentition and are replaced in the fossil record by the ecologically similar pareiasaurs near the end of the Middle Permian.

The youngest caseid, *Ennatosaurus tecton*, from the Kazanian-Tatarian boundary (middle Guadalupian) of the Mezen River Basin, Russia, is described in detail for the first time and included in a new analysis of caseid interrelationships. Several autapomorphies were identified for *E. tecton*, including a large frontal contribution to the orbit, a broad anterior ramus of the jugal, and the presence of only two premaxillary teeth. Phylogenetic analysis of Caseidae yields a very robust, single, most parsimonious tree. Interestingly *E. tecton*, the youngest taxon stratigraphically, was not a member of the most derived clade, which was instead composed of the North American caseids, *Cotylorhynchus* and *Angelosaurus*. This topology produces a relatively long ghost lineage for *E. tecton* (~8 m.y.) and suggests a complex pattern of biogeographic dispersal of caseids during the Permian. This interpretation is supported by the recent discovery of large caseids in the Early and Middle Permian of Western Europe. The relative rarity of caseid fossils may be a reflection of their preference for upland habitats, deposits and regimes that are rarely preserved in the fossil record.

Wednesday 2:45

VIRTUAL MARSUPIALS: AN APPLICATION OF DIGITAL RECONSTRUCTION TO THE CRANIAL ANATOMY OF EXTANT AND FOSSIL MARSUPIALS

MAGA, Murat, The Univ. of Texas, Austin, TX

AUJM 2002-25 is an enigmatic metatherian from the Paleogene of Central Turkey, which consists of both cranial and postcranial elements. Although the postcranial skeleton of the fossil is strikingly complete, the cranial skeleton suffered heavy weathering. Maxillae, basicranium, supraoccipital, squamosals, jugal and questionable petrosals are among the recovered fragments. The mandible is complete, but no significant portion of the cranium is articulated. AUJM 2002-25 shares with other metatherians a robust inflected angle of the mandible, 3P4M postcanine dental formula, shallow V-shaped centrocrista, and a suite of postcranial synapomorphies. A detailed reconstruction of the skull would provide additional characters to further refine the phylogenetic position of this taxon on the metatherian tree.

Here, I applied visualization techniques to digitally prepare, and then investigate the cranial anatomy of this mammal fossil by comparing it to other extant and fossil taxa. Cranial fragments of AUJM 2002-25 along with complete skulls of *Didelphis* and a North American *Peratherium* were micro-CT scanned. Individual bones that constitute the *Didelphis* skull were segmented using a commercial software, VG Studio Max. The same method was applied to the fossil specimens to the extent that the boundaries between bones could be identified. Then, by means of scaling, the isolated elements were compared visually to each other for any allometric differences due to size. Finally, the removal of the matrix within the maxilla of AUJM 2002-25 suggested preservation of a nasal fragment and some of the turbinals within the matrix in the maxilla.

Romer Prize Session, Thursday 10:15

SYSTEMATICS AND PHYLOGENY OF STEGOSAURIA (DINOSAURIA, ORNITHISCHIA)

MAIDMENT, Susannah, Univ. of Cambridge, Cambridge, United Kingdom

Stegosauria is a clade of ornithischian dinosaurs characterised by a bizarre array of dorsally projecting dermal plates or spines extending from the cervical region to the distal end of the tail. Although the first stegosaur was discovered in Swindon, U.K., in 1875, and numerous remains have since been recovered from North America, Tanzania and China, as well as locations throughout Europe, taxonomy and relationships within the group are largely unstudied. The first cladistic analysis of Stegosauria based upon direct observation of specimens is presented. In contrast to previous analyses, the resulting cladogram is well resolved, and although relationships are not strongly supported by statistical tests, groupings accord well with the current understanding of paleogeography during the Upper Jurassic and Lower Cretaceous: North American and British genera are closely related, and the African genus *Kentrosaurus* is more distantly related. Chinese genera are basal and imply a relict primitive fauna in China during the Middle and Upper Jurassic.

Poster Session II

DIGITAL DINOSAUR BIOGEOGRAPHY; DISTRIBUTIONS AND 3-D PALEO-BIOGEOGRAPHIC MAPPING OF CRETACEOUS ECOSYSTEMS

MAIN, Derek, SCOTSE, Christopher, Univ. of Texas at Arlington, Arlington, TX

The paleobiogeography of the dinosaurs is of interest to researchers due to their diversity and wide geographic occurrence during the break up of Pangea. The congruence of Mesozoic tectonics and dinosaurian evolution offers a unique opportunity to test paleobiogeographic hypotheses. Thus, the paleobiogeography of dinosaurs was modeled with a series of ArcGIS maps as part of the PALEOMAP Project. Dinosaur distribution maps for the Late Cretaceous were produced in a time slice series as rectilinear projections (2-D), which provide a broad, global view. However, 2-D projections distort the polar regions. To resolve this, a series of 3-D ArcGlobe maps were produced to model dinosaur distributions without creating regional distortion. Cretaceous paleobiogeographic maps were developed to plot the distributions of ornithomorphs (hadrosaurs), ceratopsians (chasmosaurines), sauropods (titanosaurs) and theropods (coelurosaurines) during the Late Cretaceous. Dinosaur distributions were then used to postulate paleobiogeographic patterns on 3-D paleogeographic globes. From the new Cretaceous maps, diversity and distributions of faunas were analyzed for patterns of distribution trends such as response to paleoclimatic variation with time/latitude and potential resource partitioning. Small scale faunal variances within North American faunas were used to subdivide Laramidia and Appalachia into quadrants; NW Laramidia, SW Laramidia, NE Appalachia and SE Appalachia. Cretaceous paleogeography is discussed with emphasis on rates of seafloor spreading, timing of land bridge formation and fluctuating eustatic cycles. The Beringian land bridge is considered as a biogeographic dispersal route between Eurasia and North America while the continued separation of Africa from South America and the advance of the Western Interior Seaway and Alpine Tethys are considered as biogeographic barriers that spawn trends in isolation and allopatric speciation.

Friday 11:15

ONTOGENETIC CHANGES IN *PSITTACOSAURUS*: IMPLICATIONS FOR TAXONOMY AND PHYLOGENY

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The ceratopsian genus *Psittacosaurus* comprises 8-11 relatively uniform species from the Lower Cretaceous of Asia. The taxonomy and phylogeny of *Psittacosaurus* is complicated by a conservative body plan combined with a poor understanding of the distribution of taxonomically significant cranial characters, some of which vary ontogenetically. In order to better understand the relationship between ontogeny and the distribution of potentially diagnostic characters, we studied their development throughout the ontogeny of two species, *P. mongoliensis* from Mongolia, and a second taxon from the Yixian Formation of Liaoning, China. Specimens were aged using skeletal histology and growth stage determination was established using the Developmental Mass Extrapolation technique. Presence or absence of 17 potentially informative characters such as head shape, dentary flange, jugal horn shape, and denticle counts were noted for individual specimens along the curves.

Growth curves for the two species differ substantially with *P. mongoliensis* showing greater maximum growth rates and larger maximum size than the Yixian Fm. taxon, indicating that life history patterns can be used to distinguish between *Psittacosaurus* species. Both ontogenetic and individual variation was observed in some of the characters examined.

For example, presence of a well developed flange along the lower edge of the dentary, a trait diagnostic for some species, is correlated with ontogeny and a fully developed flange only occurs in older, subadult individuals. Individual variation in the expression of this character during ontogeny is also observed for the Yixian Fm. species. Conversely, characters such as skull and orbit shape and denticle counts appear to show relatively little ontogenetic variation, which does not transcend character state boundaries.

Novel understanding of character evolution gained through this study has important implications for the validity of some species of *Psittacosaurus* and also for the phylogeny of the group. This study demonstrates the potential of life history studies for understanding evolutionary patterns and processes in extinct clades.

Poster Session II

A FOSSIL LORICARIIDAE (SILURIFORMES: LORICAROIDEA) FROM THE TAUBATÉ BASIN, EASTERN BRAZIL

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The Taubaté basin is a rift basin situated in eastern São Paulo (Brazil), in the area of the present Paraíba do Sul River. Its origin has been associated to continental break-up and opening of the Atlantic Ocean. The clay layers and greenish shales of the Tremembé Formation, the lacustrine unit of this basin, have been dated as late Oligocene-early Miocene. Siluriformes are commonly represented in the basin by articulated skeletons of the pimelodid *Steindachneridion*. However, loricariid fossils are rare and some isolated body plates and finspines are the only findings recorded so far. In this paper, a new species of loricariid from the Taubaté Basin, based on a sole specimen represented by a neurocranium ventral impression is described. It can be phylogenetically defined as a Loricariidae based on three derived characters: dorsal margin of the metapterygoid contacting the lateral ethmoid; a mesethmoid disk; and a pterotic fused with supracleithrum. Also, the Baudelot's ligament forms a distinct wall, as occurs in most loricariids. Some characters assignable to loricariid subfamilies or genera were preserved. Among the loricariine characters are: a wide and low parasphenoid, the shape of pterotic-supracleithrum and the size and position of the mesethmoid disk. The lateral ethmoid presents a longitudinal, low ridge and a posterior condyle for contacting the metapterygoid. The presence of this ridge is generalized in loricariids, but it is rounded and low in Hypostominae, some loricariines, and most hypoptomatines. On the other hand, this condyle is synapomorphic for Hypostominae plus Ancistrinae. Still, it shares a pointed distal margin of transverse process with Hypostominae and a wide and low parasphenoid with Rhineleporini. A triangular and expanded lateral ethmoid is synapomorphic for some hypoptomatines. The fossil still shares some characters with subgroups within Loricariinae such as a trapezoidal pterotic with the Loricariini. The derived characters recognized in this fossil, form a puzzled pattern that makes it hard its assignment to a subfamily, but allow us to distinguish it from the other known loricariid, assigning it to a new species.

Friday 1:45

KINEMATICAL MODELING IN MSC.VISUALNASTRAN PROVES BIPEDALITY OF *PLATEOSAURUS*

MALLISON, Heinrich, BACHMANN, Egon, Univ. Tübingen, Tübingen, Germany

Was *Plateosaurus*, the best known prosauropod, an obligate or habitual biped? Or an obligate quadruped? This question has received much attention in paleontology, as it has significant impact on the understanding of saurischian locomotory evolution. Only recently did a functional analysis of the *Plateosaurus* elbow show that the hand could not take an active part in locomotion. This still leaves many of the arguments for quadrupedality unaddressed, especially the often voiced claim that *Plateosaurus* was front-heavy, and could not stand balanced on the hind limbs.

By creating digital 3D models from laser and CT scans of a mounted skeleton at the Institute for Geosciences, Tuebingen, and individual bones, we show that this claim is based on significantly flawed reconstructions of the body shape of *Plateosaurus*. Erroneous placement of the scapulacoracoids, misshaping of the anterior body due to misalignment of the ribs, underestimation of the muscles on the tail and often a significant shortening of the tail lead to a shift of the center of gravity anteriorly in most mounts, reconstruction drawings and plastic models.

Kinematical computer analysis of our improved model in MSC.visualNastran 4D shows that *Plateosaurus* was well-balanced on the hind feet alone, and would be seriously unbalanced during locomotion when forced into a quadrupedal position. The additional claim (*Plateosaurus* cannot stand with the femur held subhorizontally enough to balance the animal due to too great a force necessary to arrest the femur in this position) can also be shown false by the digital model, where only negligible forces are needed to keep the animal in the balanced posture.

We also modeled a scaled-down *Plateosaurus*, adapted to the size and proportions of known *Massospondylus* babies to investigate center of gravity position through ontogeny. We find that evolutionary development of saurischian locomotion is hardly understood. It appears that an ontogenetic shift from quadrupedal to bipedal locomotion may be ancestral for saurischians, possibly making the permanent quadrupedy of sauropods a neotenuous feature.

Wednesday 5:45

DINOSAUR TRACK 3D GEOMETRY AND DIMENSIONLESS SPEED

MANNING, Phillip, Univ. of Manchester, Manchester, United Kingdom

The underlying assumption of many track interpretations is that they represent surface features. Therefore, dimensional parameters (foot length (FL), stride length, etc.) on which speed calculations are based are interpreted as records of FL (sediment/foot interface). Laboratory track simulations coupled with observations of fossil tracks, casts serious doubts on the use of track length in such 'calculations' of speed.

Dinosaur tracks are often used to calculate FL of a trace-maker. FL in-turn is used to estimate a track-maker's hip height (h), when calculating the speed at which an animal was travelling, using a non-dimensional parameter, the Froude number, allowing comparison between animals of varying size using physical similarity theory. The resulting equation was written so that speed (u) is estimated from known values y (stride-length) and h (estimated by multiplying FL by 4).

$$u = 0.25g^{0.5}y^{1.67}h^{-1.17}$$

Since the first application of this formula it was clear that if h were overestimated, u would be underestimated. Creating large discrepancies in speed from fossil trackway data is not difficult; for example, a track length of 0.10 m gives a hip height (h) of 0.4 m. However, if the 0.10 m track was a transmitted feature and the true foot length measured 0.07 m, h should have been calculated as 0.28 m, meaning speed (u) from the larger track would be underestimated in excess of 25%. Such error can easily arise from how a track is measured or by being an incomplete transmitted, under or over-track feature.

The recovery of subsurface track layers from laboratory simulations provides a useful method to reconstruct the 3D subsurface track geometry and morphology for comparison with 'true' surface track features. Information gained from the laboratory track simulations confirms that many fossil tracks collected and described are transmitted features and do not represent 'true' surface tracks. This has significant implications for the interpretation, taxonomy and wider application of all fossil vertebrate tracks.

Saturday 4:15

THE PERFORMANCE OF STRATOCLADISTICS UNDER GEOGRAPHICALLY VARIABLE PRESERVATION

MARCOT, Jonathan, FOX, David, Univ. of Minnesota, Minneapolis, MN; FISHER, Daniel, Univ. of Michigan, Ann Arbor, MI

Use of stratigraphic data in phylogenetic analysis remains contentious. Central to this debate is stratocladistics, in which optimal trees minimize both homoplasy and implied gaps in the fossil record. The implicit assumption in stratocladistics that probabilities of preservation of taxa are roughly equal within single time intervals has been criticized because violations might cause stratocladistics to yield incorrect phylogenetic estimates, and because preservation potential is known to vary among taxa and over both time and space. We explore one particular violation of equal preservation across taxa: variable preservation among geographic areas. This has been cited as a serious concern for stratocladistics and is one case in which stratigraphic data could consistently conflict with character data. Conflict arises if ancestral taxa existed in regions with poor preservation, and their descendants dispersed to other areas with better preservation, which could lead to descendants being preserved earlier than their ancestors with some frequency. Other models of preservation can lead to such instances, but geographically variable sampling is one in which this might be the case systematically. In principle, geographically variable preservation should not affect conventional cladistics.

We addressed this by simulating clades and corresponding character and stratigraphic data. We simulated two geographic areas, one with low and one with high preservation probability. Simulations began in the area of low probability. At cladogenetic events, new species had a fixed probability of dispersing to the opposite region. We then analyzed each resultant data set with both cladistics and stratocladistics and measured the accuracy of both using the maximum correspondence between the resulting sets of trees and the true tree. The numbers of analyses in which one method outperformed the other were statistically indistinguishable; stratocladistics was at least as accurate as cladistics, even under these theoretically adverse conditions. Our results indicate that stratocladistics is not systematically misled by geographically variable preservation under conditions explored thus far.

Romer Prize Session, Thursday 10:30

QUANTIFYING CHANGES IN SUTURE MORPHOLOGY IN *EUSTHENOPTERON*, *ACANTHOSTEGA*, AND *PHONERPETON*: IMPLICATIONS FOR FEEDING SHIFTS ACROSS THE FISH-AMPHIBIAN TRANSITION

MARKEY, Molly, Harvard Univ., Cambridge, MA

Do changes in cranial suture shape across the fish-amphibian transition reflect changes in feeding? In this study, I address this question by: 1) Quantifying the morphologies of selected sutures in taxa that span the fish-amphibian transition and the subsequent terrestrialization of tetrapods: i.e., in the osteolepiform fish *Eusthenopteron*, the early amphibian *Acanthostega*, and the Permian terrestrial amphibian *Phonerpeton*; 2) Inferring the strain types these fossil sutures experienced using correlations between suture deformation and morphology determined experimentally in the extant fish *Polypterus*; and, 3) Connecting specific suture morphologies and inferred skull deformation patterns with aquatic (suction) feeding or terrestrial (biting) feeding in these fossil taxa. In *Polypterus*, suction feeding

loads the interfrontal (IF) suture in tension and compresses the interparietal (IP) suture. The IF and IP sutures of *Eusthenopteron*, which also employed suction feeding, are morphologically similar to those of *Polypterus*. Therefore, we hypothesize that the pattern of sutures that reflects "tension anteriorly, compression posteriorly" strains in the skull probably is indicative of suction feeding. In contrast, the morphologies of the IF and IP sutures of the terrestrial amphibian *Phonerpeton* suggest that the sutures of the skull experienced compression only, which in turn suggests that widespread compression in the skull roof is correlated with biting on prey items in the terrestrial realm. Interestingly, the cranial sutures of the aquatic amphibian *Acanthostega* are not consistent with prey capture via suction, but suggest that while *Acanthostega* may have occasionally captured prey via suction, this amphibian may also have bitten directly on prey items in the water or near the water's edge. Analysis of the suture morphologies of other transitional forms, such as *Tiktaalik* and *Ichthyostega*, will aid in interpreting these morphological differences and their associated functions across the fish-amphibian transition.

Romer Prize Session, Thursday 10:45

FUNCTIONAL MORPHOLOGY OF THE JAW OF *ACYNODON IBEROCITANICUS* (CROCODYLIA): IMPLICATIONS FOR THE DIET OF A LATE CRETACEOUS ALLIGATOROID WITH A PECULIAR DENTITION

MARTIN, Jeremy, Université Lyon 1, Villeurbanne, France

A description of new material of the short-snouted alligatoroid *Acynodon* from the Late Cretaceous of southern France is given. According to a cladistic analysis, it is viewed as a basal globidontan, together with the contemporaneous North American short-snouted genera *Stangerochampsia*, *Brachychampsia* and *Albertochampsia*. Some contradicting hypotheses have been proposed to explain the function of posterior crushing teeth in those genera. The aim of this study is to clarify the diet of *Acynodon* and other basal globidontans by comparing the jaw adductor and abductor musculature of some extinct and extant taxa. Origins and insertions of the jaw musculature are constant through extant Crocodylia and it is assumed here that the same arrangement can be applied to fossil Crocodylia. A reconstruction of the jaw adductors in *Acynodon* is proposed and shows that adductor muscles organized around the supratemporal and medial mandibular fossa are larger in *Acynodon* than in extant Crocodylia. A previously established functional model permitted to assess the distribution of forces at the level of the jaw articulation of *Acynodon* when biting. In fact, biting on tough food items implies a constraint at the level of this articulation, which tends to be dislocated. Developed depressor and pterygoideus muscles, implied by the presence of well-marked scars, may have counteracted the forces of jaw dislocation. The presence of posterior bulbous dentition is another evidence for a crushing functional strategy. The premaxillary and most of the maxillary teeth of *Acynodon* are spatulated. An analogous morphology is observed in Permian caseids, which are viewed as herbivorous. Considering the occlusion of the dentary teeth lingual to the maxillary toothrow in alligatoroids, the spatulated morphology could have served to cut off, tear or scrape surfaces. The combination of premaxillary-maxillary spatulated teeth and posterior crushing teeth suggest that *Acynodon* was more restricted in its diet than the North American globidontans, which display anterior-piercing teeth reminiscent of an omnivorous diet. According to the dental morphology of *Acynodon* alone, a carnivorous diet cannot be justified.

Poster Session III

CONCRETIONS: NATURAL AND L'EAU NATURELLE

MARTIN, Larry, ROTHSCHILD, Bruce, Univ. of Kansas, Lawrence, KS

E. H. Galbreath made a collection of fossil eggs from the early Oligocene (Orellan) of Logan County, Colorado that included a structure resembling a spherical egg 30 mm in diameter. Close examination showed it to be decidedly unlike an egg. It was composed of 0.5-0.8 mm spherical layers, which peeled off, revealing in cross-section a crystalline architecture oriented perpendicular to the surface. The surface was covered by small uniform projections. Organic structures resembling this specimen include bezoars, gall stones and kidney or bladder stones, as well as geologic concretions. Bezoars are composed of hair (tricho-) or plant fibers (phyto-) No casts of hair or plant fibers were present. Gallstones may be single or multiple. Single gallstones are solid, composed of plate-like cholesterol crystals or organic components which do not form crystals. While concretions are well known from this formation, they do not have the distinctive spherical structure, separating into multiple crystalline layers of the putative fossil. It is likely that the object is a bladder or kidney stone. Several varieties of kidney stones are known: Staghorn (resembling a cast of the renal pelvis); urate, which do not contain calcium; rare cystine, which are not calcified; and calcium phosphate and/or oxalate, which present as laminated or spiculated calcific stones of uniform internal density. A mammillated appearance, similar to that of the specimen is sometimes noted. The appearance of the Oligocene calcific mass is that of multiple layers of crystals, all aligned perpendicular to the surface, which radiologically would be recognized as laminated or spiculated. This appearance is diagnostic enough to warrant identification as a fossil kidney or bladder stone. This type of kidney stone can be a complication of parathyroid gland over-activity or tumors or occasionally from excess dietary vitamin D and calcium. Bladder stones result from outlet obstruction or from kidney stone localization to the bladder.

A CT SCAN OF A TITANOSAURIFORM SKULL (DINOSAURIA:SAUROPODA) FROM CENTRAL PATAGONIA, ARGENTINA

MARTÍNEZ, Rubén, VITA, Javier, CEMPENTA, Comodoro Rivadavia, Argentina; LAMANNA, Matthew, Carnegie Museum of Natural History, Pittsburgh, PA; IBIRICU, Lucio, Drexel Univ., Philadelphia, PA

We preliminarily report the results of a computed tomographic study of a titanosauriform skull from the Bajo Barreal Formation (Cenomanian-Turonian, early Late Cretaceous) of southern Chubut Province (central Patagonia, Argentina). For the study, we made a series of helical computed tomographies with a Multiple Slice System (MXTwin Multislice). Of the 281 images, 22 are three-dimensional reconstructions, 21 are sagittal, and 238 coronal. The slice thickness was two mm. The CT images allow the recognition of the olfactory bulb (CN I), the optic (CN II), trigeminal (CN V), and hypoglossal nerves (CN XII), the three subequal semicircular canals, middle and posterior cerebral veins, metotic fissure, and pituitary fossa. The latter is comparable in size to that in the endocranial mold of *Camarasaurus grandis*, although more rostrally oriented in the Chubut form. The exit points of the cranial nerves IX and X are tentatively identified. In the premaxillae, maxillae, and mandibles, the replacement teeth, adductor fossae and Meckelian grooves are visible. The latter are open medially as in *Brachiosaurus* and other forms. Other structures are more difficult to identify and will be the object of future studies. It is expected that the analysis of these images, and their comparison with related forms such as *Brachiosaurus* and more derived titanosauriforms, will allow to establish, in addition to the total encephalic volume of this dinosaur, characters and encephalic topographical features common to this sauropod lineage.

Wednesday 10:45

NEW MULTIPLE LATE JURASSIC DINOSAUR ICHNOCOENOSSES OF SWITZERLAND: EVIDENCE FOR ENDURING DINOSAUR COMMUNITIES ON THE NORTHERN TETHYS PLATFORM

MARTY, Daniel, PARATTE, Géraldine, Office de la culture, Porrentruy 2, Switzerland; MEYER, Christian, Naturhistorisches Museum Basel, 4001, Switzerland; BILLON-BRUYAT, Jean-Paul, AYER, Jacques, Office de la culture, Porrentruy 2, Switzerland

Since 2002 dinosaur tracks are systematically excavated in Late Jurassic (Kimmeridgian) carbonate platform sediments (Canton Jura, Switzerland). This platform formed part of the Northern Tethys passive margin in Late Jurassic times. To date, over 55 essentially narrow-gauge trackways of sauropods, and over 90 trackways of bipedal, tridactyl dinosaurs chiefly attributed to theropods, have been excavated and documented on multiple (>15) track-bearing surfaces. This provides insight into track formation and taphonomy, in particular the distinction of true tracks from under- and overtracks, a key point for consistent ichnotaxonomical and paleoecological interpretations. Multiple ichnocoenoses (associations of true tracks on a single surface) include (1) trackways of tiny (FL (footprint length)<25 cm) and large (FL>100 cm) sauropods with trackways of small (10<FL<25 cm) theropods; (2) trackways of tiny and medium-sized (25<FL<40 cm) sauropods with trackways of minute (FL<10 cm), small and medium-sized (25<FL<30 cm) theropods; (3) trackways of tiny and medium-sized sauropods with trackways of medium-sized and large (FL up to 50 cm) theropods. These ichnocoenoses exhibit diverse trackway orientation patterns and trackways with changes in gauge and gait of both sauropods and theropods. Even if these ichnocoenoses only partially reflect the former terrestrial vertebrate ecosystem of the platform, they indicate a recurrent presence of diverse dinosaur communities, at least during periods with prolonged inter- to supratidal conditions. The repeated associations of trackways of similar patterns and track morphology of very small and medium or large sauropods give a hint for different age classes within a single species. Moreover, this suggests that—contrary to recent publications—stance and resulting trackway gauge of sauropods is not necessarily related to ontogeny. This might be corroborated by more ichnocoenoses obtained by ongoing excavations. Finally, the paleogeographic situation implies that the platform was frequently connected to continental landmasses. This probably prevented a development of insular, dwarfed faunas, as has been postulated for similar carbonate platform settings.

Vertebrate Development Symposium, Wednesday 10:45

EVALUATING CRANIAL DISPARITY, MORPHOLOGICAL INTEGRATION, AND MODULARITY OF THE ARCHOSAURIAN CRANIUM USING GEOMETRIC MORPHOMETRICS

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Shape analysis via Landmark-based Geometric Morphometrics is currently one of the best suited methodologies for the study of the organization and evolution of the phenotype, hence its usefulness in Paleobiology. While the multivariate statistical apparatus of geometric morphometrics is readily set, for instance, for the exploration of allometry, other conceptual proxies such as morphological integration and modularity are becoming prevalent among morphologists, mostly among those interested in the role of and mechanisms by which the developmental program might bias the direction of evolution. Evolutionary developmental biology research is making giant steps into unveiling the mechanisms underlying such phenomena, thus providing the experimental basis upon which to interpret morphological integration and modularity at a phenotypic level. We have explored the major patterns of endocranial shape variation and integration at a macroevolutionary scale across modern avian and some fossil Theropod dinosaurs by means of geometric morphometric

procedures. Interlacing our morphological observations and the statistical accounts of the analyses with current developmental proceedings in experimental biology carried out in modern birds (i.e. chick and quail embryos), we render a hypothesis from which to propose the integrated and modular nature of the theropod skull, and possibly of representatives of the node Archosauria.

Preparators Symposium, Thursday 11:15

THE THRILL OF THE FRILL: WEAR AND TEAR DEMANDS RESTORATION OF A *DILOPHOSAURUS WETHERILLI* SKULL, UCMP 77270

MASON, Jane, Berkeley, CA

As the research interest in theropod dinosaurs has soared while museum budgets dwindle, the resulting wear-and-tear on fossil collections has been magnified by inexperienced researchers having fewer role models to follow in handling fossils as collection and preparation staff are also slashed.

Unique and key specimens, sometimes types, must bear the challenge of this intense interest and heavy traffic. Such a specimen is the double-crested *Dilophosaurus wetherilli*, UCMP 77270, used as a model for the “Spitter” in the movie Jurassic Park. The original preparation of UCMP 77270 was done before the presently available, more archival choices of glues, consolidants, and reconstructive mediums. These earlier materials did not offer the greater strength and flexibility tolerances of those now used by fossil preparators.

This charismatic theropod specimen has been stressed over time by a latex-lined jacket that abraded the transparently thin and topographically complex parts of the skull’s crest as the jacket cover was removed and replaced during study. Because access to this spectacular fossil is often sought, redesign of the clamshell jacket that will permanently house the specimen will be a crucial step in assuring the specimen’s future preservation.

The use of a custom-fitted sandbox has allowed placement of sculpted acrylic elements at key areas of structural stress. These supports have allowed further preparation of the ventral surface of the brain case, which was previously unknown, un-photographed and unstudied due to the specimen’s fragility; it could not have been turned upside down before.

To reduce unskilled handling in the future, as far as possible with visual clues, an archival graphic device that warns in the international signs and symbols code, “DO NOT TOUCH”, was developed and placed on key areas of weakness. Protection of other specimens in our collection with similar problems of fragility, combined with near universally comprehensible of warning labels, is also now addressed.

Poster Session II

NEW SPECIMEN OF *PROGNATHODON* (REPTILIA: MOSASAURIDAE) FROM THE BEARPAW FORMATION OF ALBERTA

MASSARE, Judy, SUNY College at Brockport, Brockport, NY

An exceptionally complete mosasaur was recovered from a mining operation on the Blood Nation Reservation near Lethbridge, Alberta. The *Prognathodon* specimen is from the lower Bearpaw Formation, approximately equivalent to the DeGrey Member of the Pierre Shale. It may be one of the best specimens of the genus from North America. The pectoral region and forelimbs were damaged by the mining operation, but the remainder of the skeleton was recovered. It includes a flattened skull that is missing parts of the posterior region, but has well preserved preorbital skull region, jaws, and teeth. The articulated vertebral column is nearly complete, missing only a few anterior vertebrae, and extending beyond the region of elongated neural arches, usually interpreted as a tail fluke. The hind limbs are fairly complete, as is the pelvis. The specimen is tentatively assigned to *P. rapax* on the basis of the shape of the quadrate, the dentary not projecting anterior to the first tooth, and the lack of a medial ridge on the frontal. If the tentative identification is correct, it expands the geographic range of *P. rapax* into the Western Interior Seaway. Moreover, this discovery provides new details about the morphology of this poorly known species.

Friday 9:30

THE CRETACEOUS OF ANGOLA

MATEUS, Octávio, Lourinhã, Portugal; MORAIS, Maria, Universidade Agostinho Neto, Luanda, Angola; SCHULP, Anne, Natuurhistorisch Museum Maastricht, Maastricht, Netherlands; JACOBS, Louis, POLCYN, Michael, Southern Methodist Univ., Dallas, TX

The coastal region of Angola has long been known to be richly fossiliferous, but until recently no continuous vertebrate paleontology and collecting has been undertaken there since the pioneering work of Miguel Telles Antunes in the early 1960’s. In May 2005, two of us (O.M. and L.L.J.) performed a short field reconnaissance in the Angolan provinces of Namibe and Bengo, from where rich Cretaceous faunas, including mosasaurs, fishes, turtles, plesiosaurs and other marine taxa have been known, bringing to light the first dinosaur from Angola, a Late Turonian non-titanosaurian sauropod.

The stratigraphic sequence extends from the Early Cretaceous (Barremian, 128 Ma) through the Neogene, making this the longest continuous fossiliferous section known in Africa. In addition to dinosaurs, this section records (1) the formation of the eastern margin of the South Atlantic Ocean; (2) a nearly continuous and biostratigraphically significant sequence of sharks and bony fishes that record changes in oceanic currents; (3) the opening of the Atlantic Ocean and the disruption of a land connection between South America and Africa; (4) the biogeographic invasion of the South Atlantic by marine amniotes, including turtles, plesiosaurs, and mosasaurs; (5) interbedded nearshore marine and igneous rocks; (6) a superbly exposed Cretaceous-Paleogene Boundary section; (7) Paleogene squamates and turtles; and (8) Neogene cetaceans and a rhinoceros.

Besides the rich fish fauna, the known Cretaceous tetrapod fauna comprises turtles (including a recently collected undescribed genus of cryptodiran), mosasaur squamates *Globidens* sp., at least two *Prognathodon*-like taxa, *Angolasaurus bocagei*, *Plioplatecarpus* sp, and *Tylosaurus iembeensis*, plesiosaurs aff. Cimoliasauridae, and a non-titanosaur sauro-pod dinosaur.

Friday 9:30

COMPARISON OF NEOGENE RECORDS OF ENVIRONMENTAL CHANGE IN THE GREAT PLAINS, U.S.A., BASED ON PALEOSOL CARBONATES AND PALEODIETS OF EQUIDAE

MATSON, Samuel, FOX, David, MARCOT, Jonathan, Univ. of Minnesota, Minneapolis, MN; JANIS, Christine, Brown Univ., Providence, RI

Neogene records of environmental change in the Great Plains, U.S.A., derived from paleosols and paleodietary studies of fossil Equidae exhibit surprising contrasts. The stable carbon isotope composition ($\delta^{13}\text{C}$) of paleosol carbonates suggests C₄ grass comprised ca. 20% of plant biomass throughout the Miocene, increased to about 40% of biomass by the early Pliocene, and reached modern abundance by the early Pleistocene. Equids evolved high-crowned (hypsodont) teeth, an adaptation for open habitats and/or grazing by ca. 18 Ma, and $\delta^{13}\text{C}$ values of equid tooth enamel indicate C₃-dominated diets during the Miocene until 6.6 Ma, at which point several species began to consume C₄ vegetation while others maintained C₃-dominated diets. To understand these contrasts better, we examined equid paleodiet in the context of a genus level phylogeny. Hypsodonty increased in parallel in several lineages and high $\delta^{13}\text{C}$ values characteristic of C₄ consumption arose independently within several derived genera nested within the tribes Equini and Hipparionini. Evolution of hypsodonty and consumption of C₄ biomass do not appear to have promoted taxonomic diversification. Average magnitudes of evolutionary changes across the phylogeny towards increased hypsodonty and $\delta^{13}\text{C}$ values were greater than those towards decrease, consistent with driven trends, but the patterns were not sufficiently distinct to reject null hypotheses of passive trends. A weak negative correlation between $\delta^{13}\text{C}$ values and stratigraphic range in equid genera suggests C₄ consumers may have had higher extinction rates. A possible explanation for the low variability in Miocene paleosol $\delta^{13}\text{C}$ values is that habitats dominated by C₄ grasses were patchily distributed across the landscape and migrated laterally on timescales rapid relative to carbonate formation; shorter-lived, C₄-consuming genera may have been specialists that utilized C₄-dominated patches and habitat change was sufficiently rapid to promote greater extinction. Parallel analyses of clades with similar diversity histories in the region, such as Camelidae, could help elucidate the basis of the contrasts between paleosols and equids.

Poster Session II

ISOTOPIC AND GEOCHEMICAL ANALYSES OF FOSSIL FISH REMAINS FROM THE UPPER DEVONIAN ESCUMINAC FORMATION (MIGUASHA, QUEBEC): IMPLICATIONS FOR PALEOENVIRONMENTAL INTERPRETATION

MATTON, Olivier, STEVENSON, Ross, CLOUTIER, Richard, Université du Québec à Rimouski, Rimouski, QB, Canada

Devonian Old Red Sandstone fish assemblages have been classically considered to be freshwater in origin. This includes the Escuminac assemblage, renowned for the abundance and quality of preservation of fossil vertebrates as well as for the phylogenetic and evolutionary importance of its biota. However, the paleoenvironmental context of the Escuminac Formation is still a matter of debate, ranging from lacustrine to marine, with a recent consensus for a transitional, brackish estuarine paleoenvironment. Our goal is to address this paleoenvironmental debate through direct geochemical (Rare Earth elements) and isotopic (Rb-Sr, Sm-Nd) analyses of fossil material. Apatite-bearing anatomical structures (e.g., teeth, bony plates, scales) of different fish species (acanthodian *Homalacanthus concinnus*, actinopterygian *Cheirolepis canadensis*, placoderm *Bothriolepis canadensis*, dipnoan *Scaumenacia curta*, osteolepiform *Eusthenopteron foordi*) from the base to the top of the Escuminac Formation were analysed. The isotopic analyses were performed by Thermal Ionisation mass spectrometry (TIMS) and compared with Sr isotope data obtained *in-situ* by laser ablation multi-collection inductively coupled mass spectrometry (MC-ICP-MS). Preliminary TIMS $^{87}\text{Sr}/^{86}\text{Sr}$ isotope ratios vary from 0.70815 to 0.70830 with an average laser ablation analysis of 0.70854 for a single tooth. These ratios are consistent with Devonian seawater Sr isotope compositions and suggest that the fish species and the Escuminac Formation formed within a brackish to marine water environment.

Poster Session III

OLD SPECIMENS NEWLY DESCRIBED: CAMP'S PAREIASAUR SKULLS FROM THE KAROO BASIN OF SOUTH AFRICA AND THEIR IMPLICATIONS FOR BASAL PAREIASAUR TAXONOMY

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In the mid-1930s Charles Camp excavated numerous vertebrate fossils from the Permian sediments of the Karoo Basin in South Africa and sent them overseas to the Univ. of California at Berkeley, where they became part of the Univ. of California Museum of Paleontology (UCMP) collections. Among this material are many pareiasaur specimens, rare in North American collections, which have never been described. The pareiasaur material Camp collected includes a great deal of well-preserved post-cranial and cranial specimens. This study describes the osteology of three pareiasaur skulls for the first time since their collection 70 years ago. These specimens provide new insights into the morphology,

phylogeny and taxonomy of basal pareiasaurs. The three UCMP pareiasaur skulls belong to the most basal pareiasaur genus *Bradysaurus*. The most basal taxon of this genus, *Bradysaurus seeleyi*, possesses no autapomorphies, therefore the genus *Bradysaurus* can be considered a metataxon. Two of the three UCMP pareiasaur skulls are assigned to the other existing taxon within the genus, *Bradysaurus baini*. *B. baini* possesses three autapomorphies that separate it from *B. seeleyi*: a large round lump on the maxilla immediately behind the external naris, a swollen distal portion of the paroccipital process and teeth of the upper jaw directed ventromedially.

The third UCMP pareiasaur skull may constitute a new taxon within the genus *Bradysaurus* due to three potential autapomorphies, though further comparative work is required to confirm or deny the existence of a new species. The three autapomorphies are: a large boss flanking the anterior portion of both nasals, supratemporal bosses that rise above the skull roof to form a saddle between them, and a posterodorsally facing shelf posterior to the ridge that is formed between the supratemporal bosses. This potentially new taxon also possesses all three autapomorphies of *B. baini*, which would make those characters synapomorphic for both taxa. This would establish these two taxa firmly as sister groups, which results in *B. baini* as yet another taxon within the genus *Bradysaurus* that possesses no autapomorphies and could therefore be considered a metataxon.

Poster Session III

THE ANATOMY OF THE EMU WING: AN EXAMPLE OF PRIMARY DIGITAL REDUCTION IN ARCHOSAURS

MAXWELL, Erin, MICHEL, Adam, LARSSON, Hans, HEPPLESTON, Audrey, McGill Univ., Montreal, QB, Canada

The Emu (*Dromaius novaehollandiae*) is a palaeognathous bird native to Australia that has undergone extreme wing reduction, both in relative size and in the number of ossified elements. It usually ossifies only a single digit corresponding to the digitum majoris in other birds, and has no free carpal elements. This digital reduction is thought to have taken place over a very short evolutionary time scale since it has occurred since the divergence of the Emu from the rest of the extant ratites. In order to examine the developmental changes accompanying such an extreme adult morphology, we studied the mesenchymal skeletogenic condensations of a series of early stage Emu embryos. We also cleared and stained sets of later stage embryos for the presence of bone and cartilage. Our results indicate that the Emu is the only known example of primary digit reduction in birds. In other words, unlike the state in Ostrich (*Struthio*) in which five digits chondrify, or the chicken in which five digits condense and four chondrify, only three to four digits condense and three chondrify in the Emu. Furthermore, while the number of elements ossifying in flying birds as well as in the Ostrich is constant, the Emu ossifies either one or two digits. There is a wide range of variation in terms of shape, number and position of the elements that remain cartilaginous in late stage embryos. This variability is also seen at the level of wing musculature in adult Emus. This variation in digit number and shape is similar to that observed in the Kiwi, a New Zealand palaeognath that has independently converged on a reduced wing morphology. Emus differ from other birds in that they ossify the distal phalanx of their single digit first. This is most similar to the pattern seen in the pes of other birds (including the Emu); the manus normally ossifies in a proximal-distal direction. Digital reduction has taken place multiple times in birds, and in the theropod lineage more generally. This research sheds light on some morphological and developmental changes that result in a single-digit phenotype in an adult tetrapod.

Poster Session III

ADULT SKELETAL REMAINS OF IANTHASAURUS, THE OLDEST KNOWN EDAPHOSAUR (SYNAPSIDA:EUPELYCOSARIA) FROM THE UPPER PENNSYLVANIAN OF KANSAS

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Infills of an abandoned channel near Garnett, Kansas preserve the most abundant and diverse assemblage of amniotes known from the Carboniferous. Most of the vertebrate remains recovered from the locality are those of terrestrial tetrapods. The most commonly found skeletal remains belong to the diapsid reptile *Petrolacosaurus* and the sphenacodontian *Haptodus garnettensis*. However, other synapsids, represented either by single specimen or relatively few individuals include an undescribed ophiacodontid, an undescribed sphenacodontid, the rare and enigmatic *Xyrospondylus*, and the sphenacodontian *Ianthodus*. The sixth synapsid is the edaphosaur *Ianthasaurus hardestiorum*, known from two fragmentary skeletons and a few isolated vertebrae, all belonging to juvenile individuals.

Recently uncovered parts of a skeleton of *Ianthasaurus* represent an adult individual. Its adult condition is indicated by its large size, 30% larger than all previously known specimens, and the fusion of the neuro-central suture. *Ianthasaurus* is the oldest known member of Edaphosauridae, and significantly smaller than any of the better known members of this clade. The new specimen provides important new, phylogenetically informative cranial and vertebral features. The maxilla is long, with place for at least 32 teeth; both the marginal and palatal teeth are slightly bulbous near their apex, resembling those in the oldest known herbivorous amniote *Edaphosaurus*. The anterior part of the pterygoid is shorter than in the carnivorous sphenacodontids, and similar in relative length to that in *Edaphosaurus*. The tall neural spines have up to eight pairs of lateral tubercles, nearly twice as many as on vertebrae in the comparable region of the column of the juveniles. These adult skeletal features indicate that *Ianthasaurus* may be more closely related to the large *Edaphosaurus* than pre-

viously considered. However, despite the presence of the modified dentition, the teeth on the transverse flange of the pterygoid are unlike those in *Edaphosaurus* in being nearly twice as large as those on the rest of the palate, indicating that *Ianthasaurus* may have had an omnivorous diet.

Poster Session I

REASSIGNING *GLOSSOTHERIUM CHAPADMALENSE* AND INCREASED SPECIES DIVERSITY IN *PARAMYLODON* (MAMMALIA: XENARTHRA)

McAFEE, Robert, Northern Illinois Univ., DeKalb, IL

Species diversity of the mylodontid sloth *Paramylodon* is low, with only one species, *P. harlani*, currently recognized from the Irvingtonian and Rancholabrean of North America. Recent investigations of cranial characters and morphology have validated the continued separation of *Paramylodon* from the South American genus *Glossotherium*, and have created an opportunity to address the species diversity of the northern genus. A possible second species is known from Blancan deposits but has remained in relative limbo as "*Glossotherium*" *chapadmalense*; due in part to a small number of available specimens for comparative studies. Using new generic characters generated for *Glossotherium* and *Paramylodon*, crania belonging to "*G.*" *chapadmalense* were studied to establish its true placement within one of the two genera. Examination shows "*G.*" *chapadmalense* to have a greater affinity with *Paramylodon*, as has been suggested by some authors. Characters uniting the two include: a well-defined parasagittal crest, relating to a larger fossa for the M. temporalis; palatine bones extended more posteriorly behind M4; a low angle of tooth-row divergence; skull width across the lacrimals nearly equal to those across the post-orbitals; and the size and position of the basilar tubercles. These results expand our assessment of *Paramylodon*, repositioning it as a distinct genus which migrated into North America during the Blancan and then evolved into the larger Irvingtonian-Rancholabrean form.

Poster Session III

DEPOSITIONAL ENVIRONMENT AND TAPHONOMY OF A THERIZINOSAURID (DINOSAURIA) FROM THE TROPIC SHALE (CENOMANIAN-TURONIAN), KANE COUNTY, UTAH

McCORMICK, Kaitlin, Northern Arizona Univ., Flagstaff, AZ; HORTON, Travis, JOHN-SON, Ben, Univ. of Puget Sound, Tacoma, WA; GILLETTE, David, Museum of Northern Arizona, Flagstaff, AZ

Fieldwork in the Tropic Shale (Cenomanian-Turonian) in southern Utah has resulted in the recovery of several vertebrate fossils, including a therizinosaurid, a terrestrial dinosaur. How a one to two ton terrestrial dinosaur was preserved relatively intact 100 kilometers from the paleoshoreline seems contradictory with the numerous predators in the Cretaceous Western Interior Seaway. The depositional environment of the therizinosaur site and other plesiosaur sites was investigated to determine if there are similarities in setting. Preliminary clay mineralogy and foraminiferal biostratigraphy results indicate a normal, offshore marine environment. X-ray analysis of the clay mineralogy demonstrates no significant variation in clay mineral percent. Planktonic foraminifera present indicate shallow water up to 100 m deep and the benthonic foraminifera present indicate normal marine salinities.

$\delta^{18}\text{O}$ values determined for calcite cements at the therizinosaur fossil site range from -6.5‰ to -8‰ (PDB) from a 1.5m thick section surrounding the bone layer. These values fall in between calculated Cretaceous meteoric water $\delta^{18}\text{O}$ values (-10‰) and normal marine $\delta^{18}\text{O}$ values. Petrographic analysis of the bone layer shows that extensive carbonate diagenesis has not occurred; calcite $\delta^{18}\text{O}$ values at least partially record primary paleoenvironmental conditions. The presence of aragonitic shell material, as identified by X-Ray diffraction, further supports this interpretation. In contrast to the clay mineralogy and foraminiferal biostratigraphy results, the stable isotope data suggest the therizinosaur was deposited in a mixed water setting such as an estuary.

The therizinosaurid probably died along the shoreline and swept out to sea, the carcass bloated and floated until the gases escaped and sank into the muddy bottom of the seaway. The skull is the only part of the skeleton missing and it may have been detached prior to burial by scavenging or by a small fault at the site. Although the preservation of terrestrial organisms in marine settings is not unusual, there is a lack of studies regarding transport of these organisms.

Thursday 2:00

A BIOMECHANICAL MODEL OF *SMILODON FATALIS* BASED ON FINITE ELEMENT ANALYSIS

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How do we reconstruct behaviour in extinct species? Since behaviours result in forces and loads that act upon an animal's skeleton, biomechanical analyses can summarise the range of forces that a given skeleton could have resisted. This information can be used to assess the range of behaviours that a species was capable of.

This approach is particularly useful when dealing with extinct taxa that have no clear living analogue. The saber-toothed cat *Smilodon fatalis* is one such taxon and the behaviour of these iconic predators remains the source of perennial debate. Hypotheses of their killing technique vary with respect to: (1) the placement of the killing bite—was it directed at the

throat or 'belly'—and (2) whether the bite itself was adapted from that applied by more generalized cats (the canine-shear model), or was it a fundamentally different, largely neck driven stabbing bite.

Finite element analysis (FEA) is a numerical engineering approach that can simulate mechanical behaviour in complex structures, and the use of FEA in biomechanics is growing as technological advances allow biologists to explore the mechanics of even complex biological structures, such as carnivorous skulls. We have constructed finite element models of the skull and mandible in *Smilodon fatalis* and the African lion *Panthera leo*. Models were generated upon CT data, and included the behaviour of the jaw adductor muscles and the Tempo-Mandibular Joints. A range of load cases, based upon published descriptions of behaviour in African lions and hypothesized behaviours in sabrecats, were applied to each model and the mechanical performance of each model was quantified.

The differences and similarities in mechanical performance of each model allow the biomechanical performance of the *S. fatalis* skull and mandibles to be discussed with reference to the biomechanics of the lion. Our results have important implications for the interpretation of behaviour in this extinct predator.

Poster Session I

AGING *PANTHERA ATROX* FROM RANCHO LA BREA

MEACHEN, Julie, UCLA, Los Angeles, CA; BINDER, Wendy, Loyola Marymount Univ., Los Angeles, CA

The Rancho La Brea tar seeps are well known for their unusual preservation of more carnivores than herbivores. This may reflect repeated episodes of entrapment of carnivores feeding on a mired herbivore. Possibly, the tar seeps attracted a vulnerable segment of large carnivore populations, such as the very old, injured, or young and naive. Here, we use a radiographic aging technique to assess the age distribution of American lions (*Panthera atrox*) preserved at Rancho La Brea.

African lions, *Panthera leo*, have been aged using a combination of cranial and dental features and pulp cavity diameter of the canine teeth. The diameter of the pulp cavity shrinks as the animal lays down dentin with age. *P. atrox* is closely related to the African lion, but cranial and dental features that could be used to age them may have different growth rates attributable to size difference in the two species. Previous work used tooth wear to age individuals, but this can be confounded by diet. The closure of the dental pulp cavity may be a more reliable method to age *P. atrox* and is unlikely to be affected by functional differences. Here, we estimate the relative age of individual *P. atrox* at Rancho La Brea by comparison with a sample of African lion skulls from museum collections.

Ages of wild African lions were estimated using a combination of craniodental features and radiographs of the dentaries. Cranial and dental age estimates were correlated with the extent of canine pulp cavity closure. Radiographs of all *P. atrox* dentaries in the Rancho La Brea collection were taken and the lower canine pulp cavity diameter measured. The pulp cavity dimensions were compared with those of the African lions to estimate their age at death. The ages of individual lions at Rancho La Brea were found to span a fairly wide range. Most individuals were young adult to middle-aged at death, and there was no evidence of predominance of old individuals.

Poster Session II

LATE QUATERNARY *PYGOPUS* AND *DELMA* (PYGPODIDAE) AND *RAMPHOTYPHLOPS* (TYPHLOPIDAE: SQUAMATA), FROM WESTERN AND SOUTH AUSTRALIA CAVE DEPOSITS

MEAD, Jim, HOLLENSHEAD, Marci, SWIFT, Sandra, Northern Arizona Univ., Flagstaff, AZ

New species of living squamates of Australia are still being described even though there is a profusion of published articles concerning the modern fauna. In vivid contrast, the fossil lizard fauna is still poorly known. The pattern of evolution and the geographic distribution of squamates dating from the Oligocene to Pliocene are better known than those of the Holocene and Pleistocene. The deposits at Riversleigh, Queensland, have produced most of the earliest squamates from the continent, along with the oldest and only pygopod (*Pygopus hortulanus*; Pygopodidae) and vertebrae assigned to *Ramphotyphlops* (Typhlopidae). Cave deposits in Western Australia, excavated during the 1950s-1990s for late Quaternary mammalian and archaeological contents have produced 1000s of squamate fossils. Skeletal remains of *Pygopus* and *Delma* recovered from Hastings Cave (Jurien coast) and Webbs and Wombat caves (greater Nullarbor Plain) of Western and South Australia provide the first Quaternary record of these pygopod genera. Hastings Cave and the well-known Madura Cave (greater Nullarbor Plains) have also produced vertebrae of *Ramphotyphlops*. Our overall project includes an on-going description of cranial morphology of modern squamates along with their distribution and evolution in WA during the Neogene.

Poster Session I

KINEMATIC ANALYSIS OF STRIKE BEHAVIOR IN CROCODYLIANS: IMPLICATIONS FOR THE EVOLUTION OF CRANIAL MORPHOLOGY AND ECOLOGY

MEERS, Mason, Univ. of Tampa, Tampa, FL; McHENRY, Colin, Univ. of Newcastle, Callaghan, Australia

The functional morphology of crocodylian crania has been the subject of much debate in the recent past, particularly with regard to flattening of the rostrum and its mechanical and

hydrodynamic tradeoffs. Recent work, for example, has shown that the platyrostral morphology is not well adapted to resist torsional loads likely experienced by many taxa during feeding. It follows then that the specific morphology of the rostrum may be constrained by other factors, including hydrodynamic properties of the rostrum. Crocodylians typically strike prey items by means of a rapid, lateral sweeping motion of the head, resulting in prey capture near the middle to distal portion of the rostrum. The effectiveness of this kinematic pattern is profoundly affected by the morphology of the structure being accelerated through the water. In order to examine the possible effects of hydrodynamic constraints on crocodylian morphology, we examine the kinematics of feeding crocodylians. Specifically, strike behavior is quantified in the American alligator (*Alligator mississippiensis*), with pilot data also collected for the American crocodile (*Crocodylus acutus*), using high speed videography. The results of the kinematic analyses are discussed in the context of extant and extinct crocodylian cranial morphology, which varies relatively widely from short, broad snouts to extraordinarily longirostrine taxa. It is apparent from our analyses that rostral morphology largely reflects hydrodynamic constraints imposed by prey choice and availability. The evolution of crocodylian rostral form is then discussed in phylogenetic and functional contexts.

Poster Session II

CONGRUENT AFTER ALL—A NEW LOOK AT THE CHEEK AND PALATE OF *PLACODUS GIGAS*

MERCK, John, Univ. of Maryland, College Park, College Park, MD

Reexamination of the cranial material of the familiar placodont *Placodus gigas* indicates a revision of its temporal and basicranial osteology. Phylogenetic analyses of the last decade agree on the position of Placodontia as the sister taxon of Eosauropterygia within Sauropterygia, and on its general phylogenetic structure. The evolution of some diagnostic cranial characters within Placodontia has been less clear, however. Although often treated as the “classic” placodont, *Placodus* as currently described, displays atypical configurations of the squamosal/quadratojugal relationship and the basicranium for Placodontia, raising questions about their evolution and polarity within Sauropterygia. In other placodonts for which it is known the quadratojugal is broad and tall, closely approaching the supratemporal fenestra, whereas in *Placodus*, it is seen as confined to the lower third of the cheek plate. In those cyamodontoids in which it can be assessed, the basiptyergoid processes are broad and closely applied to the pterygoids and palatines anteriorly, whereas in *Placodus* they are typically shown as cylindrical and visible in posterior view. This view of *Placodus* is based largely on the complete skull BP13 in Bayreuth. Reexamination of this and other material, notably BSP 1968175 in Munich, suggest that in both respects, *Placodus* follows the pattern seen in other placodonts, with a broad, tall quadratojugal and anteriorly directed basiptyergoid articulation. While not altering placodont phylogeny *per se*, this revision influences our understanding of the polarity of these features’ evolution in Eosauropterygia and has implications for the homology of temporal elements in ichthyosaurs.

Wednesday 2:15

A PHYLOGENY AND TIMESCALE FOR MARSUPIAL EVOLUTION

MEREDITH, Robert, Univ. of California Riverside, Riverside, CA; WESTERMAN, Michael, La Trobe Univ., Victoria, Australia; CASE, Judd, St. Marys College of California, Moraga, CA; SPRINGER, Mark, Univ. of California Riverside, Riverside, CA

Even though marsupials are taxonomically less diverse than the placentals they exhibit a morphological and ecological diversity that is comparable as a result of their long and often isolated evolutionary history. However, much of their fossil record is missing. This problem is most evident for the Australasian groups. The approximately 300 living species of marsupials are grouped into three American (Didelphimorphia, Microbiotheria, and Paucituberculata) and four Australasian (Dasyuromorphia, Diprotodontia, Notoryctemorphia, and Peramelemorphia) orders. Higher-level interrelationships have been investigated using a wide range of methods that have often yielded contradictory results. Much of the controversy has focused on the placement of *Dromiciops* (Microbiotheria). Studies either support a sister-taxon relationship to a monophyletic Australasian clade or a nested position within the Australasian radiation. Familial relationships within the Diprotodontia have also proved difficult to resolve. Here, we examine higher-level marsupial relationships using a nuclear multigene molecular data set representing all living orders and employ a relaxed molecular clock to present a timescale for marsupial evolution. Using the molecular divergence dates and the known fossil record we estimate the completeness of the marsupial fossil record.

Preliminary results support a paraphyletic Ameridelphia with Didelphimorphia sister to all other marsupials. Within Australidelphia, *Dromiciops* is the sister-taxon to a monophyletic Australasian clade. Within the Australasian clade, Diprotodontia is the sister taxon to a Notoryctemorphia, Dasyuromorphia, and Peramelemorphia clade. Within the Diprotodontia, the wombat koala clade is the sister taxon to a paraphyletic possum clade (Phalangeriformes) with kangaroos nested inside. Estimated dates of divergence suggest a Late Cretaceous date for all interordinal divergences. All intraordinal divergences were placed in the Cenozoic except for the deepest splits within the Diprotodontia.

Poster Session I

IS THE CLADE CETERUMINANTIA RELEVANT? REVIEW OF MORPHOLOGICAL CHARACTERS IN EARLY SELENODONTIA AND ARCHAEOCETES

MÉTAIS, Grégoire, BEARD, Chris, Carnegie Museum of Natural History, Pittsburgh, PA
New fossil discoveries of postcranial material of early whales show they share what had been thought to be a key synapomorphy of artiodactyls, the double-trochleated astragalus. These results are consistent with molecular data that strongly support a close relationship between whales (Cetacea) and artiodactyls, with numerous studies nesting Cetacea deeply within a paraphyletic Artiodactyla. Recent molecular analyses identified three successive basal dichotomies within cetartiodactyls: Tylopoda, Suina, and Ceteruminantia including Ruminantia and Cetancodonta (hippos and cetaceans). Moreover, estimates of divergence time between between Ruminantia and Cetancodonta indicate about 60 Ma, thus implying several long ghost lineages yet to be discovered in the early history of the Tylopoda and the Suina, both of which first appeared in the middle Eocene. The phylogenies of cetartiodactyls based on morphological data tend to support the existence of a clade Selenodontia including Tylopoda and Ruminantia. Here we review the relevance of the clade Ceteruminantia in the light of morphological data and the fossil record of both Selenodontia and archaeocetes. It appears that these discrepancies between morphological and molecular data sets are probably biased by the inconsistency of the current fossil record of artiodactyls in Asia, and the resulting poor resolution of the phylogenetic relationships between Asian, European, and North American. Although the emergence of Ruminantia in the Paleocene appears unlikely, the analysis of the early evolution and definition of the basal Selenodontia is of critical importance for testing the validity of the clade Ceteruminantia.

Poster Session II

REVISION OF MIOCENE MACKAREL SHARKS (CHONDRICHTHYES, LAMNIFORMES), WITH SPECIAL REFERENCE TO “*ISURUS*” *ESCHERI* FROM NORTHERN GERMANY

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Generally, Cenozoic lamniform sharks are represented by isolated teeth and vertebrae. Articulated skeletal remains are conversely very scarce. In 1989, a partially articulated skeleton of a specimen referable to “*Isurus*” *escheri* including 42 slightly disarticulated teeth and 49 vertebrae was recovered from Miocene clays during an excavation of whales in Groß Pampau (northern Germany). This specimen proves to be important for reconstructing the relationship of fossil lamniform sharks because it provides morpho-meristic data of the vertebral column and allows us to reconstruct the dentition of this taxon. It is the first and, until now, only time that more than few isolated teeth of this species have been found. Here, we are presenting results of our study of this specimen and other lamniform sharks such as *Carcharodon carcharias*, “*Carcharodon*” *megalodon*, “*Isurus*” *hastalis*, and “*Isurus*” *escheri* using dental and skeletal characters to create a modified phylogenetic hypothesis of Cenozoic lamniform sharks and to gain a better understanding of the evolution of the modern White Shark. There are two hypotheses on this topic: either “*C.*” *megalodon* or *Isurus* (e.g., “*I.*” *hastalis*) was the predecessor. *Isurus* is generally abandoned now after reintroducing the name *Cosmopolitodus*. There is genetic and now also fossil evidence that the mako and great white lineages must be separated. But even if *Cosmopolitodus* is accepted to be valid, the taxonomic identity of species such as “*I.*” *planus* and “*I.*” *escheri* remains ambiguous. In addition, the processes responsible for the evolution of “big” lamniforms in the Miocene are analysed and compared with that of teleosts and whales to gain a better understanding of the mechanisms underlying the size increase in these sharks.

Poster Session III

INSECTIVORES OF CHADRONIAN AGE FROM THE CYPRESS HILLS FORMATION, SASKATCHEWAN

MEYER, Taran, Univ. of Saskatchewan, Saskatoon, SK, Canada; BRYANT, Harold, Royal Saskatchewan Museum, Regina, SK, Canada

The Cypress Hills Formation of Saskatchewan preserves sediments of Uintan (middle Eocene) to Hemingfordian (middle Miocene) age, but the best-represented period is the Chadronian North American Land Mammal Age. The best-known site, with the highest known biodiversity, is the middle Chadronian Calf Creek Locality, from which over 70 mammal and 25 non-mammal species are known. The Calf Creek material was recovered from two sub-localities: the Hunter Quarry, which produced relatively complete skeletal elements of larger bodied taxa including brontotheres, and the screening sub-locality, which is located opposite the quarry on the other side of a small coulee. The majority of these taxa have been described in the literature, but the portion of the fauna which includes the “insectivores,” members of the orders Leptictida, Apatotheria, and Lipotyphla, have not been formally described.

The current research undertook to identify and describe the insectivores of the Calf Creek Locality, together with the insectivores from the nearby Chadronian-aged Horse Locality. The latter served two purposes: (1) to begin the formal description of material from the Horse Locality, and (2) to compare the two faunas to identify possible differences between the two. The insectivore faunas of the two sites were found to be very similar, with the same genera and species occurring at both localities. Although the non-insectivore taxa suggest that the Horse Locality dates from either later in the middle Chadronian or the Late Chadronian, in the groups studied here an evolutionary change between the Calf Creek and the Horse localities could not be detected. Taxa described at these sites include:

Leptictida—*Leptictis* sp.; Apatotheria—*Sinclairiella* sp.; Lipotyphla—*Apternodus* sp., *Micropternodus strophensis*, *Domnina thompsoni* and *D. gradata*, *Centetodon chadronensis*, *Oligoryctes altitalonidus*, and *Cryptoryctes* sp. Specimens of the possible chiropteran, *Wallia* sp., are also described.

Student Poster Session

AN ANALYSIS OF NORTH AMERICAN *MARTES* (CARNIVORA: MUSTELIDAE) CRANIA USING GEOMETRIC MORPHOMETRICS AND ITS IMPLICATIONS FOR THE STATUS OF THE EXTINCT TAXON *MARTES NOBILIS*

MEYERS, Jeffrey, Northern Arizona Univ., Flagstaff, AZ

First described by Hall in 1926, the taxon *Martes nobilis* (*M. caurina nobilis*), a Pleistocene variant of the North American pine marten, was initially recognized from specimens recovered from the Samwel and Potter Creek caves, Shasta County, California. Hall differentiated *M. nobilis* from the extant pine marten, *M. americana*, largely through qualitative observations based on the size divergence between the modern and extinct taxa, the latter being generally more robust. Since Hall's description, the validity of *M. nobilis* as a taxon separate from *M. americana* has been controversial. For example, Anderson supported the division between *M. nobilis* and *M. americana* whereas more recent work by Youngman and Schueler, synonymized the two taxa. In my investigation of both modern and fossil taxa, geometric morphometric techniques, in addition to statistical and ordination analyses, were brought to bear on the issue of the binomial validity of *M. nobilis*. Using these techniques, a comprehensive examination of the modern cranial morphology variance of *Martes* was undertaken. Present data indicate that the use of geometric morphometrics can accurately distinguish members of the genus *Martes*, even at the subspecies level. A canonical variate analysis (CVA) was applied to the partial warp scores obtained from the basicranium of 14 different modern subspecies of *Martes*. The program was able to correctly identify these modern crania (n=90) to subspecies with 99.98% accuracy. All crania were placed into their correct subspecies except for one specimen, which was incorrectly placed in the adjacent morphologically most similar subspecies. This analysis suggests that subspecific and specific divisions of the genus *Martes* can be accurately discerned using geometric morphometrics. As a result, it can be determined whether specimens of *M. nobilis* fall within the range of variance of modern North American, independent of linear body size.

Thursday 2:15

AN OVERVIEW OF PALAEOISCOID ACTINOPTERYGIAN VERTEBRAE FROM THE BEAR GULCH LIMESTONE OF MONTANA

MICKLE, Kathryn, Lawrence, KS

The Bear Gulch Limestone (Serpukhovian, Mississippian) of Montana presents a vast assemblage of palaeoiscoiid actinopterygians, many of which preserve details of the vertebral column. In this study, the vertebral column of numerous specimens of undescribed Bear Gulch palaeoiscoiids were examined. The condition and associations of neural arches and spines, haemal arches and spines, interdorsals, and intercentrals surrounding an unrestricted notochord are described. The presence of supraneurals anterior to the dorsal fin is also discussed. These features are compared to those seen in previously described Bear Gulch and non-Bear Gulch palaeoiscoiids.

A caudal skeleton unlike the previously known Bear Gulch forms is described. This caudal skeleton is composed of a series of centra-like bones with ventral hypurals, similar to the condition of the caudal skeleton in *Pygopterus* and a palaeoiscoiid from Hamilton, Kansas. After further examination, it is more likely that these centra-like bones are expanded bases of hypurals and that the notochord remains unrestricted caudally. These observations support Schultze and Chorn's reinterpretation of the caudal skeleton in *Pygopterus* being composed of an unrestricted notochord with ventrally placed hypurals with expanded bases. This appears to be one of many vertebral patterns seen in Paleozoic actinopterygians, which range from completely unrestricted notochords with small hypurals to restricted notochords with well ossified centra. The specimens from the Bear Gulch Limestone, which preserve vertebral elements in relatively complete fish to disarticulated specimens, can provide additional clarification on the vertebral condition in palaeoiscoiid fishes.

Friday 2:15

A NEW BRONTOTHERE FROM CALIFORNIA, ITS PHYLOGENETIC POSITION, AND REVISED STATUS OF THE GENUS *DIPLACODON*

MIHLBACHLER, Matthew, Old Westbury, NY; DEMÉRE, Thomas, San Diego Natural History Museum, San Diego, CA

Excavations at Ocean Ranch, northern San Diego County, exposed a regressive sequence of marine, estuarine, and fluvial deposits of the Santiago Fm with an early Uintan to Duchesnean vertebrate succession. The Duchesnean assemblage includes rodents *Metanoiamys* sp. cf. *M. marinus* Chiment and Korth, *Microparamys* sp. cf. *M. tricus* (Wilson), the creodont *Hyaenodon venturae* Mellett, the amyndodont *Amyndontopsis bodei* Stock, and a new horned brontothere. The Ocean Ranch brontothere resembles *Diplacodon elatus* Marsh from the Uinta Basin. Both have a deep nasal cavity, a narrow constriction between the parasagittal ridges, strong P2 preprotocrista, and a cusp on the anterior molar cingulum. *Diplacodon elatus* was considered a *nomen dubium* due to the crushed holotype, while other specimens comparable to *D. elatus* were assigned to *Pseudodiplacodon progressus* (Peterson) and *Eotitanotherium osborni* (Peterson). However, diagnostic features of these species, including variable horn size, nasal thickness, and variations in the upper pre-

molars, are intraspecific polymorphisms found in nearly all brontotheres. These species are synonyms of *D. elatus*. The Ocean Ranch brontothere differs from *D. elatus* by its curved zygomatics, more anterior posterior nares, lack of sphenoidal fossae, loss of an upper incisor, and absence of p3 metaconid. The lateral edges of the nasal lack the dorsal curvature seen in *D. elatus*. The strict consensus based on analysis of 87 cranial, mandibular, and dental characters, coded for every known brontothere, positions the Ocean Ranch brontothere as the sister of *D. elatus*. The cladograms imply 9-12 dispersals between North America and Asia occurring within the Brontotheriidae during the middle Eocene. *Diplacodon* and the Ocean Ranch brontothere are closely related to *Pachytitan ajax* from Sharamurian aged strata of Inner Mongolia, suggesting that these species are close to an immigration event that may have given rise to the eubrontothere radiation consisting of advanced brontotheres such as *Megacerops*.

Poster Session III

PALAEONVIRONMENTAL RECONSTRUCTION OF THE MAMMALS FROM WADI MOGHRA, EGYPT

MILLER, Ellen, Wake Forest Univ., Winston Salem, NC; EL-BARKOOKY, Ahmed, MOHAMED, Hamdan, KORANY, Mohamed, Faculty of Sciences, Cairo, Egypt; NICHOLS, Courtney, Wake Forest Univ., Winston Salem, NC

Wadi Moghra, Egypt, is an early Miocene fossil locality that preserves a large array of extinct mammals (21 genera, 23 species). Moghra has been an especially important site for primate evolution, because the site has yielded remains of one of the world's earliest known Old World monkeys (cercopithecoiid) and an ape (hominoid), shortly after the initial divergence of the two lineages. Recent work on the geology of Moghra has documented that the deposits were formed as part of a large river system trending southeast-northwest, combined with episodic marine transgressions trending in the opposite direction. Fossils of land mammals are recovered from fluvial/estuarine channel deposits but not from marine facies. In 2005, a series of hypotheses were designed to investigate whether the animals recovered were likely inhabiting the area around the distal fluvial/estuarine system preserved at Moghra, or whether these animals were more likely to have been living further upland and were transported to this distal fluvial/estuarine area after death by the actions of the river system (i.e., essentially whether mammalian faunal elements are primarily autochthonous or allochthonous). Each fossil recovered during the 2005 season was scored for a number of attributes (e.g., provenance, taxon, anatomical element), including degree of transport damage evident. Initial analyses support the hypothesis the Moghra fauna represents a combination of autochthonous and allochthonous species, however results are considered preliminary and were complicated by the diagenetic effects of recent sand erosion on some specimens.

Friday 11:00

TAPHONOMY OF TEMPERATE LARGE-MAMMAL DEATH ASSEMBLAGES: A LIVE-DEAD ANALYSIS OF YELLOWSTONE NATIONAL PARK

MILLER, Joshua, Univ. of Chicago, Chicago, IL

Understanding the taphonomic processes that influence the ecological composition of modern death assemblages is essential for accurate paleoecological interpretations of fossil communities. Previous live-dead studies of mammal communities have focused on African savannas and provided insight into the quality of ecological data housed in modern semi-arid death assemblages. The rates and mechanisms by which bones from an individual decompose and are destroyed, however, vary with body size, ontogenetic age, environment, and composition of the local scavenger community. A broader sampling of environments and ecologies is thus needed to more fully understand the taphonomic dynamics influencing ecological composition of large-mammal death assemblages. Yellowstone National Park, WY, with its abundant, diverse, and well-studied large-mammal community provides an excellent system for evaluating the fidelity with which a modern death assemblage captures the living community in a temperate environment. Surficial bone accumulations of four Yellowstone habitats were surveyed and compared to living population census data for agreement in species composition, relative abundance, and habitat occupation. In addition, observations of the remains of carcasses with known dates-of-death illuminated bone decay rates and disarticulation patterns. Results indicate high ecological fidelity between the living community and the death assemblage in terms of species composition, relative abundance, and habitat preferences. Bone decomposition and loss rates in Yellowstone are slower than those previously documented for African localities and indicate prolonged time-averaging potential for cold-weather death assemblages. Comparisons between the Yellowstone death assemblage and surveys of the living community also suggest that temperate death assemblages are sources of historical ecological data useful for wildlife conservation and management efforts. Continued live-dead studies in diverse environments will expand understanding of the taphonomic filters influencing death assemblage composition and improve ecological interpretations of both modern and fossil skeletal accumulations.

Wednesday 5:30

SWIMMING BEHAVIOR IN EARLY JURASSIC THEROPOD DINOSAURS BASED ON SPECTACULAR SWIM TRACKS FROM SOUTHWESTERN UTAH

MILNER, Andrew, St. George Dinosaur Discovery Site at Johnson Farm, St. George, UT; LOCKLEY, Martin, Univ. of Colorado at Denver, Denver, CO; HARRIS, Jerald, Dixie State College of Utah, St. George, UT; KIRKLAND, James, Utah Geological Survey, Salt Lake City, UT

Numerous vertebrate track-bearing layers in the Whitmore Point Member of the Moenave Formation, within a 1 km² area of the St. George Dinosaur Discovery Site at Johnson Farm (SGDS) preserve unique, marginal lacustrine deposits of Early Jurassic (Hettangian) "Lake Dixie." The best-preserved track-bearing horizon, called the "Main Track Layer," demonstrates dramatic lateral changes in facies and trace fossils from onshore to offshore. This bedding surface records a transition from exposed mudflats, with tracks and sedimentary structures formed onshore (e.g., deep mudcracks, salt casts, and rain drop impressions), to mud, silt, and sand scoured away by longshore currents that display definitive subaqueous sedimentary structures, invertebrate traces, fish swim trails, and hundreds of theropod swim tracks. Onshore firm substrate consistencies along the "Main Track Layer" surface resulted in a preservational bias of tracks by larger theropods rather than by smaller vertebrates. On the offshore "Main Track Layer" surface, the majority of swim (or floundering) tracks are referable to *Grallator*-type theropods. Exceptional details are preserved, including skin impressions, claw marks, and scale scratch lines in association with current-oriented sedimentary structures such as flute casts, scratch semi-circles, tool marks, groove casts, scours, and current ripples. The simultaneous infilling of tracks and sedimentary structures by fine-sand, along with high clay content in the underlying mud, accounts for this exceptional and detailed preservation. The majority of swim tracks are oriented both parallel to and opposite the current flow direction indicated by the scour marks, suggesting animals possibly reacting to being swept off-balance by N-S currents that flowed parallel to the paleo-shoreline. The SGDS swim tracks are by far the best-preserved and largest collection of such fossils known in the world.

Saturday 11:45

STEGOPS, A PROBLEMATIC SPIKY-HEADED TEMNOSPONDYL

MILNER, Andrew, The Natural History Museum, London, United Kingdom; SCHOCH, Rainer, Staatliches Museum fuer Naturkunde, Stuttgart, Germany

The spiky-headed temnospondyl amphibian *Stegops divaricata* from the Middle Pennsylvanian coal of Linton, Ohio has remained neglected and enigmatic for several decades. It has been argued to be the ancestor of the Permian Zatrachydidae, also spiky-headed temnospondyls, although there are few resemblances other than the spikes. An examination of previously undescribed material of *Stegops*, along with a re-evaluation of the original specimens, permits a redescription and partial systematic assignment of it. All specimens have bony spikes on the tabular, quadratojugal and angular, but in apparent dimorphism, only some have squamosal and supratemporal spikes. A phylogenetic analysis of 52 characters in 15 temnospondyl taxa places *Stegops* within the dissorophoid clade but leaves its position uncertain within that clade. The Zatrachydidae, represented by *Acanthostomatops*, fall outside the Dissorophoidea, and the zatrachyd affinities of *Stegops* asserted by previous workers are based on homoplasious similarities in ornamentation. Internal relationships of the Dissorophoidea remain unresolved and *Stegops* shares conflicting similarities with Amphibamidae in some resolutions and with an *Ecolsonia* + Dissorophidae + Trematopidae clade in others.

Wednesday 1:30

NEW DATA ON AVIAN BRAIN EVOLUTION FROM FOSSIL BIRDS FROM THE LOWER EOCENE OF ENGLAND

MILNER, Angela, WALSH, Stig, The Natural History Museum, London, United Kingdom
Recently recovered Cretaceous bird fossils (e.g. from Liaoning in China) have allowed important insight into the theropod-avian transition and the evolution of flight. However, despite over one hundred years of research, little is known about how the avian brain evolved in response to the development of flight, largely because very few avian endocranial casts are known. The CT-based analysis of the brain of *Archaeopteryx* led by ACM in 2004 has been followed by the investigation of braincases of two lower Eocene neornithines from the London Clay of England. Our results show that *Odontopteryx toliapica* and *Prophaethon shrubsolei* possessed brains comparable in size and shape to those of living seabirds, indicating that the bird brain had reached an evolutionary level close to that of Recent species by that time. However, the poor development of the eminentia saggitalis (which is responsible for many advanced functions including binocular vision) in both species, especially in *Odontopteryx*, shows that important telencephalic features characteristic of extant clades had not fully developed by the Eocene. These data nevertheless represent the earliest evidence of the avian eminentia saggitalis in the fossil record and have important implications for the evolution of avian cognitive ability. Our results support earlier hypotheses of a general increase in avian brain size over time, but indicate a trend toward diversification in telencephalic architecture that culminated in the extreme cerebrotypes today seen in Psittaciformes, Strigiformes and some Passeriformes.

Preparators Symposium, Thursday 8:00

REFINED PARAFFIN WAX USED TO PRESERVE 11,000 YEAR-OLD CAMELID FOOTPRINTS IN LAKEBED SEDIMENTS, ST. MARY RESERVOIR, SOUTHERN ALBERTA, CANADA

MILOT, Peter, BURNS, James, Royal Alberta Museum, Edmonton, AB, Canada
The St. Mary Reservoir site (a.k.a. Wally's Beach) lies 20 km NE of Cardston, Alberta. Lowering of the reservoir in 1998 for spillway repairs exposed to ablation a large tract of unconsolidated aeolian sediments. Thousands of late Pleistocene megafaunal tracks and trackways of woolly mammoth, equids, bovids, cervids and camelids were exposed, accompanied by skeletal remains of *Bison antiquus*, *Bootherium bombifrons*, and *Equus conver-*

sidens, as well as by Clovis and more recent stone tools. AMS dates ranged from 11,000 to 11,500 years BP.

In spring 1999, the authors were invited to the St. Mary site by co-principal investigator Prof. L.V. Hills, Univ. of Calgary Dept. of Geology and Geophysics, to research and attempt the recovery of tracks. Field work focused primarily on identifying the makers of the tracks, and on molding the surface of selected tracks. To ensure that they were truly footprints and not, for example, de-watering structures (as some had suggested), vertical sectioning of subsurface deformation of the tracks was photo-documented. Plaster molds and photo-documentation were made of 36 individual footprints, of which 7 comprise a mammoth trackway.

In addition, 2 camelid tracks were prepared, jacketed and excavated. This paper describes a methodology, using refined paraffin wax, to consolidate and preserve these camelid tracks in their original sediments. They will be used eventually in the "Ancient Alberta" gallery at the Royal Alberta Museum.

Wednesday 5:00

ARCTOSTYLOPID MAMMALS AS NON-GLIROID GLIRIFORMES: TARSAL AND DENTAL ARGUMENTS

MISSIAEN, Pieter, Univ. of Ghent, Ghent, Belgium; SMITH, Thierry, Royal Belgian Institute of Natural Sciences, Brussels, Belgium

The late Paleocene and early Eocene arctostylopid mammals are common in mammal faunas in Asia but very rare in North America. Arctostylopid mammals are almost exclusively known from their dental remains. The distinctive arctostylopid molar morphology shows surprising similarities to that of Notoungulata, and since their first discovery in 1915, the arctostylopid mammals were generally grouped with the strictly endemic South American Notoungulata. Although biogeographical and morphological arguments were suggested against the grouping of arctostylopid mammals with notoungulates, no alternative phylogenetic affinities have been proposed for arctostylopid mammals.

Recently we published and interpreted the tarsal bones of the late Paleocene Chinese arctostylopid *Palaeostylops iturus*. Comparison with previously unpublished tarsals from North American *Arctostylops*, derived from a partial skeleton also including dental material, confirms our first unambiguous identification of arctostylopid tarsals. Functional interpretation shows that *Palaeostylops* was a moderately specialized cursorial or saltatorial mammal. Phylogenetic interpretation of the arctostylopid tarsals offers does not support the grouping of Arctostylopidae and Notoungulata. Instead, the *Palaeostylops* tarsals show unexpected similarities to the basal gliroid *Rhombomylus* and the gliroid *Pseudictops*. Based on tarsal evidence, we put forward the novel hypothesis that Arctostylopidae are a family of non-gliroid gliroides.

In the light of this hypothesis, we review the dental morphology of Arctostylopidae. Although the molar morphology of arctostylopid mammals resembles notoungulates, special attention is reserved for the arctostylopid anterior dentition, which may support their gliroid affinities. Here, we present an integrated analysis of both dental and tarsal characters, providing a new step to test the phylogenetic affinities of arctostylopid mammals.

Poster Session III

AN ENIGMATIC DINOSAUR FRONTAL FROM OLDMAN FORMATION (CAMPANIAN), SOUTHERN ALBERTA

MIYASHITA, Tetsuto, Univ. of Alberta, Edmonton, AB, Canada

An isolated dinosaur frontal (TMP 87.89.8) was surface collected from the Oldman Formation (Belly River Group) in southern Alberta. The frontal exhibits unusual morphology. It is thick and longer than wide. The dorsal surface is covered with grooves along the moderately long orbital rim. The postorbital ridge rostrally borders the deep supratemporal fossa. This ridge is elevated from the dorsal surface and continues to become a low sagittal crest medially. The cross section at the midline suture becomes thickest under the ridge. A preserved part of the parietal suture suggests that the paired frontals caudally separated the parietals. Ventrally, the orbital cavity highly expands medially such that the ridge enclosing the orbital cavity reaches the midline suture, leaving an unusually narrow interorbital space. As a result, the laterosphenoid contact is displaced far medially and does not seem to continue to the postorbital. A shallow depression posterior to this contact probably marks the cerebral impression. Similarly, a depression at the broken anterior end may be the trace of an olfactory bulb. The specimen significantly differs from frontals of any dinosaur occurring in the Belly River Group. Cladistic analysis finds the specimen weakly associated with either basal neotheropods or basal ceratopsians, both without any unambiguous synapomorphy. Because many character states of the specimen such as the narrowed interorbital space are autapomorphic, its association with other taxa in the analysis mostly depends on proportional or general similarity in morphology. Neither a single pathologic cause seems to explain the unique suite of character states. The eroded lateral contacts of the frontal may be hindering its precise taxonomic identification. Had the contacts been preserved and made the identification possible, the novel combination of characters would nevertheless make the specimen unique in the taxon. With the discovery of additional diagnostic material, the specimen will undoubtedly add to the taxonomic diversity of the Oldman vertebrate fauna. The study also calls attention to similar frontals that may have been collected elsewhere.

ADDITIONAL SPECIMEN OF A NEW CORYPHODONTID PANTODONT (MAMMALIA) FROM THE EOCENE AKASAKI FORMATION, KUMAMOTO PREFECTURE, JAPAN, AND ITS TAXONOMIC AND ONTOGENETIC SIGNIFICANCE

MIYATA, Kazunori, Fukui Prefecture Dinosaur Museum, Katsuyama City, Fukui, Japan; TOMIDA, Yukimitsu, National Science Museum, Tokyo, Tokyo, Japan; UGAI, Hiroaki, HIROSE, Koji, Goshoura Cretaceous Museum, Amakusa City, Kumamoto, Japan
A new specimen of a coryphodontid (GCM-VP 133) from the Akasaki Formation (late early/early middle Eocene), Goshoura, Amakusa City, Kumamoto Prefecture, preserves left M1, mandible with complete permanent lower dentition except for left i3, and postcranial elements including some dorsal vertebrae and ribs. GCM-VP 133 is characterized by having a fused mandibular symphysis, triangular and spatulate incisors, small incisiform canines, p2 with no trigonid basin, posterior premolars (p3-4) with short talonid heels and well-developed metalophids, and bilophodont hypsodont lower molars with distinct metalophids, hypolophids, and massive metaconids. The associated M1 is narrow lingually and is bilophodont with protoloph, premetacrista, and stout protocone, although the lophes are considerably worn.

The characters of the upper and lower molars of the new specimen suggest that it belongs to an undescribed coryphodontid species—a previously recognized specimen consisting of a skull of a young individual (GCM-VP 101) also is known from the same formation and represents the same new species. This new coryphodontid taxon has a close affinity with *Eudimoceras* in having derived bilophodont molars, but it is a derived species differing from all other known Asian coryphodontids, based on the characters of the upper molar and lower premolars noted above. The new specimen, along with GCM-VP 101 which preserves the deciduous dentition, not only shows further morphological characters of derived coryphodontids, but also provides ontogenetic information, which has been poorly understood in Asian coryphodontids.

Saturday 1:30

A SPECIMEN OF THE PROCOLOPHONOID REPTILE SAUROPAREION ANOPLUS FROM THE KATBERG FORMATION OF SOUTH AFRICA

MODESTO, Sean, Sydney, NS, Canada; BOTHA, Jennifer, National Museum, Bloemfontein, South Africa; SMITH, Roger, Iziko South African Museum, Cape Town, South Africa

Collecting efforts in the South African Triassic indicate a stratigraphic separation between the procolophonoid *Procolophon trigoniceps*, the predominant reptile of the arenaceous Katberg Formation, on one hand and, on the other, the owenettids and non-procolophonoid procolophonoids (*Coletta seca*, *Sauropareion anoplus*), which are known almost exclusively from the argillaceous Palingkloof Member of the Balfour Formation. Recent fieldwork has yielded the anterior half of the skeleton of a small procolophonoid from lower strata of the Katberg Formation northwest of Middelburg in Eastern Cape Province. Weathering of the skull has resulted in loss of the median elements of the skull table and damage to the surrounding bones. Enough is preserved, however, to present a small suite of cranial characteristics, such as the presence of simple conical teeth, contribution of the parietal to the orbital margin, and the presence of a posteroventral facial process of the quadratojugal, which allow us to refer the specimen to the monotypic genus *Sauropareion*. The new specimen is significant because *Sauropareion* was known heretofore only from Palingkloof strata at Barendskraal, south of Middelburg. It allows recognition of a stratigraphic range for this procolophonoid species, one that extends from the Palingkloof Member into the lower part of the Katberg Formation. Together with the inferred range for *Coletta seca*, our discovery serves to narrow the stratigraphic gap between basal procolophonoids and *Procolophon*. It also indicates that basal procolophonoids did not succumb to a second pulse of extinctions trailing the primary extinctions that mark the boundary between the Permian and the Triassic.

Romer Prize Session, Thursday 11:00

PLIOCENE NYCTEREUTES SPP. (CARNIVORA, CANIDAE) FROM EURASIA

MONGUILLON, Angélique, Université Claude Bernard-Lyon 1, Villeurbanne, France
Our understanding of raccoon-dog systematics has long been limited by an overestimation of the impact of geography on taxonomy and the specific value of one character, namely, the relative development of the subangular lobe of the mandible. A revision of the known material from Eurasia (including undescribed European material) has clarified the taxonomy and biogeography of fossil raccoon-dogs and developed a new hypothesis regarding their phylogeny and eco-ethology.

In Eurasia, 4 fossil species of raccoon-dogs have been identified and are deemed valid. From the Early and early late Pliocene, *Nyctereutes tingi* (originally from Asia) and *Nyctereutes donnezani* (a European form) both present plesiomorphic characters, while *Nyctereutes sinensis*, an Asian species contemporaneous and sympatric with *N. tingi*, has apomorphic characters. During the late Pliocene of Europe, *N. donnezani* leads to *N. megamastoides*, which is vicarious with *N. sinensis*.

The raccoon-dog from the early late Pliocene locality of Çalta (Turkey), described as *N. donnezani*, shows affinities with *N. tingi*, despite a secondary adaptation to an omnivorous diet; a new subspecies is created. The raccoon-dog from the late Pliocene locality of Saint-Vallier (France) is assigned by new combination, to a distinctive species. It possesses a more carnivoran/plesiomorphic morphology than other western European raccoon-dogs and could be linked to the *N. tingi* lineage.

AN ICHNOFAUNAL COMPARISON OF TWO PENNSYLVANIAN (MORROWAN-ATOKAN) TETRAPOD TRACK LOCALITIES IN INDIANA

MONKS, Joe, W. Lafayette, IN; KVALE, Erik, Indiana Geological Survey, Bloomington, IN

Two Pennsylvanian tetrapod track localities in the Mansfield Formation of western Indiana have helped to provide new insight into the terrestrial vertebrate fauna of the Illinois Basin. The two localities, located in Warren County and at the Crane (NSWC) lie along the eastern margin of the Illinois Basin. Both localities were deposited on tidally influenced estuarine mud flats. However, the two localities differ from each other by the faunal constituents they preserve. The locality at Crane preserves prints of few tetrapods but several invertebrates. Tracks of the temnospondyl amphibian *Paleosauropus primaevus* and *Paleosauropus brunensis*, reptilian tracks of *Notalacerta* and two other indistinguishable tetrapod tracks have been recovered from Crane. Invertebrate traces include the insect *Tonganoxichnus*, feeding traces of *Haplotichnus*, *Plangitichnus*, *Treptichnus* and the trackway of a large millipede. The Warren County locality has produced several taxa of tetrapod and invertebrate traces. Six taxa of tetrapods from the Warren County locality include the anthracosaur amphibian *Colletosaurus indianaensis*, the reptilian *Notalacerta missouriensis* and another anthracosaur amphibian, *Cincosaurus*. Invertebrate traces include *Conosticus*, *Treptichnus*, and *Helminthopsis*.

This information implies that the ecosystem of the Illinois Basin during that time was much more diverse and complex than previously thought. Both localities preserve several taxa of tetrapods, a feature that is uncommon of most Carboniferous tetrapod localities. With the exception of Joggins, Nova Scotia (Canada) and Carbon Hill, Alabama, the Warren County locality is the most diverse tetrapod track locality in North America, with respect to the number of separate taxa that it has produced. Together, the two localities also extend the knowledge of the spatial relationships of tetrapods, with special importance to the reptilia, fossils of which are extremely scarce during this time. Reptilian fossils from the early Pennsylvanian are exceedingly important in providing insight into their early evolution and radiation.

Poster Session II

INFERRING BONE GROWTH RATES IN EXTINCT ARCHOSAURS FROM THE THICKNESS OF CALCIFIED CARTILAGE IN THEIR LONG BONES

MONTESS, Laëtitia, Université P & M Curie Paris VI, Paris, France; CUBO, Jorge, DE MARGERIE, Emmanuel, CASTANET, Jacques, DE RICQLÈS, Armand, Université Paris VII, Paris, France

The histological features of mineralized tissues can be preserved for hundreds of millions of years, and therefore are important potential sources of information for reconstructing the life history traits of extinct species. Bone growth rates and the duration of the growth period have recently been estimated in fossil Archosaurs from periosteal ossification (a mechanism responsible for bone diametral growth). Similarly, data on endochondral ossification (the mechanism responsible for bone longitudinal growth) may also yield information on growth duration and rate among extinct Vertebrates, as long as potentially informative structures are preserved. However, in order to carry out palaeontological estimations of growth rate and/or the duration of growth, it is first necessary to quantify in extant species the relationship between these life history traits and the histological features of endochondral ossification that are potentially preserved in the fossil record. Here we analyze the ontogenetic variation of both bone longitudinal growth rate and the thickness of calcified cartilage in the femora of two Galloanseræ (Aves) and find a significant positive relationship between these variables in both species. We discuss possible factors underlying interspecific differences in this relationship, and conclude that it could be applied with caution to draw palaeobiological inferences.

Romer Prize Session, Thursday 11:15

TAPHOCHARACTER ANALYSIS OF EXTINCT MAMMALIAN COMMUNITIES: EXACTLY HOW SEVERELY DO TAPHONOMIC BIASES AFFECT TERRESTRIAL VERTEBRATE FOSSIL ASSEMBLAGES?

MOORE, Jason, Univ. of Cambridge, Cambridge, United Kingdom

Paleoecologists aim to observe, document and compare patterns in fossil assemblages that result from ecological processes. In order to study ecological patterns within the fossil record it is necessary to account for the effects of the major taphonomic biases on a fossil assemblage. A quantification of the taphonomic biases affecting fossil assemblages will allow assemblages to be demonstrated to be isotaphonomic. Any differences between isotaphonomic assemblages are caused by ecological rather than taphonomic processes. Quantitative knowledge of taphonomic biases also enables the calculation of correction factors to remove the biases and then the study of the de-biased fossil communities using similar methods to those applied to extant communities by modern ecologists.

Taphocharacter analysis is a newly developed method that can be used to quantify the taphonomic biases affecting vertebrate fossil assemblages. Once a sample of a fossil assemblage has been collected, the difference between the observed and expected proportion of each skeletal element (or taxon) is calculated. These differences represent the sum total of the taphonomic biasing of the fossil assemblage. A suite of quantitative or semi-quantitative taphonomic characters are measured for each specimen within the sample, for example, mass, weathering or abrasion stage and shape factors. Multiple regression methodology is used to determine the taphonomic characters that have contributed significantly towards the

total biasing of the fossil assemblage and how much of the total biasing can be explained using the statistically significant taphonomic characters.

Taphocharacter analysis of samples of a mammalian fossil assemblage collected from the Scenic Member, Brule Formation of Badlands National Park, South Dakota, demonstrates that it is possible to explain 85% of the total taphonomic biasing with six taphonomic characters. These characters are shown to be consistent in both significance and magnitude of effect between samples. It is hoped that wider application of taphocharacter analysis will reveal underlying patterns in the taphonomic biasing of fossil assemblages and so aid in the solution of many current paleoecological problems.

Poster Session III

VARIATIONS FROM ADULT MORPHOLOGY IN A SUBADULT SKULL OF THE DINOSAUR *TRICERATOPS* FROM THE HELL CREEK FORMATION OF MONTANA

MORALES, Michael, Emporia State Univ., Emporia, KS; CAMPBELL, Carl, St. Louis Community College-Meremec, St. Louis, MO

In recent years field crews from the St. Louis Science Center (St. Louis, Missouri) and Emporia State Univ. (Emporia, Kansas) have prospected for fossils in the Upper Cretaceous Hell Creek Formation in eastern Montana. The most commonly found dinosaur taxon is *Triceratops*, which is usually represented by large/adult individuals. One smaller skull, however, represents a subadult that shows some differences with typical adult morphology. The specimen came from a gray, cross-bedded sandstone channel deposit approximately ten meters below the K-T boundary, about 15 miles northwest of Jordan. Most of the frill of the subadult specimen is missing, but the main part of the cranium is complete enough to allow it to be reconstructed. The skull is 70-80% of adult size, with relatively large orbits and some unfused sutures—indicative of a subadult stage of ontogeny. As expected, the diameter of the exoccipital is less than typical for adults or larger subadults. In contrast, however, the brow horns are nearly adult size, as is the braincase. Furthermore, the brow horns come off the main part of the skull primarily in front of the orbits, rather than mainly above the orbits as in adults. The horns extend forward (not straight up or backward) at a 30-60 degree angle. The bases of the brow horns lie mostly anterior to the braincase, rather than mostly dorsal to it as in adults. The broken bases of the brow horns have large sinuses, which connect to sinuses at the attachment point on the main part of the skull. As preserved, the horn sinuses are filled with a very dark mass of fossilized organic tissue that was probably rich with blood when the individual was alive. If this represents a highly vascularized area for bone growth, then the bony part of the brow horns may have grown outward from the base, rather than from the tip. Fragments identified as frill are smooth on both sides, without a rough reticulated anterior surface as in adults. The front side of the frill fragments is flat and has (blood) canals and tunnels, but the slightly convex back side lacks these.

Friday 8:15

EVIDENCE FOR HABITAT GRADIENTS USING LATERAL VARIATION IN STABLE CARBON ISOTOPE RATIOS WITHIN THE MIOCENE SIWALIK SEQUENCE OF PAKISTAN

MORGAN, Michele, Harvard Univ., Cambridge, MA; BEHRENSMEYER, Anna, Smithsonian Institution, Washington, DC; BADGLEY, Catherine, Univ. of Michigan, Ann Arbor, MI; NELSON, Sherry, Boston Univ., Boston, MA; BARRY, John, Harvard Univ., Cambridge, MA

The “U-level,” an interval dated magnetostratigraphically to 9.15–9.30 Ma, has produced 103 fossil localities and >4000 fossil specimens representing 60 mammalian species. This interval is named for a distinctive fluvial sandstone that is laterally traceable for over 40 km. An environmental gradient between two different fluvial systems has been documented over this lateral distance. To the west, predominantly blue-gray sandstones indicate the presence of a major river system with a distant montane source, while to the east, predominantly buff sandstones indicate smaller rivers that drained regional floodplains. The major blue-gray sand-dominated system might have supported a higher water table during the dry season than the smaller channels; alternatively, the more clay and silt-rich sediments of the smaller channels may have buffered seasonal fluctuations in rainfall more effectively than in the larger river system, which was likely subject to strong seasonal flooding.

Isotopic analysis of nearly 100 mammal teeth and 25 paleosol carbonate samples from the U-level supports a habitat gradient along the transition between fluvial systems. Fossils from the eastern third of the section are significantly more depleted in $\delta^{13}\text{C}$ than fossils from the western third, despite sampling of similar taxa including sivapithecine hominoids, equids, giraffids, suids, and anthracotheres. These data suggest that the smaller local rivers and streams of the buff system supported forage with more depleted $\delta^{13}\text{C}$ values, and perhaps generally denser tree cover. Presently available paleosol carbonate $\delta^{13}\text{C}$ values are compatible with this interpretation.

Poster Session III

CREODONTA AND CARNIVORA FROM WADI MOGHRA, EGYPT

MORLO, Michael, Forschungsinstitut Senckenberg, Abt. Messelforschung, Frankfurt, Germany; EL-BARKOOKY, Ahmed, Geology Dept., Faculty of Science, Giza, Egypt; MILLER, Ellen, Wake Forest Univ., Dept. of Anthropology, Winston Salem, NC

Six new taxa of carnivorous mammals from Wadi Moghra, early Miocene, Egypt, are described, and the implications of these taxa for interpreting the biogeography of early

Miocene mammals are discussed. The new taxa include two hyaenodontid creodonts (*Hyainailourinae* new genus, new species and cf. *Teratodon*) and four carnivorans: an amphicyonid (*Cynelos* new species), two viverrids s. l. (*Herpestides* new species and *Viverridae* s.l. new genus, new species), and a stenoplesictid (*Stenoplesictidae* new genus, new species). Previously, only two carnivorous mammals, both large creodonts (*Hyainailouros fourtaui*, *Megistotherium osteothlastes*), had been reported from Moghra. Together, the eight carnivorous taxa now known from Moghra include some representatives of widespread genera common to localities across Eurasia and Africa, but also a number of unique faunal elements, including three new genera and five new species. Evidence for two alternate hypotheses concerning the timing of carnivore migrations events are discussed: 1) an early Miocene (ca. MN 3) event followed by a slightly later (MN 4-5) one; or 2) an even earlier first migration date, in the late Oligocene-early Miocene (MN 1 or even MP 30), which is considered here to be the more likely scenario.

Poster Session II

ANATOMICAL DETAILS FROM A WELL PRESERVED SPECIMEN OF *LONGIROSTRAVIS* (AVES, ENANTIORNITHES) FROM THE JIUFOTANG FORMATION, LIAONING PROVINCE, CHINA

MORSCHHAUSER, Eric, Montana State Univ., Bozeman, MT; LIU, Jinyuan, MENG, Qingjin, Dalian Natural History Museum, Dalian, China; VARRICCHIO, David, Montana State Univ., Bozeman, MT

The lacustrine deposits of the Yixian and Jiufotang Formations from Liaoning Province, China are unparalleled in their diversity of fossil bird species and noted for the quality of their preservation. Here we report a new, exquisitely preserved enantiornithine specimen from the Jiufotang Formation. The specimen possesses the following features in common with the known species *Longirostravis hani*: 1) long, tapering and slightly curved rostrum, 2) dentition restricted to the premaxilla and rostral-most dentary, and 3) triradiate lateral processes on the sternum. The sternal lateral processes of the new specimen differ from the “moose antler” form of the *Longirostravis* type in having a more complex, three dimensional arrangement. Additionally, the new specimen has slightly smaller linear dimensions than the type and lacks the typical enantiornithine fusion of the tibiotarsus and carpometacarpus. These features suggest that the new specimen represents either a subadult *Longirostravis hani* or possibly, a younger individual of a different, as-yet-unknown species. This specimen also exhibits several unusual features. An unknown subtriangular element occurs on both sides of the specimen just lateral to the sternocoracoid contact. These paired elements have a more porous texture than the rest of the skeleton and may lack well-developed cortical bone. The pygostyle possesses two thick lateral flanges that extend roughly two-thirds the length of the element and is similar in overall morphology to that of *Sinornis*. The manus is highly derived for an enantiornithine. Each of the digits lacks unguals and the phalangeal count stands at a very modern 1-2-1-0-0. If this generic identification proves true, *Longirostravis* would be the first avian from northeastern China to be found in both the Yixian and Jiufotang Formations.

3D Imaging Symposium, Friday 9:15

THE FIRST TRULY OBJECTIVE METHOD FOR 3D REMOVAL OF GEOLOGICAL DEFORMATION WITH AN APPLICATION TO THE BRAINCASE OF *ARCHAEOPTERYX*

MOTANI, Ryosuke, Univ. of California Davis, Davis, CA; MILNER, Angela, Natural History Museum, London, United Kingdom; SCHMITZ, Lars, Univ. of California Davis, Davis, CA

Most fossils have been distorted as an unavoidable consequence of geological processes. It is known in invertebrate paleontology that geological deformation has misled taxonomy and systematics but this significant bias has largely been neglected in vertebrate paleontology. In 2005, a book was published in paleoanthropology, implicitly stating that it was impossible to objectively identify the geological compaction axis from a deformed skull. If true, this would mean that any 3D treatment of fossil skulls, including morphometrics and biomechanics, could not avoid being arbitrary at a very basic level.

We developed a method to objectively estimate the geological compaction axis by taking advantage of the minor asymmetry that exists in a skull. We then tested the method in three different ways. First, we ran simulations to see if and under what idealized conditions the correct identification of the compaction axis was possible. Second, we virtually deformed a 3D image of a living monkey skull to see if the method could identify the known compaction axis when real biological asymmetry was present. Third, we applied it to the braincase of *Archaeopteryx* to see if the method was applicable to a real fossil. The true compaction axis was unknown for the third case so we tested the outcome from five different biological and geological perspectives, including the orientation of the bedding planes. In all cases, the effectiveness of the method was well-supported by the results.

Once the deformation was removed from the braincase of *Archaeopteryx*, it became clear that the bird-like features of the genus were previously underestimated as a result of geological compaction. The brain size, which was said to be intermediate between those of typical birds and other reptiles, was indeed as large as in some living birds of similar body mass. Also, the brain was wider, with expanded optical lobes resembling those of modern birds. The new knowledge largely affects our perception of this critical genus. The result demonstrates that the removal of geological deformation is even more important in this age of rapid improvement of 3D quantification techniques.

Saturday 4:00

ENVIRONMENTAL CHANGE AND HUMAN IMPACT IN SOUTHWESTERN MADAGASCAR: EVIDENCE FROM ANKILITELO CAVE

MULDOON, Kathleen, Washington Univ., St. Louis, MO; SIMONS, Elwyn, Duke Univ. Primate Center, Durham, NC

The cause of megafaunal extinctions in Madagascar is a critical question in understanding the ecological instability that characterizes the island today. Central to this debate are accurate reconstructions of the habitats occupied by the megafauna prior to their extinction. In this study, we examine the micromammal assemblage at Ankiliteilo Cave to address the question, were habitats used by the megafauna the same as those that exist in southwestern Madagascar today, or different in ways that reflect climate change, human activity, or a mixed model "synergy"?

We compare the taxonomic and ecological diversity of the Ankiliteilo assemblage with 23 modern forests spanning the diversity of Madagascar's habitat types. Taxonomic diversity is quantified using species richness measures, which are compared among modern forests and Ankiliteilo using cluster analysis. Based on taxonomic identifications, species are assigned to diet, locomotor, activity pattern and body size categories. These categories are used to capture the ecological structure of the modern communities and Ankiliteilo and describe their habitat. The ecological structure of Ankiliteilo and each modern community are analyzed and compared using multivariate statistics.

Results suggest that the habitat surrounding Ankiliteilo during the late Holocene was similar to the succulent woodland and spiny thicket of modern southwestern Madagascar. Measures of taxonomic composition, species richness and ecological structure indicate that there have been minimal shifts in community boundaries in the last 500 years, although reductions in the geographic distribution of some individual species are documented. Community change appears to have most severely affected the highest body size levels. These results indicate that the cause of megafaunal extinctions in southwestern Madagascar represents a synergy of both human-initiated and environmental pressures.

Vertebrate Development Symposium, Wednesday 10:15

FOSSILS, SNAKE EYES, AND PROTEIN EVOLUTION

MÜLLER, Johannes, Humboldt-Universität, Berlin, Germany

Improvements in comparative sequence analysis and gene synthesis technologies in recent years have enabled investigations into the evolution of proteins and protein function not previously possible. This is important also for studies in paleontology, where often competing hypotheses arise in considering ambiguous evidence from the fossil record. A good example is the debate on the origin of snakes, in which both the aquatic and the terrestrial hypothesis of origin suffer from the problem of conflicting morphological characters and the lack of fossils. One of the widely discussed but poorly known ophidian characteristics is the anatomy of the eye, which is strikingly different from any other amniote; a better understanding of its evolutionary origin, from both a neurosensory and a developmental perspective, might contribute significantly to the enigma of snake ancestry. As such, the snake eye can serve as an example of how computational and empirical studies of protein evolution can help elucidate questions related to paleontology and the origin, or modification, of morphological structures. Modern techniques in protein research include the possibility to test for directional selection in specific evolutionary branches, the prediction of the ancestral sequence of the protein under consideration, and its recreation in the laboratory. Ongoing research on the snake eye focuses on visual pigments, which have been sequenced and analyzed in snakes for the first time and tested for patterns of selection, with a view toward the eventual use of these sequences in recreating the ancestral visual pigments of snakes. While such an approach may be easier to implement for neurosensory systems, insights from protein evolution can be feasible for aspects of development as well, though care must be taken in interpreting the results of such studies due to the complex network of interactions in many developmental systems. Regarding vertebrate eye development, the function of candidate genes such as *Pitx3* has recently been investigated in more detail; ancestral protein reconstruction methods may offer the potential for even greater insights into the origins of the snake eye.

Poster Session II

A NEW PARACLUPEID FISH (CLUPEOMORPHA, ELLIMMICHTHYIFORMES) FROM THE MIDDLE CENOMANIAN DUNVEGAN FORMATION, ALBERTA, CANADA

MURRAY, Alison, CUMBAA, Stephen, Canadian Museum of Nature, Ottawa, ON, Canada; HAY, Michael, PLINT, A., Univ. of Western Ontario, London, ON, Canada

A new, almost completely preserved, articulated fossil fish is described from black marine mudstone of the middle Cenomanian Dunvegan Formation, Alberta. The fossil was recovered from a drill core, which fortuitously encompassed the whole fish within the diameter of the core. The fish is a new genus and species of Paraclupeidae, the only family in the extinct order Ellimmichthyiformes, which is considered to be the sistergroup to the Clupeiformes. Although the composition of the family is not resolved, with disagreement on which genera are included, the new taxon shares with other members of the Paraclupeidae several characters, including the expansion and shape of the dorsal scutes. The lack of spines on the posterior edge of the dorsal scutes and the third hypural not being expanded indicate the new fish is closer to members of the subfamily Paraclupeinae (*Ellimma*, *Ellimmichthys* and *Paraclupea*), rather than to other paraclupeids. The new paraclupeid is from sediments that represent a large delta complex deposited in the Western

Interior Seaway at about 65N, where mean sea water temperature may have been about 10°C. The fish appears to have inhabited a shallow, muddy prodelta environment characterized by high turbidity and variable salinity.

Thursday 2:30

A NEW GENUS OF ?LUGANOIFORM STEM NEOPTERYGIAN FROM THE EARLY TRIASSIC OF WESTERN CANADA

MUTTER, Raoul, Natural History Museum, London, United Kingdom; NEUMAN, Andrew, Royal Tyrrell Museum, Drumheller, AB, Canada

The Early Triassic ichthyofauna of the Sulphur Mountain Formation in western Canada yields evidence of 20 specimens of a new genus of stem neopterygian. Although poor in preservation, this new genus shows highly interesting features including a long, partly edentulous lower jaw with coronoid process and a heteromorph dentition, entirely jointed segmentation in the paired fins, and poorly ossified, small scales. The conspicuous, extended dorsal fin, fin ray structure, and the small scales are reminiscent of various primitive Permo-Triassic actinopterygians, namely *Eurynotoides* (Late Permian, Russia), *Evenkia* (Early Triassic, Russia), *Fukangichthys* (Middle Triassic, Xinjiang, China), *Scanilepis* (Late Triassic, Sweden), and *Tanaocrossus* (Late Triassic, North America). This analysis suggests, however, similarity in fin structure and squamation between the new Canadian genus and any of these Permo-Triassic genera represents plesiomorphy and the skull features in the Canadian genus are relatively more derived. The shape and size of the jaws, the structure of the cheek, the broad skull, and the extended snout approach the luganoiform (Middle Triassic) and the macrosemiid (Late Triassic—Late Cretaceous) condition. Despite the new genus' overall poor preservation, it clearly reveals a remarkably unique mosaic of primitive and derived features, previously observed only separately, either in Late Paleozoic or Early Mesozoic actinopterygians.

Poster Session III

CALCIFICATION IN THE FOSSIL RECORD: WHAT CAN WE LEARN FROM RIBS?

NAPLES, Virginia, Northern Illinois Univ., DeKalb, IL; ROTHSCCHILD, Bruce, Arthritis Center of Northeast Ohio, Youngstown, OH

Many kinds of information can be inferred from the frequency of occurrence, life stage, apparent health, species associations or environment of extinct taxa in the fossil record. The amount and quality of information about a fossil specimen is further reduced by taphonomic processes that affect the likelihood of preservation of skeletal elements; larger, more robust bones often survive while fragile or smaller elements are less commonly identified or collected from a single locality. Ribs fall into the latter category. However, ribs are widely reported in both the paleontologic and archaeological records as showing evidence of a high incidence of calcific plaques. Interpretation of the pathologic nature of these features requires study of the soft tissues associated with the skeletal elements that show them. Such a study of most fossil specimens is impossible, as few retain evidence of the condition of soft tissues associated with the most commonly preserved elements, i. e., osteologic or dental materials. Few modern populations show a similar incidence of pathology; therefore the assumption that extinct species had high frequencies requires further examination. To test the hypothesis that calcific plaques indicated pathologic conditions in paleontologic or archaeological specimens, dissections of cadaver thoracic regions were performed to identify the precise tissues involved, and to assess the validity of previous assumptions. Calcific plaques were clearly identified; however, they were localized in the visceral, but not the parietal pleura. This study provides a perspective on adhesions, specifically that adherence of structures that have been interpreted as calcified tissues to ribs was taphonomic, and did not reflect circumstances in the original living host.

Student Poster Session

MIDDLE AND LATE MIOCENE TERRESTRIAL MAMMALS FROM THE PANNONIAN BASIN, CENTRAL EUROPE

NARGOLWALLA, Mariam, Univ. of Toronto, Toronto, ON, Canada

Past studies of Eurasian Miocene terrestrial mammals define two geographic blocks, East and West, between which faunal diversity and dynamics are compared. Interestingly, these blocks intersect within a single geological basin in Central Europe, the Pannonian Basin. Surrounded by the Alps, Dinarides and Carpathians, the Pannonian Basin is a relatively closed system and corridors for faunal interchange during the middle and late Miocene were limited by topography and fluctuating paleoenvironments. The purpose of this study is to determine the extent to which the Pannonian Basin faunas support the current geographic division between East and West Eurasian faunas by assessing the degree of interbasin heterogeneity. The results of a three year survey and excavation effort together with localities recorded in the NOW Database were used to conduct a basin-wide analysis of faunal diversity and dynamics in the Pannonian Basin and adjacent regions. The spatial distribution of the Pannonian Basin faunas were mapped over a series of time slices using ArcGIS 9, together with digitized paleogeographic map overlays. Measures of sampling completeness, endemism, faunal diversity and faunal similarity were implemented to assess faunal heterogeneity within the basin system. The preliminary results of this study indicate that the Pannonian Basin faunas experience the same decline in sampling completeness in MN7/8 and MN10 (Neogene Mammal biochronological zones) as faunas in the West and East blocks. However, influenced by Hungarian localities in MN11 and MN12, the Pannonian Basin faunas experience the same respective increase and decrease in diversity as faunas

from the East during these time intervals. In terms of diversity, the middle Miocene Pannonian Basin faunas behave more like faunas in the West, while towards the terminal Miocene, the Pannonian Basin faunas behave more like faunas in the East due to an influx of taxa from the Eastern Mediterranean. Further analysis of these trends can potentially elucidate further details of faunal turnover and interchange, and perhaps directionality in the latter.

Saturday 11:15

DIGESTING THE COELOPHYSIS-CANNIBAL HYPOTHESIS AND ITS IMPORTANCE TO PREY CHOICE IN THEROPOD DINOSAURS

NESBITT, Sterling, TURNER, Alan, American Museum of Natural History, New York, NY; ERICKSON, Gregory, Florida State Univ., Tallahassee, FL; NORELL, Mark, American Museum of Natural History, New York, NY

Direct evidence of prey choice in carnivorous dinosaurs is rare in the fossil record. The most celebrated example pertains to purported stomach contents in two specimens of the early carnivorous dinosaur *Coelophysis bauri* (AMNH FR 7223 and AMNH FR 7224), which besides revealing prey choice, also point to cannibalistic behavior as being commonplace among theropod dinosaurs. The *Coelophysis*-cannibal hypothesis is one of the most recognized paleobiological anecdotes presented in museum exhibitions, countless children's books, and in popular press. Here, we test this hypothesis by conducting the first comprehensive anatomical and histological examination of the famed *Coelophysis* cannibals.

Reinspection of AMNH FR 7223 revealed that the ribcage ruptured sometime during burial and that the purported remains lie underneath the *Coelophysis* skeleton. Thus, no unambiguous stomach contents are present in AMNH FR 7223. The stomach remains in AMNH 7224 lie within the posterior region of the intact ribcage. The stomach contents include an ilium, left and right femora, a sacral vertebra, and many additional fragments. None of the stomach remains bear dinosaurian synapomorphies. Instead, the elements bear character states consistent with crocodylomorph archosaurs. The preserved femur has a proximal condylar fold, which is synapomorphic for Crocodylomorpha. Moreover, histological analysis of the femur supports assignment to Crocodylomorpha rather than a Theropoda.

The results unequivocally show that the gut contents derive from early crocodylomorphs rather than juveniles of *Coelophysis*. These findings exonerate this taxon as being cannibalistic and bring into question the commonality of this behavior among non-avian dinosaurs.

Poster Session I

THE ENIGMATIC CHONDRICHTHYAN LISTRACANTHUS

NEUMAN, Andrew, Drumheller, AB, Canada; MUTTER, Raoul, Natural History Museum, London, United Kingdom

A newly discovered species of *Listracanthus*, *L. pectenatus*, represents the first Mesozoic record of this group of enigmatic chondrichthyans and highlights survival of rare cartilaginous fishes across the Paleozoic-Mesozoic boundary. *Listracanthus* is only known by two kinds of dermal denticles. These denticles fall into two distinctive size classes. The Mesozoic species occurs abundantly in certain strata of Early Triassic age in the Sulphur Mountain Formation of western Canada. Seven Paleozoic species of *Listracanthus* have been named, and Paleozoic records are predominantly Late Carboniferous in age. The locally abundant occurrence of these denticles is interpreted to be due to preservational circumstances rather than the "Lazarus" effect. The Triassic species differs from all other known species in the structure of the large denticles, whereas the small denticles appear to be less diagnostic and are readily distinguished from other small denticles traditionally assigned to the genus *Petrodus*. The study of the histology of these denticles reveals that the large denticles were originally hollow and probably secondarily ossified as acellular bone, lacking enameloid cover entirely. The conclusion drawn by previous authors that *Listracanthus* may be a petalodontid shark, based on ambiguous non-skeletal associations with *Deltoptychius*, *Petrodus* or *Calopodus*, is not supported. The size of both types of denticles, the large number of denticles and their arrangement, and the lack of enameloid cover in these denticles suggest that *Listracanthus* was a large chondrichthyan of aberrant body shape and yet unknown systematic position.

Poster Session II

EVIDENCE FOR TWO TAXA OF HIODONTIDAE IN THE CRETACEOUS DINOSAUR PARK FORMATION, ALBERTA

NEWBREY, Michael, North Dakota State Univ., Fargo, ND; WILSON, Mark, Univ. of Alberta, Edmonton, AB, Canada; ASHWORTH, Allan, North Dakota State Univ., Fargo, ND

Isolated centra recovered from fluvial localities in the Cretaceous Dinosaur Park Formation (Campanian) are used to describe hiodontid age, growth, and longevity characteristics. Previous studies of Cretaceous centrum morphology have shown only one morphotype. Growth characteristics can provide additional information to test the hypothesis that more than one taxon existed in the Dinosaur Park Formation. An examination of the growth characteristics indicates that Campanian hiodontids were shorter-lived (i.e., about 7 years longevity) and significantly smaller than extant hiodontids ($p < 0.001$). The Cretaceous centra exhibit two significantly different ($p < 0.001$) growth patterns. Initially it was predicted that two factors could explain the presence of the two growth patterns: 1) sexual size dimorphism, 2) variation in centrum size from multiple species. Sexual size dimorphism is dismissed based on two conditions; variation in extant *H. alosoides* maximum total length

significantly responds to mean annual temperature ($R^2 = 0.559$, $p = 0.013$), and the paleotemperature in the depositional environment fluctuated about 6°C. Therefore, paleotemperature fluctuation would result in a continuous distribution of growth patterns and not the discrete patterns of the Cretaceous data. Regarding centrum size variation, the coefficient of variation (CV) observed in the Cretaceous centrum size data (0.24 CV) is 25% greater than that of the two extant species of *Hiodon* combined (0.18 CV), suggesting that at least two species of hiodontids were present in the Dinosaur Park Formation. The CV of each significantly different growth pattern can also be used to infer the presence of additional species. The larger Cretaceous growth pattern has a CV equivalent to that of a single extant species (0.10 CV). The smaller Cretaceous growth pattern has a CV that exceeds that for a single species (0.14 CV), but not for two extant species. Furthermore, the data does not support the presence of three taxa because the smaller growth pattern has a centrum size distribution that is significantly different than that of two extant species ($p < 0.001$), but not significantly different than that of one species ($p = 0.428$).

Wednesday 12:00

THE ROLE OF THE PLESIOSAURIAN LONG NECK—A NEW MODEL

NOE, Leslie, The Sedgwick Museum, Cambridge, United Kingdom

The order Plesiosauria was a long-lived and globally distributed group of Sauropterygian marine reptiles that existed throughout much of the Mesozoic. The Plesiosauria has traditionally been divided into the long-necked plesiosaurs and the short-necked plesiosaurs, although this dichotomy has long been difficult to define. The plesiosaurs are analogous to fish, whales, dolphins, or seals with a relatively large head and short neck; but the long-necked plesiosaurs (Superfamily Plesiosauroidea) have no direct living analogue.

Probably the most striking feature of the plesiosaur bauplan is the extremely long neck. However the possession of a long neck in the marine environment poses a number of functional, biomechanical, ecological and physiological problems to the living animal: was neck flexible to permit feeding or stiff to allow rapid swimming, and how was the risk of predation with such a long neck overcome? However, the plesiosaur neck was a successful adaptation to life in water, with its adaptive value demonstrated by its continued presence over a large geographical range and throughout the long evolutionary history of the group. The evolution and function of the plesiosaur neck has remained enigmatic and long puzzled scholars.

Observation of the articular faces of contiguous cervical vertebral centra, the associated neural arches and cervical ribs suggests the plesiosaurian neck was predominantly adapted for ventral movement, with dorsal, lateral and rotational movement all relatively restricted. Predominant ventral movement suggests the neck may have been an adaptation to feeding on the sea floor, and cranial and dental adaptations appear to reflect this role. Hard-part anatomy, together with aspects of functional morphology, biomechanics, associated fauna, sedimentary environment and comparison to modern analogues interweave to provide a convincing explanation of the plesiosaur bauplan as a sediment/filter feeding apparatus (the head) mounted on a flexible tube (the neck) attached to a mobile feeding platform (the body). These insights provide an explanation as to how and why the plesiosaurian long neck evolved.

Student Poster Session

THE PALEOBIOLOGICAL IMPLICATIONS OF CLIMATIC INFLUENCE OVER VERTEBRATE FOSSIL DISTRIBUTION PATTERNS

NOTO, Christopher, Stony Brook, NY

Differential preservation of plant and animal tissues due to environmental conditions is generally accepted by paleontologists as a wide-spread bias in the fossil record. Therefore, drawing paleobiological inferences based on fossil distributions can be problematic. Not all environments are preserved equally well in the fossil record, and some appear to be absent altogether. In turn, environmental distribution is driven by global climate patterns, which have varied considerably in the past.

Little attention has been paid to how the interplay of environment-specific tissue degradation and biased environmental preservation affect our ecological, environmental and climatic reconstructions of the past. Identification of these biases and how they affect the patterns we observe are required for an accurate interpretation of the fossil record. Failure to do this may lead to erroneous reconstructions. Here I examine how these biases may affect our interpretation of late Mesozoic biotic reconstructions.

Using published fossil databases, comparison of dinosaur and plant distributions suggest that both reached peak taxonomic diversity around the middle latitudes. However, the peaks are offset, with the plant peaks occurring at higher latitudes. This difference corresponds to an environmental shift from taphonomic conditions favoring bone preservation to those favoring plant preservation. In light of this type of large-scale bias the question remains as to how reliably fossil distribution patterns reflect actual taxonomic diversity patterns in the past. The current equator-centered diversity curve is assumed to be ancient, yet this example suggests that diversity patterns may have shifted over time with changing climate conditions. On the other hand, changing climatic conditions may have shifted the focus of preservation bias. To better understand the ecological dynamics of past biotas, we require more accurate reconstructions. Doing so will enable paleontologists to address biotic response to climate change as well as helping to identify important factors driving taxonomic diversity patterns.

HAVERSIAN SYSTEMS AS POTENTIAL TAXONOMIC IDENTIFIERS IN MESOZOIC TETRAPODS: USING MODERN MAMMALS AS A TEST DATASET

NOVAK, Stephanie, SMITH, Joshua, Washington Univ. in St. Louis, Saint Louis, MO
Fossil vertebrates are taxonomically identified by the qualitative evaluation and comparison of a series of homologous features present within the gross morphology of the skeleton. Limitations with this method are apparent in isolated or fragmentary material which often does not show the suite of characters necessary for identification. Unfortunately, isolated and fragmentary elements comprise the majority of fossil assemblages thus stunting any additional lines of paleoecological inquiry dependent on the ability to identify the fauna in the ancient ecosystem. Incomplete material represents a powerful source of faunal data if those elements could indeed be taxonomically identified. Initial data from a test dataset suggest that the location, shape, and orientation of Haversian systems in cortical bone may be unique to each taxon and could present a partial solution to the problems related to identifying isolated bones. A preliminary dataset of Haversian system morphology was comprised from right tibia, mid-diaphyseal thin sections extracted from *Canis domesticus*, *Equus caballus*, and *Odocoileus virginianus*. A total of 1041 Haversian systems were measured for the variables Minimum and Maximum External Osteonal Diameters, Minimum and Maximum Haversian Canal Diameters, Angle of Osteonal Orientation and Angle of Haversian canal Orientation with respect to the Longitudinal axis, Angle of Osteonal Orientation with respect to the Periosteal surface, and the Minimum Diameter Ratios of the Haversian system and Haversian canal. Stepwise discriminant function analysis was used to determine whether or not these animals could be classified on the basis of their Haversian systems. Hypotheses of congruence of Haversian systems with their respective taxa were tested using squared Mahalanobis distances between the centroids of the genus groups and resulted in an average of 59.2% of the Haversian systems classified to their respective taxon. Given the small number of data cases and taxa, these results are very promising and further testing and development of both the methodology and the dataset will continue. Success of the test dataset will ultimately allow for application to the fossil record, particularly in the Mesozoic.

Wednesday 8:30

NEW SPECIES OF LIZARDS FROM THE LATE CRETACEOUS OF SOUTHERN UTAH THAT ARE CLOSELY ALLIED TO THE SCINCOMORPHAN TAXA *CONTOGENYS SLOANI* AND *PALEOSCINCOSAURUS MIDDLETONI*

NYDAM, Randall, Midwestern Univ., Glendale, AZ

Contogenys sloani Estes 1969 (Maastrichtian-mid Paleocene) and *Paleoscincosaurus middletoni* Sullivan and Lucas 1996 (early Paleocene) are paracontemporaneous scincomorph lizards from Montana and Colorado, respectively, and have been tentatively referred to either Scincidae or Xantusiidae. New specimens from the Upper Cretaceous of southern Utah's Kaiparowits Plateau represent at least two new species of lizards that share with *C. sloani* and *P. middletoni* the presence of an anteroposteriorly directed apical groove on the tooth crown and a laterally expanded inferior alveolar canal resulting in a shelf-like expansion of the posterolateral dentary. The new species from the Kaiparowits Formation (Campanian) represents a new species of *Paleoscincosaurus* and differs from *P. middletoni* in having a more pronounced dentary expansion and more numerous apical striae. The new taxon from the Smoky Hollow Member of the Straight Cliffs Formation (Turonian) represents a new genus and species that is distinguished by a smaller body size, teeth more trifid, and other morphological characteristics of the dentary. Another specimen from the Dakota Formation (Cenomanian) is referable to the new genus, but too incomplete for specific diagnosis.

These new taxa, in combination with *C. sloani* and *P. middletoni*, represent a grade of scincomorph lizards that likely comprise a 'subfamily-level' taxon. Morphological characteristics necessary for a 'family-level' referral are lacking. Indeed many of the characters previously reported support referral to Scincidae or Xantusiidae (e.g., coronoid process of dentary as lappet on coronoid) are shared by taxa in both families. Also, recognized synapomorphies (such as a closed and fused dentary tube for xantusiids) are lacking or incompletely represented in the known specimens.

Although systematic questions remain, the new material from southern Utah are representative of a lineage of scincomorph lizards that existed for more than 30 Ma, survived the K/T extinction event, and occupied areas throughout the Western Interior during its history.

Poster Session II

LONGIROSTRINE ENANTIORNITHINE BIRDS; INFORMATION FROM A NEW CHINESE SPECIMEN

O'CONNOR, Jingmai, Natural History Museum, Los Angeles, Los Angeles, CA; MENG, Qingjin, WANG, Xuri, Dalian Natural History Museum, Dalian, Liaoning, China; CHI-APPE, Luis, Natural History Museum, Los Angeles, Los Angeles, CA

Enantiornithines are a highly speciose group of birds that are morphologically very similar. Although their cranial morphology is not well known, as the skull is missing, crushed, or fragmentary in most taxa, available data shows that most of these birds possess rostra which lengths do not exceed half the length of the skull. Recently, two longirostrine enantiornithines were discovered from the Lower Cretaceous (~125–120 Ma) Jehol deposits of China; these birds also possess upper dentition that is limited to the premaxilla, lower dentition restricted to the rostral tip of the dentaries, and a long, slender dentary that is ventral-

ly concave. Previous cladistic analyses cluster these two taxa, *Longipteryx* and *Longirostravis*, suggesting the existence of a group of enantiornithine birds characterized by the presence of an unusually long rostrum (approaching or exceeding 60% the total length of the skull). While grouped by these characters, these two taxa are in other aspects very different. *Longipteryx* possesses a very robust skull with large teeth, and a primitive manus, while *Longirostravis* has a more slender skull and a reduced manus, suggesting a great deal of hidden diversity within the clade. Here, we report on a new fossil of a longirostrine enantiornithine also from the Jehol deposits (Jiufotang Formation; 120 Ma) of northeastern China. The new fossil bird possesses many characters, which support its allocation within Enantiornithes, as well as synapomorphies that cluster it with the longirostrine enantiornithines. This discovery lends support to the postulation that longirostrines were a diverse group of birds.

Thursday 3:00

NEW ARCHOSAUR DISCOVERIES FROM THE CRETACEOUS RED SANDSTONE GROUP OF THE RUKWA RIFT BASIN, SOUTHWESTERN TANZANIA

O'CONNOR, Patrick, STEVENS, Nancy, Ohio Univ., Athens, OH; GOTTFRIED, Michael, Michigan State Univ., East Lansing, MI; RIDGELY, Ryan, Ohio Univ., Athens, OH; ROBERTS, Eric, Univ. of the Witwatersrand, Johannesburg, South Africa

Four recent field expeditions (2002–2005) conducted in the Rukwa Rift Basin of southwestern Tanzania have yielded a growing diversity of terrestrial/freshwater vertebrates from the "middle" Cretaceous Red Sandstone Group (Unit I). This represents one of the most poorly sampled time intervals among continental sequences in Gondwana generally, and sub-equatorial Africa in particular. Represented among archosaurs are indeterminate crocodyliforms and multiple taxa of saurischian dinosaurs, including two different theropods and at least two titanosaurian sauropods. Intensified prospecting and quarrying efforts during 2005 resulted in the discovery of multiple new archosaurian clades, including the first rebbachisaurid sauropod recovered from sub-equatorial Africa, and multiple specimens of a new notosuchian crocodyliform. The former is based on a near complete right humerus exhibiting a sub-circular midshaft cross-section, characteristic of rebbachisaurids. This clade of diplodocoid sauropods is known only from middle Cretaceous (Albian-Turonian) strata in circum-Saharan Africa and South America. Crocodyliform specimens include both upper and lower jaws of a new notosuchian characterized by extreme size and shape heterodonty. The sculptured external surface of the dentary and thin, cylindrical tooth roots are consistent with generalized crocodyliform morphology, yet the presence of multiple, multi-cusped "molariform" teeth and posterior maxillary teeth possessing a constriction at the crown-root junction suggest possible affinities with notosuchians such as *Malawisuchus* and *Simosuchus*. Derived features of the new taxon include the presence of a mesiodistally elongate trough interposed between lingual and buccal sets of shearing surfaces. This morphology suggests possible propalinal movements between the lower and upper dentition and represents another striking example of dental convergence between select Cretaceous crocodyliforms and mammals. Taken together, the developing archosaur fauna from the Cretaceous Red Sandstone Group appears to preserve representatives of higher-level clades (Notosuchia, Rebbachisauridae) known from multiple locations throughout Gondwana.

Poster Session III

NEW MIDDLE PLEISTOCENE GALICTINI (MUSTELIDAE, CARNIVORA) FROM MATSUGAE CAVE DEPOSITS, NORTHERN KYUSHU, WEST JAPAN

OGINO, Shintaro, OTSUKA, Hiroyuki, Kagoshima Univ., Kagoshima, Japan

Middle Pleistocene mammalian fauna including deer, mustelid, rhino and wild rats had been reported by Tokunaga and Naora in early 20th century from Matsugae limestone cave deposits in northern Kyushu, west Japan. Naora described an extinct otter (*Lutra nipponica*) as a new species. New, well-preserved dentitions of the fossil mustelid are discriminated in their old collection by our recent study. Newly identified mustelid specimens suggest that *L. nipponica* by Naora should be emended as tribe galictini (Mustelidae, Carnivora) by the following characters: short muzzle; straight upper canine with deep groove; postero-lingual part of P4 is expanded posteriorly with a corn; anterior cingulum of M1 is reduced; lower cheek teeth are crowded; and hook-like lower canine is covered with shallow furrows. These fossil mustelid specimens from Matsugae are comparable with European *Enhydrictis* by the characters of upper molar. *Enhydrictis* is an extinct galictini that was distributed from the European late Pliocene to Pleistocene and includes *E. galictoides* from west Sardinia and *E. ardea* from Saint-vallier. The Chinese extinct otter, *Lutra melina* from the Middle Pleistocene cave deposits of Chou-kou-tien loc. 1 is also included in *Enhydrictis* by its characters of M1 and the mandible. Morphology of the teeth from the East Asian *Enhydrictis* suggests that galictini might be distributed over wide areas of the Northern Hemisphere until middle Middle Pleistocene. However, analysis of the geometric morphometrics on occlusal character of M1 indicates that there are obvious differences on the shape of M1 between the Old and New Worlds galictini. Those of the former extend antero-posteriorly while the latter shorten. This analysis will supply us basic data that each taxon of both Worlds have non-monophyletic origin, respectively. Principal component analysis (PCA) using dental measurements shows close relationship between *Enhydrictis* and highly carnivorous mustelids; e.g. *Taxidea*, *Eira* and *Mellivora*.

HIND LEG STAND IN A SAUROPOD: A BIOMECHANICAL TEST

OGRODNIK, Jeffrey, Orland Park, IL; SERENO, Paul, University of Chicago, Chicago, IL
Whether any sauropod dinosaur was capable of the two-legged rearing pose sometimes adopted by the largest living herbivores has been a matter of speculation. Using the African elephant, (*Loxodonta africanus*) as an extant model, we provide the first biomechanical test of rearing using *Jobaria tiguidensis*, a basal sauropod with conservative neck, limb, and tail proportions. The requisite variables to evaluate rearing stance (mass, center of gravity, limb bone orientation, stress and minimal muscle force) are measured or estimated in *L. africanus* and *J. tiguidensis*. Assuming no support from the tail, the structural model for *J. tiguidensis* suggests that a rearing pose would neither compromise the critical limb bone (femur) nor demand more muscle mass or tendon size than estimates suggested were present. Furthermore, a general relationship is presented for large-bodied quadrupeds that relates body mass, minimum humeral/femoral diameter, and footprint area.

Romer Prize Session, Thursday 11:30

STRUCTURAL ANALYSIS OF DERIVED ORNITHOPOD SKULL USING 3D FINITE ELEMENT METHOD: RECONSIDERATION OF THEIR FEEDING MECHANISMS

OHASHI, Tomoyuki, Univ. of Tokyo, Tokyo, Japan

Pleurokinesis is considered as one of the key adaptations for herbivory in the ornithomorph evolution. Presence of the pleurokinesis has been suggested from the morphological features of the skull in derived ornithomorphs, but its feasibility has not been studied mechanically.

This study analyzed the stress and deformation of a subadult ornithomorph skull in the static equilibrium using the 3D finite-element method (FEM), which is a numerical simulation method for solving complex field problems. The skull morphology is obtained from the X-ray CT images, and the finite-element model is generated from the CT images using the voxel element which is a cuboid element uniformly dividing the material region. The voxel modeling and analysis are performed mainly using the commercial FEM code (VOXEL-CON2005 by Quint Corp., Japan). The chewing motion takes the following three steps; 1) adduction of mandibular muscles; 2) rotation of the mandible around the quadrate condyle as a fulcrum; and 3) crushing of food material between the upper and lower jaws. This study sets these three components as the static boundary conditions: the point loads are applied at the muscle origin as the bite force, the quadrate condyles are fixed, and virtual food is set under the upper tooth rows. Distribution of stresses were compared in two models; 1) a rigid model which considers the skull as a homogeneous unit and 2) a suture model in which some skull sutures are flexible. The sutures are represented by the lower Young's modulus in the second model.

In the rigid model, stresses mainly concentrated at certain sutures that are in fact flexible in the pleurokinetic hinge system observed in actual ornithomorph skulls. On the other hand, stresses spread almost uniformly in the skull in the second model and did not concentrate any regions except for the loading points because of the model. The pleurokinesis at certain sutures releases the stress concentration resulted in the rigid model. It indicates that the pleurokinetic hinge system "disperses" the stress in wider areas of the skull. The system also controls the contact point of the teeth during the chewing.

Poster Session I

PLIOCENE HERPETOCETUS AND BURITINOPSIS FROM NORTHEAST JAPAN AS VALUABLE RESOURCES FOR ELUCIDATING EVOLUTIONARY HISTORY OF MYSTICETES

OISHI, Masayuki, Iwate Prefectural Museum, Morioka, Japan

Evolutionary history of Neogene mysticetes has been poorly understood and still controversial, despite the long record of study and recent morphological and molecular analyses. *Herpetocetus sendaicus* and *Buritinopsis* sp. from the Tatsunokuchi Formation (sediments in estuary environment of latest Miocene to early Pliocene) of northeast Japan, including nearly whole skeletons, are informative for study of the Neogene mysticete story.

Herpetocetus sendaicus ("Cetotheriidae", s.l.) has the primitive skull morphology such as a large alisphenoid which Middle Miocene cetotheres (e.g., *Parietobalaena*) abandoned and the derived dentary morphology such as a posteriorly projecting angular process which no other mysticete acquired.

These primitive and derived characters suggest the genus originated in the radiation of cetotheres before the middle Miocene. Abundance of ear bone remains of *Buritinopsis* sp. (*Balaenopteridae*) from the pelagic sediment in Choshi area east of Tokyo indicates that the genus is distinct from a group including *Balaenoptera*. Skulls of *Buritinopsis* sp. show that the genus is clearly distinguished from the crown-balaenopterids (recent *Balaenoptera* and *Megaptera*) by having a slender ascending process and a slim dentary that did not make allowances for growing in size.

Recent molecular studies advocating the early Miocene radiation of crown-balaenopterids require a story of low possibility, which should be verified through reevaluating the late Miocene to Pliocene stem-balaenopterids such as *Buritinopsis* and unnamed genera that have been erroneously included in *Balaenoptera* or *Megaptera*. *Herpetocetus* and *Buritinopsis* from northeast Japan provide valuable resources for elucidating the early radiation of cetotheres and the later radiation of balaenopterids.

Marine Reptiles Symposium, Wednesday 3:30

MORPHOLOGICAL PATTERNS IN ELASOSAUR NECK LENGTH: VARIATION AND TAXONOMIC UTILITY

O'KEEFE, F. Robin, NYCOM, Old Westbury, NY; HILLER, Norton, Canterbury Museum, Christchurch, New Zealand

Elasmosaur cervical vertebrae are common fossils, but their taxonomic utility is limited due to a lack of understanding concerning their shape within and among taxa. In this paper, we analyze data from complete elasmosaur necks in an attempt to quantify and understand the variation in centrum dimensions. In accord with previous studies, variation in cervical centrum shape is found to stem from at least three sources: ontogeny, intracolumn variation, and intercolumn or taxonomic variation. Ontogenetic variability is reminiscent of that seen in *Cryptoclidus*, with an overall positive allometry in the length of all centra that is accentuated in the mid-cervical region. In adult elasmosaurs, the longest centra occur in the middle of the neck, and centra in this region are longer than those at either end. This pattern yields a distinctively bowed shape curve when a shape metric such as VLI or PC score is graphed against vertebral position. Centrum length shows minor variation from centrum to centrum in all elasmosaurs, but a small group of extreme, elongate animals have a much higher degree of variability. The taxonomic utility of centrum measures is limited because there is no single pattern of centrum shape common to all taxa; variability is the rule, and therefore caution is necessary when using dimensions to diagnose taxa. There do seem to be two morphotypes of elasmosaurs, however. The first is a relatively conservative group with centrum dimensions similar to those of *Brancaesaurus*, and that achieves a long neck by adding vertebrae. A second, elongate group has centra that are very long, and there is great variability from one centrum to another in the same column. Surprisingly, the number of cervical centra is not a highly variable trait in most elasmosaurs. The elongate taxa appear to be restricted to the Western Interior Seaway in the Late Cretaceous, although there is some indication that *Tuarangisaurus* might be elongate as well. In general, elasmosaur vertebrae have some taxonomic utility, but only at the extremes of their shape range, and only if their position in the column is known with some certainty.

Thursday 2:00

PALEOGENOMICS OF PTEROSAURS AND THE EVOLUTION OF VERTEBRATE FLIGHT

ORGAN, Chris, EDWARDS, Scott, Harvard Univ., Cambridge, MA

Pterosaurs are of great interest to evolutionary biologists because they are one of three vertebrate groups to have evolved powdered flight. Many insights into pterosaur biology, including flight, have been elucidated using comparative approaches in disciplines ranging from morphology and histology, to biomechanics. However, neontological studies into the genetic and genomic characteristics associated with flight and endothermy, among other traits, have focused necessarily on extant birds and bats. For example, birds have the smallest average genome size of any amniote group and bats have among the smallest genome size of any mammalian group. The small streamlined genomes of birds and bats are primarily due to a reduced copy number of repetitive elements. The evolution of small cell size is commonly thought to have driven genome-level adaptations for flight, such as small genome size. As a consequence, phenotypic correlates of genome and cell size in birds have been proposed, such as body size, developmental rate and metabolic efficiency. The genomic landscape of pterosaurs has been inferred, yielding critical comparative data, not only for understanding pterosaur genomes by themselves, but by providing insights into possible parameters important for the evolution of powered vertebrate flight. This was accomplished by first correlating a relationship between osteocyte size and genome size for a diverse array of extant vertebrates. Using this correlation and comparative methods for inferring genome size from paleohistological data, we have estimated genome size statistics for four different species of pterosaurs (*Dimorphodon*, *Rhamphorhynchus*, *Pteranodon*, and *Pterodactylus*). These data reveal that small genomes commonly associated with flight in bats and birds also evolved within Pterosauria. We postulate that, like bats and birds, the small genomes of pterosaurs resulted from the loss of repetitive elements during pterosaur genome evolution.

Poster Session III

ANTERIOR DENTAL GROOVES AND THE INFERENCE OF VENOM DELIVERY SYSTEMS IN FOSSIL MAMMALS

ORR, Caley, TOCHERI, Matthew, SCOTT, Jeremiah, DELEZENE, Lucas, SCHWARTZ, Gary, Washington Univ., TEMPE, AZ

Paleontologists recently inferred the existence of a venom delivery system in the canines of the Paleocene pantolestid *Bisonalveus browni* and in another unidentified mammalian specimen of similar geological age (Fox RC, Scott CS, 2005. First evidence of a venom delivery apparatus in extinct mammals. *Nature* 435:1091–1093). This interpretation raises the possibility that venom injection may have evolved more frequently in Mammalia than previously recognized. However, making sound inferences from fossil material requires comparative analysis to determine a clear association between a structure and its hypothesized function. Such comparative studies should establish that 1) the trait of interest exists in extant analogue taxa and 2) the trait and proposed function are associated in all of those taxa. If extant taxa with the structure exist, but which lack evidence of the proposed function, or phylogenetic history of the function, then hypotheses relating the trait to the proposed function in fossil taxa are undermined. We show that deep, gutterlike longitudinal canine grooves similar to those exhibited by *B. browni* and the unidentified mammal fossil appear in extant non-venomous mammals, thus complicating the inference of function from

structure in this case. Further study might demonstrate finer distinctions between venomous and non-venomous canine grooves. However, the available evidence appears to be equivocal regarding the existence of a venom delivery system in these fossil specimens.

Poster Session II

PARACLUPEIDS OF EL ESPINAL QUARRY (MEXICO) AND THE INTERRELATIONSHIPS OF ELLIMMICHTHYIFORMES

OVALLES-DAMIÁN, Ernesto, Tuxtla Gutiérrez, Chiapas, Mexico; ALVARADO-ORTEGA, Jesús, Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil; ARRATIA, Gloria, Univ. of Kansas, Lawrence, KS

El Espinal Quarry is an Early Cretaceous (Late Aptian and or Early Albian) locality intensively exploited recently. This quarry is located, near Ocozacoautla de Espinosa, Chiapas, Southeastern Mexico. The fossils assemblage found in this supposedly freshwater-marine alternating or estuarine deposit involves algae, plants, gastropods, crustaceans (lobsters), isopods (myciadae), insects (odonats), and fishes (pyncodontiforms, macrosemyids, ichthyodectiforms, ellimmichthyiforms, Sauroramphus-like, Apatopholis-like, and a large number indeterminate teleostean larvae). The interrelationships of the order Ellimmichthyiformes are controversial. Two new ellimmichthyiforms from El Espinal and a revision of previous diagnostic characters and synapomorphies of the ellimmichthyiforms allows us to suggest a new hypothesis, in which this monophyletic order includes two families. Paraclupeidae (including *Scutatuspinosus*, *Ezkutuberezi*, *Ellimma*, *Ellimmichthys*, *Paraclupea*, *Diplomystus solignaci* and *Triplomystus*) and Sorbinichthyidae (involving *Sorbinichthys* and the other *Diplomystus* species). Both ellimmichthyiforms from El Espinal belong to the Paraclupeidae. One is strongly supported as a new species belonging to *Triplomystus*, genus characterized by the occurrence of a postdorsal scute series. Whereas the other species shares similar meristic characters with the Chinese paraclupeid *Paraclupea* in number of scutes in predorsal and ventral series and number of elements in anal and dorsal fins. This Paraclupea-like fish has a low supraoccipital crest and the dorsal border of its body shows a marked angle at the beginning of the dorsal fin, as occurs in other paraclupeids.

Poster Session III

NEW RECORD OF TAXIDEA (MUSTELIDAE: CARNIVORA) FROM A LATE MIOCENE DEPOSIT IN THE HAND HILLS, ALBERTA, CANADA

OWEN, Pamela, Texas Natural Science Center, Austin, TX; BURNS, James, Royal Alberta Museum, Edmonton, AB, Canada

A nearly complete right dentary of *Taxidea* cf. *taxus*, the American badger, was recovered from the upper Miocene sands at the Courtney Site in the Hand Hills, Alberta, Canada. Alveoli for the p2 and m2 are preserved and the p3, p4, and m1 are in place. The m1 trigonid is large. The m1 protoconid and talonid are both broken and missing enamel, but not so extensively as to prevent positive generic identification. The dentition shows wear, the dentary is robust, and the mandibular fossa is deep, indicating the individual was an adult at death. The length of the dentary and m1 suggest a relatively small body size, but much larger than that of *Pliotaxidea*, the small, closely-related badger of the late Miocene. The Hand Hills *Taxidea* did not attain the size exhibited by populations of extant *Taxidea taxus* (subspecies *taxus*) of the plains and prairie regions of Canada and the northern United States. Additionally, this specimen has morphological characteristics similar to those of other late Tertiary *Taxidea*, including specimens referred to *Taxidea mexicana*, warranting further taxonomic investigation.

The Hand Hills *Taxidea* is part of a late Hemphillian fauna that includes *Plesioigulo*, *Teleoceras*, *Neotragoceras*, *Dipoides*, and several equid and camelid species. At present it is the oldest known record for *Taxidea*. The Pliocene Yepómera fauna of Chihuahua, Mexico, has produced the only other Hemphillian *Taxidea*, and thus the Hand Hills specimen provides important range information, both chronological and geographical, for a taxon that was well distributed throughout the western and central regions of North America by the end of the Blancan.

Wednesday 5:00

THYROID HORMONES INCREASE RATES OF RESTING METABOLISM AND SKELETAL GROWTH IN HATCHLING ARCHOSAURS

OWERKOWICZ, Tomasz, Univ. of California, Irvine, Irvine, CA

Resting metabolic rate (RMR) has been posited to be a major determinant of bone microstructure in vertebrates. In general, endotherms exhibit higher rates of primary bone deposition and secondary bone remodelling than similarly sized ectotherms. This observation has led some palaeontologists to use microstructural features of fossils to infer whether an extinct animal was endo- or ectothermic. However, no experimental evidence exists to support the hypothesized relationship between RMR and skeletal growth.

I propose that thyroid hormones provide a mechanistic explanation for this relationship. Plasma levels of free thyroid hormones, fT3 and fT4, correlate with RMRs in amniotes—endotherms have higher levels of fT3 and fT4 than ectotherms. Thyroid hormones are also known to accelerate bone resorption and formation in mammals, and thus play a role in skeletal development and maturation.

In order to test the above hypothesis, plasma fT3 and fT4 levels were altered in hatchlings of the saltwater crocodile (*Crocodylus porosus*) and the emu (*Dromaius novaehollandiae*). Normal thyroid gland activity was suppressed with methimazole in experimental emus. Experimental emus and crocodiles received daily doses of T3 and T4 orally, and con-

rol animals received saline. Animals were weighed and measured regularly over the course of 12 weeks, and injected with fluorescent dyes to highlight contemporary changes in bone microstructure. Rates of oxygen consumption were measured with open-flow respirometry at the end of each experiment.

Both RMR and growth rate were elevated by supplements of T3 and T4. Growth in crocodiles accelerated as plasma fT3 and fT4 levels rose, and the growth response was dose-dependent. Growth rate in emus decreased as plasma fT3 and fT4 levels dropped, but was restored with greater doses of T3 and T4. A preliminary histological analysis of bone microstructure showed that faster-growing hatchlings formed new bone with higher vascular density than their slower-growing siblings. This suggests that both RMR and skeletal growth rate are dependent on plasma levels of thyroid hormones, and explains why endotherms grow faster than similarly-sized ectotherms.

Saturday 8:30

SILOPHODONTID LONG BONE HISTOLOGY AND GROWTH OF SOME “HYP-SILOPHODONTID” DINOSAURS

PADIAN, Kevin, Berkeley, CA; DE RICQLES, Armand, Univ. of Paris VII, Paris, France; HORNER, John, Museum of the Rockies, Bozeman, MT

We examined the long bone histology of the “hypsilophodontid” dinosaurs *Orodromeus makelai*, *Dryosaurus altus*, and *Tenontosaurus tilletii*, from perinate to largest available ontogenetic stages. We compared these ontogenies to each other, and to those of other dinosaurs, notably more derived ornithomorphs such as *Maiasaura* and *Hypacrosaurus*. *Orodromeus* is a small dinosaur, and its more moderate growth trajectory is consistent with those generally observed for relatively small dinosaurs and other small ornithomorphs. *Tenontosaurus* achieves a relatively large adult size, and its bone histology through ontogeny is more similar to those of hadrosaurs. *Dryosaurus* is thought to be a small dinosaur, but in its largest recognized ontogenetic stages it does not display the “adult” histological features of other ornithomorph adults, although it does suggest growth rates comparable to those of larger ornithomorphs. Determinate growth is observed in *Orodromeus*, *Tenontosaurus*, and hadrosaurs, so we are not persuaded that growth is indeterminate in *Dryosaurus*. We infer instead that the adult stage of *Dryosaurus altus* has not yet been recognized, and we propose some possible solutions to this paradox.

Thursday 3:00

UPDATES TO THE MAMMALIAN MEGAFUNA OF THE MIDDLE MIOCENE BARSTOW FORMATION

PAGNAC, Darrin, South Dakota School of Mines, Rapid City, SD

The Barstow Formation (middle Miocene) crops out in the Mud Hills region of the Mojave Desert, San Bernardino County, California. The formation contains a rich and diverse mammalian fauna of late Hemingfordian (He2) age, and contains the type fauna for the Barstovian Land Mammal Age. The Barstovian component consists of three distinct faunal units, the Green Hills Division Fauna (Ba1), the Second Division Fauna (Ba1), and the Barstow Fauna (Ba2). The three Barstovian faunal components are compared with equivalent faunas throughout the western United States. The Green Hills Division and Second Division faunas compare most favorably with the Lower Snake Creek Fauna (Ba1) of Nebraska. The Barstow Fauna compares most favorably with the fauna from the Valentine Formation (Ba2) of Nebraska. Examination of faunal composition within the Barstow Formation suggests that the most significant faunal turnover occurs between the Green Hills Division and Second Division Faunas, or within the Ba1 interval. A similar faunal turnover is not reported in any other Ba1 fauna. The Ba1 faunal turnover event corresponds with a notable floral turnover observed throughout the western United States. Classic interpretations suggest that the initial spread of grasses had a key impact on the evolution of mammals, particularly in the Great Plains. However, this scenario does not adequately account for floral and faunal events in the Great Basin. Grasses are never a dominant component of the Great Basin flora, and floral transitions during the medial Miocene involve a shift from deciduous hardwood floras to conifer and chaparral associations. This shift in Great Basin vegetation corresponds to the Ba1 faunal turnover, represented by a loss of a number of brachydont browsing taxa.

Poster Session III

WHY PALEONTOLOGISTS SHOULD PICK THROUGH THE TRASH: MICRO-MAMMALS PRESERVED IN SUBFOSSIL MATRIX YIELD VALUABLE INFORMATION ON MADAGASCAR’S PALEOECOLOGY

PARENT, Sara, SAMONDS, Karen, Mount Holyoke College, South Hadley, MA

Due to the near lack of a Malagasy Cenozoic fossil record, little is known about the origin and evolution of Madagascar’s extant fauna. The Malagasy subfossil record has been important to filling in this informational gap by contributing details on past diversity and changes in distribution, but the emphasis in such studies has been on Madagascar’s larger animals (e.g., lemurs, pygmy hippos). Little attention has been paid to the Malagasy subfossil record of micromammals, despite the fact that the latter comprise the majority of the class. Even microfossils that could have been recovered from matrix during the preparation of larger vertebrates have often been ignored.

To demonstrate the potential presence of microfaunal remains in sediments associated with previously collected larger-bodied subfossil vertebrates, we conducted the following experiment. Approximately 1 kg of associated breccia material from Anjohibe Cave, northwestern Madagascar was removed from a nearly complete skull and mandible of

Archeolemur cf. edwardsi and dissociated using acetic acid. The residue included microfossil remains of three of the five extant Malagasy mammalian orders (Carnivora, Chiroptera, Rodentia), with more than sixty identifiable fossils: postcrania, skulls, dentaries, isolated teeth, and a possible subfossil carnivoran scat. Genera identified include *Eliurus* sp. (Rodentia), *Hipposideros cf. commersoni* and *Triaenops* sp. (Chiroptera), and *Galidia cf. elegans* (Carnivora), the latter having never been previously reported from this cave system. This research has demonstrated the potential of breccia sediments for producing subfossil micromammals, and the impending loss of information if these sediments are ignored and discarded. Detailed studies on other Malagasy subfossil groups (e.g., lemurs, birds) have produced valuable results, and more thorough sampling of Madagascar's microfauna may better reveal these groups past diversity. In addition, this information may help elucidate recent changes in species diversity and geographic ranges due to environmental change and human impacts, and aid in reconstructing Madagascar's paleoenvironmental history.

Poster Session II

MORPHOLOGY AND SIZE OF AN ADULT SPECIMEN OF *DEINONYCHUS ANTIRRHOPUS*, (SAURISCHIA, THEROPODA)

PARSONS, William, PARSONS, Kristen, The Museum of the Rockies, South Wales, NY
Since the original description of *Deinonychus* there has been a certain amount of speculation relating to the various ages of all the known specimens of this taxon. This determination of the actual size and morphology of adult forms of *Deinonychus* provides new data that are essential to any further studies of the ontogenetic morphological differences within the known specimens of *Deinonychus*. Presented here is newly discovered specimen, MOR 1182, that has been determined to be an adult, based on the presence of peripheral rest lines that were revealed in the thin section analysis of a fragment of the radius. These peripheral rest lines indicate determinate growth, which adds yet another avian character to the description of this taxon. Lines of arrested growth observed on a manual phalanx indicate the approximate age of this specimen. A comparison of the number of these LAGs with those observed on the sub-adult specimen MOR 1178 indicates the approximate age of initial maturity. Comparisons between the skeletal elements of MOR 1182, MCZ 4371 and AMNH 3015 reveal enough data to make descriptive statements regarding the morphology of the adult forms of *Deinonychus*. Some of the proportional ratios between the elements of the forelimbs and hind limbs can be further defined. The range in size between the onset of sexual maturity and full physical maturity can be estimated. Also, portions of the tail structure of the specimen, MOR 1182, have been preserved. Analysis of these elements indicates that the adult caudal rods possessed a surprising degree of flexibility. This new fossil material raises questions about the nature of these caudal rods, the associated soft tissue and the manner in which they relate to the caudal vertebrae. Morphological differences between some adult and sub-adult manus and pes elements may indicate differences in behavior between adults and sub-adults. Also, other associated faunal remains from two *Deinonychus* sites may indicate a variety of smaller prey species.

Friday 2:45

VARIATIONS IN RARE EARTH ELEMENT (REE) SIGNATURES AND UNIT CELL DIMENSIONS (UCD) FOR PURPOSES OF STRATIGRAPHIC CORRELATION AND PALEOENVIRONMENTAL INTERPRETATION IN THE PIERRE SHALE, SOUTH DAKOTA

PATRICK, Doreena, WEGLEITNER, Paul, GeoChemical Solutions, Fort Pierre, SD; MARTIN, James, South Dakota School of Mines and Technology, Rapid City, SD
Our recent research has involved new methods for stratigraphic correlation and paleoenvironmental interpretations including Rare Earth Element (REE) and unit cell dimension (UCDA) analyses of fossil bioapatites. REE analysis and UCDA use variations in REE signatures and unit cell dimensions (UCD) within bioapatite from different lithostratigraphic units. During the permineralization process, bioapatite composition changes from a metastable carbonate hydroxyapatite to a more thermodynamically stable fluorapatite, incorporating Fluoride, REE and other trace elements during diagenesis. Substitution by REE and other trace elements into the cation sites and specifically into the seven fold Ca(II) site will change the crystallographic dimensions. The REE composition and UCD of fossil bioapatite are dependent upon the conditions of diagenesis and thus dependent upon availability of REE and other elements for substitution during bioapatite permineralization. Bioapatite acts as a "flight recorder" for the environment of diagenesis and can be used to interpret the condition of the paleoenvironment. REE signature and UCD variations identify distinct intervals within lithologic formations. Because these intervals represent an averaging of periods of certain depositional environments, these distinct intervals can be correlated over significant areas. Fossil vertebrate samples were obtained from the Pierre Shale, at localities between Chamberlain and Pierre, Dakota in Buffalo, Hughes, and Hyde counties. Samples were collected from the Sharon Springs, Gregory, DeGrey and Verendrye members. REE signatures and UCD variations were found to be consistent within individual lithostratigraphic units but are significantly different between these units. Therefore, REE signatures and UCD are markers for their units and are used to discriminate between units for purposes of stratigraphic correlation and paleoenvironmental interpretation. Results of our research indicate that REE analyses and UCDA provide for a finer scale of resolution for stratigraphic correlation.

Poster Session I

FUSED *CAMARASAURUS* CERVICALS PRESERVE AN ERECT, NOT HORIZONTAL, NECK

PAUL, Gregory, Baltimore, MD

Computer simulated posture of sauropod necks including *camarasaurus* is consistently horizontal. The minimal spacing between centra in these simulations is problematic. Actual neck posture is determined by a combination of bone and cartilage. The thicker intercentra cartilage is the more dorso-flexed is the neck if the zygapophyses remain in 100% neutral articulation. In some giraffe specimens and *Camarasaurus* CM 11338 large gaps separate many cervical centra when the neck is straight and the zygapophyses are in full neutral alignment, indicating the space was filled with thick cartilage. Centra may be pulled together when the intercentra cartilage dries after death, many dorsals are jammed tightly together in CM 11338. It is simply not possible to reliably restore sauropod neck posture unless the cartilage is directly preserved.

Cervicals 11 and 12 of *Camarasaurus* AMNH 5761 are fused with the zygapophyses in 100% neutral articulation. The long axes of the centra are dorso-flexed 9 degrees, it may have been higher before modest dorso-ventral crushing. Because posterior cervicals of other specimens are straight or slightly depressed when the zygapophyses are neutrally aligned and intercentra spacing is minimal, thick cartilage padding apparently was present and ossified in 5761. If *camarasaurus* normally held their necks horizontal then the two vertebrae should have fused in a straight line. That the neck base fused dorso-flexed means there were strong pressures to hold the neck erect. Sauropods had 6 or more cervico-dorsals, so 10 degrees of dorso-flexion per joint along the neck-trunk junction would add up to 60 degrees over all. Cartilage wedging may have forced habitual erect neck posture in many other sauropods. Only some diplodocids with short necks and/or low shoulders could not readily carry the head far above shoulder level. Had Osborn and Mook, who figured the 5761 cervicals in 1921, described the flexion and used them to correctly restore an erect neck then the controversy over sauropod neck posture might never have arisen.

3D Imaging Symposium, Friday 9:30

COMPARATIVE PALEOECOLOGIES OF NORTH AMERICAN MIOCLAENIDS AND "HYOPSODONTIDS" (MAMMALIA: "CONDYLARTHRA") USING COMBINED DENTAL MORPHOMETRIC TECHNIQUES

PENKROT, Tonya, Johns Hopkins Univ. School of Medicine, Baltimore, MD

Two families of "condylarths", Mioclaenidae and "Hyopsodontidae" (both as traditionally defined), comprised a significant portion of the small-bodied mammalian diversity during the Paleocene and early Eocene of North America. The paleoecologies of these families are poorly understood, despite their relative abundance in many assemblages. Consequently, aspects of the geographic and temporal distribution of mioclaenids and "hyopsodontids" including a pattern of regional endemism in the early Paleocene but a more homogeneous distribution of genera by the Eocene, and the apparent extinction of the North American mioclaenids (but not of "hyopsodontids") shortly after the end of the Torrejonian NALMA, present paleoecological puzzles. Competitive exclusion between the two families, or unequal success in adapting to different climates, may be potential explanations for the resulting distributions of these taxa through space and time.

In mammals, dental morphology is a logical means for addressing paleoecological questions, whereby diets of extinct taxa may be assessed as a proxy for ecological function. In this study, mioclaenid and "hyopsodontid" dentitions were analyzed relative to a comparative sample of modern mammals of known diets, and to a subset of other contemporary condylarths, via a combination of linear measurements and occlusal surface characterization through laser-scanning.

Results indicate that, when mioclaenids and "hyopsodontids" were contemporaneous during the Torrejonian, they occupied adjacent but distinct regions in dental morphospace. The position of "hyopsodontids" subsequent to the extinction of mioclaenids changed little, however, arguing against competition as an explanation for the disappearance of mioclaenids. Variation within "hyopsodontids" then expanded in the early Eocene with the immigration of *Hyopsodus*. This genus represents a possible ecomorphologic intermediate between traditional "hyopsodontids" and Torrejonian mioclaenids, complicating the paleoecological pattern displayed by these two families of small-bodied condylarths.

Poster Session II

LATEST CRETACEOUS IBERIAN DINOSAURS: AN UPDATE

PEREDA-SUBERBIOLA, Xabier, Universidad del País Vasco, Facultad de Ciencia y Tecnología, Departamento de Estratigrafía y Paleontología, Bilbao, Spain; TORICES, Angelica, Universidad Complutense de Madrid, Madrid, Spain; COMPANY, Julio, Universidad Politécnica de Valencia, Valencia, Spain; RUIZ-OMENACA, Jose Ignacio, Museo del Jurásico de Asturias, Colunga, Spain; CANUDO, Jose Ignacio, Universidad de Zaragoza, Ciencias de la Tierra, Paleontología, Zaragoza, Spain

Dinosaur remains from the Campanian-Maastrichtian of the Iberian Peninsula were first described at the end of the 19th century, but most of the significant discoveries have been made in the last years. The most productive sites are Laño (Treviño) and Chera (Valencia), for the upper Campanian-lower Maastrichtian beds, and the Tremp (Lleida) and Arén (Huesca) areas, in the southern foothills of the Pyrenees, for the Maastrichtian. Other localities are known in Alava, Barcelona, Burgos, Segovia, Soria, Valencia (Spain), and Beira Litoral (Portugal). Theropods include small to medium-sized dromaeosaurids, the enigmatic coelurosaur *Paronychodon* and abelisauroid-like ceratosaurians. Ornithomimosaur and

enanthornithe birds may also be present. Sauropods consists of the lithostrotian *Lirainosaurus astibiae* and indeterminate titanosauriformes. Ankylosaurs are represented by the nodosaurid *Struthiosaurus*; a new partial skull from Valencia resembles that of *S. austriacus*. Ornithopods include the basal iguanodontian *Rhabdodon priscus* and hadrosaurids. The Iberian hadrosaurian record is the best of Europe, but only one taxon has currently been named: *Pararhabdodon isonensis*. Euhadrosaurian cranial remains from Huesca, Lleida and Valencia probably belong to taxa different from *Pararhabdodon* and *Telmatosaurus*. The presence of Lambeosaurinae in the southern Pyrenees seems likely. From a biogeographical perspective, the Iberian dinosaurs are closely related to those of southern France. Minor differences (e.g., distinct titanosaurian genera) could be due to provinciality within the Ibero-Armorian Realm. Most of the suprageneric taxa known in southern Europe (Dromaeosauridae, ?Abelisauroida, Lithostrotia, Nodosauridae, Rhabdodontidae, Hadrosauridae) were already present in the Late Jurassic-Early Cretaceous of the Laurasian landmasses. Such a distribution suggests that the dinosaurian isolation by vicariance in the European archipelago during the Late Cretaceous may have played a major role, although dispersal events cannot be dismissed.

Poster Session I

TOOTH ROOT SIZE AND CHEWING MUSCLE LEVERAGE IN *HOMUNCULUS*, A MIOCENE PRIMATE FROM PATAGONIA

PERRY, Jonathan, Duke Univ., Durham, NC; KAY, Richard, Biological Anthropology & Anatomy, Durham, NC; COLBERT, Matthew, The Univ. of Texas at Austin, Austin, TX
Homunculus patagonicus from the early Miocene of Patagonia is the oldest South American monkey (Platyrrhini) for which one can assemble a composite of the cranium, the mandible, and the postcanine teeth sufficient to reconstruct the position of the temporomandibular joint, the centroids of the major muscles of mastication, the position of the canine and cheek teeth, and the area and volume of the tooth roots. Such measurements provide a picture of the force vectors of the muscles as they could have acted at various tooth positions. It also allows assessment of the relationship between muscle leverage and tooth root area. Using CT-imagery, anatomical parameters were measured and compared with small- and medium-sized extant platyrrhines. Findings include: 1) the distribution of muscle leverage on the canine and cheek teeth is similar to that seen in living platyrrhines, 2) leverage at each tooth position is less in *Homunculus* than in living species perhaps as a consequence of its greater degree of prognathism, 3) the pattern of tooth root areas and volumes is similar in all taxa, but *Homunculus* has more tooth root area and volume at each tooth position than do the extant platyrrhines. Its large tooth roots suggest that *Homunculus* experienced heavy loads in mastication, in spite of poor muscle leverage. Perhaps *Homunculus* had larger masticatory muscles than living platyrrhines, but several aspects of the anatomy make this unlikely: the zygomatic arch is not larger or more robust than that of living platyrrhines and there is no sagittal crest (despite a small endocranial volume). In *Homunculus*, cresting for the attachment of the chewing muscles is slight. However, the postcanine teeth in most specimens are heavily worn. If *Homunculus* had poor chewing muscle leverage and small chewing muscles, perhaps its great degree of tooth wear was caused by repetitive loading to break down tough and/or gritty foods. Repetitive loading might also explain the great size of the tooth roots in this extinct platyrrhine.

Friday 2:15

MORPHOSPACE OCCUPATION IN EXTANT AND EXTINCT CROCODILES

PIERCE, Stephanie, RAYFIELD, Emily, ANGIELCZYK, Kenneth, Univ. of Bristol, Bristol, United Kingdom

Patterns of diversity among extant and extinct mesoeucrocodylians were studied from a morphological and functional perspective using geometric morphometrics and finite element modelling. An analysis of 125 extant crocodile skulls from all 23 living species shows that most modern crocodylians are morphologically conservative, with the main sources of shape variation being the length of the snout and the width of the skull. Gharials, however, occupy a different area of morphospace reflecting their unique skull shape. Loading 2D finite element models representing extremes of the first principle component of skull shape (i.e., short/broad snout vs. long/narrow snout) produces a very similar distribution of stresses throughout the skull. Peak stresses in the longest, narrowest skull were roughly three times those of the shortest, broadest skull. This suggests that cranial strength is highly dependent on shape and that long-snouted crocodylians have sacrificed skull strength for increased tooth count and high velocity jaw closure.

A comparable pattern of diversity can be observed within the Thalattosuchia, Jurassic longirostine marine crocodyliforms. An analysis of 48 skulls representing the Teleosauridae and Metriorhynchidae illustrates that thalattosuchian 'species' are discriminated by the length of the snout and the width of the skull with each family occupying a separate area of morphospace. When combined with modern crocodiles, thalattosuchians and gharials share a similar region of morphospace that is distinct from other extant species. This implies that gharials are convergent on the thalattosuchian skull shape and that there may be limited ways in which crocodiles can evolve a long, narrow skull. As thalattosuchians parallel modern crocodiles with respect to morphospace occupation, a similar functional dichotomy in terms of skull strength might exist.

Student Poster Session

CONSERVATION AND DESCRIPTION OF THE FIRST *TYRANNOSAURUS REX* SKELETAL MATERIAL FROM SOUTH DAKOTA

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The sixth documented associated skull and skeletal material attributable to *Tyrannosaurus rex* was recovered from 1981 through 1983 from Butte County, South Dakota. It currently resides in the collections of the South Dakota School of Mines and Technology as SDSM 12047. Although portions of SDSM 12047 have been figured and measured for data within publications, the whole of the specimen has never been described. As a roughly 40% complete specimen, SDSM 12047 offers a great deal of potential to add to the currently popular studies of the Tyrannosauridae. In preparation for a Master's thesis that will document and describe all parts of this specimen, all associated material is undergoing various degrees of preparation and/or conservation. Preparation activities include the removal of sediment and concretion materials with mechanical and manual processes. Conservation efforts include the removal of several kinds of aging consolidants and adhesives, and the replacement of gap-filling materials. The details of these processes, as well as preliminary findings, will be documented. Potential for further research is detailed in the photographs, measurements, and documentation of unusual features seen in certain parts of the skeleton. These include enamel spalling, wear facets, and split carinae on the teeth. Also included are potential pathologies exhibited in several bones, and characters that may cloud the specimen's affinity to *T. rex*.

Poster Session III

DATA MINING PHENOTYPES: DIETARY PREDICTION AS A CASE STUDY

PLJUSNIN, Ilija, JERNVALL, Jukka, EVANS, Alistair, GIONIS, Aristides, Univ. Helsinki, Helsinki, Finland

The objective of this study is to build a fully automatic method that can predict diet of mammalian species from 3D scans of its postcanine teeth. The approach includes automatic measurement of multiple shape variables, such as number of cusps, crown relief and surface complexity (107 in total). Common data mining algorithms are then used to search for a combination of shape variables and a relation model that perform best at predicting diet. As a result, a classification system was found that could label any scan in a data set of 58 species as herbivorous, omnivorous or carnivorous, with cross validation accuracy of 81%. The same approach can be applied to predict other classifications, such as phenotypic disparity among taxa and even developmental roles of genes from mutant morphologies. The main novelty of the data mining approach is that it can be applied fully automatically to sets of highly variable morphologies. The three-dimensional data is stored in MorphoBrowser database on dental shape and the data mining can be build directly into the database as a search interface with multiple search options.

Friday 3:00

MAMMOTH METAGENOMICS: NEW TECHNOLOGIES, NEW INSIGHTS, NEW POSSIBILITIES

POINAR, Hendrik, SCHWARZ, Carsten, McMaster Univ., Hamilton, ON, Canada; MacPHEE, Ross, American Museum of Natural History, New York, NY; MILLER, Webb, SCHUSTER, Stephan, Pennsylvania State Univ., Univ. Park, PA

Several important strides in ancient DNA (aDNA) studies have been made in the past two years, including the first utilization of new sequencing-by-synthesis technology to recover large quantities of genetic information from fossil remains of an extinct mammal (*Mammuthus primigenius*). In that study, we generated and analyzed 26 x 10⁶ base pairs (bp) of sequence data in a single 6 hr run from an exceptionally well-preserved 27,700-year-old mandible collected in the Lake Taimyr region of arctic Siberia (73°N, 100°E). Approximately half (13 x 10⁶ bp) of the data set proved to be alignable, at a high level of similarity (98.55%), with previously acquired genomic sequences of the African savanna elephant (*Loxodonta africana*). (Genomic sequence data for the Indian elephant are not yet publicly available.) Since our initial study we have completed 7X coverage of the mitochondrial (mt) genome of the Taimyr mammoth sample; fidelity of results is high (99.8% similarity to two other recently-published complete mtDNA genomes of the woolly mammoth), which in turn demonstrates the accuracy and reliability of the methods employed. Using these and other data, our preliminary estimates of late Quaternary woolly mammoth diversity indicates that populations were panmictic, with shallow diversity and small effective population sizes (at least during some intervals within radiocarbon time, i.e. the past 40-50,000 ¹⁴C years). Assembling and interpreting such data provides a basis for evaluating both the promises and the pitfalls of high through-put technology, especially in regard to estimating population dynamics and evolutionary distances within extinct or partially-extinct clades. We shall also discuss the importance of preservation conditions and sample-preparation methods to take advantage of recent technological improvements.

3D Imaging Symposium, Friday 11:45

3D BIOMECHANICAL MODELS AND THE EVOLUTION OF CRANIAL KINESIS IN MOSASAUROID SQUAMATES

POLCYN, Michael, Southern Methodist Univ., Dallas, TX

Increased cranial kinesis has long been considered a key innovation in squamate evolution and much has been written on the subject. In derived mosasaurs both the metakinetic and the mesokinetic axes of the skull are obliterated by increasingly complex relationships of the constituent bones. Basal mosasaurs have long been considered to possess a more kinet-

ic skull than later forms. However, it is only in recent decades that discovery of well preserved specimens of early mosasaurs allows examination of cranial morphology in sufficient detail to address the timing, sequence, and effects of this transition. This study utilizes finite element analysis and computational inverse kinematics operating on three-dimensional models of mosasaur skulls derived from laser and CT scanning and allows both experimentation and quantitative analysis of motion, forces, and stresses to assess the possible selective pathways for loss of cranial kinesis in later mosasaurs. Reduction of mobility in the metakinetic axis is already apparent in Middle Turonian russellosaurian mosasaurs and by the Coniacian some members of that clade have limited mobility in the mesokinetic axis. In mosasaurine mosasaurs this transition occurs later, consistent with the more recent cladogenesis of that subfamily. However, those two groups of mosasaurs attain the loss of kinesis by different means and suggests that fundamental reorganization of feeding mechanisms required for submarine prey capture and consumption occur early in the evolution of mosasaurs and are achieved independently in multiple clades. Retention of the plesiomorphic mode of cranial kinesis in *Halisaurus* may indicate a later entry into the marine realm of that genus. Thus, mosasaurs provide an example of the application of new analysis, simulation, and visualization techniques to investigate a classic problem of vertebrate paleontology and morphology, resulting in a greater understanding of the functional evolution of feeding and kinesis.

Poster Session I

SUBCHONDRAL BONE DENSITY AND JOINT POSTURE IN SUBFOSSIL MALAGASY LEMURS

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This study uses an experimentally validated methodology to infer habitual knee and hip joint posture in a sample of subfossil Malagasy lemurs. More specifically, this study analyzes the spatial patterns of subchondral bone density on femoral condyles in five subfossil lemurs: *Megaladapis*, *Archaeolemur*, *Mesopropithecus*, *Pachylemur* and *Hadropithecus*. Subchondral density was measured using Computed Tomography (CT) scans of a single femur for each of these genera. Amira software was used to reconstruct the three-dimensional structure of the femora from CT slices and to apply color maps to regions of differing bone density. Two-dimensional slices were obtained through the center of the femoral head and through the medial condyles of each specimen. Relative joint angles and the range of joint loading were estimated by measuring the angular position of the center of the region of maximum relative density (RMD) on the condyle. Our results suggest that *Megaladapis* used extremely flexed knee and hip postures which is consistent with previous positional interpretations. The range of the RMD for the remaining taxa suggest that they used moderately extended knee postures and are not well distinguished. However, both *Pachylemur* and *Mesopropithecus* have more subtle density patterns that suggest some use of highly extended postures. The juvenile *Hadropithecus* had lower density and a broader spread of the RMD, suggesting a wider range of habitual knee postures. While it is likely that these species moved in different ways than extant lemurs, further analyses of other mammals are necessary to determine the locomotor behaviors that caused these patterns of bone density.

3D Imaging Symposium, Friday 10:30

CHARACTERIZATION AND COMPARISON OF 3D SHAPES USING EIGENSURFACE ANALYSIS: LOCOMOTION IN TERTIARY CARNIVORA

POLLY, P. David, Indiana Univ., Bloomington, IN; MACLEOD, Norman, The Natural History Museum, London, United Kingdom

Eigensurface Analysis is a new geometric morphometric technique for the characterization and quantitative comparison of 3D surfaces. The core of Eigensurface Analysis is interpolation of a point grid with consistent sampling characteristics irrespective of the nature or complexity of the surfaces included in the sample. Like Procrustes landmark and eigen-shape outline analyses, the 3D point grids are standardized to remove size, rotation and translation. At present the eigensurface grid must be applied to each object in a comparable orientation. Procrustes analysis using a small number of surface landmark points is used to accomplish this. Once a set of comparable grids have been obtained, shape analysis proceeds as in standard eigenshape analysis by a singular value decomposition of the covariance matrix of the objects. Resulting eigenvectors serve as shape variables for further analysis, with scores of objects on them being used to represent shape ordinations, serve as the basis for shape models, etc.

As an example, Eigensurface Analysis was used to infer the number of toes, stance, and locomotor mode from the calcaneum morphology of six Tertiary carnivores. Ten extant species were used to determine mean calcaneal shape for four- and five-toed species, for plantigrade, semidigitigrade and digitigrade species, and for arboreal, scansorial, terrestrial, semifossorial, and natatorial species. The best match for each fossil to these categories was then determined by Procrustes distance.

Locomotor inferences were mostly accurate, but with two errors. *Ichthyerium viverinum*, a Miocene hyaenid, was correctly identified as being a four-toed digitigrade terrestrial animal and *Paramachairodus orientalis*, a Miocene saber-tooth felid, as a four-toed semidigitigrade terrestrial animal. The Miocene otter *Enhydriodon latipes* was correctly identified as five-toed and semidigitigrade, but incorrectly inferred to be terrestrial. The Oligocene amphicyonid *Cynelos lemanensis* was correctly identified as five-toed and terrestrial, but incorrectly inferred to be digitigrade (it was probably plantigrade).

Poster Session III

DISTINCTIVE CHARACTERISTICS OF SUBFOSSIL MAMMAL BURROWS (FOR IDENTIFICATION OF THE TRACEMAKER)

PONOMARENKO, Dmitri, RYBCZYNSKI, Natalia, Canadian Museum of Nature, Ottawa, ON, Canada

Vertebrate burrows provide evidence of both morphology and behaviour of the animal that constructed them, but there exists no reliable method for the identification of the tracemaker. We have studied modern analogues of fossil burrows to develop methods of their identification from quantitative as well as qualitative characteristics. Diameter and angle of descent are features of the vertebrate burrow that relate primarily to the animal's dimensions and can therefore be used to identify the tracemaker. However, the certainty with which burrow architects can be distinguished is poorly defined even for living species of mammals. Variation in cross-sectional size and shape can depend on the size of the animal and on taphonomic processes.

Three-dimensional mapping of subfossil burrows at a locality in Gatineau, Quebec allowed us to describe the variability of burrow dimensions, nature and probable mode of their infill, as well as the collapse structures for two living species of sciurid mammals. Plaster casts of open burrows were used to compare the difference in variability of several parameters between open burrows and infilled burrows in soil. Taphonomic processes were examined through excavation of partially collapsed *Marmota monax* and *Tamias striatus* burrows.

Literature descriptions of burrowing movements and examinations of cadavers were used to relate burrow dimensions to anatomical and behavioural characteristics (joint range of motion, girth, shoulder width; stroke sequences, quiet standing position). Although the diameter of a mammal burrow does not correspond to any single skeletal measurement, it can be used to formulate hypotheses that involve both skeletal dimensions and the mode of digging.

Poster Session III

A REVIEW OF MESOZOIC AND CENOZOIC CHIMAEROID FISHES (HOLOCEPHALI, CHIMAEROIDEI) FROM TERRITORY OF THE FORMER USSR

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During two last decades our knowledge about Mesozoic and Cenozoic chimaeroid fishes (Holocephali, Chimaeriformes, Chimaeroidei) from territory of the former USSR are increased greatly. Their remains (isolated tooth plates mainly, a lot of head claspers and fin spines, rare egg cases' imprints) were found in Russia (80+ localities, Norian to Oligocene), Ukraine (5: Albanian? to mid Eocene), Kazakhstan (20+: Albanian to lower Oligocene), Uzbekistan (6: Albanian to mid Eocene), Kyrgyzstan (1: Yprisean) and Lithuania (3: Albanian). Some of these localities are very rich in chimaeroid material: 4500+ remains of 9 genera and 10 species were collected from Albanian-Cenomanian of Stoilenskii and Lebedinskii quarries in Belgorod Province, Russia.

Taxonomic composition of Chimaeroidei consists of three families (Callorhynchidae, Rhinochimaeridae and 'Edaphodontidae' [probably of paraphyletic origin]), 17 genera (C: 'Eomanodon', *Callorhynchus*, *Brachymylus*, *Duffinodus*, plus 1 undescribed new genus; R: *Belgorodon*, *Harriotta*, *Kushmurunia* plus 'Rhinochimaera' egg case; 'E': *Ischyodus* (dominated), *Edaphodon*, *Elasmodus*, *Elasmodectes*, *Lebediodon*, *Amylodon*, plus 2 still undescribed new genera) and about 50 species. Collected materials were come from marine (mainly locs) paleoenvironments, desalinated (some Middle Asia locs) and even freshwater ones (Mid Jurassic 'Peski' loc near Moscow).

So large and diverse material allowed me to revise the terminology, to study the morphology and variability of chimaeroid dentitions (basic available for research chimaeroid remains) and to make changes in systematics and evolution of Chimaeroidei. Following stage of the research will be revision of collections from Western Europe, Australia etc for solving some nomenclature and taxonomic problems of the Chimaeroidei and for obtaining a complete conception of the fossil chimaeroid systematics and evolution.

Poster Session III

A NEW RECORD OF CARNOTAURINAE (THEROPODA: ABELISAUROIDAE) FROM THE UPPER CRETACEOUS OF NEUQUÉN, PATAGONIA

PORFIRI, Juan, CALVO, Jorge, National Univ. of Comahue, Proyecto Dino, Argentina

We report a new pelvis of a Carnotaurinae abelisauroid from the "La Invernada" locality, placed 35 km Southwest of Rincón de los Sauces city, Neuquén, Argentina. The pelvis (MUCPv 1125) was unearthed from the Bajo de la Carpa Formation (Santonian) of the Neuquén Group. This pelvis is composed of both ilia, ischia and pubis, and 6 sacral vertebrae. As in adult ceratosaurs, all pelvic elements are fused. In MUCPv 1125 the ilium presents the ventral margin of the preacetabular blade projected downward, which is more expanded dorsoventrally than the postacetabular blade. The pubis has the obturator foramen placed proximally and shows a small pubic foot that is expanded anteroposteriorly. The pubic apron expands until the mid-half of the shaft. The opposing ischia contact on the proximal end and show a slight foot-like expansion. Carnotaurinae (middle Aptian to Maastrichtian) includes: *Genusaurus*, *Majungatholus*, *Rajasaurus*, *Pycnonemosaurus* and the Carnotaurini (*Aucasaurus* + *Carnotaurus* + unnamed specimen from Bajo Barreal Formation). The pelvis of "La Invernada" shows morphological features observed only in the Carnotaurinae clade such as the elongated and low ilium with straight dorsal border, acute ventral notch on the preacetabular blade and posterior border of the postacetabular blade of the ilium with a marked concavity forming a dorsal and a ventral projection, and

therefore is here regarded as a member of the Carnotaurinae. MUCPv 1125 resembles *Genusaurus*, confirming that the latter is also a member of that clade. The discovery of this pelvis of a Carnotaurinae increases the knowledge of this group and suggests that those theropods played a major as predators during the Upper Cretaceous of Patagonia.

Student Poster Session

CRANIAL BIOMECHANICS OF BASAL ORNITHISCHIAN USING FINITE ELEMENT ANALYSIS

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Ornithischian dinosaurs were the dominant terrestrial herbivores of the Late Mesozoic, developing a wide range of feeding strategies to process vegetation. These feeding styles diversified rapidly amongst early ornithischians; yet the jaw mechanics of the most basal clade of ornithischian dinosaurs, the heterodontosaurs, remain unresolved. It is of importance to uncover the feeding strategy utilized by heterodontosaurs to better understand the early development and evolution of herbivory within Ornithischia. In this study, the engineering technique of finite element analysis (FEA) was applied to 2D models of the skulls of the primitive ornithischians *Heterodontosaurus*, *Lesothosaurus*, and *Hypsilophodon*. Although all three animals were herbivorous, cranial and dental morphology suggests they utilized very different feeding strategies. In addition, the basal theropod *Eoraptor* was included as a biomechanical outgroup. Results from analyses of a 3D finite element model of the skull of *Heterodontosaurus* are also presented. The aims of this study are: 1) to uncover differences in the mechanical response of the skulls that may represent specializations to different feeding strategies, 2) to examine key structural differences that may have evolved in early ornithischians during the transition to herbivory, and 3) to assess the value and limitations of 2D finite element models.

Results of the 2D analyses reveal both similarities and differences in the mechanical behavior of the skulls of these early dinosaurs. Stress trajectories and areas of peak stress were generally similar across all taxa and remained unchanged despite variations in bite force. Notable differences include: the relative strength of the skulls of different taxa during various modes of biting; stress distribution and trajectories during biting on the premaxillary teeth; the effect of the size of the antorbital fenestra on relative skull strength; and the transmission of stress through the lacrimal of *Eoraptor*. Results from testing on the 3D model of *Heterodontosaurus* allow assessment of the value and limitations of 2D finite element models.

Student Poster Session

SMALL CARNIVORES AS TAPHONOMIC AGENTS ATTRIBUTING TO THE ACCUMULATION OF FOSSIL BIRD ASSEMBLAGES

PRASSACK, Kari, Rutgers Univ., New Brunswick, NJ

Taphonomic and skeletal part profiles, of bird bone assemblages produced by carnivores, should differ depending on the size relationship of predator to prey. Smaller carnivores feeding on larger or similar-sized avian prey should produce non-digested bone assemblages with a high number of tooth markings that are smaller than those produced by larger carnivores. Fragmentation rates should be low and whole elements common. Proportionally larger carnivores and/or scat-derived bird bone assemblages are expected to be highly fragmented, with a low potential for element or taxonomic identification. Masaai dogs were fed chicken and found to either completely consume bone or produce small unidentifiable fragments, supporting this hypothesis. Neotaphonomic observations were then conducted to test the effects of small carnivorous mammals (< 15kg). Small carnivores were fed carcasses of chicken, duck, and turkey. Data was obtained on the placement and size of tooth pits, punctures, and scores, fragmentation rate, carcass consumption sequence, removal of choice parts from the site, and resulting skeletal part profiles. This data was then used to analyze two modern lesser flamingo assemblages, an attritional accumulation from Lake Natron, Tanzania and a catastrophic accumulation from Lake Nakuru, Kenya. These assemblages fit the taphonomic and skeletal part profiles attributed to modification primarily by smaller carnivores. Both sites exhibit a high number of complete elements, low fragmentation, modification in the form of small tooth markings, and an abundance of forelimb versus hind limb elements. Fossil birds are common at many paleontological and archaeological localities, but taphonomic analyses are rarely conducted on them. Results of this study suggest that more attention should be lent to the taphonomic study of smaller carnivores and their effects on the survivorship of fossil bird assemblages.

Poster Session III

A NEW FOSSIL CANID ASSEMBLAGE FROM THE LATE PLEISTOCENE OF NORTHERN SOUTH AMERICA: THE CANIDS OF THE INCIARTE ASPHALT PIT (ZULIA, VENEZUELA), FOSSIL RECORD AND BIOGEOGRAPHY

PREVOSTI, Francisco, Museo de La Plata, La Plata, Argentina; RINCÓN R., Ascanio, The Univ. of Texas at Austin, Austin, TX

Canids invaded South America during the Pliocene (2.8-3.1 Ma BP) as part of the Great American Biotic Interchange, but their record on the continent is relative poor until the Pleistocene. However, even the Pleistocene record of the group is patchy and biased, with few records for the northern part of South America. In this paper we describe a new assemblage of canids found at the Inciarte asphalt pits (Zulia, Venezuela). These remains are associated with a variety of extinct Pleistocene mammals dated between 25-27 Ka BP. Canids in this assemblage include *Protocyon troglodytes*, *Protocyon* sp., *Canis dirus*, *Urocyon* cf. *U. cinereoargenteus*, and an indeterminate canid. This is the first record of *Urocyon* from

the Late Pleistocene in South America and constrains the timing of its dispersal to South America prior to 25-27 Ka. The distributional record of *Protocyon* and *P. troglodytes* is expanded 1,500 km north of previous records and constitutes the first record of these taxa in Venezuela. The presence of *C. dirus* at Inciarte constitutes the fourth locality for this species in South America.

Neoceti Symposium, Saturday 9:15

EXTRAPOLATING FROM EXTANT TO EXTINCT: RECONSTRUCTION OF EARLY NEOCETE LIFE-HISTORY STRATEGY AND ECOLOGY

PRICE, Samantha, National Evolutionary Synthesis Center (NESCent), Durham, NC

This study examines the utility of extant cetacean species in the effort to understand the origin and radiation of the Neoceti. Specifically I explore how information from extant species can be used to reconstruct aspects of early odontocete and mysticete life-history strategy and ecology using a phylogenetic comparative approach. Two different methodologies are compared and their conclusions evaluated in relation to what we know from 'evo-devo' and palaeontological evidence. The first approach uses a phylogeny of the extant cetacean species along with information about their life history, body size and ecology to reconstruct ancestral states using both maximum likelihood and parsimony. The second approach derives allometric relationships between life history, ecology and body size in extant species using the phylogenetic comparative method (PCM). These extant allometric relationships are then applied to extinct species using information from the fossil record and from ancestral state reconstruction of body size. The importance of controlling for species non-independence using PCM and its effect upon the results are explored.

Saturday 8:15

MORPHOMETRICS OF THE HADROSAURID PELVIC GIRDLE USING A NEW METHOD OF SHAPE ANALYSIS

PRIETO-MARQUEZ, Albert, JOSHI, Shantanu, PARKER, William, Florida State Univ., Tallahassee, FL

The pelvic girdle of hadrosaurid dinosaurs is known to contain phylogenetic information. However, most of the currently used characters usually separate hadrosaurids from less derived forms. We explore the morphological variation of the ilia (n = 104), ischia (n = 84), and pubes (n = 63) of sixteen hadrosaurid and two non-hadrosaurid genera with the goal of revealing new phylogenetically informative characters and test currently recognized ones. In doing so, we also aim to separate taxonomic from individual and ontogenetic variation. The morphometry of the bones is done implementing the newly developed Geodesic Distance Analysis (GDA). This method represents shapes as continuous curves invariant to translation, rotation, and uniform scaling, without resorting to salient finite dimensional landmarks. Shape differences are computed by finding geodesics (or shortest length paths) intrinsic to the shape space. GDA allows posing intrinsic statistical inferences in the infinite dimensional space consisting of full contours of shapes. We summarized GDA shape differences by generating cluster linkages (arithmetic averaging) and non-metric multidimensional scaling plots. Each pelvic element was decomposed into homologous regions or processes. GDA is implemented for the samples of each one of these homologous structures. Osteological attributes with patterns of variation that allow separation of taxa and that could be phylogenetically informative include: the dorsoventral position of the medial longitudinal ridge of the ilium, as well as its distance from the dorsal border of the bone; the location of the lateroventral apex of the supraacetabular process relative to the caudal protuberance of the ischial peduncle; the absence or degree of caudal extension of the lateral rim of the supraacetabular process; the dorsoventral or mediolateral compression of the iliac postacetabular process, as well as the angle between its dorsolateral surface and the parasagittal plane; the degree of cranial indentation and concavity of the ventral margin of the pubic ischial peduncle; and the lateral profile of the iliac peduncle of the ischium, especially the shape of its dorsal margin. Previously known characters supported by this analysis include changes in the morphology of the prepubic process of the pubis and the morphology of the distal end of the ischial shaft. Our results also reveal more patterns of variation within footed and non-footed ischia than previously recognized.

Wednesday 11:15

THE EFFECTS OF OVERSPLIT TAXONOMY ON DIVERSITY CURVES: THE DROMOMERYCID DATA BASE

PROTHERO, Donald, LITER, Matthew, Occidental College, Los Angeles, CA

The subfamily Dromomerycinae is an endemic radiation of North American Miocene cervoid ruminant artiodactyls characterized by variety of bony cranial appendages. Their species-level systematics has not been reviewed since Frick's 1937 monograph, and the group is oversplit with many redundant subgenera and over 50 named species, most of which were *nomina nuda* (no diagnosis provided) and have not been analyzed since 1937. We used modern biological concepts and statistical methods to greatly reduce the number of valid taxa in the subfamily. Among the Aletomerycini, the late Arikarean immigrant *Aletomeryx* contains three species, *A. gracilis* (with three junior synonyms), *A. marslandensis*, and *A. occidentalis*. The peculiar curve-horned *Sinclairiomeryx* is monotypic. Among the Dromomerycini, *Drepanomeryx* (*Matthomeryx*) *matthewi* is a junior synonym of *D. fal-ciformis*. The bow-horned *Rakomeryx sinclairi* is monotypic, with five junior synonyms. Straight-horned *Dromomeryx borealis* is also monotypic (with three synonyms), as is *Subdromomeryx antilopinus* (raised to generic rank), which has four junior synonyms.

As part of the separate immigration event of the Cranioceratini in the late Arikarean,

there is only one valid species, *Barbouromeryx trigonocorneus*, with two additional invalid subgenera and three invalid species. The common genus *Bouromeryx*, which had been split into eight species, has only two, the smaller late Hemingfordian *B. submilleri*, and the Barstovian *B. americanus*. The monotypic three-horned *Procranioceras skinneri* remains valid, but elevated to generic rank. *Cranioceras*, which has two straight supraorbital horns and its occipital horn pointed posteriorly, once contained seven species, but now consists of the larger *C. unicornis* and the smaller *C. teres*. Thus, 50 invalid species are reduced to just 17 species in 11 genera (most of which are now monotypic) with no subgenera. This clarification of the taxonomic confusion of such an important group greatly enhances their usefulness in biostratigraphy and paleoecology. For example, diversity curves based on the old taxonomy show a peak in the late Hemingfordian, while the new diversity data peak in the early and late Barstovian, and continue higher in the early Clarendonian than previously published curves suggest.

Neoceti Symposium, Saturday 9:45

HOW DID EARLY TOOTHED WHALES ECHOLOCATE? AN INVESTIGATION OF MORPHOLOGICAL EVIDENCE USING PHYLOGENETIC AND SOFT TISSUE INFERENCE

PYENSON, Nicholas, Univ. of California Museum of Paleontology, Berkeley, CA; McKENNA, Megan, Scripps Institution of Oceanography, La Jolla, CA

Toothed whales (Odontoceti) echolocate using sound pulses generated and received via a complex arrangement of soft and bony craniofacial structures. Inner ear morphology suggests early Neoceti had the ability to hear low-mid frequency sounds underwater; high frequency and directional hearing are apomorphic in Odontoceti. In contrast to sound reception, the evolution of the sound generation (echolocation) in Odontoceti has not been addressed quantitatively. Echolocation has not been convincingly demonstrated in living mysticetes nor inferred in archaeocetes. The presence of osteological correlates for an air sac system (e.g., premaxillary sac fossae) has been used to identify echolocation ability in fossil odontocetes, but these correlates are not discrete nor patent in all taxa. Some extinct odontocetes likely echolocated as well as living taxa, but it remains unclear how early odontocetes echolocated using even more plesiomorphic facial morphologies.

To evaluate echolocation ability of extinct odontocetes, we developed a suite of functional correlates in craniofacial morphology related to sound generation in living taxa. Living odontocetes echolocate using different configurations of bony tissue and soft tissue complexes, but three key components drive this system: a power generator, a sound production mechanism, and a signal propagator. Using 2-D images and X-ray CT scans, we quantified three osteological proxies of these drivers (angle of the nasal passageway relative to the skull anteroposterior axis; nasal passageway volume; and estimated melon size). These criteria clarify the sequence of skull transformations associated with the evolution of the sound generation complex, as well as quantifying the morphological space needed for echolocation. Our pilot study analyzed outgroup taxa (basilosaurid archaeocetes, aetiocetid mysticetes) and multiple ingroup taxa (e.g., *Simocetus*, *Squalodon*, *Prosqualodon*, *Albireo*, *Odobenocetops*) that are represented by near-complete and nondistorted crania. Mapping nasal passageway angle (NPA) values indicates that some basal odontocetes had NPAs similar to outgroup taxa, and NPA only increases past 90° in derived crown lineages (with a reversal in *Odobenocetops*).

Friday 2:00

INNER EAR MORPHOLOGY AND ITS RELATIONSHIP WITH THE PTERYGOID SINUS IN FOSSIL AND EXTANT PORPOISES (CETACEA: PHOCOENIDAE)

RACICOT, Rachel, BERTA, Annalisa, San Diego State Univ., San Diego, CA

The morphology of the cetacean inner ear and other hearing-related features, such as the pterygoid sinus system, are sources of functional and phylogenetic information. However, the functional relationships between these various structures are not well known. Features of the cochlea related to hearing capability include the basilar membrane length and the number of turns of the cochlear spiral, both of which correlate with the range of high and low frequency hearing. Scans of isolated and *in situ* tympanoperiotics of all six extant porpoise species and one fossil porpoise were obtained using high-resolution X-ray CT data. This method non-destructively provides thinner slices, higher-resolution and more precise data than traditional serial sectioning, physical dissection, or medical scanning methods. Measurements from these data, including basilar membrane length, were used to infer frequencies potentially heard by fossil and modern porpoises. These were compared with sonograms from extant species when available. Digital endcasts were also isolated from the inner ear, visualizing the bony labyrinths. The semicircular canals of *Neophocoena phocoenoides*, an early-diverging phocoenid, and the fossil phocoenid are similar in their more elliptical shape, whereas *Phocoena spinipinnis*, a later diverging phocoenid, has shorter and more ring-shaped semicircular canals. All porpoises studied have one and a half cochlear turns. However, the cochlea in *N. phocoenoides* and the fossil have spiral turns that are less tightly coiled than in *P. spinipinnis*. These features potentially indicate that the fossil had similar hearing capabilities to *N. phocoenoides*. The shapes of the pterygoid sinuses of the fossil differ from those of *N. phocoenoides*, indicating that the sinuses may not be associated in the aspects of hearing and consequently sound production that were inferred from cochlear morphology. Thus, while the medial relationship of the pterygoid sinuses to the ears suggests that they acoustically isolate them and facilitate directional hearing, the influence of the shape of these sinuses on sound production and reception remains unclear.

Friday 11:45

BIG TROUBLE AT LITTLE FISH LAKE: TAPHONOMY OF A DIVERSE VERTEBRATE MASS MORTALITY ASSEMBLAGE IN ALBERTA, CANADA

RALRICK, Patricia, Univ. of Calgary, Calgary, AB, Canada

The vertebrate assemblage found at Little Fish Lake, Alberta, Canada, preserves a unique mass mortality event with important ramifications for fossil microvertebrate and bonebed studies. It is significant because it provides a rare relatively modern example of a taxonomically diverse accumulation in a lacustrine setting. Found on the beach are countless disarticulated bones, made up mainly of fish and frog remains. Bison bones are also abundant with less common occurrences of small mammal, bird and reptile remains. Forty-five articulated fish skeletons, including such delicate elements as scales, form a sinuous line which designates the paleoshoreline. The bone layer is a thin 1 to 2 centimeters in thickness adding to the belief that the accumulation is from a catastrophic event, possibly the result of a toxic algal bloom. Historical evidence indicates that the site is 120 to 275 years old. Radiocarbon dating currently underway will help to pinpoint the date of this accumulation.

Initially it was believed that the site was a wholly disarticulated assemblage deposited on the beach by wave action. However, the site is formed by *in situ* articulated fish, frogs and possibly other fauna that are being exposed by eolian and fluvial processes resulting in their disarticulation and transport. Interestingly, there is no visible evidence of this reworking on the bones themselves. The majority of the damage to the bones has been caused by exposure rather than transport.

The processes of accumulation are currently ongoing. They can be observed and documented. For example, modern bones are being added to this subfossil site by natural attrition and transport by migratory species, mainly gulls. This could lead to a false indication of paleoecology and fauna. Future study of these processes will further elucidate the ways in which fossil bonebeds and microvertebrates sites located worldwide were formed.

Saturday 11:30

THEROPOD DINOSAURS FROM THE LATE JURASSIC OF TANZANIA AND THE ORIGIN OF CRETACEOUS GONDWANAN THEROPOD FAUNAS

RAUHUT, Oliver, Bayerische Staatssammlung für Paläontologie und Geologie, Munich, Germany

Our understanding of Cretaceous theropod faunas from the Southern Hemisphere has been greatly improved in recent years, due to numerous discoveries mainly in South America, Africa and India/Madagascar. However, the origin of these faunas is still poorly understood, owing to the paucity of theropods known from the Jurassic of Gondwana. The famous Late Jurassic dinosaur beds of Tendaguru, Tanzania, are thus of special interest, since they have yielded the only identifiable Late Jurassic theropod remains from Gondwana so far. Unfortunately, theropods are poorly represented in the material collected from that locality, but even the sparse material can give important insights in the light of the recent discoveries from the Cretaceous of the Southern Hemisphere.

Only one of the taxa described from Tendaguru is based on adequate material and can currently be regarded as valid, *Elaphrosaurus bambergi*. *Elaphrosaurus* is a very unusual taxon that combines coelophysoid-like presacral vertebrae and ilium with abelisauroid-like limbs. All other taxa described are based on undiagnostic material. The type tibia of *Allosaurus tendagurensis* represents a large basal tetanuran. The type material of *Ceratosaurus roechlingi* includes remains of a very large probable allosauroid and a smaller *Ceratosaurus*-like neoceratosaur. A *Ceratosaurus*-like animal is also indicated by the premaxillary teeth described as *Labrosaurus stehowi*, whereas the teeth of *Megalosaurus ingens* show allosauroid and even carcharodontosaurid characters. Thus, potentially only two taxa are represented by all this material, a possibly carcharodontosaurid allosauroid and a *Ceratosaurus*-like neoceratosaur. Further theropod taxa are indicated by isolated remains, including tibiae of a small basal tetanuran and a small to medium-sized abelisauroid, as well as remains of a further, slenderly built, large basal tetanuran and a robust, large abelisauroid. In summary, the theropod fauna from Tendaguru is dominated by neoceratosaurids (at least 3, probably 4 taxa) and basal tetanurans (at least 3 taxa), whereas coelurosaurids are conspicuously absent. Thus, this fauna is more similar to Cretaceous Gondwanan faunas than to contemporaneous faunas of Europe and North America, in which neoceratosaurids are rare and coelurosaurids are abundant.

Poster Session I

COMPARATIVE MORPHOLOGY AND IDENTIFICATION OF DISSOCIATED CROCODYLIFORM OSTEODERMS FROM THE UPPER CRETACEOUS MAEVARANO FORMATION, MADAGASCAR

RAVELOSON, Miky Lova, Univ. of Tananarive, Antananarivo, Madagascar; WHATLEY, Robin, Smithsonian Institution, Washington, DC

Since 1993, many hundreds of isolated crocodyliform osteoderms have been recovered from the Maevarano Formation of northwestern Madagascar by joint expeditions of Stony Brook Univ. and Univ. of Tananarive researchers. Although crocodyliform skeletal elements are common in these deposits, they are rarely preserved with articulated osteoderms, making taxonomic identification of isolated osteoderms problematic. Characteristics of size, shape, and texture of osteoderms associated with skeletal material of *Mahajangasuchus*, *Simosuchus*, and *Araripesuchus* contribute to a rubric for identifying disassociated osteoderms of these taxa. *Mahajangasuchus* osteoderms have deeply sculpted dorsal surfaces with accentuated or blade-like longitudinal keels and irregular margins. Although

Mahajangasuchus and *Simosuchus* possess quadrangular and ovoid osteoderms, the rugose dorsal surface, ventral surface grooves, and large size of *Mahajangasuchus* osteoderms discriminate these two taxa (maximum diameter of examined *Simosuchus* osteoderms is approximately two and a half centimeters, versus five centimeters maximum diameter for *Mahajangasuchus* osteoderms). In addition, an apex or slight ridge that does not traverse the entire dorsal surface of the osteoderm of *Simosuchus* is present instead of an exaggerated keel. *Araripesuchus* osteoderms are thin, rectangular, and comparatively much smaller. We also find osteoderms with unique features likely belonging to one or more of up to four additional crocodyliforms known from this extraordinarily diverse local fauna.

3D Imaging Symposium, Friday 11:30

THE EVOLUTION OF PISCIVORY IN THEROPOD DINOSAURS

RAYFIELD, Emily, Bristol, United Kingdom; MILNER, Angela, Natural History Museum, London, United Kingdom

Craniodental morphology and fossilised gut contents from spinosauroid theropod dinosaurs indicate at least a partially piscivorous diet, a unique trophic adaptation among large, non-avian dinosaurs. Furthermore, spinosaurids represent a striking example of convergent evolution towards a crocodylian-like cranial morphology; the significance of this is unclear, and partly based on the fact that the biomechanical and adaptive significance of key crocodylian characters remains to be fully explored.

Here we present new anatomical information from CT scan data, which was subsequently used to create 3D comparative Finite Element models of the skulls of the spinosaurid theropod *Baryonyx walkeri* and two extant crocodylians (*Alligator*, *Gavialis*) that are commonly interpreted as functional analogues for spinosaurids. We conducted a series of FE-analyses to determine the differential stress response of each skull during bending and torsional feeding loads.

Spinosaurids and extant gavial crania consistently function in the same manner, thus highlighting an example of extreme morphological and functional convergence towards a piscivorous trophic niche based on the acquisition of shared 'crocodylian' characters. The bony secondary palate confers strength to the alligator-type skull in torsion, but provides resistance to bending in gavials and spinosaurids. Loss of the antorbital fenestra strengthens narrow or tubular theropod and gavial snouts, but has limited influence on the broader-snouted alligator morphotypes.

Consequently, the mechanical impetus for palatal development and fenestral closure observed in crocodylian evolution is more complex than previously suggested and most theropod skulls were surprisingly sub-optimally constructed to accommodate feeding related bite loads. A set of biomechanical constraints may have governed the acquisition of particular functional complexes, and influenced the sequence of character acquisition in both crocodylian and theropod evolution.

Poster Session III

PLIO-PLEISTOCENE PALEOENVIRONMENTS AT OLDUVAI BASED ON MODERN SMALL MAMMALS FROM SERENGETI, TANZANIA AND AMBOSELI, KENYA

REED, Denné, National Museum of Natural History, Washington, DC; KANGA, Erustus, Kenya Wildlife Service, Nairobi, Kenya; BEHRENSMEYER, A. Kay, National Museum of Natural History, Washington, DC

Using calibrated methods based on modern faunas we test hypotheses of environmental change and habitat structure at the Plio-Pleistocene age Bed I assemblages from the FLK site at Olduvai. The calibration is based on modern, taphonomic assemblages of mammals weighing less than 1kg from the Serengeti ecosystem, Tanzania and Amboseli National Park, Kenya.

Modern micromammal assemblages created by owls were sampled from four localities in Amboseli and twelve localities in Serengeti. The faunas from these taphonomically generated assemblages were compared to the surrounding habitats to test whether faunal composition is consistent with the known habitat preferences of the micromammal taxa. These empirically derived micromammal communities were then plotted in a species ordination space using non-metric multidimensional scaling to demonstrate community response to habitat variation within the Serengeti and Amboseli ecosystems. Fossil species were then added to the ordination to assess their position in the species ecospace.

The Serengeti long has served as the preferred analogue for the paleoenvironments around paleo-lake Olduvai, with many researchers arguing that the Plio-Pleistocene environments were more wooded and similar to areas in the northern part of this modern ecosystem. However, the small mammal fossil assemblages at Olduvai are distinct from modern Serengeti communities in having large abundances of fossil Groove-tooth rats belonging to the genus *Otomys*. This genus is present at some localities in Amboseli, suggesting that this ecosystem, which shares many geomorphological features with paleo-Olduvai, may be a better modern analogue than the Serengeti. This calls into question the assumption that the nearest modern faunal community is the best analogue for mammalian fossil assemblages such as Olduvai.

Saturday 2:30

MANUAL PATHOLOGY INDICATIVE OF LOCOMOTOR BEHAVIOR IN TWO CHASMO-SAURINE CERATOPID DINOSAURS

REGA, Elizabeth, Pomona, CA; HOLMES, Robert, Canadian Museum of Nature, Ottawa, ON, Canada

We present evidence for a pathological process bearing on locomotion in the first manual digital ray in two chasmosaurs. The holotype of *Chasmosaurus irvinensis* (CMN 41357) includes a complete, articulated right manus. The angle of articulation of the first metacarpus and proximal pollical phalanx—based upon articular surface congruence—is abnormal; the metacarpo-phalangeal joint is medially deviated and the distal proximal pollical phalanx curves sharply laterally toward the second digit. The first metacarpus and proximal pollical phalangeal surfaces are also highly rugose; however this rugosity is not consistent with infectious periostitis. The distal articular surface of the first metacarpus and proximal articular surface of the proximal phalanx are abnormally deeply grooved. Similar abnormal morphology, also involving these same elements of the first digital ray, is exhibited by both the right and left mani of *Chasmosaurus belli* (ROM 843). The angulation of joints is most consistent with a condition in human feet known as hallux valgus, a condition caused primarily by forced habitual adduction of the distal first hallucal ray causing deformity and abnormal joint angulation at the more proximal metatarsal-proximal phalangeal joint. Articulated manual elements are extraordinarily rare in ceratopsians. Given the apparent prevalence of the condition and the modern-day etiology of the hallux valgus, we propose habitual forced adduction of the pollux which led to the observed joint angulation deformity. Implications for manual pronation during normal chasmosaur locomotion are discussed.

Saturday 11:00

ORIGIN OF DENTAL OCCLUSION IN TETRAPODS: SIGNAL FOR TERRESTRIAL VERTEBRATE EVOLUTION

REISZ, Robert, Univ. of Toronto at Mississauga, Mississauga, ON, Canada

Evolutionary changes of the tetrapod dentition can be associated with major events in terrestrial vertebrate history. In the Carboniferous, terrestrial vertebrate communities had low diversity and abundance, and little variation in dental morphology. Dental occlusion, the process by which teeth from the upper jaw come in contact with those in the lower jaw, appears first in cotylosaurs (amniotes+diadectomorphs) near the Permo-Carboniferous boundary. It coincides with the appearance of the oldest known high fiber herbivores and a dramatic increase in terrestrial vertebrate diversity. This evolutionary innovation permitted a dramatic increase in oral processing of food in amniotes and diadectids, and has been associated with herbivory. Whereas herbivory in extinct vertebrates is based on circumstantial evidence, dental occlusion provides direct evidence about feeding strategies because jaw movements can be reconstructed from the wear patterns of the teeth.

Examination of dental occlusion in Paleozoic tetrapods within a phylogenetic framework reveals that this innovation evolved independently in several lineages. Occlusion first appears among diadectomorphs, the sister taxon of amniotes. Although basal diadectomorphs have conical, non-occluding teeth, diadectids show various levels of occlusion and tooth wear. This is achieved by transverse expansion of the marginal dentition in diadectids, bringing the lingual shoulder of the upper teeth in occlusion with the labial shoulder of the lower teeth. Among amniotes, the synapsid *Edaphosaurus* and the parareptile *Bolosaurus* show the earliest examples of occlusion and tooth wear, using palatal and prearticular teeth in the former and marginal teeth in the latter. The independent, multiple acquisition of this feeding strategy represents an important signal in early terrestrial vertebrate diversification and the development of complex vertebrate communities. However, this innovation predates significantly the modern type of terrestrial ecosystem that first appears in the Late Permian, with large numbers of primary consumers supporting few top predators.

Friday 12:15

AN ONTOGENETIC SERIES OF THE CERATOPSID DINOSAUR *EINIOSAURUS PROCURVICORNIS* AS DETERMINED BY LONG BONE HISTOLOGY

REIZNER, Julie, HORNBER, John, Montana State Univ., Bozeman, MT

Histologic studies have been utilized in paleontology to determine rates of growth for several types of dinosaur, including sauropods, theropods, hadrosaurs, and the basal ceratopsian *Psittacosaurus*. However, dinosaurs of the family Ceratopsidae have largely been excluded. Several (MNI of 15) disarticulated skeletons of the centrosaurine *Einosaurus procurvicornis* Sampson 1995, varying in size, have been found in the Upper Cretaceous Two Medicine Formation of northwestern Montana. Long bones (humeri, femora, and tibiae) were sectioned, due to their minimal remodeling (infiltration of secondary osteons). After they were ground to appropriate thickness, the bone microstructure was viewed on a Nikon microscope (magnified 10X). The individuals' ages at death, age at maturity for the species, and possible longevity are assessed. Tissue types and degrees of remodeling are discussed, and visible lines of arrested growth (LAGs) were used to calculate a maximum number of LAGs that were likely present before remodeling occurred. Specimens were then placed into age classes, based on size of the bone as well as number of LAGs, and growth rate was assessed. The rate of growth appears to be highest when the animal is 1—2 years of age, and after 3 years growth slows, signifying that this may be the age at which sexual maturity is reached. Thus far, the oldest individuals are about 6 years old. This information on growth dynamics has implications for physiology, and possibly behavior, of ceratopsid dinosaurs.

Romer Prize Session, Thursday 11:45

EVOLUTION OF FORELIMB FUNCTIONAL MORPHOLOGY IN SAUROPODOMORPH DINOSAURS

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One of the key characters of the sauropod dinosaurs is their obligate quadrupedalism, which is also one of the necessary preadaptations for gigantism in this group. However, to date it has never been shown how the functional transition from “prosauropod” to “sauropod” forelimbs, i.e. from short arms with grasping hands in primary bipedal ancestors, to columnar, weight-bearing forelimbs in quadrupedal descendants might have occurred. In this work, a detailed study of bone morphology of the pectoral girdle and forelimb in a large variety of sauropodomorphs, basal saurischians, and basal dinosauromorphs was integrated with reconstructions of the forelimb musculature, which were achieved by applying the Extant Phylogenetic Bracket approach of Witmer. The results permit new insights on how this transition took place.

In the pectoral girdle, the coracoidea rotate from a ventral position parallel to the vertebral column counterclockwise, facing anteroventrally in higher prosauropods and anteriorly in basal sauropods. Thus, the humerus rotates from a ventrolaterally directed, semi-erect position to a fully erect condition, and the primary abductor-adductor muscles (M. pectoralis, M. deltoideus, and others) change their function or are reduced, respectively. Other muscles become more important, e.g. the posterior Mm. triceps complex takes over the function of the primary retractor of the humerus. A fully erect stance of the forelimb in prosauropods is impossible due to the posteroventrolateral orientation of the glenoid and the inability to fully pronate the hand, a problem that is avoided when a semi-erect stance is assumed. In the forearm, the proximal end of the radius rotates at the elbow joint from lateral to anterior, allowing for a full pronation of the manus, and the flexor-extensor musculature of the forearm and the manus becomes reduced. However, the forearm pronators and supinators are still large in basal sauropods and likely played an important role in stabilizing the limb during walking. On the line to neosauropods, these key adaptations were further optimized.

Student Poster Session

HIND LIMB AND PELVIS PROPORTIONS OF *HESPERORNIS REGALIS*: A COMPARISON WITH EXTANT DIVING BIRDS

REYNAUD, F., Fort Hays State Univ., Hays, KS

Hesperornis regalis and other hesperornithiforms are often compared to grebes or loons in terms of their life habits, means of locomotion, and hind limb morphology. This comparison is widely used and accepted, and dates back to O. C. Marsh's 1890 monograph on the toothed birds. However, no quantitative analysis has previously been published to determine whether this is an accurate morphological comparison. Ratio, multivariate, and average Euclidian distance analyses of five modern species of foot-propelled diver, including one loon and two grebes, shows that the Common Loon, *Gavia immer*, is significantly similar to *Hesperornis regalis*, *H. gracilis*, and *Parahesperornis alexi* in terms of hind limb bone length ratios, pelvis shape, and position of the acetabulum on the pelvis. The Western Grebe, *Aechmophorus occidentalis*, is also significantly similar to these three extinct species when overall body size is removed from consideration; however, the Red-necked Grebe, *Podiceps grisegena*, is not. Based on these results, the Common Loon is closely analogous to *Hesperornis regalis*, *H. gracilis*, and *Parahesperornis alexi*, and, therefore, a good model on which to base study of their hind limb musculature and locomotion.

Poster Session II

IMPRINTS OF HORSE HOOVES IN THE SOUTHWESTERN NEOGENE FOSSIL RECORD

REYNOLDS, Robert, LSA Associates, Inc., Riverside, CA

Neogene horse tracks in southern Nevada and California are reported from only six localities. These limited tracks do not represent all horse tribes known from fossil record. New and previously undescribed horse tracks in the Calico Mountains, California and Meadow Valley Wash, Nevada prompted a review of ichnite morphologies from: Prosperity Canyon, Calico Mountains, CA: late Hemingfordian (He2) NALMA Fossil Canyon area, Mud Hills, CA: middle Barstovian (Ba2) NALMA Shadow Valley Basin, north of Baker, CA: late Barstovian (Ba2) NALMA Muddy Creek Formation, Moapa, NV: late Hemphillian (Hh4) NALMA Copper Canyon Formation, Death Valley, CA: early Blancan (BI I) NALMA Lake Tecopa Sediments, Shoshone, CA: late Irvingtonian (Ir II) NALMA Track measurements are compared to determine if hoof wall thickness increases with geologic age and phylogenetic time; if the surface area of the hoof sole increases over time; and if increases in these two metrics are related. The ratio (length to width) of each horse track was computed to differentiate elongate from equant tracks. Measurements of horse hoof wall thickness from California and Nevada increase through time from the late Hemingfordian NALMA through the middle Irvingtonian NALMA, suggesting an evolutionary trend toward thicker hoof walls. A V-shaped frog in equid tracks is first noted in one of three ichnomorphs from early Blancan (4.33 Ma) sediments at Copper Canyon, where two horse ichnomorphs are equidimensional and the third is elongate. This suggests two monodactyl (pliohippine) forms and one tridactyl (hipparionine) form, the latter print containing a frog. The area displaced by the horse hoof varies through time, perhaps reflecting locomotion or habitat. Track ratio increases in the Barstovian, but remains within certain limits (1.0–1.6) through the late Cenozoic. Small slender horse tracks from the late Miocene of Moapa, Nevada may repre-

sent tridactyl *Nannippus*. This study helps quantify the record of equid foot morphology in the Neogene fossil record. Data gathered does not differentiate monodactyl equid feet from tridactyl equid feet where the lateral phalanges do not touch the ground during standing or walking.

3D Imaging Symposium, Friday 8:00

DEAD ON ARRIVAL: OPTIMIZING CT DATA ACQUISITION OF FOSSILS USING MODERN HOSPITAL CT SCANNERS

RIDGELY, Ryan, WITMER, Lawrence, Ohio Univ., Athens, OH

Medical CT scanning at local hospitals is often the best option given constraints on costs, fossil size, travel risks, etc. Advances in medical scanning have allowed greater resolution and improved ability to image high-density objects such that the capabilities of hospital scanners now overlap those of ‘industrial’ scanners. However, hospital CT techs are not paleontologists. Thus, we provide guidelines to assist both paleontologist and CT tech in optimizing data acquisition. If 3D visualization is a goal, then contiguous helically-acquired slices are essential. Thin slices are necessary to resolve fine details (such as foramina), and most modern scanners can reach sub-millimeter resolutions (500-600 microns). For large fossils, a separate thinly sliced dataset of, say, the braincase region can be digitally ‘inserted’ into a coarser dataset of the whole skull. Contrast between fossil and matrix is better at lower energies (120kV), although higher energies (140kV) may be necessary. A ‘bowtie filter’ greatly improves image quality by pre-hardening the X-ray beam. CT techs typically seek to minimize radiation dose, but high-dose scans (currents up to 200mA, slow table speeds) pose no risks to fossils and produce better results. The standard medical grayscale is optimized for the human body and can be the most severe limitation to the scanning of dense fossils; many scanners, however, have an Extended Hounsfield or High Dynamic Range mode, which provides a grayscale broad enough for very dense objects. The specimen should be aligned in the scanner to minimize the amount of material through which X-rays must travel; restoration of canonical orientation can be done later with software. Specimens plagued with ‘streaking’ artifact can be scanned in more than one orientation with differing protocols, and the resulting datasets can then be registered. Slice reconstruction with a bone algorithm is typically preferred to the ‘standard’ (soft tissue) algorithm. Data should be output in digital DICOM format rather than film for subsequent analysis.

Wednesday 9:15

MORPHOLOGY AND PHYLOGENETICS OF *EOSANIWA* (SQUAMATA: REPTILIA) BASED ON HIGH-RESOLUTION X-RAY COMPUTED TOMOGRAPHY

RIEPEL, Olivier, Field Museum of Natural History, Chicago, IL; CONRAD, Jack, American Museum of Natural History, New York, NY; MAISANO, Jessica, Univ. of Texas, Austin, TX

Eosaniwa koehni from the Eocene of Geiseltal (Germany) originally was described nearly three decades ago, but it has remained an enigma since its discovery. The only known specimen consists of a skull and fragmentary postcrania preserved in association with a partial *Diplocynodon* sp. (Crocodylia) skeleton. Because dorsal surface of the specimen is imbedded in an opaque epoxy plate, only the ventral view of the specimen has been available for description. Analysis of the exposed morphology led to an early referral of *Eosaniwa* to Necrosauridae. Earlier cladistic analyses including *Eosaniwa* were unable to resolve its placement beyond suggesting a platynotan status. Although these analyses included numerous fossil anguimorphs, they did not include mosasauroids.

We used high-resolution X-ray computed tomography (HRXCT) for improved morphological analysis of *Eosaniwa*, including the previously unknown dorsal surface of the specimen. *Eosaniwa* has dorsoventrally broad jugals, very elongate nasals, and paired frontals with well-developed subolfactory processes that do not meet at midline. We also identified the sphenoid, basioccipital, and humerus of the specimen among other new observations. We incorporated these data into a new cladistic analysis of 28 ingroup platynotans rooted to two shinisaurid outgroups scored for 155 informative morphological characters. A strict consensus of three shortest recovered trees suggests that *Eosaniwa* is the sister-taxon to a clade composed of *Paravaranus*, Dolichosauridae, and Mosasauroida. This clade is the sister group of a clade containing *Telmasaurus*, *Saniwides*, and crown varanids within Varanoidea.

Poster Session III

LOCAL EVOLUTION OF LATE PLEISTOCENE CAPRINAE AND HYAENIDAE IN THE NORTHEASTERN PART OF THE PYRENEAN MOUNTAINS (FRANCE)

RIVALS, Florent, Univ. of Hamburg, Hamburg, Germany; TESTU, Agnès, CNRS UMR 5198, Tautavel, France

The Pyrenean Mountains are characterized by high levels of endemism in modern faunas and floras (e.g. Pyrenean desman or water-mole, *Galemys pyrenaicus*; Pyrenean salamander, *Euproctus asper*; or Pyrenean rock lizard, *Lacerta bonnali*). This endemism was to be the result of glaciations which geographically isolated some areas of southern Europe during Pleistocene. We tested this hypothesis by studying the evolution of Caprinae and Hyaenidae found in three late Pleistocene localities of the northeastern Pyrenean Mountains (France), dated from 90,000 to 60,000 years B.P.: Caune de l’Arago, Arche cave, and Portel-Ouest cave. The data obtained on populations of tahr, (*Hemitragus cedrensis*), ibex (*Capra caucasica*), and cave hyena (*Crocuta crocuta spelaea*) were compared with those of the French Massif Central populations (Bouxès, Hortus, Baume Moula-Guercy, Saint-Marcel-d’Ardèche) and Provence ones (Adaouste, Bau de l’Aubiesier). This study is mainly based

upon dental and postcranial characters and measurements. Typical dental features were found on the northeastern Pyrenees species only, for Caprinae and hyena as well. Ibx, for instance, shows a reduced metastylar wing on the M3, narrow parastyle and metastyle with low relief. The two species of Caprinae present also a reduction in size of all anatomical parts, especially on metatarsal and phalanx. Populations of the Massif Central and Provence do not display such a reduction. Pyrenean populations of hyena show a narrow P4 in its anterior part and a p4 with a short protoconid. All these features suggest a local evolution of Caprinae and Hyaenidae during the late Pleistocene, supporting the hypothesis that the northeastern part of the Pyrenees was geographically isolated from the Iberian Peninsula and the rest of continental Europe during the coldest periods of the late Pleistocene.

Poster Session II

BRIEF REPORT ON NEW PTEROSAUR (PTEROSAURIA, PTERODACTYLOIDEA) SPECIMENS FROM THE CRETACEOUS OF MOROCCO

RODRIGUES, Taissa, KELLNER, Alexander, Museu Nacional/UFRJ, Rio de Janeiro, Brazil; MADER, Bryn, Long Island Natural History Museum, Levittown, NY; RUSSELL, Dale, North Carolina State Univ., Raleigh, NC

Pterosaur remains from Africa are rare. Most of them were found in Morocco, particularly in the terrestrial Cretaceous (Albian-Cenomanian) redbeds that outcrop in several areas of the country. Among the most significant is *Sirocopteryx moroccensis* (Anhangueridae), which is based on the rostral part of an upper jaw, an azhdarchid cervical vertebra, and isolated remains referred to the Pteranodontidae, Azhdarchidae and Tapejaridae. Here we report three more specimens that were collected from the Albian/Cenomanian strata of Tafilalt, southeastern Morocco. The first one is a right humerus (NMC 50814), which is broken in two parts and has an estimated length of 300 mm. The deltopectoral crest was broken off, but the distal end of the humerus is quadrangular, similar to the condition observed in the Tapejaridae. A large pneumatic foramen is present ventrally at the base of the deltopectoral crest. There is also a large and high muscle scar on the dorsal surface of the shaft and a smaller one on the ventral side, both more developed in this specimen than in other pterosaurs. This humerus differs from other pterosaurs and is tentatively referred to the Azhdarchidae, which due to its size represents an animal of a wingspan around 5.5-6 m, making it one of the largest African pterosaurs known so far. The second specimen is an elongated mid-cervical vertebra (length: 104 mm), bearing low neural spine, condition present in the Azhdarchidae. Three pneumatic foramina border the neural canal, one on each side and another dorsal to it. It lacks the ventral pneumatic openings lateral to the hypophysis present in a previous azhdarchid cervical (LINHM 014) reported from this country, suggesting the presence of at least two azhdarchid pterosaurs in this deposit. The third specimen (CMN No. 50859) is an edentulous rostral tip of a jaw, 43 mm long, which belongs either to Pteranodontidae or Azhdarchidae, the latter being favored here. Despite being incomplete, the specimens recorded from Morocco indicate the presence of a diverse pterosaur fauna in the middle part of the Cretaceous in this region.

Poster Session III

FIRST EVIDENCE OF ENVENOMATION SALIVARY APPARATUS IN FOSSIL SHREWS (MAMMALIA)

ROFES, Juan, CUENCA-BESCÓS, Gloria, Zaragoza Univ., Zaragoza, Spain

Predation using salivary venom apparatuses is extraordinary in mammals. The only venom salivary apparatus known for a living mammal is that of the Caribbean *Solenodon*, while for a fossil mammal it was described quite recently in a known Paleocene Cimolesta, *Bisonalveus*. Venomous saliva is somewhat more common; yet only Eulipotyphlans as the shrews *Blarina*, *Crociodura*, *Neomys*, and the solenodontid *Solenodon* are the living mammals with poisonous saliva. A new anatomical trait for shrews reveals the first example of what appears to be an envenomation salivary apparatus. Evidences of this character emerge in two soricine fossil taxa from the Pleistocene of Atapuerca, Burgos, Spain. Both taxa are documented by well-preserved specimens from two of the Early Pleistocene cave deposits of the Sierra de Atapuerca: the Sima del Elefante (ca. 1.25-1.5 Ma) and the Gran Dolina (ca. 0.78-0.9 Ma). Two different species of large shrews, *Beremendia fissidens* and a yet non-described soricine have evolved specialized teeth with gutter-like grooves along the medial side of the crown of the lower incisors, being similar to those described in the modern *Solenodon*. In the lower mandible, the presence of a larger symphysis probably accommodate stronger articular soft tissue. Concluding, the salivary apparatus of these large shrews may be an evolutionary adaptation that was probably related to an increase in body mass and the need of hunting larger size prey.

Poster Session I

USAGE OF IMAGE-BASED 3D MODELING PROCESS FOR RECONSTRUCTION OF UPPER CRETACEOUS BRAZILIAN SIDE-NECKED TURTLE *BAURUEMYS ELEGANS* (SUÁREZ, 1969) (PLEURODIRA: PODOCNEMIDIDAE): A PRELIMINARY STUDY

ROMANO, Pedro Seyferth, AZEVEDO, Sergio Alex, MONNERAT, Marcos Coutinho, HAGUENAUER, Cristina, CUNHA, Gerson Gomes, Federal Univ. of Rio de Janeiro (LAMCE/UFRJ), Rio de Janeiro, Brazil

Over the last decade several methodologies applied on the obtaining, editing, and physical prototyping of fossil vertebrate three-dimensional (3D) files have been developed. Most tools used to obtain such files need expensive and specialized equipments such as Computed Tomography or 3D Surface Scanners. Image-based 3D modeling is an alterna-

tive procedure for creating quality 3D files from still images using a conventional camera. A preliminary study was performed using some *Bauruemys elegans* specimens collected on type-locality (Pirapozinho, São Paulo State, Campanian-Maastrichtian) aiming to construct a 3D database of this pleurodiran fossil turtle. Photos were taken with a Fuji FinePix S5100 (4 megapixel digital camera), treated with MS Easy Camera Calibration Tool and Adobe Photoshop 7; 3D files were created using 3D Software Object Modeller Pro 2 (3D SOM). A Virtual Reality Model of *B. elegans* was constructed through the following steps: (1) prepare the room with 3D SOM specific printed mat plus a high contrast backdrop for the camera position identification and to simplify the mask of the photographs; (2) take 30-40 photos of the fossil on a printed mat from different viewpoints to get all the shape and texture details of the fossil; (3) eliminate picture distortion with a camera calibration tool; (4) clean the background and adjust brightness/contrast of all pictures; (5) automatically generate picture masks and adjust them; (6) generate wireframe and surface; (7) generate the surface texture; and (8) export the 3D file. The Virtual Reality Modeling Language (VRML) was chosen because it is an open source format fully supported that requires only a browser and a freeware plugin to be visualized and can be opened by almost every 3D modeling software. Such procedure enables fast and low cost 3D acquisition of small and medium vertebrate fossils and might be applicable with larger ones as well, which would require careful room preparation. Furthermore, the preliminary results indicated that Image-based 3D modeling is potentially a powerful alternative technique to vertebrate fossil reconstructions, especially to web publishing.

Wednesday 2:00

FIRST JURASSIC TRICONODONT FROM SOUTH AMERICA

ROUGIER, Guillermo, University of Louisville, Louisville, KY; GARRIDO, Alberto, Museo Carmen Funes, Plaza Huincul, Argentina; GAETANO, Leandro, Universidad de Buenos Aires, Buenos Aires, Argentina; PUERTA, Pablo, Museo E.Feruglio, Trelew, Argentina; NOVACEK, Michael, American Museum of Natural History, New York, NY

The Queso Rallado quarry in the Middle Jurassic Cañadon Asfalto Formation, Chubut province Argentina is so far the only South American locality providing Jurassic mammalian remains. The australosphenid *Asfaltomylos patagonicus* and a closely related form have been reported from that locality. We report here on the first discoveries of a triconodont from that locality. The first specimen and type of a new species is an isolated lower molariform. The tooth is dominated by five mesiodistally aligned cusps. The main cusp (a) is the tallest, while b and c are subequal in height; two small accessory cusps (d and e) occupy the mesial and distal extremes of the molariform. The largest cusps (a-c) are recumbent, in particular a and c. There is a poorly differentiated cusp g but no distinct cingulum is present. The roots or crown are not grooved for molar interlock, which as suggested by the flaring of cusp d was probably in echelon. The whole tooth is extremely buccolingually compressed, determining a very gracile cusp morphology. The compression of the tooth, and recumbency of cusps is reminiscent of the Early Cretaceous *Ichthyoconodon jaworowskorum* from Morocco, but the relative cusp proportions are different. The new taxon is similar to the very incomplete *Triconolestes curvicauspis* from the Jurassic of Utah in cusp proportions and recumbency, but far more compressed. The retention of a primitive cusp g and the derived nature of the remainder of the crown suggest a peculiar taxon possibly related to the generalized Jurassic triconodonts of the northern landmasses, but exhibiting a certain degree of endemic development; the same conclusion can be drawn for the australosphenidans from Queso Rallado. The molariform shows a mosaic of features present among Triconodontidae and the plesiomorphic "amphilestidae". Previously reported Cretaceous triconodonts from South America are probably best interpreted as dryolestoid premolars. New Jurassic specimens have just been collected, including cranial and postcranial remains, that will provide a much broader comparative basis for this enigmatic triconodont.

Poster Session III

QUANTITATIVE METHODS FOR EXTRACTION OF LIFE HISTORY DATA FROM PROBOSCIDEAN TUSK GROWTH RECORDS

ROUNTREY, Adam, FISHER, Daniel, Univ. of Michigan, Ann Arbor, MI

Structural features of tusk dentin in mastodons and mammoths living under temperate-latitude conditions include an intermediate scale of lamination (between years and days) marked by dark-light couplets recurring in a pattern of about 26/yr (in mastodons) or 52/yr (in mammoths). These "second-order" increments apparently form at a fixed periodicity, and a time-series of the thicknesses of consecutive increments thus monitors the rate of addition of tusk dentin, which is related to nutritional status.

Previously, identification of phases in life history defined by major physiological or social changes (e.g. eviction from the matriarchal family unit, onset of musth) was based on qualitative assessment of growth increment profiles. In this study, statistical methods were used to identify: (1) atypical annual profiles that might mark life history transitions, and (2) sets of similar profiles reflecting stages between transitions. Growth profiles for each of the 32 full years represented in a tusk of a male American mastodon were treated as separate time-series, normalized to 26 increments by linear interpolation, and analyzed using pairwise Kolmogorov-Smirnov tests and principal components analysis. Results from the Kolmogorov-Smirnov tests and from comparison of pair-wise multivariate Euclidean distances in principal component space portray a life history divided into three phases by two unique years. In agreement with the previous qualitative assessment, these tests identify the thin, aseasional year 12 as an atypical year ending the juvenile phase and probably associat-

ed with eviction from the matriarchal family unit. A homogeneous sequence of late teen years is punctuated at age 20 with a year in which growth rate is relatively high. The remaining portion of life consists of years that show similarities interpreted as reflecting annually recurring musth episodes. Qualitative and quantitative results are thus closely comparable, but quantitative methods enhance our ability to summarize patterns underlying the similarities and differences among years.

Friday 2:15

TITANOSAURS FROM THE ATACAMA DESERT

RUBILAR-ROGERS, David, Universidad de Chile, Santiago, Chile

Titanosaurs are the best represented dinosaurs in Mesozoic rocks from the Atacama Desert. Although all the specimens of those sauropods are restricted to two localities of northern Chile, the remains are comparatively abundant and well preserved. The fossils come from the Cretaceous outcrops in the Quebrada Cortadera locality (Tolar Formation), a sequence of red sediments with conglomerates, sandstones and siltstones, in the Antofagasta region; and from the Quebrada la Higuera locality (Hornitos Formation), a sequence of lacustrine deposits, in the Atacama region. The Quebrada la Higuera locality has the best preservation, presenting only slightly distorted elements. The material recovered until now, in both localities, includes several postcranial elements, but skull elements have not been recovered yet. The bones are particularly slender compared with other titanosaurs of the same size.

A preliminary phylogenetic analysis of the titanosaur specimen (SNGM-1) found in the Quebrada la Higuera, indicates that this taxon shares more affinities with the laurasian form *Opisthocoelicaudia skarzynskii* and the titanosaurinae indet. (DGM series B) from Brazil, than other titanosaurs such as Saltasaurinae from South America. The paleogeographic distribution of these specimens was restricted to a slender continental border surrounded for epicontinental seas only connected to the mainland by its southern portion, a predominant condition during the Cretaceous in the north and central Chile. The slender bones found in these specimens could be related to this condition of restricted area, which could be compared with the "island rule" of the ecological theory.

Saturday 9:15

A NEW PACHYRHINOSAURUS-LIKE CERATOPSID FROM THE UPPER DINOSAUR PARK FORMATION (LATE CAMPANIAN) OF SOUTHERN ALBERTA, CANADA

RYAN, Michael, Cleveland Museum of Natural History, Cleveland, OH; TANKE, Darren, BRINKMAN, Don, EBERTH, David, Royal Tyrrell Museum of Palaeontology, Drumheller, AB, Canada; CURRIE, Philip, Univ. of Alberta, Edmonton, AB, Canada

In 2001 an almost complete, but disarticulated, adult-sized centrosaurine ceratopsid was collected from the transgressive Dinosaur Park Formation (DPF) at Dinosaur Provincial Park (DPP) near Iddesleigh, Alberta. The skull resembles new, undescribed *Pachyrhinosaurus*-like material from the Late Campanian Wapiti Formation of Grand Prairie, Alberta, located approximately 640 km NE of DPP. The nasal ornamentation is a large pachystotic boss, whereas the postorbital ornamentations are deeply excavated bosses. Surface features indicate that this is an old individual. Extreme pathological deformations are present in the anterior parietal bar and in many of the phalanges, possibly indicating the cause of death. A preliminary phylogenetic analysis indicates that it is the sister taxon to the clade containing *Pachyrhinosaurus canadensis* and the new taxon from Grande Prairie.

The specimen occurs near the top of the DPF in a stacked channel succession that cuts out the lowest coal of the 15 m thick Lethbridge Coal Zone. The specimen was deposited on a point bar in a meandering channel that experienced seasonal-to-subseasonal variations in flow regime and depth, as a result of tidal influences and/or episodic rainfall. Dates from bentonites that bracket this interval suggest an age of 75.1 Ma. Thus, it is approximately temporally equivalent to *Achelousaurus* from the Two Medicine Formation of Montana and indicates an evolutionary trend towards the development of nasal and postorbital bosses in Late Campanian centrosaurines. In an upsection stratigraphic context within the Dinosaur Park Formation the new centrosaurine replaces *Styracosaurus* and is an additional component in a significant faunal change in the upper DPF that is also marked by the first occurrence of the chasmosaurine *Chasmosaurus irvinensis* and the lambeosaurine *Lambeosaurus magnicristatus*.

3D Imaging Symposium, Friday 12:00

A 3D CRANIAL ANIMATION OF EDMONTOSAURUS FOR TESTING FEEDING HYPOTHESES

RYBCZYNSKI, Natalia, TIRABASSO, Alexander, Canadian Museum of Nature, Ottawa, ON, Canada; CUTHBERTSON, Robin, Carleton University, Ottawa, ON, Canada; HOLLIDAY, Casey, Ohio Univ., Athens, OH

The success of hadrosaurian dinosaurs has largely been attributed to their highly specialized craniofacial system. Most notable is the hypothesized presence of a pleurokinetic hinge that permitted rotational movement of the maxilla about the premaxilla. Pleurokinesis would have allowed mediolateral displacement of the upper tooth rows during dental occlusion, resulting in a transverse powerstroke. To achieve pleurokinesis the skull must also permit mobility at other cranial "joints", including the postorbital/jugal, maxilla-jugal/lacrimal, palatine/pterygoid, and quadrate/squamosal contacts. Pleurokinesis has been previously evaluated using a kinematic linkage system (i.e., work of Weishampel), but has not been tested with a model that incorporates detailed joint geometries in 3D space. Here we report

on the development of a 3D kinematic animation model that will allow us to test pleurokinesis and other hypotheses of cranial kinesis in extinct taxa. The model was constructed by scanning the disarticulated elements of *Edmontosaurus regalis* (CMN 2289) with a 3D surface colour scanner (Arius 3D). Individual elements were imported into an animation software (3D StudioMax v.8). Elements found to be substantially deformed were digitally corrected based on data from comparative specimens. In the 3D application, a hierarchical kinematic chain of bony elements was assembled and mobilized using Inverse Kinematics (IK). IK is an animation method in which the positional orientation of the "child-element" determines the positional orientation of the "parent-element"; based on joint constraints, pivot locations, and hierarchical linkage of the elements. In our case, the dentary assumes the role of a "child" and is linked to the quadrate "parent", which in turn, is linked to the maxilla through a "wiring system" (different from IK). In the wiring system any positional change experienced by the maxilla during dental occlusion is translated back to the quadrate. Though preliminary, the model shows some of the intracranial movements to be unexpectedly large or unrealistic compared to deformations previously recorded among kinetic lizards, the most appropriate extant models. The results show that the IK modeling system is highly suitable for testing hypotheses of dinosaur chewing kinematics.

Friday 2:00

CROCODYLIAN CRANIAL SHAPE: PHYLOGENY VS. ECOMORPHOLOGY

SADLEIR, Rudyard, Univ. of Chicago, Chicago, IL

Crocodylian phylogeny remains problematic and characterized by conflicting phylogenetic signals, character homoplasy, and character atavisms. Most phylogenetic ambiguity relates to *Gavialis* and *Tomistoma*, where a secondary signal associated with their longirostrine condition accounts for 70% of morphological characters supporting incongruent topologies. The longirostrine (slender-snout) condition is one of five identified eusuchian cranial morphotypes thought to reflect functional and/or ecological specializations. Using concentrated changes, the affect of ecomorphology on cranial character state gains in phylogeny was tested for transitions among generalized, blunt, and slender snouted ecomorphs. 120 published cranial characters were tested on the gains of three skull ecomorphs using 92 taxa on morphological phylogenies, 13 taxa on molecular phylogenies, and 62 taxa on combined data phylogenies. In addition, trees were reduced to 11 taxa to test the effect of taxonomic sample size on hierarchical signals identified by reverse successive weighting. For concentrated changes tests, minimizing or maximizing the number of steps for ecomorph gains under both ACCTRAN and DELTRAN optimizations resolved tree polytomies. Because resolving polytomies limits the analytical power of concentrated changes tests, "tree-free" character compatibility tests of character independence were also conducted on the morphological data matrix. Test results suggest ecomorphs affect cranial character state gains in phylogeny. Of 120 cranial characters, concentrated changes identify 52 character state changes that significantly correlate with transformation to the slender-snouted condition, and 40 character states significantly correlating with transitions to generalized and blunt-snouted ecomorphs. Character concentrations are found for transitions to each of the generalized, blunt, and slender ecomorphotypes on morphological, molecular, and combined data tree topologies. Cranial character state transitions are affected by cranial ecomorphotypes, suggesting crocodylian phylogeny could be misled by non-phylogenetic variables affecting cranial morphology.

Saturday 3:30

THE FIRST 120 MILLION YEARS OF TETRAPOD EXPANSION: TERRESTRIAL COMMUNITY EVOLUTION THROUGH THE PALEOZOIC

SAHNEY, Sarda, BENTON, Michael, Univ. of Bristol, Bristol, United Kingdom

Recent computational advancements have allowed palaeontologists to employ databases to develop an understanding of the diversification of life. In this study a dataset of 40 communities was collected in a relational database system to track changing tetrapod alpha (community) diversity through the Paleozoic. These communities were limited to 'excellent faunas' with good preservation and collection history in order to accurately represent community diversity. Overall, the pattern of tetrapod community diversification reflects that of global diversification.

As changing geography and climate reshaped the environment through the Palaeozoic, terrestrial tetrapods expanded greatly and their interactions grew increasingly complex. Late Devonian single-species communities gave way to ecologically complex and taxonomically diverse Late Carboniferous communities of 20+ species. During the first 40my of tetrapod history, global speciation rates exploded, a trend correlated with alpha diversity. A few families conquered many geographic regions, and created global simplicity. In the Moscovian, increasing endemism developed in terrestrial communities. Herbivores filled empty niches, gaining a strong foothold by the Kasimovian and carnivores began adopting new, varied diets by feeding on insects and each other. The pattern of tetrapod alpha diversification may reflect a Late/end Carboniferous extinction. During the stages crossing the Carboniferous-Permian boundary, there is a distinct drop in alpha diversity. Though a range of body sizes existed throughout the Paleozoic, large animals were largely absent in Kasimovian communities. Changes in alpha diversity may also lend support to the suggestion that the end-Permian crisis was preceded by an earlier extinction event. Global and alpha tetrapod data indicates a significant drop in diversity at the end of the Roadian (Ufimian). Herbivores dominated these communities and piscivores, which were already in steady decline, largely disappeared at this time. The proportion of insectivores also dropped, correlating with a continued decline in insect diversity.

Saturday 2:45

NEW INFORMATION ON THE LATE TRIASSIC REPTILE *LEPTOPLEURON LACERTINUM* AND ITS IMPLICATIONS FOR THE PHYLOGENY OF PRO-COLOPHONOID PARAREPTILES

SÁILÁ, Laura, Univ. of Bristol, Bristol, United Kingdom

Procolophonoidea is a group of Permo-Triassic parareptiles that has been linked to the origin of turtles, and several taxa have potential biostratigraphic usage in some sedimentary basins. The detailed morphology of many procolophonoid taxa, however, remains poorly understood, and this makes it difficult to resolve procolophonoid interrelationships. The leptopleurine procolophonid *Leptopleuron lacertinum*, from the Upper Triassic of Scotland, is represented by numerous specimens collected since the species was described in 1851. Nevertheless, apart from a recent description of the braincase, a detailed osteological description has not been forthcoming. This is mostly due to the fact that specimens are preserved as natural molds in fine-grained, cemented sandstone. These molds, however, preserve considerable detail when modern methods, employing PVC and silicone rubber as casting material, are used, as in this study.

This redescription of *Leptopleuron* is drawn from new casts of nearly 40 specimens, including several articulated skeletons and skulls with good preservation. The new casts allow description of the suture patterns of the skull of *Leptopleuron* for the first time. The detailed structures of the vertebral column, pelvic and pectoral girdles and limbs are also revealed. In contrast to statements made in previous studies, intercentra and three pairs of sacral ribs are present in *Leptopleuron*. Study of the casts allows a composite reconstruction of the whole skeleton, which depicts *Leptopleuron* as a 250-mm-long reptile with a long tail. The high fidelity of the casts allows detailed comparisons with *Hypsognathus feneri* and other leptopleurine procolophonids. The new osteological information warrants a reanalysis of procolophonoid phylogeny, with special emphasis on the interrelationships of leptopleurine and procolophonine procolophonids.

Poster Session II

SCALING BITE FORCE IN PREDATORY ANIMALS: HOW DOES *T. REX* COMPARE WITH LIVING PREDATORS?

SAKAMOTO, Manabu, Univ. of Bristol, Bristol, United Kingdom

Estimating bite forces accurately is of utmost importance in understanding the function of the cranial skeleton as a feeding apparatus; bite forces can be used to quantitatively compare biting performance, to deduce feeding strategy or prey preference, or as loading parameters for methods such as beam theory and finite element analysis. Many studies have recorded *in-vivo* bite forces of extant animals and various methods estimated bite forces where *in-vivo* measurements are not available. Researchers have also scaled bite force with respect to body mass, however only a handful of studies have extended this to extinct species.

In this study, I compare bite force estimates in theropods with bite forces of extant predators. Bite forces were plotted against body masses to visualise scaling patterns. With one exception, previous bite force estimates in theropods do not follow the same scaling trend as measured in extant predators; bite force estimates of theropods are significantly lower than expected. Theropod bite force estimates scale in similar fashion to theoretically estimated bite forces in extant taxa, which are lower than *in-vivo* measurements.

Bite force may have been underestimated in previous studies. A re-evaluation of the maximum bite force estimate in *Tyrannosaurus rex* based on fossil bite marks has shown that significantly higher values are obtained under more detailed theoretical modelling. Different assumptions on muscle pennation also increase bite force estimates.

Saturday 10:30

A NEW TITANOSAURIFORM SAUROPOD FROM THE MID-CRETACEOUS (ALBIAN-CENOMANIAN) WINTON FORMATION OF CENTRAL-WESTERN QUEENSLAND, AUSTRALIA

SALISBURY, Steven, Brisbane, Australia; MOLNAR, Ralph, Museum of Northern Arizona, Flagstaff, AZ; LAMANNA, Matthew, Carnegie Museum of Natural History, Pittsburgh, PA

Sauropod body fossils are well known from the latest Albian-earliest Cenomanian Winton Formation of central-western Queensland, Australia. The material that has been described to date was discovered between 1913 and the 1970s, and comprises seven isolated and fragmentary skeletons, none of which has detailed collection data. Initially, this material was referred to *Austrosaurus* spp., based primarily on its close geographic proximity and similar age to the holotype of *Austrosaurus mckillopi*. A reassessment of this material has revealed that none of it can confidently be referred to *Austrosaurus*, since features previously considered diagnostic of this genus are in fact shared with other titanosauriforms. Although some of the material previously referred to *Austrosaurus* spp. does display characteristics that would ally it with Titanosauria, it is too fragmentary to permit the establishment of a new taxon.

Excavations at a new locality near the township of Winton between 2001 and 2004 have produced the associated remains of at least two titanosauriform sauropods. A single femur represents the larger of these two individuals—an animal nick-named ‘Elliot’. Cervical, thoracic and caudal vertebrae, fore- and hind limb elements, and several teeth represent the smaller individual—‘Mary’. The bones of both animals are preserved in a laterally discontinuous band of fluvial siltstone, interpreted as the remnants of either an oxbow lake or a crevasse splay from a flood event.

The material referred to ‘Mary’ provides the first detailed look at the osteology of an Australian Cretaceous sauropod. It exhibits strong similarities with non-titanosaurian titanosauriforms from the mid-Cretaceous of Patagonia, in particular *Chubutisaurus insignis*. Some characteristics of the vertebrae and the tibia, however, are more derived, indicating affinities with basal titanosaurians such as *Argentinosaurus huinculensis* and *Epachthosaurus sciuotii*. The apparent close relationship with broadly contemporaneous Patagonian sauropods provides one of the first clear links between Australian and South American dinosaur faunas during the mid-Cretaceous.

Poster Session III

QUATERNARY MAMMALS FROM CENTRAL BRAZIL

SALLES, Leandro, GUEDES, Patrícia, FRACASSO, Maria Paula, CARDOSO, Karoline, Museu Nacional, Rio de Janeiro, Brazil; PERINI, Fernando, Institute of Biology—UFRJ, Rio de Janeiro, Brazil

Quaternary deposits in Central Brazil are abundant and rich in fossil mammals. Yet, despite this abundance of remains, much is left to be done even to have a glimpse of major faunal patterns of change in the continent. During the last few years, paleontological surveillance have been consistently carried out in two Karstic environments in the region: Serra da Mesa, in the middle east part of State of Goiás, and Serra da Bodoquena, southwest part of State of Mato Grosso do Sul—Pantanal. Both regions are rich in limestone caves, but Serra da Bodoquena plateau differs from Serra da Mesa for its abundance of underwater systems that were successfully explored. The results so far show a remarkable rich fauna of small mammals in the Holocene savannas of Serra da Mesa and an extremely diverse Pleistocene megafauna in the plains of the Pantanal. Most osteological remains sampled are composed of very fragmentary remains of cranium (maxillae, mandibulae, isolated teeth) and post-cranium (scapulae, pelvic girdles, vertebrae, long bones, etc.). Whenever appropriate these were compared with extant mammals recorded for the region and, subsequently, to other Quaternary faunas in Brazil. Based on the first comparative studies, Serra da Mesa showed a particularly great diversity of small didelphid marsupials, rodents and bats, but medium-size mammals also represented, like procyonid carnivores and artiodactyls (Tayassuidae and Cervidae). Most of the sampled taxa in Serra da Mesa are still extant in the region. The region also presents the highest diversity of bats in Quaternary deposits in Brazil up to date (28 species and six families). Serra da Bodoquena, in contrast, harbors a rich extinct megafauna including ground sloths (Mylodontidae and Megatheriidae), glyptodonts (Glyptodontidae), horses (*Equus*), mastodons (Gomphotheriidae), and extinct endemic South American ungulate orders (Litopterna and Notoungulata). Other fossil mammals were also reported such as didelphid marsupials, rodents, deer, tapirs and peccaries.

Wednesday 4:00

EVOLUTIONARY MORPHOLOGY OF THE POSTCRANIUM IN AFRO-MALAGASY TENRECOIDEA (MAMMALIA)

SALTON, Justine, Bard College, Annandale-on-Hudson, NY; SARGIS, Eric, Yale Univ., New Haven, CT

Extant tenrecids employ several different positional behaviors, including terrestrial running and walking, climbing, digging, and swimming. Forelimb and hindlimb morphology was compared among 12 tenrecid, 1 macroscelidid, 1 solenodontid, and 1 erinaceid species. Qualitative and univariate analyses illustrate that many features are correlated with positional behavior within Tenrecidae. Fossorial and semi-fossorial taxa (*Oryzorictes*, *Hemicentetes*, *Solenodon*) exhibit a suite of characters related to digging: short, wide humeri with pronounced deltoid and pectoral crests, long medial epicondyles, well-developed bicipital grooves (sometimes forming a complete tunnel), elliptical humeral heads, long olecranon processes, and short, wide radii. *Microgale cowani* also exhibits some of the features characteristic of a digger. Hindlimb (and carpal) morphology of *Geogale* suggests that it is not oryzorictine, and Geogalinae may have diverged early from other tenrecids. Forelimb morphology is quite different in the swimmers *Limnogale* and *Potamogale*: *Limnogale* has a larger acromion process (which is nearly absent in *Potamogale*), larger lesser tuberosity, smaller greater tuberosity, shorter humerus, wider distal humerus with longer medial epicondyle, and a more rounded capitulum. Hindlimb morphology also differs between these two swimmers: *Potamogale* has a laterally-bowed femur with a small, distally positioned third trochanter and a narrow trochlea, whereas *Limnogale* has a short, wide femur with a large, projecting third trochanter and broad patellar groove, and a tibia with a proximal sigmoid curvature. *Limnogale* shares several of these features with other members of Oryzorictinae, whereas similarities shared with *Potamogale* were likely evolved convergently in relation to swimming. If *Limnogale* is an oryzorictine rather than the sister-taxon to potamogalines, then extant Malagasy tenrecs represent a single monophyletic radiation.

Preparators Symposium, Thursday 10:30

BUILDING A BETTER MOUSETRAP: USING NEW MATERIALS TO IMPROVE PROCESSING OF BULK MATRIX

SAMPLE, Lloyd, LSA Associates Inc, Irvine, CA

To maximize durability and function and to reduce replacement costs, LSA Associates Inc. (LSA) has developed classification devices for dry screening sediment from new industrial materials that resist fatigue, water, heat, impact, and corrosion. Modeled after standard wooden prototypes, LSA used easily accessible polyvinyl chloride (PVC) extruded plastic tubing and planks that provide exceptional durability and reduce the overall weight of a

standard pine device by six pounds. Additional features are added to the design to expedite matrix processing and increase functionality. These include self-supporting A-frame legs for stand-alone loading and sorting and a horizontal tray locking mechanism. Curved inside corners help protect against sample cross-contamination. The ergonomic design reduces operator fatigue and increases output.

Wednesday 9:00

GEOMETRIC MORPHOMETRIC ANALYSIS AND COMPARISON OF SKULL SHAPE IN FOSSORIAL RODENTS

SAMUELS, Joshua, UCLA, Los Angeles, CA

Most rodent families include species with some fossorial habits and subterranean rodent species are known from 5 extant families. The cranial and postcranial morphologies of these rodents display similarities related to three types of digging: scratch digging, chisel-tooth digging, and head-lift digging. In chisel-tooth digging, procumbent incisors powered by head and jaw muscles break up soil, followed by removal of the soil with the feet. Head-lift digging uses the incisors and skull together as a "drill and shovel" combination. In their most pronounced forms, both of these digging types have recognizable cranial and dental features. Adaptations associated with these digging types are seen in distantly related families, reflecting widespread convergence over the course of rodent evolution. As cranial material from rodents is very common in the fossil record, comparative analysis of skull shapes might reveal previously unrecognized fossorial species.

This study uses a geometric morphometric approach to examine skull shape characteristics associated with fossorial habits in rodents. Digital photos were taken and a set of landmark coordinates were scored for the skulls of 71 rodent species with a wide range of locomotor and dietary habits. The Procrustes procedure was used to scale, align, and transform data for analyses. Relative warp and thin-plate spline methods were used to characterize skull shape. Preliminary results show modifications of the skull in chisel-tooth and head-lift digging rodents relative to species not adapted for digging. The skulls of these rodents show highly procumbent incisors and elongate tooth rows, and head-lift diggers also show an anterodorsally inclined occipital region. Canonical variates analysis was used to infer the behavior of 14 extinct species from the family Castoridae based on their skull shapes. These extinct beavers displayed diverse digging habits, including chisel-tooth digging and head-lift digging forms similar to living subterranean rodents. This diversity of digging habits likely contributed to niche partitioning and prolonged co-occurrence of multiple fossorial beavers in the same habitats.

Wednesday 4:15

TALPID MOLE EVOLUTION IN SPACE AND TIME

SÁNCHEZ-VILLAGRA, Marcelo, BARROW, Eugenie, MACLEOD, Norman, The Natural History Museum, London, United Kingdom; MOTOKAWA, Masaharu, Kyoto Univ. Museum, Kyoto, Japan; HOROVITZ, Inés, Univ. of California, Los Angeles, CA

Talpid moles exhibit one of the most specialized suites of morphological characters among any small mammal group. Specialized fossorial and more generalized shrew-looking moles inhabit both North America and Eurasia but both faunas are endemic. A rich Eocene-Recent fossil record makes this biogeographic picture even more puzzling. We have investigated the origin of mole characters with a maximum parsimony analysis of 157 morphological characters using species from all 17 living mole genera and four eulipotyphlans as outgroups. The resulting cladogram is in partial agreement with previous, more restricted examinations of morphology and/or molecular data. The Japanese shrew mole clade is fairly basal and is not closely related to the American shrew mole. The desmans were the next clade in the tree, followed by *Neurotrichus*. The Eurasian fossorial mole clade Talpini is likely monophyletic. The star-nosed mole was sister group to a clade consisting of the Talpini plus *Scaptonyx* and the Scalopini. Results of morphometric analyses of the dentary shows shared patterns of integration across all modern taxa and is in agreement with results of the cladistic study. The phylogenetic position of 30 fossil genera was also examined. This was used to estimate completeness of the Talpidae fossil record (about 30%) and test hypotheses regarding migration routes and timing of intercontinental exchange. Dispersal among northern continents took place during all ages of the late Palaeogene and Neogene, at least seven times. All major talpid clades contain species from both North America and Eurasia. These results were unable to resolve the question of whether strictly fossorial habits in Talpidae evolved twice independently or just once. Studies of the ecology of the living *Scaptonyx fuscicaudus* from China are necessary to address this issue. The phylogenetic position of most talpid fossil taxa is based on just few characters, as most are based on just humeri and/or isolated dental remains. The development of the skeleton of derived moles further illustrates the uniqueness of the morphological specializations of this group among mammals.

Marine Reptiles Symposium, Wednesday 1:45

TERRESTRIAL REPTILE TRACKS AND MARINE REPTILE BODY FOSSILS FROM THE LOWER MUSCHELKALK (MIDDLE TRIASSIC) OF WINTERSWIJK, THE NETHERLANDS

SANDER, Martin, KLEIN, Nicole, Univ. of Bonn, Bonn, Germany

The Winterswijk quarry (Lower Muschelkalk, lower Anisian) in the eastern Netherlands is probably the most interesting Muschelkalk outcrop today, as far as vertebrate fossils are concerned. The quarry exposes a 40 m thick section of mud-cracked laminated carbonate

mudstones interpreted as tidal flat deposits similar to the Recent sabkhas of the Persian Gulf. In addition to the extremely common and well preserved tracks and trackways of terrestrial reptiles (mainly *Rhynchosauroides* and *Procolophonichnium*) covering countless bedding planes, the Winterswijk quarry is yielding an ever increasing amount of partially articulated or complete skeletons of marine reptiles such pachypleurosaurs (*Anarosaurus* and *?Dactylosaurus*), nothosaurs (*Nothosaurus*), and the enigmatic *Saurosphargis*. These fossils are of particular interest because of their early geological occurrence and because they provide abundant material of otherwise only poorly known taxa. Studying morphology and alpha taxonomy of pachypleurosaurs and nothosaurs from Winterswijk will result in new and important insights into the phylogeny and evolution of the Sauropterygia. Ecological questions can be answered by focussing on the different ontogenetic stages and by using bone histology to collect life history data. The highly unusual taphonomy of the Winterswijk quarry, i.e. the combination of footprints of terrestrial reptiles (but no skeletal material) and marine body fossils (but no tracks), may be explained by wind tides bringing in carcasses of marine reptiles and stranding live animals, which then were scavenged upon after the tide went out by terrestrial reptiles that had specialized on this resource.

Poster Session II

SEPARATING TERRESTRIAL FROM EXTRATERRESTRIAL EFFECTS ON K/T EXTINCTIONS: CHANGES IN VERTEBRATES AND CLIMATE DURING LAST 10 MILLION YEARS OF CRETACEOUS IN SOUTHERN NORTH AMERICA

SANKEY, Julia, Turlock, CA

Understanding the effects of climatic change on Late Cretaceous terrestrial ecosystems is important in order to separate the terrestrial from extraterrestrial factors involved in the Cretaceous/Tertiary extinctions. Big Bend National Park, Texas has one of the southernmost and well-documented Late Cretaceous vertebrate records. The Late Cretaceous paleoclimatic and paleoenvironmental record for this area has been recently refined by Nordt et al. (2003) and Atchley et al. (2004) from analysis of stable isotopes of carbon and oxygen from carbonate nodules in paleosols. Although the climate continued to cool during the Late Cretaceous and there was increased seasonality of temperature and precipitation in Big Bend, two short episodes of atmospheric warming occurred from 70 to 69 Ma and 65.5 to 65 Ma. Changes in vertebrates from the last ten million years of the Cretaceous in Big Bend are combined with this paleoclimatic record. Diversity of turtles is highest in the upper Aguja Formation (late Campanian to early Maastrichtian), deposited during warm dry climates. Turtles are less diverse in the Javelina Formation (mid to late Maastrichtian), deposited during cooler and drier climates. Diversity of theropod dinosaurs is also higher in the upper Aguja compared to the Javelina. Highest vertebrate diversity, in the upper Aguja, corresponds to higher temperatures, a high stand in sea level, abundant favorable habitats within the coastal and near coastal inland floodplain, and higher likelihood of fossil preservation. In contrast, the lowest vertebrate diversity, in the Javelina, corresponds to cooler temperatures, lower sea levels, a decrease of suitable habitats further on the inland floodplain, and lower chances of fossil preservation. An additional and important factor was seasonal aridity, which started at least as early as the late Campanian and became more intense and frequent in the Maastrichtian.

Saturday 8:15

THE EVOLUTION AND DEVELOPMENT OF PAIRED FINS: NEW DATA FROM THE OSTEOSTRACI (AGNATHA)

SANSOM, Robert, Bristol Univ., Bristol, United Kingdom; JANVIER, Philippe, UMR 5143, CNRS, Muséum National d'Histoire Naturelle, Paris, France; DONOGHUE, Phil, Bristol Univ., Bristol, United Kingdom

A growing body of evidence indicates that the extinct Osteostraci (cephalaspids) are the closest relative of jawed vertebrates. As such, the Osteostraci provide a much better perspective on the nature and origin of the primitive jawed vertebrate condition than any other group, living or extinct. Most significantly, evidence from osteostracans indicates that paired fins are not an apomorphy of jawed vertebrates but evolved earlier, in the common ancestor of Osteostraci and jawed vertebrates. The mixture of finned and finless forms within the group complicates scenarios of paired fin evolution, especially in the absence of any established computerized phylogenetic framework for the group.

Here, a comprehensive phylogenetic study of the Osteostraci is presented for the first time, the impact of which is far reaching. Loss of paired fins is found to have occurred within the Osteostraci (tremataspids) and further more, reversals from a finless to finned condition are suggested. New finds of exceptionally well-preserved *Ilemoraspis kirkinskayae* Obruchev (Middle Devonian of Khakassia, Siberia) demonstrate the presence of pectoral fins in this unusual, previously poorly known, osteostracan. *Ilemoraspis* is firmly allied with the Siberian Tannuaspid and nested the finless tremataspids, by a number of morphological features despite the presence of fins. The implication is that at an early stage in the evolution of vertebrate paired appendages, the acquisition, loss and possible reacquisition of fundamental character complexes, like paired fins, was not as exceptional or rare as previously envisaged. Rather, in this case at least, development programmes were quite plastic with loss and reversal being common. This may have implications for understanding the staggered acquisition of pectoral and pelvic paired appendages, and the presence of forms that appear to possess supernumerary fins, amongst basal jawed vertebrates.

INTEGRATING PALEOBIOLOGY AND DEVELOPMENTAL GENETICS: CONTRIBUTIONS OF THE FOSSIL RECORD TO THE STUDY OF FIN LOSS IN TELEOST FISH

SANTINI, Francesco, Univ. of Toronto, Toronto, ON, Canada; CARNEVALE, Giorgio, Università di Pisa, Pisa, Italy

With over 28,000 species, teleost fish represent the largest vertebrate clade. Most teleosts rely on the movement of a combination of paired and median fins for their locomotion. As such, fins might be thought to be highly conserved structures. A survey of the morphological diversity of extant and fossil teleosts, however, reveals that some kinds of fins can be very easily modified or lost, while others are much more highly conserved. The pelvic fins, for example, have been lost at least 70 times independently, while the caudal fin is very rarely lost.

Until now, relatively little attention has been paid to how fins are reduced or lost. In our presentation we will discuss briefly the pattern of fin loss in teleosts. We will employ the extant and fossil pufferfish and allies (Tetraodontiformes) as a case study to more closely investigate the morphological and genetic phenomena that might play a role in causing a convergent loss of the pelvic and first dorsal fin. We will discuss evidence that morphological modules can be identified within the skeletal system of these fishes. We will also show how some of these modules can be modified—likely through processes taking place during the early stages of development—until their final disappearance in adult individuals. Finally, we will formulate some hypotheses about the relationships between morphological complexity and developmental regulatory genes in this clade. These hypotheses could perhaps be tested experimentally using developmental genetic methods. We will also show how fossils play a key role in the study of fin loss in many groups, by providing intermediate stages that illustrate how morphological transitions occurred in lineages now characterized by extant taxa with highly divergent morphologies.

Marine Reptiles Symposium, Wednesday 3:00

AN ELASMOSAURID PLESIOSAUR FROM JAPAN AND ITS PHYLOGENETIC RELATIONSHIPS

SATO, Tamaki, National Science Museum, Tokyo, Japan; BRYANT, Harold, Royal Saskatchewan Museum, Regina, SK, Canada; HASEGAWA, Yoshikazu, Gunma Museum of Natural History, Tomioka, Japan; MANABE, Makoto, National Science Museum, Tokyo, Japan

A new genus and species of elasmosaurid plesiosaur is recently described based on a partial skeleton from the Lower Santonian (Upper Cretaceous) Tamayama Formation, Futaba Group, in Fukushima Prefecture, Japan. Indeterminate elasmosaurids are common in the Upper Cretaceous of the circum-Pacific region, but the holotype of the Japanese taxon is the first elasmosaurid diagnosable at the species level from the Western Pacific, and the oldest in the Northern Pacific.

Phylogenetic relationships of the new taxon and other elasmosaurids were analyzed using 176 characters coded for 33 operational taxonomic units (OTU). More than a half of the OTUs have more than 50% missing data, but there were only two MPTs. CI and RI were low in comparison with those in previous studies of plesiosaurian phylogeny, indicating a high level of homoplasy. In the strict consensus, all Cretaceous elasmosaurids except for *Brancaesaurus* formed a clade, and the Japanese taxon appeared as a basal member of this clade, within which most species from the Upper Cretaceous of the North American Western Interior Seaway formed a subclade. *Microcleidus* and a clade of cryptocleidooids were successive outgroups of the large elasmosaurid clade. Bootstrap support for these clades was very low (less than 50%), and the relationship within the elasmosaurid clade is very sensitive to the selection of OTUs and characters. For example, in a re-analysis in which a small number of OTUs represented only by juvenile specimens were removed, although most Cretaceous elasmosaurids still formed a clade, relationships within the clade changed drastically. Poorly known elasmosaurids from the Southern Hemisphere such as *Tuarangisaurus* and *Aristonectes* appeared outside of this clade. The subclade of Western Interior elasmosaurids was recovered but its internal relationships were different from the first analysis, and the Japanese taxon was more closely related to this subclade than in the first analysis.

Neoceti Symposium, Saturday 11:30

FEATURES IMPLYING THE BEGINNING OF BALEEN GROWTH IN AETIO-CETIDS

SAWAMURA, Hiroshi, Ashoro Museum of Paleontology, Ashoro, Japan; OTANI, Seiji, The Institute of Cetacean Research, Tokyo, Japan; ICHISHIMA, Hiroto, Fukui Prefectural Dinosaur Museum, Fukui, Japan; ITO, Haruka, National Research Institute of Fisheries Science, Yokohama, Japan; ISHIKAWA, Hajime, The Institute of Cetacean Research, Tokyo, Japan

Aetiocetidae, which shows the most diverse features in Oligocene toothed mysticetes, is expected to narrow the gap between Archaeoceti and the true (baleen-bearing) Mysticeti. Two crown genera of Aetiocetidae, *Aetiocetus* and *Morawanocetus*, not only have teeth but suggest to have the incipient baleen in the upper jaw. But features about the baleen and the feeding behavior are different between these genera, showing the mosaic pattern when being compared to basilosaurids or minke whale fetuses.

Characters of the genus *Aetiocetus* include: homodonty, pointed cusped and single rooted molars with small denticles, large diastema with irregular width, increase in tooth num-

ber in some species, pits for the reception of the opposite molar apices between alveoli, nutrition foramina and grooves around teeth in a species (*A. weltoni*), large occipital shield and antero-posteriorly thick cervical vertebrae. On the other hand, *Morawanocetus* (include AMP14, undescribed) has: heterodont, double-rooted and triangular crowned molars with accessory cusps, very small diastema in molars, the basin on the inside of upper molar row associated with a number of nutrition foramina, nutrition foramina between foretooth alveoli, small occipital shield and thin cervical vertebrae.

In minke whale fetuses a large number of unerupted temporal conical teeth are formed and the epitherial ridge grows just inside of tooth row in the upper jaw. In the later stage of the fetus in the wake of degradation of temporal teeth baleen buds start to grow at the posterior part on the epitherial ridge.

Morawanocetus may be succeeded from basilosaurids features in both of the situation of the incipient baleen and the dentition and is agreeing only with the baleen situation of minke whale fetuses. In characters of the dentition *Aetiocetus* is similar to minke whale fetuses. Aetiocetids are closing morphological gaps between Archaeoceti and baleen-bearing mysticetes as some contradictions are remained within the family Aetiocetidae.

Poster Session III

A PRELIMINARY REPORT OF A NEW SPECIMEN OF *CHIROSTENOTES* (OVI-RAPTOROSAURIA: THEROPODA) FROM THE HELL CREEK FORMATION OF NORTH DAKOTA

SCHACHNER, Emma, Univ. of Pennsylvania, Philadelphia, PA; LYSON, Tyler, Yale Univ., New Haven, CT; HANKS, Harold, Marmarth Research Foundation, Marmarth, ND
Chirostenotes is a rare and poorly known, medium sized theropod dinosaur from the Late Cretaceous of North America. The genus is known mostly from cranial fragments, the vertebral column, and distal hindlimb and manual elements. Recent collections in channel sandstone deposits of the Hell Creek Formation (North Dakota) have resulted in the discovery of a new specimen of *Chirostenotes* composed of multiple corresponding postcranial elements. Recovered elements include three cervical vertebrae, a complete scapulocoracoid, a radius, an ulna, and a single dorsal rib.

The genus *Chirostenotes* encompasses two morphs that have been divided into distinct species, *C. pergracilis* and *C. elegans*, however there are no diagnostic features on the new specimen that allow for any conclusive species assignment. The vertebrae of the new specimen share the following features with previously described specimens: the centrum is long and narrow, there are pleurocoels in the centrum, the neural arch is low and broad, and the transverse processes are robust and subtriangular in transverse section. An unusual feature of the new specimen is the fusion of the cervical ribs with both the transverse processes and the ventral portion of the centrum. The scapulocoracoid is a single fused element indicative of an adult individual. The radius and ulna are approximately equal in length, and the ulna is bowed as in other oviraptors. The scapula, radius, and ulna are all elements previously undescribed for the genus *Chirostenotes*. Due to the general paucity of oviraptorosaurian remains this specimen should help to resolve some of the phylogenetic ambiguities within this group.

Friday 2:00

FINALLY, A VIRTUALLY COMPLETE SKULL OF *CAMPTOSAURUS DISPAR*

SCHEETZ, Rodney, Brigham Young Univ., Provo, UT; WEISHAMPEL, David, Johns Hopkins Univ. School of Medicine, Baltimore, MD; BRITT, Brooks, Brigham Young Univ., Provo, UT; CLOWARD, Karen, MILES, Clifford, Western Paleontological Laboratories, Lehi, UT

A partially articulated skeleton of *Camptosaurus dispar* was recently recovered from the Morrison Formation of Bone Cabin West Quarry, Wyoming. The juvenile specimen (femur length = 460 mm, 60% of largest known specimen) is important because it includes the first virtually complete skull of *Camptosaurus*—a skull that differs substantially from previous reconstructions. Marsh's long, rectangular skull restoration featured on most *Camptosaurus* mounts was largely based on a more derived iguanodont skull, referred to *C. amplus*, collected near Colorado Springs, Colorado in 1886. The new *C. dispar* skull shows the skull is triangular in lateral and dorsal aspects, with a wide occiput and a short, pointed snout. *C. dispar* differs from "*C. amplus*" in having a much larger lacrimal that extends along the top of the maxilla, a jugal that lacks a ventrally deflected flange, a short ventral process of the squamosal, a shorter quadrate, and less derived posterior mandible. Although juvenile, this specimen reveals cranial elements that differ significantly from the "*C. amplus*" skull in features that do not reflect ontogenetic status, allying itself more closely to *Dryosaurus* than to *Iguanodon*.

Poster Session III

A NEARLY COMPLETE *THORACOSAURUS NEOCESARIENSIS* (CROCODYLIA: GAVIALIDAE) FROM THE LATEST CRETACEOUS-EARLIEST TERTIARY HORNERSTOWN FORMATION OF NEW JERSEY, U.S.A.

SCHEIN, Jason, LACOVARA, Kenneth, Drexel Univ., Philadelphia, PA; GALLAGHER, William, New Jersey State Museum, Trenton, NJ; POOLE, Jason, Academy of Natural Sciences of Philadelphia, Philadelphia, PA

Fossilized remains of *Thoracosaurus neocesariensis* (Crocodylia: Gavialidae) are relatively common within late Cretaceous to early Paleocene-age sediments of North America. Unfortunately, these remains typically include little post-cranial material. The specimen of *T. neocesariensis* (NJSM NH 2005.2) described herein, excavated from the Maastrichtian-

Danian Hornerstown Formation of New Jersey, is represented by cranial elements and an unusually complete post-cranial skeleton.

Skull elements include approximately 30 isolated teeth, a partial premaxilla, the caudal portion of the left dentary, a partial surangular, the dorsocaudal region of the skull including both frontals and portions of the postorbitals, the parietals, and squamosals, and the brain case, including the basioccipital, basiptyergoid process, exoccipital, partial foramen magnum, and a partial paroccipital process. Postcranial elements include the atlas, axis, partial left ilium, partial ischium, two partial humeri, a scapula and coracoid, nine cervical vertebrae, one complete and numerous partial cervical ribs, twelve dorsal vertebrae with numerous partial ribs, one sacral vertebra, a partial pubis, nine caudal vertebrae, two femora, an astragalus and partial calcaneum, three complete phalanges, a partial metacarpal, and approximately 30 osteoderms. The presence of finished bone on the caudal margin of the dentary indicates the presence of a mandibular fenestra, which previously has been a matter of some debate. The presence of incompletely fused sutures between vertebral centra and dorsal processes, and between the frontals and prefrontals, indicate that this individual was a sub-adult at the time of its death.

The specimen was recovered from glauconitic sands, interpreted as a shallow, biologically productive, paralic environment. This environmental setting is consistent with other occurrences of *Thoracosaurus* sp. throughout North America.

Student Poster Session

AMNIOTE OSTEODERM AND TURTLE SHELL BONE HISTOLOGY: TURTLE ORIGINS REMAIN ENIGMATIC

SCHEYER, Torsten, Univ. of Bonn, Bonn, Germany

The turtle bauplan is unique among vertebrates in having an anapsid skull configuration and a rigid shell consisting of a dorsal carapace and ventral plastron. Shoulder girdle and hip are shifted into the rib cage. Because of the fact that earliest turtles already exhibit such a body configuration and the lack of intermediate fossils, the origin of turtles is difficult to assess. Prevalent morphological hypotheses proposed turtles either as the descendants of parareptilian pareiasaurs or as sister clade to Sauropterygia or to Lepidosauria within diapsid reptiles, while embryological studies suggest the turtle bauplan to be an evolutionary novelty. Recent molecular studies detected turtle-archosaur sistergroup relationships. To test this latest hypothesis, shell bone microstructures of basal turtles *Proganochelys quenstedtii* and *Proterochersis robusta* were assessed and compared to osteoderms of archosaurs, a group for which dorsal osteoderms are synapomorphic. The other hypotheses were addressed by studying pareiasaur, placodont, and lepidosaur (i.e., *Anguis fragilis*) osteoderms. The neomorphic origin, though a possibility, is not testable by comparison with armored possible sistergroups.

The bone histology suggests that archosaur, lepidosaur, and pareiasaur osteoderms are homologous to the ossified dermal parts of the turtle shell. Even though turtle shell bone histology is highly derived, the turtle-archosaur relationship is in accordance with observed structures. Osteoderms are not synapomorphic for lepidosaurs, but a turtle-lepidosaur sister clade cannot be refuted. On the other hand, the theory that turtles are deeply nested within the Pareiasauria with affinities to derived dwarf pareiasaurs is not reflected by the bone histology. Placodont body armor is distinct from that of all other amniotes in retaining cartilaginous tissue in the bone, opposing a relationship of turtles to sauropterygians. Furthermore, the histological comparison to recent turtles that either prefer terrestrial or aquatic habitats independently endorses the palaeoecological hypothesis that basal turtles lived in terrestrial environments.

Poster Session III

QUARRYING IN THE PASCAGOULA FORMATION: FIRST MIOCENE (HEMPHILLIAN) FAUNA OF TERRESTRIAL MAMMALS FROM THE CENTRAL GULF COAST EAST OF THE MISSISSIPPI

SCHIEBOUT, Judith, HILL, Julie, TING, Suyin, HAGGE, Mark, WILLIAMS, Michael, Louisiana State University, Baton Rouge, LA; BOARDMAN, Grant, Baton Rouge, LA

The first vertebrate fauna from the Pascagoula Formation, and the first Miocene terrestrial vertebrate fauna from the central Gulf Coast east of the Mississippi has been recovered by quarrying at a new site christened the Tunica Hills Site, beginning in June of 2005. Previously, the formation had been considered Miocene based on stratigraphic position. Miocene (early Late Barstovian) vertebrates from the Fort Polk region, west of the Mississippi River, now number over 6,359 cataloged specimens, mainly recovered via chemical treatment and screening of rocks which formed as concentrations of soil-formed nodules. The new eastern Louisiana Tunica Hills Site yields mainly large and medium-sized mammals from a blue-green, clayey silt, rich in burrows and trails, which was probably deposited in an estuary. A proboscidean (palate with two teeth and both tusks, one nearly seven-foot-long) and the rhinoceros *Teleoceras* (pelvis, ribs, humerus, femur, and part of the tail) probably originally arrived at the site as floating carcasses. Initial identification of the artiodactyls and horses from the site suggests a Hemphillian age, between Hh2 and Hh4. The most abundant artiodactyl is a lamine camelid, either *Pleiolama* or *Alforjas*. A six-horned antilocaprid, either *Hexameryx* or *Hexobelomeryx*, and a juvenile cervid are also represented by teeth. Perissodactyl material in addition to *Teleoceras* includes a dwarf rhinoceros fragmentary tooth, a lower premolar and two lower molars which resemble *Neohipparion eurystyle*, and an upper premolar, two lower premolars, and two lower molars which appear most similar to *Nannippus*.

The Pascagoula Formation is not even shown on the most recent Louisiana geologic

map, because of its occurrence in steep creek walls and under modern creek sands, but more fossils from spots similar to the Tunica Hills Site are now expected throughout the Tunica Hills area. Trial screening for small forms has yielded a single molar of the rodent *Copemys* and a natricine snake vertebrae, along with fish, turtle, and crocodylian remains similar to those recovered from Fort Polk.

Friday 3:00

ARCHIVING THREE-DIMENSIONAL MODELS OF SPECIMENS WITH HIGH-RESOLUTION PHOTOGRAPHIC IMAGES—TEXTURE-MAPPING THE REAL ON THE VIRTUAL

SCHLADER, Robert, Idaho State Univ., Pocatello, ID; CHAPMAN, Ralph, PETERSEN, Christian, CLEMENT, Nicholas, Idaho Virtualization Laboratory, Pocatello, ID

One of the biggest complaints about virtual models of paleontological specimens is that they only preserve the shape—the visual detail of the specimen is not conserved in rendered versions. This is indeed true for models built on either the three-dimensional point clouds produced by surface scanners or from the fused cross-sections provided by CT and other medical scanners. Three-dimensional models produced using photogrammetry are more photorealistic, providing images more like the original, but the three-dimensional data they generate are not as complete as that provided by surface or medical scanners. They are also less useful for subsequent processes like animation and prototyping. To produce the best archive of our important specimens, and the most visually effective research and outreach, we want to have the best of both worlds—high resolution models and high resolution photographs. The solution can be drawn from Hollywood's digital effects industry: texture-mapping high-resolution two-dimensional photographs onto the three-dimensional models generated by surface or medical scanners. This is a labor-intensive process but the results can be spectacular. The results are virtual models that can be worked with in their basic form (e.g., a point cloud) and given various characteristics during the rendering process, or they can be viewed—in full three-dimensions—in a form that looks just like the original. This serves to optimize the quality of the archived specimen while providing an additional impetus to thoroughly photograph these important specimens. The end result is a product that will better serve education, exhibition, and research needs. Examples are given from various vertebrates, including dinosaurs, Tertiary mammals, and humans.

Poster Session II

DESCRIPTION OF A NEW SPECIES OF PLESIOSAUR FROM THE UPPER CRETACEOUS TROPIC SHALE, SOUTHERN UTAH

SCHMEISSER, Rebecca, Northern Arizona Univ., Flagstaff, AZ

A closely associated pliosauromorph (short-necked plesiosaur) skeleton was excavated in 2005 from a site in the Upper Cretaceous (Cenomanian-Turonian) Tropic Shale. The site is located within Glen Canyon National Recreation Area and is the first nearly complete individual recovered from this region. The skeleton is remarkably well preserved, although heavily fractured. The specimen consists of a nearly complete skull and jaws, teeth, an incomplete set of vertebrae and ribs, scapulae, coracoids, nearly complete forelimbs, ilia, ischia, pubes, nearly complete hindlimbs, and associated paleogastroliths.

Following preparation and description, the new plesiosaur skeleton can be placed within the family Polycotyliidae. Several characters are similar to those seen in other polycotyliid plesiosaurs. However, the unique combination of characters found in the new specimen, as well as the presence of several previously unrecognized characters permits the assignment of a new species. Additionally, several characters are similar to one genus of polycotyliid (*Dolichorhynchops*) while several other characters are similar to another genus of polycotyliid (*Trinacromerum*). This suggests that the new specimen could be an intermediate between the two genera. Therefore, specimens of *Dolichorhynchops* and *Trinacromerum* should be reevaluated to determine whether they should be synonymized.

Vertebrate Development Symposium, Wednesday 9:00

OSSIFICATION SEQUENCES AND SKULL EVOLUTION IN LOWER TETRAPODS

SCHOCH, Rainer, Staatliches Museum fuer Naturkunde, Stuttgart, Germany

Recent discoveries of ossification sequences in several temnospondyls have prompted comparisons of ontogenetic data with extant vertebrates. The branchiosaurs are known from smallest sizes on, which preserve the early patterning of skull formation. In branchiosaurs, cranial ossification proceeded rather slowly, with circumorbital, visceral, and braincase elements remaining rudimentary throughout their known lifespans. In other temnospondyls, only the latest phases of skull development are known from fossils, but the formation of the postcranial skeleton is well preserved. The best sequences are known from *Sclerocephalus*, *Onchiodon*, and *Micromelerpeton*, which all diverge from the developmental pattern of branchiosaurs in that the skull ossified early and was rapidly completed, whereas the post-cranium required a long period to be fully ossified, particularly the axial skeleton. The studied developmental sequence includes dermal and braincase bones and various postcranial elements. The comparison reveals that the ossification sequence of branchiosaurs is similar to that of extant lissamphibians, notably hynobiid salamanders, while the other temnospondyls preserve an apparently more plesiomorphic pattern. Both fossil and extant outgroup taxa (*Eusthenopteron*, *Polypterus*) indicate which of these sequence similarities may be derived and which plesiomorphic. Mapping event-pair data on a phylogeny suggests that branchiosaurs and some lissamphibians share derived character-states, but a large amount of similarity is due to the shared possession of plesiomorphic character-states.

AMPHIBIANS AND REPTILES OF THE MIO-PLIOCENE GRAY FOSSIL SITE AND THEIR PALEOECOLOGICAL IMPLICATIONS

SCHUBERT, Blaine, WALLACE, Steven, ETSU, Johnson City, TN

Identification of fossil reptiles and amphibians from the Gray fossil Site to lower levels of classification has proved to be a difficult endeavor. Herein the challenges are discussed, and tentative designations are reported.

Two families of salamanders are represented based on trunk vertebrae, the Plethodontidae and Ambystomatidae. Vertebral variation in plethodontids limits identifications to the family level. Ambystomatids however, are congeneric (genus *Ambystoma*) and vertebrae from the site are indistinguishable from this taxon.

Testudines are primarily represented by carapace and plastron elements, and are identified here to the family or generic level. The most abundant taxa are the emydids *Trachemys* and *Chrysemys*. Two other turtles, *Terrapene* and Chelydridae, are represented by isolated individuals. Alligatoridae material is limited to a partial cranium, postcranial elements, and osteoderms; unfortunately cranial and mandibular characters are required for a more specific taxonomic assignment. The excavation of a partially articulated specimen is underway and may assist in this classification. Squamates are only represented by snakes of the families Viperidae and Colubridae. As with other localities, trunk vertebrae are the primary fossil elements. The most common snakes from the site are colubrids in the subfamily Natricinae; much less common are colubrine colubrids and vipers.

Despite the fact that lower levels of classification have not been determined, paleoecological inferences can still be made based on phylogenetic bracketing. In sum, the reptiles and amphibians from the site are indicative of a ponded environment; a reconstruction that matches the site's lacustrine sediments.

Marine Reptiles Symposium, Wednesday 5:15

A NEW *PROGNATHODON* (SQUAMATA: MOSASAURIDAE) FROM THE CRETACEOUS OF ANGOLA

SCHULP, Anne, Natuurhistorisch Museum Maastricht, Maastricht, Netherlands; MATEUS, Octávio, Museu da Lourinhã, Lourinhã, Portugal; POLCYN, Michael, JACOBS, Louis, Southern Methodist Univ., Dallas, TX

Recent field reconnaissance in Angola provides a new sample of rich marine Cretaceous faunas including mosasaurs, fishes, turtles, and plesiosaurs. The new material includes two partial mosasaur skulls from the Namibe province tentatively assigned to the globidensine mosasaur genus *Prognathodon*. However, the new *Prognathodon* possesses a dentition documenting broader variation of dental morphologies in that genus than previously recognized. The new material includes well-preserved premaxillae, maxillae and dentaries, and preserves the entire marginal dentition. It has slender teeth with constricted bases and displays the characteristic prognate condition, reduced number of marginal teeth and wrinkled enamel diagnostic of the genus.

In the context of prey preference and feeding guild models recognized by previous workers, the new taxon overlaps with the genus *Mosasaurus* and suggests that *Prognathodon* may have adapted to a broad variety of feeding niches. The taxic assemblage of the Maastrichtian of Angola is reminiscent of that seen in the Maastrichtian of northwestern Europe and allows a comparative exploration of habitat segregation and prey preference.

We present the new material and discuss the geographic, temporal and ecological distribution of globidensine mosasaurs, and review prevailing prey preference guild models in light of recently documented diversity of tooth morphologies in globidensine mosasaurs.

Thursday 1:45

ANALYSES OF LOWER ACTINOPTERYGIAN INTERRELATIONSHIPS, CONTRADICTIONARY HYPOTHESES

SCHULTZE, Hans-Peter, ARRATIA, Gloria, Univ. of Kansas, Lawrence, KS

There is great contradiction in available hypotheses of interrelationships of lower actinopterygians. The disagreements are clearly illustrated by major changes in the relationships of living polypteriforms, acipenseriforms, amiiforms, and lepisosteiforms to fossil forms and also to teleosts. *Polypterus* is in most cases placed as the most basal actinopterygian, nevertheless different Paleozoic taxa (*Lophosteus*, *Dialipina*, *Cheirolepis*) are displacing *Polypterus* to a higher position. There is no agreement concerning the interrelationships within palaeonisciforms and neopterygians. Several hypotheses of sister-group relationship to teleosts have been proposed based on morphological evidence (e.g., mobile maxilla, presence of supramaxilla, position of symplectic); i.e.: (other actinopterygians + [*Lepisosteus* + [*Amia* + Teleostei]]) or (other actinopterygians + [*Amia* + [*Lepisosteus* + Teleostei]]). Different results are obtained when fossil taxa (i.e.: Pycnodontiformes, *Dapedium*) are added as sister groups. The discrepancies are caused by different reasons, as for instance the selection of taxa and different assumptions over homologies. An analysis of different hypotheses of actinopterygian interrelationships will be presented, the role of fossils will be discussed, as well as the major problems concerning homologization of structures in lower actinopterygians.

Poster Session III

CAN LOW MAGNIFICATION MICROWEAR BE USED TO INFER THE DIET OF AUSTRALIA'S MARSUPIALS? A PILOT STUDY OF TEN SPECIES OF MACROPODIDS

SCHWARTZ, Leah, New York Univ., New York, NY

Discerning feeding habits of fossil animals has implications for paleoenvironmental interpretations, many of which have been controversial in Australia, particularly in the late Oligocene and early to mid Miocene. Primarily disagreement here is over the beginning of aridity and the opening of grasslands, a question which ungulate paleoecology has been used to address on other continents. Despite being ecological correlates, Australian macropodoids are traditionally more difficult to interpret than ungulates, with hypsodonty and body size analyses having only limited success. While analysis of wear features of mammalian teeth is a powerful way of predicting diet, applying such analyses to Australian marsupials using traditional methods has been cost prohibitive.

A new method has recently been developed using low magnification stereo light microscopy to analyse wear features. This method has been shown to be effective in predicting the diets of placental mammals, and has so far been used in perissodactyls, artiodactyls, notoungulates, xenarthrans, sciurids and primates. This study extends the use of this method to the diprotodontid marsupials of Australia by examining ten species of extant macropodoids with varying diets. Macropodoids are usually classed into grazers, browsers and mixed feeders but also include animals whose diet is primarily frugivorous and mycophagous. The majority of macropodoids are to some degree seasonal in their diets, responding to Australia's El Niño affected climate. Nevertheless, clear differentiation of dietary type can be seen in the microwear signal, which will allow use of this nascent database to interpret the diet of fossil species.

Saturday 2:00

CHEMICAL AND MOLECULAR ANALYSES OF SOFT TISSUE MATRIX FROM *TYRANNOSAURUS REX* (MOR 1125): PRELIMINARY RESULTS

SCHWEITZER, Mary, WITMEYER, Jennifer, North Carolina State Univ., Raleigh, NC

Soft tissue components, including flexible fibrous matrix, pliable, hollow and transparent blood vessels, and two populations of microstructures with cell-like morphology, were identified in a well preserved *Tyrannosaurus rex* (MOR 1125) Here we report preliminary chemical and molecular analyses of the soft tissue matrix components of demineralized cortical and medullary bone, recovered from MOR 1125. Transmission EM, coupled with elemental analyses, reveals that even after demineralization some biogenic apatite remains tightly bound to the matrix. AFM shows fibers in some demineralized matrix that exhibit a banding pattern consistent with collagen. Immunochemical evidence is consistent with the presence of collagen and osteocalcin protein epitope preservation, and amino acid analyses reveal the presence of diagnostic amino acids in some sample preparations. However, results of multiple extractions and treatments show considerable variation in results. While existing data support the presence of original molecular components in some treatments, there is also strong evidence for a high degree of alteration in these same components. Evidence for molecular and chemical interactions leading to preservation will also be presented.

Saturday 8:30

***MEGALOCOELACANTHUS DOBIEI*: MORPHOLOGICAL, RANGE AND ECOLOGICAL DESCRIPTIONS OF THE YOUNGEST FOSSIL MARINE COELACANTH**

SCHWIMMER, David, Columbus State Univ., Columbus, GA

The coelacanth *Megalocoelacanthus dobiei* was a gigantic (>3.5 m) latimeriid known primarily from Late Cretaceous (Campanian) marine deposits in eastern USA. Placement of the monospecific genus *Megalocoelacanthus* in the Latimeriidae has been questioned, with some favoring inclusion in Mawsoniidae; however, all available characters support its inclusion in Latimeriidae. *Megalocoelacanthus* shares derived characters with *Latimeria* including: a vertically elongate palate with sigmoid ventral margin; large, roughly square principal coronoid; and a lateral posterior foramen on the mandible for the subopercular sensory canal. However, unlike all other latimeriids, *Megalocoelacanthus* lacked marginal dentition and had a laterally compressed, dorsoventrally exaggerated skull. Gular and opercular surfaces are externally smooth, but a well-preserved posterior angular shows external surface ornamented with parallel ridges. Planktivorous or obligate suction feeding habit is indicated by the large skull and strongly denticulate branchials, and absence of marginal teeth.

Here I propose that the resemblance to *Mawsonia* (Mawsoniidae), another clade of giant coelacanth (but freshwater and Gondwanan), is probably convergent due to large size and feeding habit. The *Megalocoelacanthus* type series was based on two principal specimens from Alabama with preserved palates, lower jaws, a basisphenoid, principal coronoid, operculars, gular plates, ceratohyals, ceratobranchials and a partial shoulder girdle. Cheek bones, skull roof and most appendicular elements are unknown, but a recently discovered principal coronoid extrapolates to a fish ~4.5 meters long, assuming typical proportions for latimeriids. The species is now represented by 9 regional specimens, plus referred fossils from the Atlantic Coastal Plain and the Campanian of Kansas. The inclusion of *Megalocoelacanthus* within Latimeriidae is evolutionarily significant because it is the most recent coelacanth known only from fossils, aside from a fragmentary large coelacanth angular from the Maastrichtian of France, which may be at least congeneric with *M. dobiei*.

Wednesday 4:30

FIRST SKELETAL MATERIAL OF *LITOCHERUS NOTISSIMUS* (SIMPSON) (MAMMALIA, ERINACEOMORPHA) FROM THE LATE PALEOCENE OF SOUTH CENTRAL ALBERTA, CANADA

SCOTT, Craig, Univ. of Alberta, Edmonton, AB, Canada; BOYER, Doug, Stony Brook Univ., Stony Brook, NY

Although modern eulipotyphlans (hedgehogs, moles, shrews, solenodons) are unknown from the fossil record prior to the Eocene, dentitions attributed to possible archaic members of the group are known from Paleocene-aged localities in North America, Europe and Asia. Due in part to a lack of non-dental information, many of these attributions remain tenuous. We report recovery of the first non-dental material of one such taxon, *Litocherus notissimus*, initially classified as a "hyopsodontid" condylarth, but now regarded as an erinaceomorph eulipotyphlan. Dentally-associated remains from the late Paleocene DW-2 locality of Alberta document petrosals, basisphenoid, partial maxilla, dentary, incomplete innominate, femur, astragalus, calcaneum, cuboid, entocuneiform and phalanges. The basicranium and tarsus resemble those of many eulipotyphlans (promontorium with rostral tympanic process, grooves for stapedial and promontory arteries, no evidence of ossified bullae, calcaneal shaft laterally convex, calcaneal ectal facet concavoconvex, astragalar body relatively short proximodistally) and differ in these ways from *Hyopsodus*. Characters that unite apheniscine "condylarths" with macroselideans (astragalar cotylar fossa, calcaneal tuber relatively long, long axis of astragalar head oriented sagittally) are also lacking. The tarsus of *Litocherus* most closely resembles that of Paleogene nyctitheriids (possible eulipotyphlans) with some similarities between the two also present in many euarchontan mammals (astragalofibular facet dorsoplantarily deep, fossa on fibular facet proximally positioned, no superior astragalar foramen, astragalonavicular facet ascends medial side of neck). Despite similarities to arboreal euarchontans, the postcranium of *Litocherus* suggests a cursorial or saltatorial locomotor mode (femur with third trochanter large and shaft mediolaterally narrow and anteroposteriorly deep, astragalotibial facet grooved, astragalonavicular and sustentacular facets separate, calcaneocuboid facet oriented obliquely, phalanges with straight, robust shafts). Cladistic analyses using published character matrices support eulipotyphlan affinities of *Litocherus*.

Wednesday 9:45

ANAGENESIS OR CLADOGENESIS IN THE ORIGIN OF *EQUUS*: A REVIEW OF PLIOCENE EQUIDS FROM ANZA-BORREGO DESERT STATE PARK, CALIFORNIA

SCOTT, Eric, San Bernardino County Museum, Redlands, CA

The genus *Equus* is interpreted to have arisen from *Dinohippus* during the Pliocene Epoch. The nature of this speciation event, by anagenesis or cladogenesis, remains unresolved. Fossils from the Anza-Borrego Desert State Park (ABDSP) are critical to this question. Remains assigned to cf. *Dinohippus* are reported from the Deguynos Formation (early Pliocene), the Imperial Group-Palm Spring Group transition (early Pliocene), and the Hueso Formation (middle to later Pliocene) in the ABDSP. A partial mandible from the Hueso Formation was considered to potentially represent the youngest occurrence of *Dinohippus* in North America. Fossils of plesippine *Equus* are also known from the Hueso Formation, leading to suggestions that *Dinohippus* and *Equus* may have co-occurred at Anza-Borrego. If confirmed, this indicates a cladogenetic speciation event for *Equus*. Co-occurrence of *Dinohippus* and *Equus* has not been demonstrated elsewhere.

Fossils assigned to cf. *Dinohippus* from the ABDSP include isolated upper cheek teeth, a partial maxilla with associated cheek teeth, and a partial mandible. Upper cheek teeth have short crown heights, likely due to advanced wear, and exhibit simple enamel patterns and small protocones resembling both *Dinohippus* and plesippine *Equus*. Buccolingual curvature of most teeth is not as pronounced as in *Dinohippus*, but falls within the range for *Equus*. The partial maxilla has a shallow facial fossa, similar to *Equus* (*Plesippus*) and some later equids. The partial mandible assigned to cf. *Dinohippus* also resembles plesippine *Equus* in the morphology of the incisors, the penetration of the molar ectoflexids, and the position of the canine tooth. Previous referral of this fossil to cf. *Dinohippus* was based upon estimates drawn from broken or reconstructed portions of the specimen. A more conservative assignment of this specimen to *Equus* (*Plesippus*) is preferred. The fossil record from the ABDSP does not demonstrate a late Pliocene occurrence of *Dinohippus*, provides no data validating co-occurrence of *Dinohippus* and *Equus*, and consequently does not support cladogenetic evolution of *Equus* from *Dinohippus*.

Vertebrate Development Symposium, Wednesday 12:00

THE CORRELATED EVOLUTION OF RUNX2 TANDEM REPEATS AND FACIAL LENGTH IN CARNIVORA

SEARS, Karen, Univ. of Colorado Health Sciences Center, Aurora, CO; GOSWAMI, Anjali, London Museum of Natural History, London, United Kingdom; FLYNN, John, American Museum of Natural History, New York, NY; NISWANDER, Lee, Univ. of Colorado Health Sciences Center, Aurora, CO

Currently, general consensus is that evolutionary changes in morphology are driven primarily by changes in the cis-regulatory regions of genes. In this study, we test the hypothesis that mutations within the protein-coding region of Runx2, specifically within glutamine-alanine (QA) tandem repeats, provide a major source of variation that can drive morphological evolution in a group evolving under natural selection, the mammalian order Carnivora.

Runx2 (runt-related protein 2) is a transcription factor essential for bone formation.

QA rich regions, like that within Runx2, are thought to mediate transcription with polyglutamines driving transcription and polyalanines repressing transcription in a length dependent manner. Fondon and Garner (2004) demonstrated that glutamine to alanine ratios in Runx2 tandem repeats are positively correlated with facial length in domestic dogs. However, others have commented that the protein-coding variation Fondon and Garner observed "may have accompanying deleterious, pleiotropic effects that, while manageable under domestication, would limit its contribution under natural selection."

To address this issue, we sequenced Runx2 and quantified skull morphology for 34 species of Carnivorans, the naturally evolving group containing domestic dogs. We found a strong correlation between Runx2 QA ratio and facial length (corrected for body size) within the Carnivora (Spearman Rank Correlation, $p = 0.03$). This correlation was statistically significant ($p < 0.005$) when phylogenetic autocorrelation was statistically mediated using independent contrasts. Functional assays also reveal a positive association between QA Runx2 tandem repeat ratios and transcription of downstream targets of Runx2 (e.g., ColX).

By combining these correlational and functional assays, we directly link changes within the protein-coding region of a gene to the evolution of a specific morphology in a naturally evolving group. As a result we are able to conclude that, although the pleiotropic effects of protein-coding mutations may be greater than those in regulatory regions, protein-coding mutations have the potential to drive phenotypic evolution.

Poster Session III

DIETARY RECONSTRUCTION OF PALEOCENE AND EOCENE UINTATHERES (ORDER DINOCERATA) FROM NORTH AMERICA AND ASIA

SEMPREBON, Gina, Bay Path College, Enfield, CT; DREWNIAK, Patricia, Bay Path College, Longmeadow, MA

Uintatheres (order Dinocerata) were large mammals known from Paleocene-Eocene deposits in both Asia and the western United States. Despite having the distinction of being among some of the most distinctive-looking and first truly large terrestrial herbivores to appear within the Mammalia, very little is known about their systematic affinities or paleoecology. In this study, we followed dietary trends in both Asian and North American uintatheres using stereoscopic microwear analysis of molar teeth. Results depict a long-standing commitment by uintatheres to a browsing dietary strategy. The most primitive uintatheres (Prodinoceratidae) from the late Paleocene of both North America and Asia have microwear consistent with browsing on relatively hard fruit and/or seeds, while the more derived forms (Uintatheriidae) show a greater diversity in their dietary behavior. Within the Uintatheriidae, *Gobiattherium* from the middle Eocene of China apparently relied heavily on relatively hard fruits and/or seeds according to its microwear, while the North American Uintatheriinae have results consistent with browsing either on both leaves and softer fruits or more consistently on leaves. Among these latter forms, early Eocene uintatheres (*Bathyopsis*) display microwear consistent with browsing on both leaves and fruits, while the larger and more derived middle Eocene forms (*Uintatherium*, *Tetheopsis*, and *Eobasileus*) have wear typical of committed folivores. Dietary distinctions among folivorous taxa are apparent.

Poster Session III

EVOLUTIONARY TRENDS IN FORELIMB FUNCTION IN THEROPODS

SENER, Phil, Lamar State College-Orange, Orange, TX

I manually manipulated fossil and cast forelimbs of a taxonomically wide spectrum of theropods to find trends in range of forelimb motion across Theropoda, using *Herrerasaurus* and *Plateosaurus* as outgroups. The manual manipulations reveal the following trends, under the assumption that the edges of joint surfaces represent the limits of motion. Plesiomorphically, saurischian palms face medially, the elbow can approach but not achieve full extension and can flex only to a sub-right angle, and the humerus can be protracted to a subhorizontal position but cannot be protracted beyond a subvertical position nor elevated much through the transverse plane. Strong elbow flexion appears in Maniraptora. Ability to raise the humerus to a subhorizontal position is independently achieved in Ornithomimidae and Paraves due to a lateral extension of the glenoid floor, and in Ceratosauroidae due to modification of the humeral head. Several theropods exhibit unusual specializations, such as extremely hyperextensible fingers in *Dilophosaurus*, immobile elbows in *Carnotaurus*, and opposable fingers (fingers I and III) in *Bambiraptor* (the only known dinosaurian opposable fingers). Taphonomic evidence shows that the pectoral girdles of *Archaeopteryx* and confuciusornithids were oriented as in typical theropods, with glenoids anteroventral to the ribcage and facing ventrally but with a lateral glenoid extension that allowed the humerus to be elevated until subhorizontal. In Ornithothoraces the scapulae were reoriented as in extant birds, with glenoids dorsal to the ribcage and the scapulae rotated so that the costal surface faced ventrally, allowing the humerus to be raised high above the dorsum.

Poster Session II

BASAL LEPIDOSAURS FROM THE LOWER CRETACEOUS OF NIGER AND MONGOLIA

SERENO, Paul, Univ. of Chicago, Chicago, IL

The fossil record for lepidosaurs during much of the Early Cretaceous is poorly established on many continents. Basal sphenodontian lepidosaurs, which are common in Upper Triassic and certain Jurassic horizons, are scarce or absent during this interval. Likewise, basal squamates (crown clade lizards) or their immediate outgroups, which are well repre-

sented in Upper Cretaceous horizons, are poorly known in earlier beds. Two new lepidosaurs of Early Cretaceous age, the first a sphenodontian and the second a basal squamate, are here described.

A small sphenodontian, represented by a complete right maxilla (15 mm length), comes from the Tiouraren Formation (Neocomian, ca. 135 Ma) of Niger. Its diagnostic dentition includes a robust anterior canine followed by a series of six small fused crowns and then eight larger subtriangular crowns. The noncaniniform teeth of new species are primitive in form and wear, unlike the transversely broadened crowns of larger-bodied sphenodontians described from South America.

The basal squamate, represented by a nearly complete skull, comes from the Oshih Formation (Valanginian-Barremian, ca. 130 Ma) of Mongolia. The small skull (18 mm length) has large orbits and a relatively broad, low snout. Basal squamate status is suggested by the narrow width of the nasals, the simple transverse frontoparietal suture, broad interpterygoid vacuity, and absence of pterygoid-vomer contact. Features that may be plesiomorphic within Squamata include paired parietals, a pineal foramen, and a rudimentary row of teeth on the pterygoid. Probable apomorphic features within Squamata include a pendant prootic flange extending onto the basipterygoid process and a well-developed frontal subolfactory process. The new taxon may well lie just outside Squamata, like the younger (Albian) *Huehucuetzpalli* from Mexico, or it may reside at a basal position within Squamata. At present the new Mongolian skull cannot be linked with confidence to any squamate subclade, including Gekkota, Scincoidea, Lacertoidea, Anguimorpha or Iguania.

Wednesday 11:30

RIFT VALLEY DINOSAURS: A NEW LATE CRETACEOUS VERTEBRATE FAUNA FROM KENYA

SERTICH, Joseph, Utah Museum of Natural History, Salt Lake City, UT; MANTHI, Frederick Kyalo, National Museums of Kenya, Nairobi, Kenya; SAMPSON, Scott, LOEWEN, Mark, GETTY, Mike, Utah Museum of Natural History, Salt Lake City, UT The Cretaceous vertebrate record of the Gondwanan landmasses-including South America, India, Antarctica, and Madagascar-has received considerable recent attention, resulting in a multitude of hypotheses regarding phylogenetic and biogeographic relationships during this period. Africa has provided significant insights into Gondwanan biogeography during the Early and early Late Cretaceous. However, knowledge of vertebrates from post-Cenomanian Late Cretaceous horizons on this continent remains woefully inadequate, precluding meaningful biogeographic comparisons with other Gondwanan landmasses for which fossils from this interval are much better known. In 2004, a joint National Museums of Kenya-Univ. of Utah expedition was undertaken to explore the Lubur sandstone (Turkana Grits) of northern Kenya. This brief reconnaissance foray yielded a relatively diverse vertebrate fauna including turtles, crocodyliforms, and dinosaurs. Crocodyliform material is referable to at least two taxa, a longirostrine dyrosaurid and an unidentified large-bodied brevirostrine form. Among dinosaurs, dental and appendicular materials suggest the presence of two abelisaurid theropod taxa, one large-bodied and the other giant-sized. Distinct vertebral morphologies are consistent with at least two taxa of lithostrotian titanosaurs. The deposits also yielded remains of an intermediate-sized ornithomimid. Unfortunately, to date, efforts to establish solid chronostratigraphic dates for the Lubur sandstone have not met with success. However, preliminary faunal analysis suggests close similarities with post-Cenomanian Cretaceous faunas recovered on other Gondwanan landmasses. If this age hypothesis is confirmed by additional evidence, these deposits will offer some of the first significant terrestrial vertebrate remains from Africa during this critical interval, providing important evidence for testing biogeographic hypotheses.

Vertebrate Development Symposium, Wednesday 9:45

PARALLEL GENETIC AND DEVELOPMENTAL ORIGINS OF PELVIC REDUCTION IN VERTEBRATES

SHAPIRO, Michael, Univ. of Utah, Salt Lake City, UT; BELL, Michael, Stony Brook Univ., Stony Brook, NY; KINGSLEY, David, Stanford Univ., Stanford, CA Despite longstanding interest in parallel evolution, little is known about the genes that control similar traits in different lineages of vertebrates. Pelvic reduction in stickleback fish (family Gasterosteidae) provides a striking example of parallel evolution in a genetically tractable system. Pelvic reduction has evolved in multiple populations and genera of sticklebacks throughout their modern distribution in the northern hemisphere, and in Miocene fossil populations as well. Previous studies suggest that changes in a hindlimb-specific gene (*Pitx1*) that is well-characterized in tetrapods also controls pelvic reduction in a population of threespine sticklebacks (*Gasterosteus aculeatus*) from British Columbia. Here, we present evidence that the same major gene may control pelvic reduction in ninespine sticklebacks (*Pungitius pungitius*), which shared a most recent common ancestor with threespine sticklebacks no less than 10 million years ago. A much more phylogenetically distant mammalian example of pelvic reduction shows a similar left-right size bias that is a morphological signature of *Pitx1* mediated pelvic reduction in sticklebacks. These multiple lines of evidence suggest that changes in *Pitx1* may represent a key mechanism of morphological evolution in multiple populations, species, and genera of sticklebacks, as well as in unrelated vertebrate lineages.

Poster Session I

THE CAVE OF SLOTHS: A DESCRIPTION *MEGALONYX JEFFERSONII* REMAINS FROM ACB-3 CAVE, COLBERT COUNTY, ALABAMA

SHAVER, Wendi, SCHUBERT, Blaine, WALLACE, Steven, East Tennessee State Univ., Johnson City, TN

The purpose of this project is to better understand the life history of *Megalonyx jeffersonii* in the context of cave paleoecology. ACb-3 Cave, located in northwestern Alabama, has produced the largest sample of ground sloths from any single cave. Excavated from 1984-1987, ACb-3 was part of a series of digs organized by the Red Mountain Museum. These collections are now housed at the McWane Center, Birmingham, Alabama. According to those who excavated the sloths, as many as sixteen individuals are represented. Many age classes are present, which may indicate that *Megalonyx* used caves throughout their lives. A description and faunal analysis of this remarkable sample is now underway that will 1) establish the total number of individuals present in the collection, 2) determine which age classes are represented, 3) determine the taphonomic history of the remains, and 4) record skeletal part frequencies. The results of these analyses should answer the following questions: 1) did all age classes utilize ACb-3, 2) did the specimens die in the cave or were there other factors responsible for their deposition (e.g., predators or transport) 3) are there signs of disease or injury that may have contributed to the death of these animals, or that may provide some insight into the "typical life" of this taxon.

In addition to the remains at the McWane Center it is possible that ACb-3 may have been the site that provided the specimens for Joseph Leidy's 1855 comprehensive study of the genus *Megalonyx* (curated at the Philadelphia Academy of Natural Sciences). Rare Earth analyses are being performed on sloth remains from both collections to determine whether or not they originate from the same cave. This not only has the potential of increasing the sample size of the current study, but may also verify the location of Leidy's *Megalonyx* collection.

Student Poster Session

SLOTHS *ET AL.* TEACHING THE "E" WORD: USING EXTANT AND EXTINCT XENARTHAN CRANIAL MATERIALS TO EXEMPLIFY FOR MIDDLE SCHOOL STUDENTS CHANGE THROUGH TIME AND HOW SCIENCE WORKS

SHAW, Barbara, Portland State Univ., Portland, OR

K-12 science education in the United States is in crisis. According to the National Science Foundation, the public by and large does not understand how science works or even what science is. Specifically, they do not understand the reasoning for evolution as the best explanatory framework for the diversity of life currently extant; further, a battlefield has been drawn in a struggle for teaching evolution vs. creationism under the guise of so-called intelligent design. In Oregon, state benchmarks include an inquiry portfolio. However, testable questions are not required until the 10th grade! Standardized test scores have become the golden calf of the current political administration. Those tests do not evaluate the *process* of science, but rather the rote memorization of basic facts in all disciplines. Students do not without guidance automatically transform knowledge learned in inquiry formats into concepts. Using skulls from 44 extant and extinct Xenarthra, 86 students grades 4-8 engaged in an inquiry based curriculum on the testable question, change through time, and cognition of time. A pre- and post-assessment of the cognitive, biological and geologic skills, and the testable question, were given to the students on the first and last days of class. In addition, students were assigned to write one benchmark style question and present it to the class to help them transform their inquiry experience into conceptual understanding. Paired Student-*t* test was used to evaluate overall learning and various cognitive skills, and significant differences were observed between pre- and post-tests results.

Poster Session II

MESOZOIC ORIGIN FOR MEGAMOUTH SHARK (LAMNIFORMES: MEGACHASMIDAE)

SHIMADA, Kenshu, DePaul Univ., Chicago, IL

The extant megamouth shark, *Megachasma pelagios* (Lamniformes: Megachasmidae), is a large (up to ca. 5.5 m), enigmatic filter-feeding elasmobranch, that is regarded as one of the most spectacular ichthyological discoveries in the twentieth century. Some megachasmid teeth have been recognized in the Tertiary fossil record, but it has been suspected that the megachasmid lineage originated during the Mesozoic. A recent re-examination of shark teeth collected from the basal Greenhorn Formation (Upper Cretaceous: Middle Cenomanian) in southeastern Colorado, suggests the Mesozoic origin for the megachasmid lineage. The specimens, that were previously identified as teeth of a Cretaceous odontaspimid lamniform, cf. *Johnlongia* sp. (e.g., FHSM VP-15095 and VP-15176 housed in Fort Hays State Univ., Sternberg Museum of Natural History, Hays, Kansas), measure up to 6 mm in height and are characterized by osteodont histology, sharply pointed, lingually curved, hook-like crown, and an exceptionally deep nutritive groove on its massive root. The discovery marks not only the geologically oldest megachasmid, but also putatively the oldest filter-feeding elasmobranch in the fossil record. The Cretaceous megachasmid may be a new taxon, and it could have measured at least 3.3 m in total body length. Certain dental features in the Cretaceous megachasmid resemble *Johnlongia*, posing an intriguing phylogenetic problem regarding the systematic relationships among Megachasmidae, Odontaspidae, and another lamniform family, Pseudocarchariidae. The evolution of the fossil megachasmid is considered to represent a part of the adaptive radiation of lamniform sharks during the Cretaceous.

Poster Session II

UTILIZING 3D LASER SCANS AND COMMERCIALY AVAILABLE SOFTWARE TO CREATE AND ANALYZE VIRTUAL MORPHOLOGICAL DATA SETS
SHINKLE, Levi, HARTMAN, Scott, Wyoming Dinosaur Center, Thermopolis, WY

Virtual data sets, i.e. 3D models of bones in a computer, compliment and enhance analyses that can be done on physical data sets. Analysis done on virtual data sets is non-destructive to the original material. Virtual data can be easily shared with other researchers, and provide a secure record of the original in the event of physical destruction. It also makes the manipulation of large bones feasible, simultaneously reducing the probability of long-term lumbar pathology in graduate students.

The Wyoming Dinosaur Center has embarked on a project to scan and make available for study the specimens in its collections. The first specimens scanned are two specimens of *Camarasaurus*; these data sets are being used to assess the osteological neutral position of these individuals. Fossils are scanned with a Steinbichler T-SCAN TW-S laser wand, being tracked by a Northern Digital In. Optotrak 3020 V.3. Raw data is recorded and processed in T-SCANplus. Post processing and model creation is completed in the 64-bit version of Polyworks. Once a polygonal mesh model is made from the data set, the manipulation of models may be carried out in a Digital Content Creation (DCC) animation software, such as the 64-bit version of Softimage XSI. DCC applications excel in precise transformation of bones in virtual space, and allow the creation of animations that display the results of range of motion studies on joints. The use of 64-bit operating systems and software leverages more memory than traditional 32-bit operating systems.

Ensuring the long-term integrity of these data sets is vital to their scientific use. Manipulation of large data sets requires that they be kept either on a local hard drive or on a dedicated file server. Regular backup of the server is necessary to protect against catastrophic failure. In addition, projects are backed up on DVDs. The DVD format has a limited shelf life and must be replaced from time to time, but they can be easily transported for storage off site, and provide an inexpensive third layer of protection for data.

Student Poster Session

GEOMETRIC MORPHOMETRIC, EIGENSHAPE AND FINITE ELEMENT ANALYSIS OF CRANIAL VARIATION IN TYRANNOSAURID DINOSAURS
SHYCHOSKI, Lara, Univ. of Bristol, Bristol, United Kingdom

Significant research has progressed our understanding of biomechanics in extinct animals as well as contributed to our knowledge of anatomy, form and evolution. However, few studies have been developed to address scaling and its associated effects on functional efficiency, particularly within dinosaurian crania. Similarly, ontogenetic evaluation of morphological variation to understand functional adaptations in response to these changes in size deserves more consideration; specifically in regards to tyrannosaurids for which there are fairly complete ontogenetic series known. In this study, data collected from geometric morphometrics and finite element analyses are presented regarding tyrannosaurid interspecific and ontogenetic adjustments to evaluate the effects of biomechanical scaling in cranial design. Geometric morphometric landmark analyses and Eigenshape analyses were conducted on various tyrannosaurid crania to observe principal components of cranial modification and the results are illustrated utilizing thin-plate spline graphics. Finite element analyses identified principal areas of stress and strain within each morphologically unique cranium to elucidate tyrannosaurid evolution in response to mechanical function. Conducting these analyses on various morphologies within theropod crania have allowed insights into the biomechanical aspects of scaling and increased our knowledge of efficient cranial design in small-scale and large-scale tyrannosaurids.

Saturday 2:15

THE AFFINITIES OF *ASIOPLESIAIDAPIS YOUNGI*: THE MOST PRIMITIVE ASIAN PRIMATE?

SILCOX, Mary, Univ. of Winnipeg, Winnipeg, MB, Canada

Asioplesiadapis youngi Fu, Wang, and Tong, 2002 is known from a single dentary with i1, p4-m3, and alveoli for p2 and p3 from the Early Eocene of the Wutu Formation, China. This specimen was described as a plesiadapid plesiadapiform on the basis of its reduced lower dental formula (1-0-3-3) and the presence of a margoconid and margocristid on the enlarged i1. However, these are not diagnostic plesiadapid features, since dental reduction is a feature of multiple plesiadapiform families, and one carpoledid (*Elphidotarsius wightoni*) also has a margoconid and margocristid on i1. *Asioplesiadapis* lacks features that would be expected in any plesiadapid, such as an m3 hypoconulid lobe (a plesiadapoid trait), no p4 cristid obliqua (a feature of all plesiadapoids except *Chronolestes*), and a stepped postvalid on m1 (found in all plesiadapoids but saxonellids). As such, it seems unlikely that *Asioplesiadapis* is a plesiadapid, or a plesiadapoid.

Asioplesiadapis also lacks the diagnostic features of most other plesiadapiform families, such as the exodaenodont p4 of micromomyids. An attribution to Apatemyidae is unlikely in the absence of distinctive apatemyid features such as an anterolabial expansion of m1 and a curved lingual molar profile. Some features of *Asioplesiadapis*, such as the crestiform paracristids on the molars and the enlarged but non-lobate m3 hypoconulid, are also found in *Purgatorius janisae* and in the most primitive micromomyid, *Micromomys fremdi*. These features suggest that *Asioplesiadapis* may belong closer to the base of the primate tree than had been supposed. A possible solution to the problem of the classification of *Asioplesiadapis* is to assign it to the "Palaeothonidae", a paraphyletic assemblage of primitive plesiadapiforms, which contains likely ancestors for several other groups. Most of

Asioplesiadapis features can be found in some palaeothonid. This would position *Asioplesiadapis* as the most primitive Asian primate known, making it a critical taxon for the consideration of primate biogeography.

Poster Session III

LOCOMOTOR MORPHOLOGY AND ECOLOGICAL IMPLICATIONS OF PALEOGENE AFRICAN FROGS

SIMONS, Verne, Ohio Univ., Athens, OH; HOLMAN, J. Alan, GOTTFRIED, Michael, Michigan State Univ., East Lansing, MI; STEVENS, Nancy, Ohio Univ., Athens, OH

The earliest true frog fossils are known from deposits dating as far back as the Jurassic. Due to their relatively long lifespan, philopatric lifestyle, and water permeable skin, modern frogs have proven to be sensitive ecological indicators of environmental quality, with many species exhibiting anatomical correlates related to humidity and seasonality of climate. Studies of extant frogs have documented a number of morphological features linked with particular locomotor modes and other behaviors. For example, anurans that rely predominantly upon leaping in the terrestrial environment exhibit longer tibiofibulae and/or longer hind limbs relative to their forelimbs. Tree frogs possess expanded toe pads, whereas aquatic forms tend to have more fully webbed feet. And morphologies such as the presence of spade like metatarsal tubercles, skull modifications such as a snout with a hardened tapered tip and stout robust forelimbs have been associated with digging behaviors in living forms. Yet fewer studies have employed modern analogues to assist in the interpretation of the locomotor ecology and habitat types in fossil anurans. A diversity of new fossil anurans has recently been discovered in Oligocene deposits in the Rukwa Rift Basin of Tanzania. Representing the largest sample of vertebrates recovered from these localities to date, many specimens consist of postcranial elements, some of which have been found in articulation. Specimens range in snout-vent length between 20 mm and 80 mm. A preliminary examination of pelvic morphology indicates at least one form preserving Emerson's Type II B pelvis, which has been associated with strong jumping in modern forms. This information, combined with other vertebrate fossil evidence and geological interpretations may assist in deciphering the paleoenvironments of these newly discovered localities.

Poster Session III

SITE ANALYSIS OF THE BUFFALO ALLEY BONE BED LOCATED IN THE LOWER SCENIC MEMBER OF THE BRULE FORMATION, WHITE RIVER GROUP, BADLANDS NATIONAL PARK, SOUTH DAKOTA
SIREN, Sarah, Stantec Consulting Inc., Irvine, CA

A bone bed, herein named Buffalo Alley, located in the Sage Creek Wilderness Area, Tyree Basin, was used as a focal point for the understanding of the genesis of fossiliferous deposits within the lower Scenic Member in Badlands National Park. The purpose of this study is to determine a taphonomic mechanism of preservation, place the bone bed in the stratigraphic framework of Badlands National Park using marker beds delineated by Evanoff, and to obtain paleopedologic information about the Buffalo Alley Bone Bed in the hope that recognition of similarly created bone beds in the Scenic Member (Orellan) of the Brule Formation may one day lead to their prediction.

Buffalo Alley Bone Bed represents a typical Orellan assemblage. Over 100 specimens were recovered from the site, 80 of which are identifiable. Fossils occur in pockets or lenses, separated by bone scatter, and weather from the fossil-bearing unit, commonly referred to as the lower red unit.

Paleopedologic evidence suggests that ancient soil conditions were neutral to alkaline. The pedogenic nature of the fossil-bearing layer within the lower red unit is well-developed, contrasting sharply with the other less developed A/C and A/Bw/C profiles. These paleosols are new, differing from those previously found within the lower Scenic Member. The taphonomy of the site suggests surface exposure of the fossils, as they occur with *Celtis* endocarps and root traces. A few of the fossils show weathering to stage 3, suggesting a maximum exposure of up to six years. The carnivore coprolites limit the time of exposure on the surface to under six months. Breakage patterns are consistent with post fossilization fracturing rather than carnivory or trampling.

As compared with the Brian Maebius Site's fluvially deposited bone bed in Tyree Basin, which has strong evidence of carnivory, the Buffalo Alley Bone Bed is more typical of Badlands floodplain fossil accumulations. The Buffalo Alley Bone Bed also contrasts with the Pig Dig watering hole, in that the specimens at Buffalo Alley are incomplete, disarticulated and fragmentary, and comprise a time-averaged assemblage.

Preparators Symposium, Thursday 9:00

CHARACTERIZATION OF FOSSILIZED DINOSAUR BONES

SIROIS, P., Canadian Conservation Institute, Ottawa, ON, Canada; KAMINSKA, Elzbieta, InfoSciTech, Orleans, ON, Canada

The paper summarizes a number of physical and chemical properties of fossilized dinosaur bones used in a study of the degradation of cyanoacrylate adhesives in the presence of a fossil material. To fully characterize bone samples from various sites, a wide range of instrumental analytical techniques was applied. The heterogeneity within the samples was investigated by determining the elemental composition of distinct areas by scanning electron microscopy/energy dispersive x-ray spectrometry (SEM/EDS). The samples were analysed for overall elemental composition by inductively coupled plasma (IPC), and major crystalline compounds were identified by X-ray diffraction (XRD). Additionally, extractive pH, apparent porosity, as well as moisture and ash content of selected bone samples were deter-

mined by conventional analytical methods. A wide variability in composition and physico-chemical properties of the analyzed bones was observed.

Poster Session III

TAXONOMIC DIVERSITY OF ESTIVATING SPECIES IN THE LOWEST PERMIAN OF NORTH AMERICA: ONSET OF SEASONALITY AND COMMENTS ON PHYSIOLOGICAL PLASTICITY

SMALL, Bryan, Denver Museum of Nature and Science, Denver, CO; PARDO, Jason, Univ. of Colorado, Boulder, CO; HUTTENLOCKER, Adam, California State Univ., San Bernardino, San Bernardino, CA

Recently described localities in the Eskridge Formation (Council Grove Group) near Humboldt, Nebraska document a diverse earliest Permian (Asselian) vertebrate fauna from the mid-Continent of North America. The presence of verticols and aridosols, petrocalcic horizons, and root traces and burrowing structures in the fossil-bearing mudstones suggests seasonal drying.

Much of the skeletal material recovered from these localities is attributable to lysorophian lepospondyls and gnathorhizid lungfishes. The lysorophians *Brachydictes elongatus* and *B. newberryi* are both represented, and can be differentiated by mandible morphology, skull proportions, and morphology of the second epibranchial. The gnathorhizids *Gnathorhiza dikeloda* and a new species of *Monongahela* are distinguishable by toothplate and skull morphology. These localities represent the first appearance of *B. elongatus* and the last appearance of *B. newberryi* and are the only documented co-occurrence of these species. This also represents the earliest unequivocal record of *G. dikeloda*.

The lysorophian *B. elongatus* and the gnathorhizids *G. dikeloda* and *Monongahela* show an extensive record of estivation at these localities and throughout the lower Permian, as evidenced by burrows containing skeletal material. The presence of estivation burrows corroborates studies suggesting the mid-continent experienced increasing monsoonal seasonality across the C/P boundary. The evolution of estivation during this transition reflects conserved physiological adaptation to increased environmental stress within marginal freshwater environments. The appearance of conspicuous estivating behavior in two distinct taxa (lysorophians and lungfishes) at this transition suggests that evolution of some physiological characters may occur relatively quickly as a response to environmental stress or that mechanisms underlying this environmental/physiological response are highly conserved across vertebrate taxa.

Marine Reptiles Symposium, Wednesday 2:15

CRANIAL ANATOMY AND SYSTEMATICS OF LOWER JURASSIC PliosauRS—NEW INFORMATION FROM THE NATIONAL MUSEUM OF IRELAND

SMITH, Adam, Univ. College Dublin, Dublin, Ireland

The type material of the plesiosaur *Rhomaleosaurus cramptoni* from the Toarcian of Yorkshire, England, has a long and convoluted history, but it is now in storage in the National Museum of Ireland (Natural History). This complete skeleton is of vital importance in resolving the taxonomy and understanding the evolution of plesiosaurs. A reconstruction of the dorsal surface of the skull is possible, however, the current state of the type material is poor and parts of the specimen as mounted are erroneous. The specimen will be transported to the Palaeontological Conservation Unit in the Natural History Museum, London, where it will be cleaned and prepared to allow a more detailed description. *Rhomaleosaurus sensu stricto* contains a maximum of only four species, all from the Toarcian of Yorkshire (*cramptoni*, *zetlandicus*, *propinquus*) and Northhamptonshire (*thorntoni*). Thus, many other species previously pertaining to *Rhomaleosaurus* require revised generic names. A newly prepared plesiosaur skull from the Hettangian of Street, Somerset, has been identified as *Rhomaleosaurus megacephalus* and provides new information on the cranial and pectoral anatomy of this species. Notable features of the newly exposed palate include clear lateral palatine fenestrae, a large ectopterygoid contacting the medial border of the suborbital fenestra, and an elongate jugal exposed on the palatal surface and contacting the posterior border of the suborbital fenestra, bounded laterally by the maxilla. All four species of *Rhomaleosaurus* share very similar skull construction and proportions, and possess the following synapomorphy—a large dorso-median foramen between the external nares. The validity of these four species shall be tested after the holotype is prepared. Another plesiosaur skull, from Barrow, Leicester, is also undergoing preparation (in Dublin), and will shed further light onto the systematics of Lower Jurassic plesiosaurs.

Poster Session II

JAW MUSCULATURE AND FUNCTION IN OVIRAPTOROSAURS

SMITH, David, Northland Pioneer College, Show Low, AZ; MOLNAR, Ralph, Museum of Northern Arizona, Flagstaff, AZ

Theropods are typically regarded as hypercarnivorous. At least some were characterized by a highly kinetic skull with varying degrees of streptostyly ranging from none to considerable. However, oviraptorids depart from these generalizations. These theropods were unusual in that they possessed a lightly constructed, akinetic skull with a non-streptostylic quadrate. The intra- and intermandibular joints were akinetic, preventing independent movement of the jaws, as seen in other theropods.

The adductor musculature of oviraptorids was reconstructed leading to a reconsideration of their trophic level. We reconstructed the jaw musculature with avian and crocodylian models using observed attachment areas on the oviraptorid skull. Despite evidence for a

strong bite, the skull construction remained delicate. Oviraptorids were characterized by having proportionately greater moment arms in the adductor musculature than typical for theropods. The attachment sites for the *M. pseudotemporalis* and *M. adductor mandibulae profundus* are larger than expected, with a correspondingly large adductor chamber. Placement of muscle attachment points suggests the presence of partial cheeks enclosing the back of the jaw.

The observed suite of characters indicates that a suitable functional modern analogue for the oviraptorid skull would probably be a parrot or turtle, rather than the cassowary. Points of similarity with turtles include a short, deep skull and a strong adductor moment arm and extension. Convergences with parrots include the overall jaw form with a trough-like symphysis and elevated dorsal margin; elevated nares; a ridged palate; and the location of the orbit in the middle of the skull. In this case the convergence of skull and mandibular morphology is such that it suggests evidence for similar diets—not leaf consumption in the edentulous species as was previously argued, but some form of frugivory.

Poster Session II

LATE CENOZOIC HISTORY OF COLORADO RIVER FISHES DATED WITH FOSSILS AND DNA SEQUENCE DIFFERENCES

SMITH, Gerald, Univ. of Michigan, Ann Arbor, MI; SPENCER, Jon, Arizona Geological Survey, Tucson, AZ; DOWLING, Thomas, School of Life Sciences, Tempe, AZ

Ages of volcanic rocks in sedimentary sequences at the mouth of the Grand Canyon constrain the initial age of Colorado River in the canyon at about 5 Ma, but current hypotheses do not account for where the upper Colorado drainage drained prior to its connection to the lower Colorado basin. Fossil and recent fish distributions indicate possible explanations while supporting the young age of the canyon. Fish DNA sequence differences provide age estimates of Pliocene to Pleistocene barriers among the segments of the Colorado River. Genetic distances, calibrated with ages of appropriate apomorphies of fossil fishes (corrected with the methods of Marshall and others) and adjusted for effects of metabolic rate on mutation rates, indicate several constraints: The upper Green River did not flow to the North Platte and the Upper Colorado River did not flow to the Rio Grande. Fossil cyprinid fishes in the lacustrine upper Bidahochi formation in NE Arizona include close relatives of modern fishes in the Colorado River; their body sizes, fin sizes, and body shapes indicate connection to a sizeable river. By contrast the Great Basin segment (Lower Colorado River Basin below Grand Canyon) has an ancient, endemic fish fauna that has experienced only partial mixing with the upper basin following establishment of the Colorado River in Grand Canyon.

Friday 9:15

NEW DINOSAUR DISCOVERIES FROM THE EARLY CRETACEOUS OF LIBYA

SMITH, Joshua, Washington Univ., St. Louis, MO; TSHAKREEN, Sefau, Petroleum Research Center, Tripoli, Libya; RASMUSSEN, D., Washington Univ., St. Louis, MO; LAMANNA, Matthew, Carnegie Museum of Natural History, Pittsburgh, PA

Although the interval has been rather well sampled, a solid understanding of the nature of the Cretaceous tetrapod faunas of mainland Africa remains elusive. This is particularly true of Libya, which has produced only a few fragmentary Cretaceous tetrapod remains. For example, the previous record of Dinosauria from the country is limited to a few isolated bones and teeth from the ?Early Cretaceous (provenance is unclear for some of the remains) of the Jabal Nafusah area (between Tunisia and Tripoli) and several bones from the Late Cretaceous (probably Cenomanian, ~99-93 Ma) of the Ghadames and Draa Ubari regions. In August 2005, as an expansion of ongoing research in the Late Cretaceous of Egypt, we conducted what appears to have been the first joint Libyan-American dinosaur expedition. Over three weeks we traveled ~4000 km in northeast and south-central Libya, penetrating to ~450km north of the Chad border. Along Jabal Nafusah we produced fossil vertebrates from 13 localities in the Aptian-Albian (~125-99 Ma) Chicla Formation and the underlying uppermost Cabao Formation (uppermost strata regarded as upper Neocomian, ~125 Ma). The assemblage from these sites consists largely of shark, turtle, lungfish, and crocodyli-form (?two species, including bones and teeth of a very large form) remains, and numerous unidentified tetrapod elements. Dinosaurs are currently represented by fragmentary remains of a ?titanosauriform sauropod and the partial skeleton of a theropod. The theropod, the most complete record of a Libyan dinosaur to date, was found at the top of the Cabao Formation near the town of Nalut, ~40 km east of the Tunisian border. It consists of vertebrae and appendicular elements. This specimen, which appears to be a previously unrecorded taxon as evidenced by several autapomorphies, possesses femoral and tibial characters very similar to *Masiakasaurus* and is thus perhaps a large-bodied noasaurid. If correctly identified, this find extends the African record of Abelisauroida into the Neocomian.

Wednesday 9:30

BIOGEOGRAPHIC RESPONSE OF LIZARDS TO THE PALEOCENE/EOCENE THERMAL MAXIMUM: EVIDENCE FROM THE BIGHORN BASIN, WYOMING, U.S.A.

SMITH, Krister, Yale Univ., New Haven, CT

Intensive study of the Paleocene/Eocene boundary over the past 15 years has revealed a global Thermal Maximum (the PETM), widespread floral and faunal biogeographic shifts, and the reorganization of terrestrial communities. In North America, the boundary marks

the first appearances of several mammalian higher taxa. The response of reptilian groups is generally less well understood, yet the close relationship of fossil reptilian taxa to groups still living in North America may permit an understanding of intracontinental biogeographic patterns in response to rapid climate change.

The earliest Eocene (Wa0) Castle Gardens local fauna in the Bighorn Basin provides considerable insight on the response of lizard communities to the PETM. Fourteen species are documented from jaw fragments and significant cranial material: two iguanids, two xantusiids (night lizards), a “higher” amphisbaenian, six anguids, an anguimorph of uncertain affinities, and two varanoids. Among the anguids are the earliest species certainly referable to Gerrhonotinae (alligator lizards) and a new glyptosaurine morphologically intermediate between the primitive “melanosaur” and later glyptosaurus.

Diploglossine anguids (galliwasp), represented by fragmentary material at Castle Gardens, are presently confined to Central and South America and the Caribbean. Likewise, the genus *Lepidophyma*, to which one of the xantusiids is related, currently resides only in Central America (the specimens from Castle Gardens constitute the only record of the lineage in the Rocky Mountain interior). That both first occur in Rocky Mountain region during the carbon isotope excursion suggests migration from the south in response to earliest Eocene warming and is consistent with previously described biogeographic patterns in plants.

Saturday 4:00

WEIGHTED BROOKS PARSIMONY AND TIME-SLICING IN BIOGEOGRAPHIC ANALYSIS

SMITH, Nathan, Univ. of Chicago-CEB/FMNH, Chicago, IL; MAKOVICKY, Peter, The Field Museum of Natural History, Chicago, IL

Temporal information is crucial for accurate inference of biogeographic patterns from organismal phylogenies. Recently proposed time-slicing methods seek to infer biogeographic patterns during a chosen time period by limiting the analysis to taxa that were present in that particular time-slice. Although generally effective at assessing temporal congruence while minimizing deleterious effects of biogeographic overprinting, these methods ignore informative biogeographic data from taxa that postdate the time slice, but whose presence is implied by phylogeny.

Here, we present an alternative time-slicing approach, modified from the biogeographic method Brooks Parsimony Analysis (BPA), which takes such information into account. A taxon-area cladogram is coded into a data matrix as in traditional BPA. Clade history is then divided into a series of time-slices suited to the biogeographic question and organismal group at hand. Biogeographic patterns for each time-slice are inferred through parsimony analysis of the matrix, with a weighting function applied to syntaxa based on their temporal distribution relative to a select time-slice. Syntaxa pre-dating the chosen time-slice are omitted, whereas remaining syntaxa are progressively down-weighted with decreasing age relative to a base weight given to the time slice under analysis.

The method was applied to the crocodyliform dataset of Turner (2004), using stage-level time-slices. Analyzed with traditional BPA or tree reconciliation analysis, this dataset suggests a close biogeographic relationship between South America and Indo-Madagascar to the exclusion of Africa during the Cretaceous. However, time-sliced BPA reveals that this pattern of area relationships is primarily a post-Aptian signal, with analyses for earlier time-slices recovering a closer biogeographic relationship between South America and Africa. These results are robust to both the type (linear vs. exponential), and degree of weighting implemented. Thus, an important advantage of the time-sliced BPA method is its ability to track changes in biogeographic patterns through time, a primary goal of the “chronobiogeographical” paradigm.

3D Imaging Symposium, Friday 8:30

LASER SCANNING AUTOMATION AND STANDARDIZATION

SMITH, Nicholas, STRAIT, Suzanne, Marshall Univ., Huntington, WV

While 3D data from laser scanners have been employed in a number of morphometric studies, no standardized processes have been developed to regulate model accuracy. Using previous methods, 3D data manipulation is cumbersome, and left largely to the discretion of the user. The goal of this study was to automate and standardize one laser scanning technique for the mass-production of models suitable for both morphometric analyses and web-publication.

The laser scanner used in this study was a LDI Inc. RPS 120 probe, mounted on an ISEL Automation gantry unit. Coordinate point cloud data from this instrument were acquired as multiple 2D profiles of the object similar in concept to the slices of CT data. Specimens were first coated with a thin layer of ammonium chloride to diffuse the laser light. To adequately represent the surface, five scans per specimen were collected and imported into Geomagic Studio 6.0, for manual registration. Once merged, noise reductions were performed, and the point cloud was wrapped with a polygonal mesh.

To streamline the process, the development of software macros with predefined parameters automated 7 operations of image processing including: global registration, select disconnected, select outliers, uniform sample, merge, wrap, refine. Now following registration, the remaining procedures can be performed with a single command, minimizing sources of human error. To determine the linear and volumetric accuracy of this technique, an extensive error study was performed. A screw with a known thread-pitch of 250 microns, and a certified scale bar were scanned as control objects. Using a trio of 3D analysis programs (AutoCAD Mechanical Desktop, Geomagic Studio, 3D-Doctor), the system was found to

be accurate within +/- 0.001 mm in the x-y plane, and volumetric analyses differed from the original by 0.7%-2.8%.

While the use of 3D data affords the ability to examine questions once unattainable, it is imperative that standards are applied to maintain morphological accuracy. Automation minimizes subjectivity and limits variation in model generation yielding comparable data from one researcher to the next.

Wednesday 4:45

EARLIEST BATS FROM INDIA

SMITH, Thierry, Royal Belgian Institute of Natural Sciences, Brussels, Belgium; RANA, Rajendra, HNB Garhwal Univ., Srinagar, India; SAHNI, Ashok, Panjab Univ., Chandigarh, India; ROSE, Kenneth, Johns Hopkins Univ. School of Medicine, Baltimore, MD

The oldest known bats are recorded from the early Eocene of North America, Europe, Africa, and Australia. Recently, bats have also been reported from the early Eocene of India in the Vastan Lignite Mine east of Surat, Gujarat. Associated foraminifera of this locality indicate a middle Ypresian age, confirming that these are the first early Eocene bats from India and the oldest bats known from Asia. No confirmed bats have been found in the earliest Eocene anywhere in the world.

The bats are the most abundant and diversified mammals of Vastan Mine, which may locally represent a mangrove environment. Bats are represented by teeth and jaws, and also by isolated postcrania such as typical limb bones. At least four species are present. The largest species has the size and morphology comparable to the European *Archaeonycteris brailtoni* from Mutigny (France) but differs by having higher p3 and canine. The most frequent species is a medium-sized bat close to *Icaronycteris? memui* from Mutigny but differs by having more developed metaconid on p4 and a non reduced p3. This species presents particularly primitive characters also visible in nyctitheriid insectivores. Another medium species, somewhat smaller than the previous one, is characterized by a more nyctalodont condition with the hypoconulid near the back of the entoconid but without a crest between the hypoconid and entoconid. A fourth species, very rare, is extremely small.

The new important micromammal material from Vastan indicates that the purported nyctitheriid insectivore *Cambaya* and didelphid marsupial *Jaegeria* recently described from Vastan actually belong to the most frequent medium bat species. Resemblances to European taxa in particular suggest earlier Eocene biotic contact between India and Eurasia.

Saturday 8:45

A REDESCRIPTION OF THE ANATOMY OF *TRISTICHOPTERUS*, WITH COMMENTS ON THE VALIDITY OF *EUSTHENOPTERON* AND THE MONOPHYLY OF THE TRISTICHOPTERIDAE

SNITTING, Daniel, BRAZEAU, Martin, Uppsala Univ., Uppsala, Sweden

Tristichopterus alatus, from the Middle Devonian (Givetian) of Scotland, was originally described by Egerton in 1861, and has been considered to be the most basal member of the Tristichopteridae, a probably monophyletic group of tetrapodomorph fishes. Historically, *Tristichopterus* has been described very much in the shadow of the well-studied taxon *Eusthenopteron*, mainly known from the work of Erik Jarvik. Descriptions of *Tristichopterus* have often been very brief, partly because of the similarity to *Eusthenopteron*, and partly because of the lack of good *Tristichopterus* material. The similarities between the two taxa are great indeed, and ever since its original description by Whiteaves, the validity of *Eusthenopteron* has been questioned. This discussion has continued up until the present, and no consensus has been reached on whether *Tristichopterus* is a senior synonym of *Eusthenopteron*. Considering the widespread use of *Eusthenopteron* in the literature, and the general familiarity of the name, this is more than a trivial taxonomic issue.

Data from a large number of new well-preserved specimens of *Tristichopterus* is presented here, shedding light on both the taxonomy and interrelationships of basal tristichopterids. Two of the specimens have also been CT-scanned at the Univ. of Texas, Austin, giving a composite picture of the neurocranium. Other new structures that are described for the first time include the palate, the hyomandibula and the endoskeleton of the pelvic fin.

Poster Session I

POSTCRANIAL ANATOMY OF EARLY CENOZOIC CARNIVORAMORPHA (“Miacoids”), AND THEIR USE IN RESOLVING TAXONOMIC AND PHYLOGENETIC AMBIGUITY

SPAULDING, Michelle, FLYNN, John, American Museum of Natural History, New York, NY

Recent phylogenetic analyses of the Carnivoramorpha have identified the “Miacidae” as a paraphyletic stem lineage leading to the crown group Carnivora. “Miacids” are represented in collections by a moderate amount of postcranial material. This material typically receives little attention, however, with studies focusing instead on the variation among the much greater amounts of dental material available. Here we present the first detailed cranial and postcranial description of “*Miacis*” *uintensis* (italics reflect almost certain paraphyly of this genus). This AMNH specimen, collected for the AMNH from the Bridger Basin over 100 years ago, is particularly interesting because of confusion surrounding its taxonomic assignment and phylogenetic position. Opinion varies as to if “*M. uintensis*” belongs in “*Miacis*” or if it is more fitting to resurrect the genus *Prodaphaenus* and include this taxon within it. A taxonomic revision of “miacids” is needed, with the many species assigned to “*Miacis*”

requiring the most emphasis; this study is a step towards resolving the positions of the individual species historically placed in the “miacid” “waste basket” at the base of the Carnivora. Also discussed is an array of other skeletons from both historical and more recently recovered collections. Many prior studies of “miacid” postcranial anatomy have taken an exemplar approach, often making sweeping generalized comparisons between “miacids” and Viverravidae or crown-group Carnivora. Here the detailed and more individualized comparisons of several “miacids” begin to detail the amount of postcranial variation within the stem lineage, and elucidates its potential for more precisely resolving the diversification pattern of early Cenozoic Carnivoramorphs. Future comprehensive analyses will build on these results by incorporating our observations on these specimens and detailed study of other new postcranial specimens (e.g., *Tapocyon*, *Oodectes*, etc.).

Student Poster Session

PHYLOGENETIC POSITION OF *XENOSMILUS HODSONAE*

SPEARING, Kurt, DeKalb, IL

The rare Pleistocene saber-toothed cat *Xenosmilus hodsonae* is known primarily from two partial skeletons discovered in Irvingtonian deposits from Florida. While hypotheses have been made about the relationships of this taxon since its description in 1999, no phylogenetic analysis has been performed to assess its systematic relationships. The osteology of *Xenosmilus* places it in the subfamily Machairodontinae along with the other saber-toothed felids, but *Xenosmilus* is unusual in showing a mosaic of characters that prevent it from being easily classified with either the “dirk toothed” Smilodontini (short limbs, robust body form), or the “scimitar toothed” Homotherini (coarsely serrated, robust, and elongated upper canines). This study describes a phylogenetic analysis of this felid and several of its probable relatives from the subfamily Machairodontinae. I used several characters from the skull, dentition, and postcranial skeleton in an attempt to get a clear view of its relationships. Several variations of exhaustive maximum parsimony analyses were used to examine the phylogeny of this genus. Many different outgroup, taxa, and character variations were tried to assess their effect on the phylogeny as well. The results of these analyses are that *Xenosmilus* belongs to the tribe Homotherini. In a strict consensus, *Xenosmilus* was in a polytomy with *Homotherium*, *Machairodus*, and the distinct tribe Smilodontini. However, when individual trees are examined, the reason for the polytomy becomes clear. *Xenosmilus* appears to have three different positions on the tree. In a majority of the most parsimonious trees, *Xenosmilus* was basal to all of the Homotherini and Smilodontini. The other results were trees where *Xenosmilus* was in a polytomy with the Homotheres and Smilodonts or was basal to the Smilodontini.

Poster Session II

THE ANATOMY OF PELVIC GIRDLE IN *PALAEOCHERSIS TALAMPAYENSIS* AND ITS RELATIONSHIP WITH THE SHELL: PHYLOGENETIC IMPLICATIONS

STERLI, Juliana, DE LA FUENTE, Marcelo, Museo de Historia Natural de San Rafael, San Rafael, Argentina; ROUGIER, Guillermo, Univ. of Louisville, Louisville, KY

The anatomy of the pelvis region and the relationship of the pelvis with the shell in *Palaeochersis talampayensis*, a Late Triassic turtle from Argentina, is a controversial subject in turtle evolution. We have studied *Palaeochersis talampayensis* holotype and we recognize two characters relevant for evaluating the evolution of the pelvis-shell relationship. One of these characters is the suture between the pelvis and the shell, as it occurs in panpleurodiran turtles. As a result, *Palaeochersis talampayensis* is considered for some authors as a panpleurodiran turtle. The second character is related to the nature of the relationship between the ischium and the xiphiplastron. This relationship is very different to that present in panpleurodiran turtles, because in *Palaeochersis talampayensis* the relationship is established through the medial portion of the ischium and not with its medial part and lateral process, as is the case in panpleurodira. To test the homology of the “pelvis-shell suture”, these two characters were included in a phylogenetic analysis using 88 additional characters from the skull and postcranium scored across 15 taxa. The result obtained from the analysis corroborates early results indicating that *Palaeochersis talampayensis* and *Australochelys africanus* form a monophyletic group, which is the sister group of the remaining turtles (except of *Proganochelys quenstedtii*). The tree rejects, therefore, panpleurodiran affinities for the *Palaeochersis*. As a corollary, we conclude the character “pelvis-shell suture” developed twice during turtle evolution: once in *Palaeochersis talampayensis* and a second time in panpleurodiran turtles.

3D Imaging Symposium, Friday 10:45

3D VISUALIZATION OF ALLOMETRIC CHANGE IN WHOLE SKELETONS: POSTURE, PROPORTION, AND RANGE OF MOTION

STEVENS, Kent, WILLS, Eric, Univ. of Oregon, Eugene, OR

Allometry, the differential growth of body parts in relation to an entire organism, is usually analyzed and presented graphically, wherein a measure of relative growth is expressed by a power law, for either an intraspecific (ontogenetic) or interspecific (phylogenetic) range of individuals. In contrast, dynamic visualization of a three-dimensional skeletal model that undergoes allometric change provides a more immediate and inclusive grasp of that same progression. To visualize allometry, two or more skeletal models are created parametrically in the DinoMorph™ software. The modeled individuals that comprise the sequence are homeomorphic, e.g., they have identical phalangeal and vertebral formulae. The models differ geometrically, not only in the major dimensions of corresponding bones,

but for each bone, the geometric model capturing its specific morphology is also homeomorphic across the individuals in the sequence. This permits visualization of morphological change for individual bones in addition to appreciating their proportional changes during the allometric progression of the overall skeleton. While conventional allometric analyses frequently use femur length as a proxy for overall body size, the current method permits allometry with respect to reconstructed body size directly, and indeed to test the often-presumed isometry of femur length as a function of overall body size. For animals in which the hindlimbs are themselves involved in significant functional change, such as tyrannosaurid allometry, the ability to select other, functionally independent, bases is particularly advantageous. DinoMorph™ further provides a representation of joint flexibility that quantifies the full six degrees of freedom of relative orientation and position of each articulated pair of bones. As a consequence, changes in posture and flexibility can also be interpolated and appreciated with relation to a given stage of allometric growth. Body movements, expressed relative to the individual achievable range of motion, can then be correlated with allometric change to the entire skeleton.

Poster Session III

MACROSCELIDEANS FROM THE OLIGOCENE OF SOUTHWESTERN TANZANIA

STEVENS, Nancy, Ohio Univ., Athens, OH; NGASALA, Sifa, Univ. of Dar es Salaam, Dar es Salaam, Tanzania; GOTTFRIED, Michael, Michigan State Univ., East Lansing, MI; O’CONNOR, Patrick, Ohio Univ., Athens, OH; ROBERTS, Eric, Univ. of the Witwatersrand, Johannesburg, South Africa

The phylogenetic affinities of macroscelideans have been the source of considerable debate. These small mammals have been described as “living fossils”, with an evolutionary history variably linked with anagalids, condylarths, and tethytheres. Modern sengis are restricted to continental Africa, and molecular studies have placed them in a somewhat unconventional grouping of African mammals (Afrotheria), an arrangement that lacks strong morphological character support. Fossil macroscelideans have been described from the Paleogene of northern Africa, and are represented by *Herodotius* and *Metoldobotes* from Oligocene strata in the Fayum Depression of Egypt, *Chambius* from the early Eocene Chambi Massif of Tunisia, and more recently by the Eocene *Nemenchatherium* from Bir el Atar, Algeria. Until recently, the macroscelidean record has been interrupted by a hiatus in fossiliferous localities until the Miocene and later faunas of Kenya, Namibia, and South Africa. Based in southwestern Tanzania, the Rukwa Rift Basin Project is beginning to fill in some of the critical gaps in the African fossil record. In particular, recent work has revealed a diverse micro-vertebrate fauna of mid-late Oligocene age, preserving invertebrates, fish, anurans, crocodylians, and a diversity of mammals. Here we describe two new elephant shrews from Unit II of the Red Sandstone Group. In both, upper and lower molars are intermediate in morphology between described Paleogene and Neogene forms. Specimens resemble herodotines in preserving upper molars that are wider than long, with substantially less hypsodont cheek teeth than in, for example, *Myohyrax*. The larger of the two taxa is similar in size to *Metoldobotes*, and is represented by a single quadrangular upper molar. The smaller taxon, based on a partial maxilla, preserves an M3 that is triangular in outline but relatively more reduced than that observed in *Chambius*. A calcaneus referable to Macroscelididae has also been recovered and is similar in size to extant *Petrodromus*, preserving strikingly modern facet morphology. Taken together, these finds document a rare window into macroscelidean evolutionary history at the close of the Paleogene.

Poster Session III

NEW VERTEBRATES FROM THE PALEOGENE OF EASTERN TEXAS AND THEIR IMPORTANCE FOR STRATIGRAPHY AND CORRELATION

STIDHAM, Thomas, College Station, TX

Although early Paleogene vertebrates have been known since the 19th century in eastern Texas, major questions about the biota, biotic change, and the age of the formations have yet to be addressed. A combination of published data and new field and lab work has expanded the known fossil record of the Paleogene of eastern Texas and has begun to place the Texas stratigraphic column into a regional and global context. Previously, the Paleocene-Eocene Boundary has been suggested to lie below the Carrizo Sandstone. The Carrizo Sandstone has the FAD of the pollen taxon *Platycarya*, indicating at least an early Eocene age of the formation. Some workers have considered the unconformably underlying Calvert Bluff Formation as Paleocene. A recently discovered vertebrate fauna from a storm bed low in the Calvert Bluff Formation contains a diversity of sharks, rays, fish, and crocodylians. One of the rays, *Burnhamia*, is not currently known from the Paleocene in North America and occurs in the early Eocene Bashi Formation of Mississippi. Based on these data, the Paleocene-Eocene Boundary appears to occur either very low in the Calvert Bluff Formation or in the conformably underlying Simsboro Sand. Further refinement of Eocene stratigraphic correlations has been aided by examination of marine and terrestrial vertebrate fossils. Recent work has uncovered the first fossil vertebrates from several Eocene formations in eastern Texas, including the Calvert Bluff Formation, Reklaw Formation, Queen City Sand, and Weches Formation. The majority of these fossils are sharks and rays, but do include terrestrial taxa. Additional work in the middle Eocene Cook Mountain Formation has produced a variety of marine and terrestrial vertebrates including a diversity of sharks, rays, and fish and specimens of turtles, lizards, snakes, crocodylians, mammals, and birds. These taxa likely are equivalent with other faunas from the Bridgerian NALMA and underlie the Uintan NALMA mammals of the Yegua Formation.

3D Imaging Symposium, Friday 8:45

PALEOVIEV3D: AN INTERACTIVE DATABASE OF MAMMALS FROM THE PALEOCENE/EOCENE BOUNDARY

STRAIT, Suzanne, SMITH, Nicholas, Marshall Univ., Huntington, WV

The most dramatic temperature change of the Cenozoic occurred during the late Paleocene/early Eocene. This global warming had an extensive impact on ecosystems world-wide, affecting both marine and terrestrial organisms. Study of the late Paleocene/early Eocene fossil record is essential to understanding the consequences of climatic change on biota and the origins of modern clades. Key to this work is ready access to the fossil evidence of these events, and internet accessible high resolution digital models are one of the most effective means to make these data available to the widest body of researchers.

PaleoView3D is a web-based interactive database of late Paleocene and early Eocene North American fossil mammals. The Paleoview3D database currently includes interactive 3D models of over 100 specimens. When completed, this number will exceed 700 specimens, representing 300 species. Data for these surface models were acquired with a laser scanner and converted into surface models that can be viewed in either 2D or 3D, magnified and rotated by the user. These models are more than images; researchers can use them to gather quantitative data. Simple measurements (i.e., linear distance, circumference, and arcs) of models can be made directly on the web-site with simple point and click features. Users can also download models as data files so that more sophisticated 3D measurements can be made utilizing CAD, GIS, or 3D measurement software. PaleoView3D also includes a substantial user's guide, about both model development and how to use a variety of software programs which are available to view and analyze the downloadable data.

The ability to create high-resolution 3D models is restricted due to significant investments in equipment and personnel training. With this website any scientist, teacher, or student can view the images or download data to be analyzed in a variety of software programs. By making these 3D data so easily accessible, PaleoView3D's goal is to stimulate quantitative research in morphology and systematics and lead to a more informed understanding of faunal turnover and adaptation during a past period of substantial global warming.

Poster Session II

A PRELIMINARY REVIEW OF CIMOLESTID SYSTEMATICS WITH COMMENTS ON THE GENUS *PROCKERBERUS*

STRAUSS, Justin, San Diego, CA

Cimolestids, Late Cretaceous mammals known primarily from western North America, are suspected to include the origin of Carnivora as well as other placentals. This hypothesized relation is based on their position biostratigraphically, within late Cretaceous (70-64 mya) sediments, as well as on the carnassial-like occlusion of their dentition. Current systematic relationships of cimolestids are based almost entirely on tooth morphology, and remain largely unresolved. One cimolestid in particular, *Procerberus*, is of especial interest because of its uncertain placement in relation to a number of other taxa. Once considered basal to the leptictids, *Procerberus* is currently regarded as a member of the family Palaeoryctidae, along with cimolestids, based on tooth morphology. Recent studies suggest some species of *Procerberus* may actually be ancestral to Taeniodonta. While much speculation has been made about the exact placement of *Procerberus*, little study of the numerous specimens collected has been done; and complete descriptions, necessary to make accurate systematic placements have not been published.

It has been hypothesized that *Procerberus* is a descendant of *Cimolestes* based on the placement of accessory cusps on both the premolars and the molars. Preliminary morphological analyses weakly support this conclusion, which may call for a systematic revision of *Cimolestes*, as this clade would be paraphyletic in this instance. However, the molari-formization of the premolars in *Procerberus* is also seen in leptictids, which has been used to suggest a relationship. The paracone and metacone of the premolars of *Procerberus* are of nearly equal size, which is almost identical to the state of these cusps in the leptictid *Gypsonictops*. In the premolars of *Cimolestes*, the metacone is significantly smaller than the paracone. A more thorough analysis of a greater number of morphological characters is being conducted to bring greater resolution to these systematic relationships. It is expected to show greater support for the hypothesis that *Procerberus* is a close relative and possible descendant of *Cimolestes*, with little direct relation to leptictids.

Student Poster Session

THE EFFECTS OF CONSOLIDANTS ON FOSSILS WITH RESPECT TO FUTURE CHEMICAL ANALYSIS

STRICKLAND, Kaitlin, North Carolina State Univ., Raleigh

With the advent of increasingly specific and sensitive analytical methods, new techniques for understanding extinct organisms are quickly being incorporated into the field of paleontology. However, field collection and preparation of fossils have failed to evolve at the same rate, and the field practices of today are much the same as they have always been, with little attention attributed to a fossil's subsurface chemical and structural preservation. In order to fully conserve all molecular and chemical information stored within fossil bone matrices, it is critical that these long-established methods for fossil collection and stabilization be re-examined in the context of future analytical procedures. The porous nature of fossil bone has been ignored while selecting fossil consolidants, and vascular channels and

pore spaces from well preserved fossils contain the potential for uptake of chemicals through capillary action. Presented are the results of a study designed to determine the depth of penetrance of common field-applied consolidants, and examine the potential of chemical interactions between externally applied chemical preservatives and organic matrices of fossil material.

Poster Session III

VERTEBRATE FAUNAS OF THE WIND RIVER AND BRIDGER FORMATIONS, WYOMING (EARLY TO MIDDLE EOCENE): STRATIGRAPHIC CONTEXT AND FUTURE EVOLUTIONARY STUDIES

STUCKY, Richard, HARDY, Tom, Denver Museum of Nature & Science, Denver, CO; VAN REGENMORTER, John, Grand Valley State Univ., Allendale, MI

The vertebrate faunas of the Wind River and Bridger Formations of Wyoming serve as the standards for the transition in western North America from the early to middle Eocene. This period of time encompasses the interval of peak warming during the Cenozoic. Field research since the 1970s has resulted in substantial samples of vertebrate fossils, particularly those of mammals, from many different stratigraphic horizons. Differences in depositional environment, geographic location, and stratigraphic position provide a framework for future studies of species and faunal evolution. This poster will show the stratigraphic context and species diversity of these fossil assemblages. Faunas from the Wind River Formation across the early-middle Eocene boundary (Lostcabinian to Gardnerbuttean) have higher mammalian species diversity than do those from the Bridger Formation. The Wind Formation faunas also have more evenly distributed species abundance whereas those from the Bridger Formation are often dominated by a few taxa: In particular, *Hyopsodus* spp.

Saturday 3:00

ANATOMY AND RELATIONSHIPS OF THE TRIASSIC PARAREPTILE *SCLE-ROSaurus*

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Based on excellent, newly prepared casts of the two known specimens, we have reassessed the skeletal structure and phylogenetic relationships of *Sclerosaurus armatus*, an enigmatic parareptile from the Middle and Upper Buntsandstein (Early to early Middle Triassic) of Baden (Germany) and northern Switzerland. This taxon has been variously assigned to Procolophonidae, Pareiasauria, stem-group of Pareiasauria, or its own family-level taxon. *Sclerosaurus* is distinguished from other known parareptiles by a number of autapomorphies including: enormous, posterolaterally projecting spikes on pedicles presumably formed by the supratemporals, teeth with bluntly conical crowns except for posterior dentary teeth, which have mesiolingually aligned, slightly labiolingually flattened, and somewhat overlapping crowns, and a narrow median band of dorsal dermal armor with two or three rows of sculptured osteoderms on either side. Phylogenetic analysis supports placement of *Sclerosaurus* in Procolophonidae, close to Leptopleuroninae, rather than in or as a proximate sister-taxon to Pareiasauria. It is the largest procolophonid known to date.

Romer Prize Session, Thursday 12:00

THE EVOLUTIONARY ORIGINS AND FUNCTIONAL SIGNIFICANCE OF THE CHARACTERISTIC HIND LIMB FEATURES OF CRUROTARSAN ARCHOSAURS

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Numerous structural changes occurred in the hind limb as archosaurs diversified during the Triassic. In basal archosaurs, such as proterosuchids, the astragalus and calcaneum were attached to the crus, and ankle movement occurred at poorly consolidated mesotarsal and infratarsal joints. The calcaneum bore a posterolateral process analogous to that of extant varanid lizards. Rotoscopic animations based on X-ray footage of *Varanus exanthematicus* show that this process acts as a heel, increasing the moment arm of M. peroneus longus about the ankle, and this was probably also true in basal archosaurs. In crocodylians and other advanced crurotarsan archosaurs, however, the calcaneal process is posterior, and associated with the gastrocnemii. The calcaneum is integrated into the pes, and most ankle movement occurs between the astragalus and calcaneum. Rotoscopic study of *Alligator* shows that the distal hind limb remains nearly parasagittal during movement, although knee rotation allows the femur to maintain a position of partial abduction. The combination of a parasagittal crus and a partly abducted femur may have characterized many extinct crurotarsans, although in some the entire limb was parasagittal.

Consideration of ankle structure in a phylogenetic context shows that the crurotarsan condition evolved in at least two stages. In *Euparkeria* and phytosaurs, the calcaneum was mobile with respect to the astragalus, but the heel was still posterolateral and the astragalocalcaneal joint was poorly developed. Subsequent evolution in derived crurotarsans involved reorientation of the heel, and division of the articular surface on the calcaneum into anterior and medial facets. Ornithosuchids possess a variant of the crurotarsan pattern in which this division is absent, and the astragalus is instead recessed to accommodate the calcaneum. Descriptions of ornithosuchid and advanced crurotarsan ankles as respectively crocodile-reversed and crocodile-normal are misleading, due to the basic similarities between the two types. However, it remains unclear whether one type represents a secondary modification of the other, or whether both evolved independently.

Thursday 2:00

DEVONIAN ACTINOPTERYGIAN PHYLOGENY AND EVOLUTION BASED ON A REDESCRIPTION OF *STEGOTRACHELUS FINLAYI*

SWARTZ, Brian, Berkeley, CA

Basal actinopterygian phylogeny is in a state of flux. Discoveries of new Devonian and Carboniferous taxa have not only contributed to our knowledge of these animals, but have also complicated our understanding of their interrelationships. The Early Devonian *Dialipina* has been described as the oldest articulated actinopterygian, however, the position of this taxon within the Actinopterygii remains contentious. With the exception of *Kentuckia hlavini* and *Stegotrachelus finlayi*, all articulated Devonian actinopterygian genera have been discovered or redescribed within the last thirty years. Although Gardiner (1963) re-examined the original specimens of *S. finlayi*, new material has been recently collected in 1973 and 2002. These new specimens contain additional skull roof, cheek, shoulder girdle, and postcranial data not included in the 1926 or 1963 descriptions of *Stegotrachelus*. This study seeks to synthesize information from original and new material to redescribe *S. finlayi*, and incorporate these data into a cladistic analysis that examines the interrelationships of Devonian actinopterygians. The inclusion of a hypothetical ancestor, *Dialipina*, and three Carboniferous taxa (*Melanecta*, *Wendyichthys*, and *Woodichthys*) are used to test the stability of phylogenetic results.

Two separate cladistic analyses 'reaffirm' the sister relationship of *Dialipina* with the Actinopterygii, although every character state corroborating this topology remains contentious. Four independent analyses yield a close relationship of *Limnomis* + *Cuneognathus* and *Howqualepis* + *Tegeolepis* among a new clade of Carboniferous-only taxa. The sister relationship of *Stegotrachelus* and *Moythomasia* emerges within a clade also including *Mimia* and *Krasnoyarchthys*. This topology supports a monophyletic *Stegotrachelidae*, expands the hypothesized relationship of *Krasnoyarchthys* and *Moythomasia*, and integrates the similarities shared by *Krasnoyarchthys* and *Stegotrachelus*. While this clade is not supported by a conclusively robust suite of synapomorphies, the inclusion of new taxa and characters in future phylogenetic analyses will test its status among Palaeozoic ray-finned fishes.

Poster Session II

REASSEMBLY OF BROKEN TERTIARY MAMMAL SPECIMENS FROM PIECES COLLECTED MORE THAN 20 YEARS APART

TABRUM, Alan, Carnegie Museum of Natural History, Pittsburgh, PA

Broken pieces of seven different Tertiary mammal specimens from three localities in southwestern Montana were collected between 20 and 48 years apart. These specimens retain tight contacts and exhibit little or no deterioration subsequent to initial breakage even after decades of exposure on or near the surface. In cases where pieces of the same specimen were collected by field parties from different institutions, locality information can occasionally be greatly enhanced. Fragmentary teeth of *Merychippus* collected from the Canyon Ferry Reservoir area by Earl Douglass in 1902, for which only general locality data were available, fit together with specimens collected by T. E. White's field party in 1950 which have relatively precise locality information. Under ideal conditions it is possible to pinpoint the site from which a specimen was collected by an earlier party to within a few feet, as in a maxilla fragment of *Hesperocyon gregarius* from the Cook Ranch Formation, part of which was collected by J. R. Hough's field party in 1953, and fits with a piece that I collected in 1977.

Poster Session I

EARLY PLEISTOCENE FOSSIL SNAKES (REPTILIA: SQUAMATA) FROM OKINAWA ISLAND, THE RYUKYU ISLANDS, SOUTHWESTERN JAPAN

TADAHIRO, Ikeda, HIROYUKI, Otsuka, Kagoshima Univ., Kagoshima City, Japan

Many vertebral remains of snakes associated with other vertebrate fossils were excavated from the Early Pleistocene lacustrine deposits (1.5±0.3 MyrBP) in Gogayama, Nakijin Village in Okinawa Island. This snake assemblage is the oldest record from the Ryukyu Islands until now. Therefore, those fossils are important specimens for discussing the origin of the snake fauna in the Ryukyu Islands. We analyzed 29 character states of the vertebral morphology from 54 extant species and subspecies of snakes of the Japanese Islands and Southeast Asia. From those character states of extant snake vertebrae, we identified the Early Pleistocene fossil snake vertebrae from Okinawa Island as *Cyclophiops* sp. (Colubridae), *Dinodon* sp. (Colubridae), *Protobothrops* sp. (Viperidae) and *Sinomicrurus* sp. (Elapidae). Distribution of genus *Cyclophiops* and *Protobothrops* indicate the possibility that Tokara Strait of the biogeographical boundary between the Oriental and Palearctic regions had been already formed during the Early Pleistocene. This theory is not contradictory to paleogeographical theories proposed by paleoenvironments, faunal change, and recent biogeography.

Saturday 4:15

ONE MAN'S TREASURE IS ANOTHER MAN'S TRASH: THE ROLE OF OLD GARBAGE TO IDENTIFY FOSSIL QUARRIES AND FIELD CAMPS IN ALBERTA, CANADA

TANKE, Darren, Royal Tyrrell Museum, Drumheller, AB, Canada

Early fossil collectors in Alberta were not environmentally conscious. Trash was commonly discarded in camp and quarry sites. Some was deliberately buried, covered by eroded sediments or through pedogenesis. Old newspaper, glassware, and other trash are now being

re-exposed as the sediments erode away. The interpretive value of this trash has been recognized and exploited. Many old dinosaur quarries in Dinosaur Provincial Park (DPP) are unidentified and the vintage of trash contained therein, coupled with other lines of evidence can be used to identify them. Newspaper pieces are identified, dated, and the place of publication linked to a specific museum (i.e. 1927 Toronto Star = 1927 ROM expedition). Trash buried to depths of 45 cm has also recently been discovered by use of metal detector. Besides producing some interesting human artifacts, fascinating details emerge regarding the personal habits of famous field workers long dead. Who would have guessed the AMNH's Peter Kaisen or Barnum Brown used ladies fancy cold cream in DPP c. 1912-1913?

Presently 29 lost or mystery DPP quarries (1914-1954) have been redocumented and the whereabouts of 18 field campsites (from 28 1910-1956 expeditions) located. Nearly 25% of all the 1954 and older DPP quarries have been found through this project. Relocation of camps is important as the pre-1921 crews, lacking motor vehicles, camped close to their quarries. Knowing where crews camped can lead to the discovery of a lost quarry, or at least suggest a smaller search area. Relocated quarries increase the scientific value of the specimen and especially its critical stratigraphic context. A case report, dealing with the discovery and eventual identification of a scientifically and historically important WWI *Centrosaurus* quarry will be presented.

Poster Session III

ENVIRONMENTAL CONTROLS ON LATEST TRIASSIC NONMARINE TETRAPOD TURNOVER

TANNER, Lawrence, Le Moyne College, Syracuse, NY; LUCAS, Spencer, New Mexico Museum of Natural History, Albuquerque, NM

Rather than one or two major tetrapod extinctions during the Late Triassic, as previously interpreted, the fossil record suggests that tetrapod turnover progressed in stages. The Norian and Rhaetian were characterized by decreasing diversity, primarily in central Pangea, as widespread aridification of the continental interior enforced heightened provinciality and adversely impacted communities that were dependent on aquatic environments or the disappearing *Dicroidium* flora. Consequently, the non-aquatic tetrapod fauna, particularly dinosaurs, increased their dominance over a broad area. Meanwhile, greater diversity was maintained in less-arid regions of northern and southern Pangea. While there is no evidence of a catastrophic tetrapod extinction at the Triassic-Jurassic boundary, the loss of many non-dinosaurian archosaurs, particularly primitive crurotarsans, is noted during and up to the end of the Rhaetian. This turnover coincides with environmental degradation caused by the prolonged CAMP eruptions, which began during the Rhaetian and lasted several million years. Stomatal frequency data from fossil plants are consistent with the widespread effects of outgassed SO₂, suggesting that atmospheric cooling by volcanogenic aerosols was an important consequence of the eruptions. Interestingly, in addition to dinosaurs, Upper Triassic tetrapods that continue to the Jurassic include documented endotherms such as pterosaurs, advanced cynodonts and mammals. We propose, therefore, that instead of super greenhouse warming, as generally accepted, end-Triassic tetrapod turnover was driven by an extended interval of volcanogenic aerosol-driven global cooling that favored survival of tetrapods with enhanced metabolisms, regardless of body size.

Friday 11:15

TESTING PALEOECOLOGICAL ASSUMPTIONS USING TAPHONOMIC DAMAGE PATTERNS OF SMALL-MAMMAL BONE ASSEMBLAGES AT HOMESTEAD CAVE, UTAH

TERRY, Rebecca, Univ. of Chicago, Chicago, IL

Shifts in the composition and structure of small-mammal communities have long been recognized as important sources of information on past environmental change as well as the ecological consequences of such change, particularly over the Holocene. Raptors are major contributors to the Holocene small-mammal subfossil record; creating death assemblages of their prey in localized masses of bone-rich pellets. These stratified pellet accumulations represent valuable archives; recording shifts in faunal composition over time-scales critical to conservation efforts (100's-1000's of years). Although shifts in small-mammal community composition through Holocene successions are typically assumed to have been environmentally driven, similar shifts can be generated by changes in the raptor taxa responsible for concentrating the remains. Correct interpretation of the impact of Holocene environmental change on small-mammal communities thus requires a solid understanding of the taphonomy of small-mammal death assemblages.

Here I test the assumption of constant raptor identity through the Holocene at Homestead Cave. Using ordination and discriminant function techniques, I show that assemblage-level skeletal damage patterns in modern pellet death assemblages can be used reliably to distinguish assemblages created by owls from those created by diurnal raptors and mammalian carnivores. The persistence of these skeletal damage patterns into stratified deposits in arid settings supports the use of sub-fossil damage patterns for raptor identification. By applying this multivariate approach to the stratified Holocene mammal record from Homestead Cave, I am able to examine the temporal concordance between shifts in assemblage-level damage patterns and shifts in the composition and structure of the local small-mammal community to test the assumption of constant raptor identity over the formational history of this record. Despite an observed diurnal to nocturnal switch in prey dominance, results suggest occupation of the cave by owls throughout the Holocene, indicating climatically-driven environmental change as the most likely driver of this trend.

Poster Session I

TAPHONOMY AND PALEOBIOLOGY OF CARNIVORES AND ARGALI FROM A MIDDLE PLEISTOCENE ASSEMBLAGE (CAUNE DE L'ARAGO, TAUTAVEL, FRANCE)

TESTU, Agnès, CNRS UMR 5198, Tautavel, France; RIVALS, Florent, Univ. of Hamburg, Hamburg, Germany

Observation of taphonomic details preserved on bone assemblages gives access to the paleobiological information lost during fossilization and of the paleoecology of the bone collector. An argali (*Ovis ammon antiqua*) assemblage from the Middle Pleistocene cave of the Caune de l'Arago (Tautavel, southern France) is studied in terms of taphonomy. The level analyzed is 550,000 years old. Previous observations leave no doubt that carnivores are responsible for this accumulation and non-selectively transported argali carcasses into the cave. The type of bones in articulation and the gnawing marks are characteristic of carnivores. Analytical study of this accumulation reveals hunting rather than scavenging as procurement mode of carcasses. This is consistent with the association of carnivores from these levels, where the hyena is absent, represented by ursids, and strict carnivores such as felids (lion cave, leopard with *uncia*-like features) and canids (wolf), whose body size and food habits are compatible with argali as game. The hypothesis tested consists in defining the species involved in this process. A similar association can be observed today in the Himalayan Mountains. In addition, the topography of the site (plateau, cliffs), as well as the climatic conditions (cold and dry) contemporaneous to the deposit of these levels favored such an association. This unique assemblage provides relevant elements for interspecific competition between carnivores, in southern Europe, during the lower middle Pleistocene.

Poster Session III

DARWINCOPE, A PALEONTOLOGICAL EXTENSION FOR THE DARWINCORE 2 DISTRIBUTED DATABASE SCHEMA

THEODOR, Jessica, Univ. of Calgary, Calgary, AB, Canada

DarwinCoPE (DarwinCore Paleontology Extension) is a proposed draft extension of the DarwinCore 2 XML schema (<http://darwincore.calacademy.org>), to provide the specialized data for geologic time and lithology needed to search fossil collections. The DarwinCore schema forms the basis of the DIGIR distributed database protocol (<http://www.digir.net>). DIGIR is used by a number of data portals, such as MANIS (mammals), ORNIS (birds), HerpNet (amphibians and reptiles) and Fishnet (fishes) to retrieve collection records from multiple museum collections.

DarwinCoPE was developed at an NSF-sponsored Paleontology Collections Databases meeting held at the Illinois State Museum in May 2005, as a draft for a community standard. It is very similar to the schema used by the PaleoPortal project, and is compatible with the proposed European schema, ABCDEFG, used in GeoCASE (http://projects.naturkundemuseum-berlin.de/synthesys_activity_d/). DarwinCoPE has been proposed to the Taxonomic Databases Working Group (<http://www.tdwg.org>) as a draft standard extension to DarwinCore 2. As a standard extension to DarwinCore 2 DarwinCoPE would allow collections database developers a standard interface that would allow collections managers to make their collections data more easily and widely available over the web.

DarwinCoPE includes fields for geologic time units, biostratigraphic zonations, and lithostratigraphic units, which, when combined with field from DarwinCore 2.0 and the Geospatial and Curatorial extensions, should allow more widespread adoption of the DIGIR protocol for creating distributed databases among paleontological collections.

Saturday 3:30

MY THEROPOD IS BIGGER THAN YOURS OR NOT: ESTIMATING THEROPOD BODY SIZE FROM SKULL LENGTH

THERRIEN, Francois, HENDERSON, Donald, Royal Tyrrell Museum of Palaeontology, Drumheller, AB, Canada

Most large theropods are known from incomplete skeletal remains, often only by a skull, which gives free course to the imagination when it comes to estimate the body length and body mass of the "largest terrestrial predators." Unfortunately, most body size estimate methods require a degree of mathematical prowess that prevents widespread application. To develop a simpler method to estimate body size, the scaling relationship between skull length, body length, and body mass was investigated using 14 strictly carnivorous, non-avian theropod taxa ranging in size from the 1-m *Sinosauropteryx prima* to the 12-m *Tyrannosaurus rex*. Body length was obtained from the literature for complete to nearly-complete specimens and body mass was obtained through 3D mathematical slicing of those same specimens to ensure accurate body length-body mass associations. Least-square regressions on logarithmic plots reveal a tight correlation between skull length and body length ($R^2=0.98$, %SEE=11.6%, %PE=9.3%) and skull length and body mass ($R^2=0.99$, %SEE=34.4%, %PE=22.1%). The skull length/body length regression (SK-BL) is negatively allometric (slope < 1), which indicates that skulls become longer relative to body length with increasing body size. In contrast, the skull length/body mass regression (SK-BM) is positively allometric (slope > 3), indicating that body mass increases faster than skull length with increasing body size. These conclusions confirm that the common practice of scaling isometrically smaller relatives of a given taxon to obtain body length and body mass estimates is not valid.

To test the validity of SK-BL, it was applied to taxa of known body length that were not previously used in the regression. Although the body length of abelisaurids was underestimated, indicating that these theropods have short heads relative to body size, SK-BL pre-

dicts body lengths very close to published values for more "typical" theropods (e.g., *Sinraptor* 7.15 m, *Velociraptor* 2.12 m), which confirms its validity. Body size estimates for *Carcharodontosaurus*, *Giganotosaurus*, and *Spinosaurus*, approaching 13 m and 14 tonnes, suggest that they may have surpassed *Tyrannosaurus* in size.

Vertebrate Development Symposium, Wednesday 11:45

DEVELOPMENTAL CONSTRAINTS ON EVOLUTION: THE CETACEAN BODY-PLAN

THEWISSEN, J.G.M., COOPER, Lisa, Northeastern Ohio Universities College of Medicine, Rootstown, OH

The rapidly growing field of Evolutionary Developmental Biology is elucidating the mechanistic link between gene control of development, embryology, and adult morphology. It has been shown that some dramatic morphological differences in adult morphology are underlain by a mechanism that includes relatively minor changes in gene control of development in early embryology: a possible mechanism for macroevolution. Such changes in gene expression may be pleiotropic: they influence the adult morphology of many, disparate body parts.

The cetacean body plan includes a number of features that are unusual among mammals: modern cetaceans are edentulous or polydont, hyperphalangeous, lack hind limbs and (nearly all) hair, and have a fluke and dorsal fin. Study of cetacean embryos can thus be used to test both the hypotheses of the role of control genes in macroevolution and that of the pleiotropic effects of these control genes.

Interestingly, teeth, baleen, forelimbs, hind limbs, hair, dorsal fin and fluke all form at the interface between ectodermal epithelium and underlying mesodermal mesenchyme. Interactions between these tissues during organ formation are controlled by a genetic toolkit that includes many of the same genes in spite of the very different end organs formed. Studying the development of these organs forms a robust test of the developmental control gene hypothesis, and, combining the results of these studies, the pleiotropy hypothesis can also be tested. The fossil record provides a necessary control on the timing of origin of some of these organs.

Thursday 1:30

ACTINOPTERYGIAN FISHES ACROSS THE PERMO/TRIASSIC BOUNDARY

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Though Early Triassic actinopterygian fishes are rather well represented all over the coastal seas around Pangea, very few records are known around the P/Tr boundary. Most of the Early Triassic faunas is Olenekian in age and shows a more or less homogeneous composition, based on about a dozen actinopterygian genera. Basalmost Triassic fish faunas are still unknown, but specimens with different state of preservation are recorded from northern Italy (Dolomites) and western Australia. In the Dolomites, both above and below the P/Tr boundary, isolate remains (tooth bearing plates) were found: they had been wrongly ascribed to the semionotid *Paralepidodus*, a Late Triassic genus, but they can be better interpreted as pharingel teeth of *Bobasatrania*, the only genus so far known both below and above the P/Tr boundary. In Australia several scattered specimens of the same genus had been found (in a drill core) just above the P/Tr boundary. It must be stressed, however, that stout teeth are much easier to be preserved. *Bobasatrania*, a deep-bodied, laterally compressed form, is generally well represented in Wapiti Lake (BC, Canada) Madagascar and Greenland Olenekian fish faunas, but it is apparently absent from the Guizhou Province (southern China) coeval ones. Body shape and dentition point to an uneven bottom dweller feeding on rather hard shelled benthic prey. Concerning size, inferred length for the Dolomites specimens is at least 25 cm, but this genus could reach 1 m. Just above the P/Tr boundary from the same Dolomites area comes an almost complete specimen, not revised yet, determined as *Archaeolepidodus leonardii*, showing again quite stout teeth, even if it could not be considered as strictly durophagous. The presence of fishes with similar dentition seems to contrast with the poor bottom environment characterizing the P/Tr boundary, when most of benthic organisms almost disappeared. Also, it must be pointed out that a widespread durophagy in actinopterygians was achieved only in the Norian, thus more than 25 m.y. after the P/Tr crisis.

Poster Session III

THIRTY-THREE YEARS AFTER VINCENT MAGLIO: A NEW LOOK AT THE ORIGIN AND EVOLUTION OF THE ELEPHANTIDAE

TODD, Nancy, Manhattanville College, Purchase, NY

In 1973, Vincent Maglio published a seminal monograph on the evolution of the Elephantidae. In Maglio's phylogeny, 3 lineages of elephants, *Loxodonta*, *Elephas* and *Mammuthus*, evolved from *Primelephas* in Africa, approximately 6 Ma. *Loxodonta* never left Africa, with all species going extinct except for the modern African elephant. The *Elephas* lineage also ultimately goes extinct in Africa, but at least 1 migration event occurred in the early Pliocene, out of Africa to Eurasia, where it diversified and underwent a major adaptive radiation, leaving only 1 species alive at the end of the Pleistocene (*Elephas maximus*).

Mammuthus also goes extinct in Africa ~2 Ma, but also migrated out in the early Pliocene. Beden (1979) further revised the African species only, delineating subspecies of *Elephas recki* and *Loxodonta adaurora*, and suggesting *Stegotetrabelodon* as a possible ancestor of *Loxodonta*. With addition of new specimens and species, and revisions of

chronology and morphology evident in recent publications, a new analysis of the phylogeny and systematics of this family is warranted.

New cladistic and morphological analysis indicates many interesting relationships, and offers new insight into the evolution and paleogeography of this family. In this analysis, early *Loxodonta* and early African *Mammuthus* are virtually indistinguishable in dental morphology. The *Elephas* lineage is polyphyletic, breaking into 3 intriguing clades, which may correlate to 3 possible migration events to Eurasia: an event ~2.5 ma leading from early *Elephas recki* to *Elephas namadicus*, and possibly to some of the Mediterranean dwarf *Elephas*; an event ~2 ma leading from late *Elephas recki* to *Elephas hysudricus* (including *Loxodonta atlantica*), and possibly to other species of dwarfed *Elephas*; and a much later, third event leading to *Elephas antiquus* and *Elephas maximus*. These new results suggest a much more complex picture of elephantid origins, evolution and paleogeography.

Poster Session I

ENAMEL MICROWEAR OF MODERN CAVIOMORPH RODENTS AND DIETARY INTERPRETATION FOR THE SANTACRUCIAN RODENT *NEOREOMYS*

TOWNSEND, Kathryn, CROFT, Darin, Case Western Reserve Univ., Cleveland, OH
Modern caviomorph rodents are a spectacular example of adaptive radiation; they are unlike most other rodents in many respects and various species have been compared to deer, hyraxes, pygmy hippos, and rabbits. Despite this diversity, no study has examined morphological correlates of diet in the group as a whole. This lack of functional dietary information has precluded rigorous interpretations of caviomorph paleodiets, and thus the diets of extinct taxa are virtually unknown.

In this study, we examined the relationship between enamel microwear and diet in modern caviomorphs with the goal of interpreting the diet of the early Miocene rodent *Neoreomys*. A comparative dataset of nine microwear variables was compiled for 12 modern caviomorph taxa (87 specimens total). This dataset was used to construct a discriminant model of three broad dietary categories: fruit/seed, grass/leaf, and fruit/leaf consumers. The discriminant model resulted in 100% correct dietary classification of modern caviomorphs based on enamel microwear characteristics; gouges, large pits, and scratches were found to be most useful in characterizing diets. The model classified *Neoreomys* (N=6) as a fruit/leaf consumer, but with a low probability. The microwear profile of *Neoreomys* is characterized by low frequencies of gouges, large pits, and puncture pits, and low scratch counts, suggestive of soft fruit feeding. Unlike other "dasyproctids," which are known to consume seeds and fruits with tough pericarps, *Neoreomys* does not exhibit microwear consistent with hard fruit feeding. It also does not exhibit numerous scratches indicative of grazing.

Rodents are common in most Tertiary South American faunas and detailed paleobiological reconstructions of these animals are necessary for precise paleoecological analyses. Our initial investigations suggest that enamel microwear is a sound method for inferring diet among caviomorphs and that wider application of this method will significantly clarify trophic relationships among extinct South American herbivores.

Wednesday 3:30

ORIGIN AND COMPLETENESS OF THE PENGUIN FOSSIL RECORD

TRICHE, Nina, Austin, TX

Penguins (Aves, Spheniscidae) have what is arguably the best fossil record of any extant bird lineage. The current oldest known specimen dates from the late Early Paleocene (about 62mya) and the 40 or so remaining fossil species are known from nearly every geologic stage after this. The preservation potential of penguins is excellent, considering their lack of skeletal pneumaticity, near-shore aquatic environment, and nesting behavior (where most extant species group in huge colonies during the majority of the year). The abundance and distribution of fossil remains are large, occurring as thousands of bones in some locations and covering the entire geographic distribution of extant taxa. This, however, is the first quantitative analysis of the quality of the penguin fossil record and of the estimated timing of origin of the Spheniscidae based on fossil data.

The three most common tests of relative completeness of a fossil record (Relative Completeness Index (RCI), Stratigraphical Consistency Index (SCI), and Gap Excess Ratio (GER)) are applied here to the record of penguins, allowing evaluation of the correlation of the penguin tree to its stratigraphic occurrence, and of the proportion of ghost lineages that are unrepresented in this record. Also, confidence intervals are calculated from the penguin record to propose a divergence time for the clade; this divergence lies well before the Cretaceous/Tertiary extinction. Recent molecular estimates for the origin of the crown-Spheniscidae lie in the Eocene, suggesting that penguin stem-groups originated prior to the K/T boundary and diversified during the Paleocene, prior to crown-group evolution. The relative completeness of the penguin record supports the use of these data in future comparative studies and strengthens the contention that the fossil avian record is not actually as poor as previously thought.

Poster Session III

OXFORDIAN PARK: U/PB AGES FROM SHRIMP ANALYSIS FOR THE UPPER JURASSIC MORRISON FORMATION OF SOUTHEASTERN WYOMING WITH IMPLICATIONS FOR BIOSTRATIGRAPHIC CORRELATIONS

TRUJILLO, Kelli, CHAMBERLAIN, Kevin, The Univ. of Wyoming, Laramie, WY; STRICKLAND, Ariel, Stanford Univ., Stanford, CA

The Morrison Formation of the western interior of North America previously has been radiometrically dated using many different methods, most commonly K-Ar and Ar-Ar. These methods have yielded a range of ages from 154.87±0.52 Ma (Ar-Ar on sanidine from the Tidwell Mbr.) to 134 Ma (K-Ar on biotite from the Brushy Basin Mbr.). All but one of these dates comes from western parts of the depositional area. In preliminary work to determine the utility of U/Pb dating for the Morrison Fm. as well as to understand the zircon population of the Morrison Fm. in southeastern Wyoming, we performed U/Pb SHRIMP analyses of single zircon crystals separated from a smectitic mudstone collected from the upper third of the formation exposed at Ninemile Hill near Medicine Bow. The sample locality is at the same stratigraphic level as three microvertebrate quarries, most notably Quarry Nine at Como Bluff. Analyses of 8 individual, euhedral zircons, including shapes commonly associated with ash-falls, yielded a weighted mean ²⁰⁶Pb/²³⁸U date of 156.3 ± 2 Ma. We interpret this as the age of the ashfall component of the smectite. Additional SHRIMP dates document detrital components with ages of 297, 433, 1087 and 1150 Ma. This result is at least 10 m.y. older than previous estimates based on biostratigraphic correlations. We envision two endmember possibilities: either the zircons were reworked from sources farther west, and so do not give the age of deposition of the Wyoming strata, or deposition began earlier than previously assumed in eastern parts of the formation. As the euhedral, 156 Ma zircons are the dominant zircon population, however, the first scenario would imply little or no primary volcanic input to the Morrison Fm. in Wyoming, which seems unlikely. Our favored interpretation is that 156 Ma represents the depositional age. This interpretation challenges previous stratigraphic correlations and has implications for the ages of the ecosystems of the Morrison Fm. in southeastern Wyoming as well as faunal and floral associations worldwide that are thought to be contemporaneous with those of the Morrison Fm.

Thursday 2:30

PALEOBIOGEOGRAPHY OF THE GENUS *HYAENICTITHERIUM* *KRETZOI* (CARNIVORA, HYAENIDAE) AND THE FIRST RECORD OF *H. HYAENOIDES* ZDANSKY IN INNER MONGOLIA

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The genus *Hyaenictitherium* represents a transitional form between the mixed feeding icthiheres and the more specialized hyaenines, exemplified by the spotted hyena. The morphological trend towards more robust premolars and overall increase in body size of *Hyaenictitherium* set the stage for subsequent diversification into two clades. One clade includes the bone-cracking taxa; the other includes the highly cursorial, hunting dog-like chasmaporthetine affinities. Here we review the spatial and temporal distribution of species of *Hyaenictitherium*. In addition, we report an important new record of *H. hyaenoides* in the Baogeda Ula Formation of Inner Mongolia, representing the eastern-most known occurrence of the genus. The new record also represents one of the few eastern Asian localities associated with capping basalt, which in conjunction with the small mammal fauna constrains the age of Baogeda Ula at 8-7 Ma. The occurrence of *Hyaenictitherium* spans the late Miocene to the late Pliocene, with highest number of localities during the later late Miocene. The genus is found in Eurasia from Spain in the west to China in the east and in Africa from Morocco in the north to South Africa. In Eurasia, the genus was widespread by MN9 (NMU8) in the mid-latitudes. It was not until ~7 Ma (MN12/13) that species of *Hyaenictitherium* were found in the northern and southern latitudes of Eurasia, and into Africa. Furthermore, we propose two distinct clades within the genus, one composed of the more ancestral *H. intuberculatum* and *H. minimum* clade, and the other composed of the rest of the genus, with *H. wongii* as the most ancestral. The two clades seem to have diverged by the first occurrence of the genus in MN9, before *Hyaenictitherium* migrated into Africa. Therefore, the clades probably migrated to Africa independently. Spatial morphological trends support an easterly migration route into Africa. The genus persisted until the latest Miocene in Europe, and early Pliocene in Asia. The last record of the genus is represented by *H. ? barbarum* in the late Pliocene of Morocco.

Poster Session II

PALEOGENE ANTHRACOTHERIID AND PRIMITIVE RHINOCEROTOID MAMMALS FROM THE KOBE GROUP OF JAPAN AND THE AGE OF THE KOBE GROUP

TSUBAMOTO, Takehisa, Hayashibara Center for Paleobiological Research, Okayama, Japan; MATSUBARA, Takashi, Museum of Nature and Human Activities, Hyogo, Sanda, Japan; SAEGUSA, Haruo, Himeji Institute of Technology / Museum of Nature and Human Activities, Hyogo, Sanda, Japan; TANAKA, Satoshi, Kyoto Univ. of Education, Kyoto, Japan

We report two new fossil dental specimens of Paleogene terrestrial mammals discovered from the Yokawa Formation of the Kobe Group at the Sanda basin, Hyogo Prefecture, western Japan. The two mammalian fossils reported here are lower dentitions of a selenodont anthracotheriid artiodactyl and a primitive rhinocerotoid perissodactyl. The anthracotheriid fossil consists of a right mandibular fragment with p2-m3 and is morphologically most similar to *Bothriodon advena* from the upper Eocene of Canada in having buccolingually very compressed and lingually very concave lower premolars. The primitive rhinocerotoid fossil consists of right m1-3 and can be referable to *Hyrachyus* in having similar molar size, low crowned dentition, and moderately-developed molar cristid obliqua and paracristid and in lacking m3 hypoconulid. Besides, in the Yokawa Formation, a *Zaisanamynodon*-like amynodontid perissodactyl have been previously reported.

The Kobe Group had traditionally been correlated to the Miocene based on plant, molluscan, and benthic foraminiferan fossils. However, recent studies of radiometric ages and marine invertebrate fossils have suggested an upper Paleogene correlation for the group. The three fossil mammals reported from the Yokawa Formation of the Kobe Group are *Bothriodon advena*-like, *Hyrachyus*-like, and *Zaisanamynodon*-like mammals. *B. advena* and *Zaisanamynodon* are indicative of the late Eocene; on the other hand, *Hyrachyus* is indicative of the early to middle Eocene. Therefore, based on mammalian fossils, the Yokawa Formation of the Kobe Group is most probably correlated to the uppermost middle Eocene or lowermost upper Eocene (around the Bartonian-Priabonian boundary: ca. 37 Ma). This correlation is consistent with the correlation of the Kobe Group based on recent studies of radiometric ages and marine invertebrate fossils, and denies the traditional Miocene correlation.

Poster Session I

INFERENCE OF MUSCLE AND LIGAMENT ANATOMY IN THE CERVICAL REGION OF DIPLODOCID SAUROPODS USING THE EXTANT PHYLOGENETIC BRACKET

TSUIHJI, Takanobu, Ohio Univ., Athens, OH; PARRISH, J., Northern Illinois Univ., DeKalb, IL

Because of their great size, sauropod dinosaurs tend to bear prominent osteological correlates (e.g., scars and processes) of attachment sites of muscles and ligaments on their skeletons, thus serving as good test cases for the Extant Phylogenetic Bracket approach for reconstructing soft tissue anatomy. We used this approach to infer the anatomy of the axial musculature and spinal ligaments in the cervical region of diplodocid sauropods. The origins and insertions of homologous cervical muscles are topologically very similar between extant crocodylians and birds, enabling a safe inference on positions of such attachments in sauropod skeletons. In diplodocids such as *Diplodocus* and *Apatosaurus*, attachments of tendons of m. spinalis, m. longissimus, and m. iliocostalis can be recognized as prominences bearing scars. In extant archosaurs, the anterolateral aspect of the prezygapophysis is the shared origin of m. longissimus and m. tendinoarticularis, or their homologs. In diplodocids, this area is marked by a prominent process, which is especially robust and projects anteriorly in *Barosaurus*, suggesting that these muscles may have been well-developed in these sauropods. A positional shift of the osteological correlate for the attachment of the m. semispinalis tendon is observed near the cervico-dorsal boundary in a specimen of *Diplodocus*, suggesting that this tendon probably changed its attachment near the cervico-dorsal boundary in diplodocids as it does in extant archosaurs.

As previously described, a well-developed prominence is present in the notch between metapophyses of each cervical vertebra in these dinosaurs, marking an attachment site of a ligament. In *Diplodocus* and *Apatosaurus*, this prominence tends to project posterodorsally, likely indicating the direction in which a branch of a long ligament would have inserted there as previously hypothesized. In *Barosaurus*, however, the attachment site is marked with strong, longitudinal striations in the notch or on the medial surface of the metapophysis, suggesting that the spinal ligament of this dinosaur may have had a configuration that is different from those in other diplodocids.

Poster Session II

A REEXAMINATION OF *PARASAUROUS GEINITZI* (AMNIOTA: PARAREPTILIA); THE FIRST PAREIASAUR

TSUJI, Linda, MUELLER, Johannes, Humboldt-Universität zu Berlin, Museum für Naturkunde, Berlin, Germany

Parasaurus geinitzi von Mayer, 1857 from the Late Permian Kupferschiefer deposits of Germany was the first pareiasaur ever named. Whereas all other pareiasaurs have been named and studied since that time, these first specimens have not been reexamined, making this taxon problematic in terms of both identification and systematics. Other fragmentary material has subsequently been assigned to the species including a partial skull, on the basis of which *Parasaurus* is believed to be a derived pareiasaur closely related to *Elginia*, the only other Western European taxon. This skull was assigned to *Parasaurus* because it is the lone pareiasaur found in the Kupferschiefer localities. However, there is no common anatomical material linking the type with the cranium.

An examination of the original type material for the first time since its initial description has interesting implications for the taxonomy of the group. The presence of four to five sacral ribs combined with the swollen neural arches of the dorsal vertebrae allow the recognition of the postcranial remains as pareiasaurian, however examination of the lectotype specimen of *Parasaurus* reveals no autapomorphic features that can positively identify this material as a distinct taxon.

The skull of *Parasaurus* is very small for a pareiasaur, and was assigned to the Pareiasauridae primarily on the presence of distinctive multicusped teeth. The teeth are labio-lingually compressed, fan shaped, and possess approximately 7-9 cusps. Many of the cranial sutures are difficult to interpret due to the unfavorable condition of the specimen, but other than the characteristic teeth, there is little to definitively classify this animal as pareiasaurian. The odd placement of the large tabulars on the posterolateral corner of the skull table and the unornamented ventral edge of the quadratojugal could also support identification of the specimen as a parareptilian rhipaosaurid, which are also known to have multicusped teeth. Little detailed information is available concerning this enigmatic group, however, and more taxonomic and anatomical study is necessary to fully explore this possibility.

Poster Session I

ON THE OCCURRENCE OF FIBROLAMELLAR BONE IN ALLIGATOR

TUMARKIN-DERATZIAN, Allison, Vassar College, Poughkeepsie, NY

The histology of modern crocodylians is typically characterized by zonal bone, in which regions of active growth (zones) alternate with regions of slowed growth (annuli) and lines of arrested growth (LAGs). Zones generally consist of a slow-growing lamellar or parallel-fibered (pseudolamellar) bone tissue. There are few references to the presence of rapidly growing woven or fibrolamellar bone (FLB) in modern crocodylians. The examples given are most often captive animals raised under artificially ideal environmental conditions (high ambient temperature, excellent nutrition, etc.). The implication is that only under artificial conditions are individuals able to sustain the high growth rates associated with the formation of FLB, and that in the wild crocodylians grow at a slower "normal" rate. Moreover, it is generally maintained that FLB can be formed only by juveniles or early in ontogeny when growth is most rapid.

Histological examination of long bones of wild American alligators from central Florida reveals weakly defined growth zones and extensive FLB formation in some individuals, including adults. The occurrence of FLB in these animals suggests that the high growth rates needed for formation of this bone tissue are not confined solely to juvenile and captive alligators, as has been widely supposed in the literature. It is possible that occurrences of FLB are more common in modern crocodylians than has heretofore been appreciated. This has significant implications for understanding growth in modern crocodylians, as well as for studies of growth patterns in fossil archosaur taxa, since the latter often draw heavily on modern crocodylian mode

Poster Session II

RESOLVING DROMAEOSAURID PHYLOGENY: NEW INFORMATION AND ADDITIONS TO THE TREE

TURNER, Alan, American Museum of Natural History, New York, NY; POL, Diego, Conicet, Museo Paleontológico Egidio Feruglio, Trelew, Argentina; NORELL, Mark, American Museum of Natural History, New York, NY; HWANG, Sunny, New York College of Osteopathic Medicine, Old Westbury, NY

In the last few years, the number of described dromaeosaurids has increased from six to more than 18 putative taxa. Resolving the interrelationships among these theropods has proven problematic. The first known dromaeosaurids (*Deinonychus*, *Velociraptor*, *Dromaeosaurus*) are morphologically similar. The recently discovered small-bodied, avian-like taxa *Microraptor*, *Sinornithosaurus*, and *Buitreraptor*, along with putative dromaeosaurids previously thought to be avialans (*Unenlagia* and *Rahonavis*), greatly increase the range of morphological variation within the Dromaeosauridae and alter what may be reconstructed as the basal conditions for dromaeosaurids.

Here we describe three new dromaeosaurid taxa. These taxa were collected from the Upper Cretaceous Djadokhta Formation in Ukhaa Tolgod and Tugrugyin Shireh as well as the Lower Cretaceous Öösh deposits in Baykhangor Mongolia by joint Mongolian Academy of Sciences-American Museum of Natural History expeditions. Respectively, these taxa comprise a complete well-preserved skull and cervical series; a partial cranium and well preserved postcranium; and a partial rostrum and mandible. This material, coupled with CT imagery of the Ukhaa Tolgod skull expands our understanding of dromaeosaurid anatomy and morphological variation.

These specimens offer new information to explore the phylogenetic relationships within Dromaeosauridae and provide an opportunity to expand both taxonomic and character sampling within a broad sample of coelurosaurian dinosaurs. Preliminary phylogenetic analysis indicates the presence of at least three distinct dromaeosaurid clades. The Ukhaa Tolgod specimen is found closely related to the contemporaneous *Velociraptor mongoliensis*, while the other two taxa occupy more basal positions.

Preparators Symposium, Thursday 8:15

RELOCATION OF NEW FOSSIL DEPOSITS AT THE RANCHOLABREAN TYPE LOCALITY, LOS ANGELES, CALIFORNIA

TURNER, Robin, ArchaeoPaleo Resource Mgmt Inc, Venice, CA; HARRIS, John, SHAW, Christopher, George C. Page Museum, Los Angeles, CA

The Mexican land grant of Rancho La Brea received its name from the asphalt seeps in its southwest corner that became the type locality for the late Pleistocene RanchoLabrean Land Mammal Age. The remnants of the Rancho La Brea tar pits, including the ongoing Pit 91 excavation, may be viewed in the now extensively landscaped Hancock Park in the Miracle Mile district of Los Angeles but opportunities to find and exploit new fossil deposits at this locality occur only rarely. The last two major deposits discovered in Hancock Park were those found during the construction of the Page Museum in 1975 and of the Japanese Pavilion of Art for the Los Angeles County Museum of Art (LACMA) in 1986.

Construction of LACMA's new underground parking structure adjacent to the west edge of Hancock Park, beginning in February 2005 and monitored by ArchaeoPaleo Resource Management staff, uncovered at least five fossiliferous asphaltic accumulations at varying depths below ground surface. The construction schedule did not permit detailed in situ excavation of these localities and inclement weather plus the size of the deposits precluded their being jacketed in segments as took place with the Page Museum salvage operation. Representative samples of plant and insect remains were obtained from the periphery of each deposit. Then each bone bed was delineated, wrapped in plastic, and encased in the kind of wooden container used by landscapers for relocating large trees. Voids between

the edge of the deposit and the enclosing box were filled with expanded polyurethane foam. Each deposit was then relocated by crane to a corner of the excavation site that was not affected by the ongoing construction. Relocation of the entire deposit permitted more thorough investigation of its stratigraphy and taphonomy than would have been possible had the deposit been salvaged in situ.

Poster Session I

THE DIET OF SAUROPOD DINOSAURS—CARBON ISOTOPE COMPOSITIONS OF FOSSIL BONES AND POTENTIAL FOOD PLANTS

TÜTKEN, Thomas, Institut für Geowissenschaften, Universität Tübingen, Tübingen, Germany; HUMMEL, Jürgen, Institut für Tiervissenschaften, Universität Bonn, Bonn, Germany; SANDER, Martin, Institut für Paläontologie, Universität Bonn, Bonn, Germany. Sauropod dinosaurs were the largest living land vertebrates. As megaherbivores they played an important role in terrestrial Jurassic ecosystems with a gymnosperm-pteridophyte flora. Differences in sauropod skeletal and dental morphology, tooth wear, neck length and biomechanics indicate different feeding strategies.

The bone carbon isotope composition ($\delta^{13}\text{C}$) of sympatric sauropod taxa (*Apatosaurus*, *Diplodocus*, *Barosaurus*, *Brachiosaurus*, *Camarasaurus*), mostly from the Upper Jurassic Morrison Formation and Tendaguru beds, was analysed to investigate their niche partitioning and feeding behaviour. $\delta^{13}\text{C}$ values from leaf samples of modern gymnosperms (e.g., araucaria, ginkgo, cycads) and ferns were analyzed to infer potential sauropod food plants.

Apatite $\delta^{13}\text{C}$ values of bones and teeth are related to that of the animals' diet. The diet-skeletal apatite offset is known for large herbivorous mammals (~14%) and birds (~16%); however, it might be different for dinosaurs. $\delta^{13}\text{C}$ values of the sauropod bones range from -5.5 to -10.9%. Differences between average bone $\delta^{13}\text{C}$ values of some sauropod taxa might indicate the ingestion of isotopically distinct food plants. However, bone is liable for diagenetic alteration, which must be monitored. If the bone $\delta^{13}\text{C}$ values are not significantly altered and the bird diet-apatite offset is valid for non-avian sauropod dinosaurs, $\delta^{13}\text{C}_{\text{diet}}$ values of -21.5 to -26.9‰ can be calculated. These values are similar to those measured for gymnosperm and fern leaves ($\delta^{13}\text{C} = -21.9$ to -36.4‰, $n = 180$), which cover a range typical for terrestrial C_3 plants. Plant $\delta^{13}\text{C}$ values can vary due to photosynthetic pathway, tissue-type, plant species, $\delta^{13}\text{C}_{\text{CO}_2}$ value and/or environmental factors. Niche partitioning and preferred feeding of sauropods on cycads (-26%), conifers (-27%), and/or ferns (-29.5%) with different mean $\delta^{13}\text{C}$ values can explain differences in their bone $\delta^{13}\text{C}$ values.

In general sauropods fed exclusively on terrestrial C_3 plants, most likely conifers such as araucaria with high nutritional value, though feeding on CAM plants can not be excluded. However, the consumption of plants with high $\delta^{13}\text{C}$ values such as C_4 or marine plants seems unlikely.

Neoceti Symposium, Saturday 8:00

BIOGEOGRAPHIC AND TEMPORAL ORIGIN OF NEOCETI

UHEN, Mark, Cranbrook Institute of Science, Bloomfield Hills, AK. Basilosaurid archaeocetes are known from all continents except Antarctica (reported specimens from Antarctica are probably mysticetes), and Australia (basilosaurids are known from New Zealand). Fossils of basilosaurids are found in shallow marine deposits, and are abundant in Zeuglodon Valley, Egypt, the Gulf Coast of the US, and in the newly discovered Archaeocete Valley in Peru. Archaeocetes were thought to have gone extinct at the end of the Eocene, but recent discoveries from New Zealand show that they persist until the late Oligocene.

The earliest representative of the Neoceti is *Llanocetus* from the Eocene/Oligocene boundary in the La Meseta Formation, Seymour Island, Antarctica. What is known of this animal is similar to basilosaurids. Other mysticetes have been noted from the early Oligocene, but they are poorly known or their ages are poorly constrained. Mysticetes diversify in the late Oligocene, when both toothed and toothless forms are known from several continents in both hemispheres.

There are several reports of early Oligocene odontocetes, but they are poorly known or their ages are poorly constrained. Late Oligocene odontocetes are known from several continents in both hemispheres. Areas that have produced abundant fossils include the Pacific Northwest of North America, Japan, New Zealand, southeastern Australia, and South Carolina.

The archaeocete currently thought to be most closely related to Neoceti is *Chrysocetus* from South Carolina. *Llanocetus* is the most basal mysticete known and *Archaeodelphis*, *Xenorophus*, and *Agorophius* are near the base of the odontocete clade. Given that *Chrysocetus* is from North America, *Llanocetus* is from Antarctica, and the basal odontocetes are from North America, the most parsimonious reconstruction of the time and place of origin of Neoceti is in the latest Eocene of North America. Archaeocetes from the late Oligocene of New Zealand may represent a refugium for archaeocetes given the duration and intensity of collecting that has occurred in the Oligocene of North America.

Poster Session I

ESTIMATION OF DIETARY AND HABITAT PREFERENCES OF *DESMOSTYLUS* AND *PALEOPARADOXIA* BASED ON CARBON AND OXYGEN STABLE ISOTOPE AND TRACE ELEMENT ANALYSES

UNO, Hikaru, National Institute for Environmental Studies, Japan, Tsukuba, Japan; YONEDA, Minoru, Univ. of Tokyo, Graduate School of Frontier Sciences, Kashiwa, Japan; TARU, Hajime, Kanagawa Prefectural Museum of Natural History, Odawara, Japan; KOHNO, Naoki, National Science Museum, Japan, Shinjuku, Japan

Desmostylus and *Paleoparadoxia* often occur at the shore of the North Pacific Ocean in the late middle Miocene. We measured the carbon and oxygen isotope compositions ($\delta^{13}\text{C}$ and $\delta^{18}\text{O}$) and the ratios of trace elements (Sr/Ca and Ba/Ca) of the *Desmostylus* and *Paleoparadoxia* teeth, which are excavated from a same locality in Hokkaido, Japan. The carbon and oxygen isotopes of mammal body correlate with the diet and ambient water, respectively, and the trace element ratios (Sr/Ca and Ba/Ca) reflect a relative position in trophic level. The carbon and oxygen isotopes of *Desmostylus* are significantly different from those of *Paleoparadoxia*. The trace element ratios (Sr/Ca and Ba/Ca) show a difference between the two taxa, the ratio of *Desmostylus* is apparently lower than that of *Paleoparadoxia*. These results may reveal that *Desmostylus* and *Paleoparadoxia* share a nearly same habitat under an effect of freshwater on the basis of the value and variation of $\delta^{18}\text{O}$, but that they have distinct dietary preferences; *Desmostylus* may have a tendency to be an omnivore in comparison with *Paleoparadoxia* based on the values of the $\delta^{13}\text{C}$ and ratios of trace element. These data cannot clearly decide their diets but limit some combinations of nutrient sources corresponding to the isotope and trace element information (e.g. mollusks and plants). Identification their diet in the environment of the late Middle Miocene is required as a future work.

Friday 10:45

DINOSAUR BIOGEOGRAPHY AND THE BREAK-UP OF GONDWANA: A REAPPRAISAL USING CLADISTIC BIOGEOGRAPHIC METHODS

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New data on Gondwanan dinosaurs has prompted debate about the role of continental fragmentation in determining Cretaceous distributions. Three main hypotheses have been proposed: 1) the "traditional model" in which Gondwana was first divided into western (Africa-South America) and Eastern (Antarctica-India-Madagascar-Australia) portions; 2) the "Africa-first model" in which Africa separated from the rest of Gondwana in the mid-Cretaceous, while S. America remained in contact with East Gondwana until the Late Cretaceous; and 3) the "pan-Gondwana model" in which the southern continents remained in contact via three landbridges until at least the Late Cretaceous. Models 1 and 2 predict different vicariance patterns, while model 3 suggests that distributions were largely determined by dispersal and extinction. Paradoxically, both palaeogeography and biogeography have been cited as supporting evidence by advocates of all three models. However, the majority of these studies are "narratives" based on a relatively literal evaluation of the fossil record and palaeogeography. The more rigorous analytical methods of cladistic biogeography are superior because they attempt to distinguish between true distribution "signals" and the background "noise" created by sampling biases, phylogenetic error etc. Such approaches have only rarely been applied to dinosaurs.

Application of cladistic biogeography to Gondwanan dinosaurs reveals signals for the Early and Late Cretaceous and provides strong support for the role of Gondwanan fragmentation in creating vicariance patterns. The Early Cretaceous was dominated by the separation of Gondwana into western and eastern portions, whereas by the Late Cretaceous the signal is consistent with the Africa-first model. This two-stage model explains the complexity of Gondwanan distributions in the Cretaceous and illustrates the recently acknowledged biogeographic principle that area relationships may be "reticulate" rather than purely hierarchical.

Thursday 2:45

CRYPTIC EXTINCTION OF A UNIQUE PLEISTOCENE WOLF ECOMORPH

VAN VALKENBURGH, Blaire, UCLA, Los Angeles, CA; LEONARD, Jennifer, VILA, Carles, Uppsala Univ., Uppsala, Sweden; WAYNE, Robert, UCLA, Los Angeles, CA

Although the late Pleistocene extinction of the megafauna removed many large herbivore and carnivore species, there were some survivors, such as the gray wolf (*Canis lupus*). Whether the survivors sailed through the extinction event easily or suffered near-extinction is not known and difficult to assess with fossil data. However the presence of DNA in the bones of mammals preserved within Pleistocene permafrost deposits now allows documentation of genetic history over the past 40,000 years. To examine the effects of the late Pleistocene on a surviving taxon, we compared the genetic and morphologic diversity of gray wolves from the Alaskan Pleistocene to that of extant North American wolves. Remarkably, the late Pleistocene wolves of Alaska appear to have been a unique genetic clade of unusual morphology. Fifteen mtDNA haplotypes were recovered from a sample of 21 permafrost wolves (radiocarbon dated as 12,600 to > 47,170 ybp), none of which were shared with, or closely related to any modern wolf. Multivariate analyses of 11 measures of craniodental shape indicate that these ancient wolves had broader palates, larger teeth, and deeper jaws relative to a broad sample of 126 modern North American wolves. Moreover, the extinct Alaskan wolves exhibit very high levels of tooth wear and breakage relative to extant wolves. Together, these data suggest that the permafrost wolves were adapted for regular bone consumption and intense carcass utilization. Thus, despite surviv-

ing as a species, the gray wolf suffered in the late Pleistocene due to the loss of a uniquely adapted, genetically distinct ecomorph. It has been suggested that greater specialization (e.g. large body size, hypercarnivory) leads to greater extinction vulnerability among species, and this may be equally true within species, as exemplified by these ancient wolves.

Poster Session II

SAUROPOD TRACKWAYS FROM THE MIDDLE JURASSIC OF YUNNAN, CHINA

VARRICCHIO, David, Earth Sciences Dept., Bozeman, MT; YANG, ChuanWei, ZHONG, ShiMin, Museum of the Chuxiong Autonomous Prefecture of the Yi Nationality, ChuXiong, Yunnan, China; HUANG, Timothy, DinoDragon International Research Foundation, Asian Operation, Taipei, Taiwan, ROC; KNELL, Michael, Earth Sciences Dept., Bozeman, MT
A recently discovered footprint locality occurs in the Chuanjie Formation of the central Chuxiong Prefecture of Yunnan, China. The Chuanjie Formation is equivalent to the basal section of the forenamed Upper Lufeng Formation or Upper Lufeng System and has a potentially early Middle Jurassic age. The trackway horizon sits within a 2 m plus sequence of dull red siltstones and mudstones. These are thinly bedded from < 1 cm to 5 cm and show multiple alternating layers of mud cracks and ripple marks. The track-bearing unit is a thin (~5 cm), dull red muddy siltstone and exhibits both ripples and mud cracks. The horizon covers 105 m² and contains six distinct trackways as well as an additional band of densely packed and overprinted tracks representing at least two additional trackways. Each of the narrow-gauge trackways consists of alternating manus/pes couplets. Manus tracks are crescent shaped, but their appearance changes with stride length and overprinting by the pes track. Pes tracks are sub-triangular to oval with a laterally pointing apex. A few show four small impressions of anteriorly directed unguals. Strides measure from just less than 1 to 1.7 m and roughly correlate to pes size (length). Within single trackways, same-side manus and pes tracks remain distinct and non-overlapping with short stride lengths. But as stride lengthens, pes tracks begin to overprint the posterior margin of the manus track. The quadrupedal posture, semi-digitigrade pes, and digitigrade manus with reduced phalanges indicate a sauropod origin for these tracks. Only one sauropod taxon, *Chuanjiesaurus*, of unknown affinities is currently known from the formation; its manus and pes are represented by only a single ungual phalanx. The narrow gauge and forward pointing digits of these tracks suggest a more primitive sauropod with a morphologic grade akin to *Shunosaurus* or *Vulcanodon*. This is consistent with recent interpretations on the timing of basal sauropod evolution.

Friday 8:00

ANALYSIS OF DINOSAUR DIVERSITY AND PROVINCIALITY IN LATE CRETACEOUS NORTH AMERICA

VAVREK, Matthew, LARSSON, Hans, McGill Univ, Redpath Museum, Montreal, QB, Canada

Previous studies on diversity across North America in the Late Cretaceous have often ignored modern methods of diversity estimation, such as non-parametric incidence estimators. However, these methods have been shown using modern datasets to give precise and accurate estimates from patchy sampling. As well, comparison of dinosaur assemblages and delimitation into faunal provinces has often been restricted to comparisons of presence or absence of species, ignoring for effects of abundance and sampling intensity. However, there is a strong relationship between shared species between two collections and the size of those collections; as sample size increases, so does the number of shared species. By analyzing some datasets of Late Cretaceous dinosaur collections, we were able to obtain differing results before and after we corrected for sampling intensity and species abundance. Taking into account all these effects of sampling method and data analysis, we may be getting a false view in some respects in regards to our understanding of dinosaur ecology and provinciality. By using what neoecology has already learned, we can avoid major possible pitfalls in paleoecological research.

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Poster Session I

DINOSAUR EGGS AND CLUTCHES FROM PINYES LOCALITY (SOUTHERN PYRENEES) AND COMPARISON TO AUCA MAHUEVO (PATAGONIA)

VILA, Bernat, Sabadell (Barcelona), Spain; GARRIDO, Alberto, Museo Carmen Funes, Plaza Huinacul, Argentina; GALOBART, Angel, Institut de Paleontologia M. Crusafont de Sabadell, Sabadell (Barcelona), Spain; BRAVO, Ana Maria, Unidad de Paleontología,

Dpto. Biología, Universidad Autónoma de Madrid, Spain; JACKSON, Frankie, Montana State Univ., Bozeman, MT

Recent review of the literature reveals that significant differences may exist between Late Cretaceous megaloolithid egg localities from Europe and India, compared with the Auca Mahuevo site in Argentina. To test this possibility, we compare and contrast a new megaloolithid locality in Catalonia (NE Iberian Peninsula) with the Argentine locality. Four distinct egg layers at the Late Cretaceous Pinyes site near Coll de Nargó, Spain occur within extensively developed, vertically-stacked paleosols. Ten clutches containing 114 eggs were excavated and mapped. Trimble Total Station data allowed reconstruction of the clutch geometry in three dimensions, and taphonomic aspects were recorded. Clutches contain a maximum of 15 eggs, 20 to 24 cm in diameter. Elliptical egg shape results from compaction due to tectonic stress. The Catalan eggs are larger and the clutches contain significantly fewer eggs than the 30-40 eggs reported from Auca Mahuevo. Shell thickness of the Catalan eggs is greater, and pore density and gas conductance are 20 and 12 times higher, respectively, than those at Auca Mahuevo. Plan view and cross sectional mapping supplements 3D reconstruction of egg positions and allows more accurate interpretation of egg and clutch distribution. While similarities exist in clutch architecture, the high gas conductance in eggs of the Pinyes locality suggests an incubation environment that differed from that of Auca Mahuevo. Although both localities occur in pedogenically modified, fine-grain overbank deposits, the paleovertisol features at Auca Mahuevo indicate significant differences in climatic regime.

Poster Session I

WEICHSELIAN *PHOCA GROENLANDICA* IN THE NORTH SEA (MAMMALIA; PINNIPEDIA)

VISSCHER, Tjitske, Univ. of Utrecht, Utrecht, Netherlands; REUMER, Jelle, Nat.Hist.Mus. Rotterdam, Rotterdam, Netherlands

A large collection of bones of harp seal (*Phoca groenlandica*) has been dredged by fishing vessels from the North Sea between Great Britain and The Netherlands. The bones are ¹⁴C-dated to the pre-LGM Middle Weichselian (50,000—35,000 years BP). Nowadays, this pinniped species inhabits only the Arctic Oceans. Among fossil phocid bones, especially humerus and femur are identifiable to the species level and thus useful for study. Interestingly, at first sight they seemed smaller than recent *P. groenlandica* bones. If the correlation between bone size and total body length would be significant, the body size of Weichselian harp seal might have been smaller than that of recent specimens.

We measured all available humeri (n = 256) and femora (n = 137). Distinction has been made between different life stages; we only used bones of adult animals and compared them to measurements of recent harp seal bones. As a result, it was confirmed that the bones of Weichselian harp seal are significantly smaller than those of their recent conspecifics. The correlation between bone size and total body size was calculated from measurements in recent specimens with known body lengths. It was totally insignificant (R-square = 0.0023 and 0.0531 for femur and humerus, respectively). As a consequence, precise estimation or reconstruction of the total body sizes of the fossil animals was impossible. Although we assumed that there was a significant size difference between recent and Weichselian harp seals, this hypothesis can therefore not be proved or disproved.

Small bone size (and possibly smaller body size) may be due to various reasons, such as a lower sea-level during the late Pleistocene, influencing sea currents and the amount of nutrient supply. The amount of food available for harp seal in the North Sea may have been limited at several stages during the Pleistocene. However, the influence of climate (Bergmann's rule) or of genetic drift (in an isolated population) cannot be ruled out.

Saturday 2:45

RECONSTRUCTING THE PALEOECOLOGY OF THE SANTACRUCIAN FAUNA (EARLY-MIDDLE MIOCENE; PATAGONIA; ARGENTINA) FROM FORM AND FUNCTION. ARMADILLO AND PRIMATE EXAMPLES

VIZCAÍNO, Sergio, BARGO, Susana, Museo de La Plata, La Plata, Argentina; KAY, Richard, Duke Univ., Durham, NC

The Santacrucian (early-middle Miocene) fauna is taxonomically rich, including Marsupialia, Xenarthra, various ungulate orders, Rodentia, and Primates. This year, we discovered two new fossil localities from the coastal exposures of the Santa Cruz Formation between 51° and 52° south, notable in their species diversity and unusually complete skeletal material. They provide a temporally constrained collection that documents skulls and skeletons of many species. Such recoveries are essential for reconstructing the community using ecomorphology. A number of key niche parameters may be inferred from living analogs, including body mass, locomotion and substrate use, diet, and activity pattern. Preliminary results for armadillos exemplify this approach. armadillo's body masses are inferred from the limb dimensions based on scaling in living taxa. Locomotion, especially the relative importance of cursoriality or digging behavior, is determined from limb proportions and muscular lever arms. Dietary interpretations are based on the jaw mechanics, the morphology of the jaw and tooth shape and wear. Santacrucian armadillos were as diverse, or more so, than the most rich armadillo communities today. Species body masses fall within the range of medium-sized living ones. They occupied a narrower locomotor range, there being no obligate burrowers, nor extremely cursorial forms. The dietary range was broader than today's armadillos: within the context of generalized omnivory are distinct specializations for carnivory and herbivory. Thus, dietary specialization was a larger determinant of niche partitioning in the santacrucian armadillos than it is today. The primate community

consists of a single Cebus-sized monkey, Homunculus. New cranial, dental and postcranial remains reveal an arboreal quadruped with some leaping ability that had a diet of fruit and leaves. Extreme tooth wear suggests marked dietary seasonality as befits an animal that lived at >50° South latitude. Orbit- and the optic-canal size indicate diurnality and acute vision. The brain endocast shows a large visual cortex and small olfactory bulb despite the comparatively well-developed scroll bones in the nose.

Poster Session I

THE KANSAS BOE AND EVOLUTION—A TALE OF ADAPTATION, REVERSALS, AND THE FITNESS OF KANSAS SCIENCE CURRICULA

VLAMIS, Ted, Wichita, KS

Challenges to the inclusion of evolution in K-12 curricula continue to be made in a wide variety of states in the USA. One arena in which this debate has repeatedly occurred during the past several years has been the Kansas State Board of Education, with some outcomes favorable to anti-evolution forces and some to pro-evolution forces. Because different election results have driven these different outcomes, analysis of the reasons for these results can be instructive for those from other states facing similar challenges as well as for Kansans.

In 2005 the Kansas State Board of Education enacted Science standards hostile to the teaching of evolution on a 6-4 vote. Subsequent actions by the BOE taken on identical 6-4 votes have made it clear that opposition to evolution is only a part of the ideology motivating the current majority of the BOE.

In the August 7, 2006 primary 4 of the 6 BOE members who voted in favor of the Science standards hostile to evolution will face primary opposition. The results of this primary election and the November 7 general election are likely to determine the fate of evolution in K-12 curricula for many years to come in Kansas, and will serve as a bellwether for other states.

This presentation will analyze the results of the primary and will compare these results with previous BOE elections in order to identify successful strategies. It will look at the place of the pro-evolution anti-evolution issue in the primary and at how this issue can become part of a broader agenda. It is hoped that these lessons can be used in other states facing similar issues.

Poster Session II

REDISCOVERY OF WILBUR KNIGHT'S 1898 MEGALNEUSAURUS REX SITE. NEW MATERIAL FROM AN OLD PIT

WAHL, William, Wyoming Dinosaur Center, Bighorn Basin Foundation, Thermopolis, WY; ROSS, Mike, Bighorn Basin Foundation, Casper, WY; MASSARE, Judy, SUNY College at Brockport, Brockport, NY

We report the rediscovery of Wilbur Knight's original 1895 excavation site of the large Jurassic pliosaur *Megalneusaurus rex* known only from the type specimen, present material includes both large humeri and corresponding articulated epipodials (2m limb length) but originally included vertebral and pectoral elements as well.

The site was found using old maps identifying the original shallow oil basin described by Knight. The triangular excavation pit, not much larger than the specimen itself is in the Wind River Basin near the original western border of Natrona County. No spoil piles were nearby but isolated rib scraps and parts of an epipodial were discovered on the surface surrounding the site. The preservation matches that of the mounted articulated paddle at the Geological Museum, Univ. of Wyoming. Additionally, the sandy, green-stained glauconitic matrix matches material mixed into the original plaster filler used by Knight to reconstruct the pliosaur limb.

We can now verify that *Megalneusaurus rex* was from the upper Redwater Shale Member of the Sundance Formation, within about 10m of the Windy Hill Sandstone, near the base of the Morrison Formation. The sandy matrix suggests that *Megalneusaurus rex* frequented shallower portions of the Sundance Sea during the regressive phase of deposition. Sections of the sandy matrix contained dense amounts of thousands of coeloid cephalopod tentacle hooklets, which may have been gastric contents of the pliosaur. This site rediscovery returns focus to the largest member of the Sundance marine reptile fauna.

Poster Session III

POSTCRANIA OF BRISTOL'S RED PANDA, *PRISTINAILURUS BRISTOLI* FROM THE LATE MIOCENE OF THE SOUTHERN APPALACHIANS

WALLACE, Steven, SCHUBERT, Blaine, East Tennessee State Un., Johnson City, TN

The original description of Bristol's red panda, *Pristinailurus bristolii* from the late Miocene-Early Pliocene Gray Fossil Site of eastern Tennessee included an upper first molar (Holotype = ETMNH-360) and an additional referred canine (ETMNH-359). Continuing excavations at the site have yielded another canine and numerous postcranial elements affording a closer look at this unique carnivoran. Tentatively identified elements include: an associated partial left front limb (distal humerus, nearly complete ulna, proximal radius, unciform, cuneiform, MC4, MC5, two proximal phalanges, one medial phalanx, and several sesamoids); an ulna; an associated tibia and calcaneus; several isolated astragali; isolated caudal vertebrae; and a metatarsal. Overall morphology of the elements is strikingly similar to that of the living red panda (*Ailurus fulgens*), however major limb elements average around 20-25% larger. Smaller elements are only slightly larger.

At least one major difference between the Gray taxon and the living form is worth noting. The medial phalanx from the associated front limb from Gray is significantly longer

with a large, raised distal articular surface compared to the living form (or other equal-sized carnivorans). Living pandas have very large claws (for their body size), which are semi-retractable. Aside from the length and the distal articular surface, the morphology of the Gray medial phalanx is nearly identical to that of the living *Ailurus*, suggesting that *P. bristolii* also possessed semi-retractable claws, which were even more exaggerated in size and at the end of longer digits. Increased body size alone could not explain the difference in digit and claw dimensions, therefore an alternative explanation is required. Perhaps the less derived dentition of *P. bristolii* necessitated a more omnivorous (to even carnivorous) diet than in *Ailurus*. The highly curved and cat-like claws of *Ailurus* are ideal for climbing; however, it seems possible that *P. bristolii* used its digit/claw morphology in a more cat-like fashion, perhaps to capture and/or bring down small prey.

Wednesday 5:45

A NEW VERTEBRATE FAUNA IN LATE PLIOCENE OF KUNLUN MOUNTAIN PASS, NORTHERN TIBETAN PLATEAU AND ITS PALEOENVIRONMENTAL IMPLICATIONS

WANG, Xiaoming, Natural History Museum of Los Angeles County, Los Angeles, CA; QIU, Zhuding, LI, Qiang, Institute of Vertebrate Paleontology and Paleoanthropology, Beijing, China; WANG, Yang, Florida State Univ., Tallahassee, FL; TSENG, Jack, Univ. of Southern California, Los Angeles, CA

Vertebrate fossils are exceedingly difficult to find on the high Tibetan Plateau due to a combination of factors such as low diversity and low productivity of paleocommunities, lack of suitable depositional environments, and lack of access to fossil localities. We report a late Pliocene fauna in the Kunlun Mountain Pass area. At an elevation of 4,786 m above the sea, it is the highest late Cenozoic vertebrate assemblage in the world so far known. Preliminary explorations during two field seasons have yielded a small collection of large and small mammals in a fluviolacustrine deposit in the lower member of the Qiangtang Formation, and the new fauna is paleomagnetically dated between 2.1-2.4 Ma.

Small mammals consist of cf. *Metasayimys* sp., *Chardinomys* sp., *Mimomys* sp., *Soricidae* indet., *Cricetidae* indet., and *Ochotona* sp. Of these, *Chardinomys* and *Mimomys* are known from the Pliocene of North China. Morphologically the Kunlun *Chardinomys* and *Mimomys* represent advanced forms of these genera, indicating a late Pliocene age and consistent with the magnetic results. The small mammal fauna also boasts possibly the latest occurrence of *Metasayimys* in Asia, a tenodactylid rodent previously thought to be extinct in the late Miocene of Pakistan.

Large mammals are represented by a rhino, a hipparionine horse, one or two bovids, *Chasmaporthetes* sp., and *Plesiogulo* sp. Overall, the fauna is north China or central Asia in character, with the possible exception of *Metasayimys*. Although it currently consists of fragmentary material, the fossil assemblage presents an exceptional window of opportunity to peek into the past biota and environment of the high plateau. Preliminary analysis on the ¹³C isotopes on herbivore enamels yielded a range of -5.4 to -9.0 per mil. In our limited sample, fossil teeth are consistently enriched in the heavy ¹³C compared to modern herbivore teeth, suggesting that C4 grasses were an important component of local ecosystems in the late Pliocene.

Poster Session II

GEOLOGICAL AND GEOGRAPHICAL DISTRIBUTION OF BIRD-LIKE THEROPOD, *AVIMIMUS* IN MONGOLIA

WATABE, Mahito, SUZUKI, Shigeru, Center for Paleontological Research, Okayama, Japan; TSOGTBAATAR, Khishigjav, Mongolian Paleontological Center, Ulaanbaatar, Mongolia

Avimimus is a bird-like theropod with specialized forelimb structure found from the upper Cretaceous bed in the Gobi desert, Mongolia. A holotype specimen of the genus was reported by Soviet-Mongolia joint paleontological expedition in 1980's. The locality of its discovery was assigned to a late Cretaceous (Djadokhta age) locality called Udan Sayr. Fossiliferous beds in the locality with mainly eolian origin yielded protoceratopid (*Ceratopsia*) and pinacosaur (*Ankylosauria*) in addition to multituberculate mammals and lizards.

Hayashibara Museum of Natural Sciences and Mongolia Paleontological Center Joint Paleontological Expedition found additional specimens of *Avimimus* from localities in southern Gobi region such as Shar Tsav and Yagaan Khovil. Shar Tsav yielded theropod footprints and trackways comparable in size with the animal, and Maastrichtian gastropod: *Mesolanistes*. Yagaan Khovil is located close to Udan Sayr and Dzamin Khond where a theropod genus *Oviraptor* was found. Bone fossils of a large theropod and an ornithomimid, footprints of a large ornithomimid, dinosaur eggshells (ovaloolithid and elongatoolithid forms), and thick-shelled large turtle were also found from the locality. Fossiliferous beds in those two localities are of fluvial origin and their fossil assemblages indicate that they are correlated with the Nemegt Suite. *Avimimus* fossils (mainly vertebrae and metapodials) were also found by the joint expedition from the Nemegt Suite of Bugin Tsav, western Gobi region where *Tarbosaurus*, *Saurolophus*, and *Nomingia* (*Oviraptorosauria*) were found.

In spite of intensive prospecting works by the expedition party, no bones of *Avimimus* were found from Udan Sayr which had been considered as the locality where the holotype of the genus was found. On the other hand, from Yagaan Khovil located close to Udan Sayr a several skeleton of the animal consisting of vertebrae, fore- and hindlimbs and sternum were abundantly found.

It is probable that the locality where the holotype of the genus was not Udan Sayr but Yagaan Khovil, and a name of the locality was mistakenly assigned. Fossils of *Avimimus* are limited in occurrence to the Nemegt Suite (Maastrichtian), and its fossils have not been found from the Djadokhta (Campanian) beds.

Student Poster Session

PNEUMATICITY, NECK LENGTH, AND BODY SIZE IN SAUROPODS

WEDEL, Mathew, Berkeley, CA

Long necks are synapomorphic for sauropods, and additional neck elongation occurred independently in different sauropod clades. Increases to 15 or more cervical vertebrae occurred at least four times, in mamenchisaurids, diplodocids, *Euhelopos*, and *Rapetosaurus*. Necks longer than 10 meters also evolved at least four times, in mamenchisaurids, diplodocids, brachiosaurids, and giant titanosaurs like *Puertasaurus*. The longest-necked sauropod for which a rigorous estimate is possible is *Supersaurus*, which had a neck at least 14 meters long. The sauropods with the longest necks, such as *Supersaurus*, *Sauroposeidon*, and *Puertasaurus*, are also among the largest known terrestrial vertebrates.

Pneumatic vertebrae facilitated neck elongation in sauropods. The lightest sauropod vertebrae were 89% air by volume and had a specific gravity (SG) of 0.22. By comparison, cervical vertebrae of the giraffe have an SG of 1.3, and are scarcely lighter than other postcranial elements (SGs up to 1.7). The cervical column of *Brachiosaurus* is 8.5 meters long but the vertebrae would have totaled less than 600 kilograms—about the same mass as the animal's paired humeri, which are each only two meters long.

The relationships between body size, neck length, and pneumaticity can be evaluated statistically using phylogenetically independent contrasts. I used the PDAP module in Mesquite v1.06 to test the correlations among femur length (FL), trunk length (TL), absolute neck length (ANL), proportional neck length (PNL; neck length/dorsal length), cervical count (CC), and air space proportion (ASP) in 14 sauropodomorphs. ASP and the size-independent measures of neck length (PNL and CC) form a pool of mutually-correlated variables (at $p < 0.05$), as do the variables related to absolute size (FL, ANL, and DL). However, only two significant correlations link the two pools: ANL is correlated with ASP and PNL. Neck elongation in sauropods is tied to pneumaticity but largely independent from size-related variables.

Poster Session III

LATE CRETACEOUS DUCKBILL MANDIBLES AND DUCKBILL DINOSAUR CHIN SKIN SCALES: CHEEKS, CHEWING KINETICS, AND SKIN

WEGWEISER, Marilyn, Draper Museum of Natural History, Cody, WY; BREITHAUPT, Brent, Univ. of Wyoming, Laramie, WY; WAHL, William, Wyoming Dinosaur Center, Thermopolis, WY; BREITHAUPT, Brent, Univ. of Wyoming Geological Museum, Laramie, WY; HARTMAN, Scott, Wyoming Dinosaur Center, Thermopolis, WY
Duckbill dinosaur chin skin (DCS) has been discovered in direct association with the underside of a hadrosaurine mandible from the "This Side of Hell Wyoming" (TSOH) quarry in the Lance Formation. This is the first report of dinosaur chin skin associated with a mandible from Late Cretaceous Lance Formation sediments in northwestern Wyoming. Surface morphology of dinosaur chin skin found beneath the jaw of a large duckbill dinosaur is now related to an exact location on the dinosaur mandible. The DCS remains, and associated elements, are preserved within regionally laterally continuous very fine-grained sandstone beds of the Upper Cretaceous, Maastrichtian Lance Formation. The quarry is located on Bureau of Land Management administrated lands. Quarry excavation has been ongoing, for 6 years to carefully observe and record taphonomic features associated with the skeletal elements. Duckbill DCS is characterized by a pavement pattern of non-overlapping, closely spaced and tightly packed polygonal scales having a morphological pattern akin to a radiating sunburst design, allowing a detailed look at the surficial appearance of this Late Cretaceous dinosaur. The mandible itself exhibits a gentle sigmoid curve along the long axis, so that jaw width narrows quickly from the predentary to the tooth row. An associated predentary preserves traces of the keratinous rhamphotheca. The rhamphotheca forms vertical ridges on the predentary. Because the thickened ridges would have worn more slowly, the rhamphotheca may have formed an ever-growing serrated structure on the lower jaw that could be used to crop plants prior to oral processing by the dental batteries.

Student Poster Session

A FOSSIL HORSE SPECIMEN FROM NORTHERN OREGON (HEMPHILLIAN) WITH UNCOMMON PATHOLOGIES AND PRESERVATION OF RARE FEATURES

WEILER, Matthew, South Dakota School of Mines & Technology, Rapid City, SD
The Alkali Canyon Formation of the Dalles Group, northern Oregon (Hemphillian) has produced several unique specimens, one being a nearly complete skeleton of an adult *Pseudhipparion* sp. cf. *P. gratum* with many uncommon pathologies and rare features preserved with exceptional detail. The preservation within the specimen includes fossilized sternal cartilages and a complete hyoid apparatus. The sternal cartilages are smaller in width than their corresponding ribs and are more tubular. The cartilages appear to be strongly attached, as they cover the entire distal end of the corresponding ribs. The hyoid apparatus in the specimen is composed of seven distinct bones with a weak degree of fusion at the points of articulation between the individual elements.

The pathologies in this *Pseudhipparion* specimen include a distinct injury to the right

dentary, associated disease and malocclusion of the dentary, as well as what appears to be a broken rib. CT scans of the dentary indicate that a continuous sub-vertical fracture bisects the ramus just posterior to the p2. This malocclusion produced a significant offset of the p3 leading to abnormal wear of the p3 and the corresponding P2 and P3. As a result of the fracture, the normal growth was altered and a disease may have resulted. Evidence from the CT scans include noticeable alterations of the roots in the area surrounding the fracture, most likely caused from the trauma and possibly by disease.

Wednesday 2:30

EVOLUTION OF SYNDACTYLY IN THE MARSUPIAL FOOT: A MORPHOMETRIC AND DEVELOPMENTAL REASSESSMENT

WEISBECKER, Vera, Univ. of New South Wales, Sydney, Australia; NILSSON, Maria, Univ. of Lund, Lund, Sweden

Syndactyly (fusion of digits II and III) in the foot of marsupials has long been recognized as a highly significant character in marsupial phylogeny. It has attracted much attention regarding its precise character, origin, and functional implications, on which no consensus has yet been reached. The aim of this study was to revise available information on syndactyly from the literature and supplement it with developmental and morphometric data from a broad range of syndactylous species. Visual examination of museum specimens, clear staining of feet of pouch young specimens, and morphometric measurements of length and width of metatarsals, proximal and intermediate digits in 29 syndactylous species were conducted. Analysis of covariance and correlation matrices showed that measurements of syndactylous digits are more correlated than either is to digits IV and V, or digits IV and V with each other. This suggests integration between digits II and III. Developmental data support this, showing that syndactyly manifests itself in the earliest stages of digital chondrification. Diversity of relative size and development in syndactylous digits is high across the marsupials tested, ranging from extremely thin and nearly fused (e.g. in kangaroos) to sturdy and well developed (e.g. in wombats), suggesting that syndactyly has not constrained pedal proportions. However, there is a convergent emphasis of digit V among the hopping/bounding kangaroos and Peramelemorpha (Bandicoots), which is unique within Mammalia. The convergent concurrence of reduced syndactylous toes and a hopping/bounding locomotion in these two clades suggests that syndactyly may facilitate the evolution of hopping. The possible presence of syndactyly in some South American marsupials suggests a deep origin of syndactyly within marsupials, or alternatively a general tendency towards it. It is therefore possible that contrary to the traditional view, syndactyly of Peramelemorpha and Diprotodontia is a plesiomorphic character for a larger grouping of marsupials.

Saturday 1:45

ENDOSTEALLY DERIVED TISSUES IN DINOSAURS AND THE EVOLUTION OF MEDULLARY BONE

WERNING, Sarah, Univ. of Oklahoma, Norman, OK; LEE, Andrew, Univ. of California, Berkeley, Berkeley, CA; BYBEE, Paul, Utah Valley State College, Orem, UT

Medullary bone is an endosteally derived tissue found naturally only in extant birds, where it acts as a labile calcium reserve for eggshell production. This tissue was described recently in *Tyrannosaurus rex*, and it was proposed that medullary bone evolved early in the theropod lineage. Here we report two new observations of this tissue in other dinosaurian taxa, the theropod *Allosaurus fragilis* (JUPV 5300; Late Jurassic, North America) and the ornithomimid *Tenontosaurus tilletti* (OMNH 34784; Early Cretaceous, North America). Both specimens exhibit endosteal tissues that are morphologically homologous to the medullary bone described in *T. rex* and extant ratites, with rapidly-deposited cancellous bone internal to endosteal lamellae. Although the tissues are morphologically homologous, the functional homology of medullary bone in extant taxa and similar tissues in any fossil taxon is untestable. As expected, some differences in morphology also exist among the three known examples of dinosaurian medullary bone, including the organization of cancellous tissue and evidence of remodeling, but these are most likely the result of phylogenetic disparity among the taxa. These new specimens offer insight into the process of medullary bone tissue deposition in dinosaurs, and suggest that the ability to produce medullary bone evolved at least as early as the Saurischian-Ornithischian divergence in basal Dinosauria.

Wednesday 9:15

UNUSUAL FOSSIL RODENT FAUNAS FROM SOUTH CENTRAL CHILE

WERTHEIM, Jill, HERRIOTT, Trystan, Univ. of California, Santa Barbara, Santa Barbara, CA; CROFT, Darin, Case Western Reserve Univ., Cleveland, OH; FLYNN, John, American Museum of Natural History, New York, NY; GANS, Phillip, Univ. of California, Santa Barbara, Santa Barbara, CA

Laguna del Laja, Chile (LdL) is one of few places that preserves stratigraphically superposed fossil mammal faunas in South America; taxa that occur elsewhere in at least four South American Land Mammal Ages (SALMAs) are represented. The volcanogenic nature of the strata at LdL permits high-precision $^{40}\text{Ar}/^{39}\text{Ar}$ analysis; 17 dates (~20-9 Ma) are distributed throughout most of the ~1.8 km thick section, significantly improving age control particularly for the early to middle Miocene segment of the SALMA sequence.

All twenty rodent taxa from LdL (37.5°S 71.2°W) represent new species, but temporal ranges for relevant genera elsewhere span much of the early late Miocene. The lowest levels of the Cura-Mallín Fm. exposed at LdL produce taxa differing modestly from Patagonian contemporaries. *?Neoreomys* n. sp. from LdL resembles the rare *?Colhuehuapian Neoreomys* sp. from El Pajarito, Chubut, while Santacrucian *Protacaremys*

n. sp. and *Acarechimys* n. sp. from LdL compare closely to but are distinct from Colhuehuapian-Colloncuran species from Patagonia and Neuquén. *Prostichomys* n. sp. and *Luanthus* n. sp. from LdL, genera previously restricted to the ?Santacrucian Pinturas Fm. (and Colhuehuapian portion of the Sarmiento Fm. for the latter taxon), also show strong similarities to their high latitude relatives. Rodents from higher stratigraphic levels at LdL are strikingly distinct from their closest known relatives; at least 10 are new at the generic level. The Cura-Mallín Fm. in this region shows no evidence of syn-contractual deposition prior to ~14 Ma, arguing that the high degree of endemism does not reflect geographical isolation by local shortening. Some taxonomic novelty could be attributable to sampling between currently recognized SALMAs and within poorly-known SALMAs. Harder to reconcile is the absence of typically abundant age-diagnostic taxa (e.g., *Perimys*, *Neoreomys australis*, *Eocardia*, *Stichomys*), and the increase in post-early Santacrucian endemism between the LdL faunas and those reported from Argentina.

Poster Session III

FIRST OCCURRENCES OF *DEINOSUCHUS* IN MEXICO

WESTGATE, James, Lamar Univ., Beaumont, TX; BROWN, R., Instituto Nacional Antropología Hist., Chihuahua, TX, Mexico; PITTMAN, Jeffrey, Lamar Univ., Beaumont, TX; COPE, Dana, College of Charleston, Charleston, SC; KALB, Jon, Texas Natural Science Center, Austin, TX

Remains of *Deinosuchus* have been found in Chihuahua, MX. Near Ojinaga, the Late Cretaceous San Carlos Formation has yielded a large dermal scute from *Deinosuchus* sp. The underlying, uppermost Ojinaga Formation bears earliest Campanian open marine ammonites and oysters including *Submortoniceras tequesquitense*, *Placenticerias planum*, *Eutrophoceras dekeyi alcesense*, *Baculites* sp. and *Exogyra poderosa erraticostata*. Paralic strata in the overlying San Carlos Formation are early Campanian and include *Flemingostrea* sp. oysters, *Baculites* aff. *B. taylorensis* ammonites, and *Hardouinia florealis* echinoids. The San Carlos Formation *Deinosuchus* sp. is similar in age to *D. rugosus* specimens reported from the southeastern U. S. (Schwimmer, 2002). Near Los Altos, several *Deinosuchus* teeth were collected from the paralic Aguja Formation. These specimens are correlative with late Campanian *D. riograndensis* specimens reported from the Aguja Fm. in Big Bend National Park and are referred to that species. *Deinosuchus* is also known from late Campanian strata in Montana and Wyoming. Schwimmer (2002) suggested that all *Deinosuchus* specimens may be conspecific, and if so, should be referred to *D. rugosus*. If San Carlos Fm. *Deinosuchus* are proven to be significantly larger than the southeastern U. S. *D. rugosus* population, then two species of *Deinosuchus* may have lived during the early Campanian. However, size differences might also reflect clinal variation in a single species.

Poster Session I

THE PALEOECOLOGY AND TAPHONOMY OF THE EARLIEST MAMMALS AND THEIR CONTEMPORARIES: A MULTI-CONTINENT STUDY

WHATLEY, Robin, BEHRENSMEYER, Anna, Smithsonian Institution, Washington, DC
It is widely assumed that the success of the earliest mammals was grounded in ecological niches distinct from those of the large-bodied archosaurs. Despite the considerable amount that we know about the anatomy, biogeography, and phylogenetic relationships of the earliest mammals and their closest relatives, the advanced cynodonts, relatively little is known about the ecology of these taxa or co-occurring small reptiles within early mammalian faunas. We have examined taxonomic, dietary, and body mass distributions within and across three of the best-preserved Early Jurassic mammal-bearing assemblages from the Kayenta Formation, Arizona; St. Bride's Island Fissure Fills, southern Wales; and the Upper Elliot Formation, South Africa. Numerous small vertebrates (weighing 100 grams or less) with dentitions consistent with herbivory and faunivory are present in all assemblages, with faunivores making up greater than 70% of the small vertebrate faunas. Lower Jurassic sediments preserving mammal fossil assemblages generally fall into two depositional categories: fluvially-deposited silty mudstones or fine-grained sandstones, and hematitic marls or clay in-fillings in limestone fissures. Taxonomic composition of faunas may differ greatly from locality to locality (e.g., Welsh Fissure Fills, versus the Kayenta Formation Silty Facies where the taxonomic distribution among localities is less variable), indicating local taphonomic, environmental, and/or ecological controls on individual fossil assemblages. Regardless of these differences, Early Jurassic mammal-bearing assemblages possess a consistent taxonomic composition at the family level, suggesting a trans-Pangaean small vertebrate fauna. We also have compared the osteology of the earliest mammals, advanced cynodonts, and lepidosaurian contemporaries to extant mammals and squamates to characterize ecomorphologic traits associated with substrate use. Specialized postcranial adaptations present in some of the earliest mammals and co-occurring small vertebrates provide evidence for a range of locomotory habits, including strong scansorial or possibly arboreal capabilities.

Friday 3:00

CROCODYLIAN ECOLOGY: ESTABLISHING PATTERNS FOR USE IN THE FOSSIL RECORD

WHEATLEY, Patrick, KOCH, KOCH, Paul, Univ. of California, Santa Cruz, Santa Cruz, CA
Crocodilian paleoecology is poorly understood because crocodilians are often preserved in deposits formed at the land-sea interface (e.g. deltaic deposits). This situation makes it difficult to determine if crocodilians found in these deposits were freshwater, estuarine, or marine. Sometimes marine, estuarine, and freshwater taxa can be separated using tradi-

tional paleontological tools such as morphology or phylogeny, but often they cannot. Stable carbon and oxygen isotope ratios provide an empirical way to study aquatic and marine animals to learn more about diet and habitat. For estuarine animals, stable isotopes provide a unique opportunity to estimate proportions of diet and drinking water provided by oceanic versus terrestrial sources. Marine and estuarine mammal ecology has been previously studied using a stable isotope approach, but systematic data for marine and estuarine reptiles does not exist. Our carbon and oxygen data from tooth enamel carbonate indicate that modern reptiles (including crocodylians) from freshwater habitats differ significantly from animals from marine or estuarine habitats. Habitats and diets may be differentiated based on $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ values from tooth enamel carbonate as well as the $\delta^{18}\text{O}$ value variability when multiple individuals of the same species are measured. Physiology and could potentially provide information useful in the phylogenetic debates concerning crown clade crocodylians.

Romer Prize Session, Thursday 12:15

EVOLUTION OF ADAPIFORM ECOLOGICAL DIVERSITY: A GEOMETRIC MORPHOMETRIC ANALYSIS OF MOLAR OCCUSAL SURFACE SHAPE

WHITE, Jessica, Univ. of Iowa, Iowa City, IA

Interpretations of extinct adapiform dietary behavior add to our growing appreciation of primate ecological diversity during critical periods in primate history. This study aimed to provide sharper resolution of dietary inferences by utilizing Thin-Plates Splines analysis to address molar shape variation in extinct and extant prosimians. The relative orientation of homologous molar landmarks was analyzed in extant taxa (lemurs and lorises) using taxonomic, as well as dietary, categories to determine if intra-sample variation was associated with phylogeny and/or function. Results suggest that lemurid frugivores (and graminivores) generally exhibit a relatively wide anterior talonid basin and reduced trigonid torsion (observed as the angle of the protolophid relative to the long axis of the molar). Lemurid folivores, on the other hand, generally exhibit a constricted anterior talonid and higher degrees of trigonid torsion. Lorisid insectivores and omnivores were used as outgroups, and were found to exhibit constricted anterior talonids, but little trigonid torsion.

Using an extant phylogenetic framework to address the goal of interpreting adapiform dietary patterns, the shape data obtained using extant taxa were applied to a sample of extinct notharctine and adapine taxa in order to constrain functional interpretations. Like their extant counterparts, adapiforms generally varied also in the relative orientation of the trigonid basin and in the dimensions of the anterior talonid basin. Adapines (*Palaeolemur*, *Adapis*, and *Leptadapis*) generally exhibited a shape most similar to extant folivorous taxa, with constricted anterior talonid basins and high degrees of trigonid torsion. Notharctines (*Cantius*, *Smilodectes*, *Notharctus*), however, exhibited variation in the constriction of the talonid basin and, in some cases, an omnivore-like degree of reduced trigonid torsion. These data can be used to supplement existing methods of paleodietary reconstruction and suggest a broader perspective of morphological diversity in fossil primates can be appreciated by highlighting shape variation within several prosimian lineages.

Saturday 3:00

ONTOGENETIC GROWTH IN THE SKULL OF *DIPLODOCUS*

WHITLOCK, John, Univ. of Michigan, Ann Arbor, MI

Diplodocus sauropods are characterized by cranial characters that may be directly related to herbivory: the maxilla and premaxilla are elongated, with the teeth located far anterior of the quadrate/articular joint, and the quadrate is inclined, such that it lies beneath the orbit ventrally and posterior to the orbit dorsally, bringing the jaw joint itself forward. Preliminary investigation of the morphology of juvenile *Diplodocus* indicates that younger individuals do not completely share this morphology.

The present study represents an empirical approach to quantifying ontogenetic change in the skull of *Diplodocus* through geometric morphometrics. Individual skulls of varying size were reconstructed in lateral, dorsal, and anterior view. Landmark and semi-landmark based morphometric analyses on these reconstructions indicate allometric growth, particularly in the facial regions. Of particular significance are the changes that occur in the tooth-bearing regions. Such changes include the relative repositioning of the last tooth, which moves anteriorly relative to the rest of the face with increasing skull size. The anterior margin of the skull, formed by the premaxillary and maxillary bones, broadens, forming the truncate, flattened shape of the adult. Little relative change occurs in the region of the braincase. The observed changes represent a shift in shape from a more conventional oral morphology to the divergent shape typified by *Diplodocus* adults. Moreover, the largest excursions occur between the large sub-adult and adult specimens. This may be concurrent with the plateau observed at the upper range of growth rates, but without strict age controls on isolated skulls, no firm correlations can be made. The nature and timing of these changes, therefore, have important consequences for interpretations of the life history and feeding mechanics of *Diplodocus*.

Student Poster Session

MICROVERTEBRATE ASSEMBLAGE FROM A DINOSAUR QUARRY IN THE LOWER MORRISON FORMATION, BIGHORN BASIN, WYOMING

WILBORN, Brooke, Norman, OK

Microvertebrate assemblages are known from several localities within the Upper Jurassic Morrison Formation, providing information about the non-dinosaur components of the fauna. However, there are few microvertebrate fossils known from the northern geographic

extent of the formation. Screen washing of matrix from a new dinosaur quarry in a lower Morrison Fm. locality in the northern Bighorn Basin of Wyoming, near Shell, has produced microvertebrate remains. This quarry is stratigraphically lower than previously described microvertebrate localities from this area.

The dinosaur quarry is in a stacked channel deposit seven meters above the marine Sundance Formation. The microvertebrates recovered so far are from the upper channel facies, consisting of a medium-grained sandstone with calcite cement. Preliminary sampling has demonstrated a relatively high yield of fossils per quantity of processed matrix. To date, the remains of herp vertebrae, a partial herp skull, an atoposaurid crocodile tooth, and a lower right molar from *Amblotherium debilis* have been recovered. *Amblotherium debilis* has been reported previously from the Morrison Fm. sediments of Como Bluff in south-eastern Wyoming.

Thursday 2:15

3D ANALYSIS AND RECONSTRUCTION OF A PTEROSAUR WING SKELETON WILKINSON, Matthew, Univ. of Cambridge, Cambridge, United Kingdom

The potential for gaining a deeper understanding of pterosaur locomotion has greatly increased in recent years, thanks to the discovery of several near-complete, three-dimensionally preserved fossil skeletons in the Santana Formation (Lower Cretaceous) of Brazil, most of which have been assigned to the Ornithocheiridae (Pterodactyloidea). Every principal limb joint is preserved in excellent detail in at least one of these specimens, offering an unprecedented opportunity to accurately reconstruct the pterosaur wing and elucidate its range of motion in 3D. While no single complete skeleton exists, a morphometric analysis of the material indicates that, within the Ornithocheiridae, skeletal proportions remain roughly constant over a wide size range. The skeletal dimensions of a composite ornithocheirid could therefore be calculated with a high degree of confidence. These morphometric data were used to construct a virtual 3D model of a fleshed-out ornithocheirid skeleton. Joint movement was analysed by marking and articulating casts of the fossil bones, making due allowance for articular cartilage. Articulating elements were photographed at their limits of movement, the photographs were digitized, and the coordinates of the markers found. Rigid body equations were applied to the coordinate pairs to find the position and orientation of each joint axis and the range of motion about each axis. The axes were then mapped onto the virtual model. Application of rotation matrices to the 3D surface could then be used to generate any possible configuration of the wing skeleton. The analysis confirms that the pteroid—a bone unique to the pterosaurs that articulated at the wrist and supported a membranous forewing—was directed forwards in flight, not towards the body as indicated in several flattened articulated specimens. While the pteroid could be swung away from a forward-pointing position, at maximum flexion it pointed ventro-medially, not medially, and the resulting forewing shape would not have been effective for flight. The pteroid was therefore not a mere passive element, but enabled the forewing to act as a high-lift device, airbrake, and versatile control surface.

Poster Session I

NEW UINTAN PRIMATES FROM TEXAS AND THEIR IMPLICATION FOR NORTH AMERICAN PATTERNS OF DIVERSITY IN THE EOCENE

WILLIAMS, Blythe, Duke Univ., Durham, NC; KIRK, Edward, Univ. of Texas at Austin, Austin, TX

New primates have been recovered from middle Eocene Uintan deposits of the Devil's Graveyard Formation in Trans-Pecos Texas by field crews from the Univ. of Texas and Duke Univ. One taxon most closely resembles *Omomys* and *Chumashius*. Another is a new species of *Mahgarita*. These new taxa and other primates identified from Texas increase our appreciation of primate diversity during the Uintan. There are now at least ten primate species known from the Uintan of Texas. The Uintan Land Mammal Age (LMA) was a time of increasing aridity and seasonality in the northern interior basins, but in Texas the climate remained equable and more humid. It has often been noted that primates became increasingly rare and less diverse throughout the northern Rocky Mountains during the Uintan. Our perception of changing patterns of mammalian diversity during the Uintan has been influenced by patterns seen in the northern Rocky Mountains, particularly the southern Green River and Uinta Basins. Comparisons in the past have shown that during the Bridgerian LMA in the southern Green River Basin, the number of primate species ranged from 8-11 with primates comprising 11-15% of the total mammalian diversity. During the succeeding Uintan LMA in the nearby Uinta Basin, there are just five primate species known, and they comprise just 5% of the mammalian diversity. This change in diversity has been extrapolated as the North American pattern. However, primates in Texas comprised from 12-20% of the total mammalian diversity; equivalent to or greater than the relative diversity in the Bridgerian of the southern Green River Basin. This is approximately equal to the number of taxa known from Uintan deposits in California. We emphasize the need to recognize greater primate diversity during the Uintan and caution against over-interpreting local patterns of diversity.

Poster Session III

RENEWED PALEONTOLOGICAL INVESTIGATIONS INTO THE MIOCENE VERTEBRATE FAUNA OF SOUTHERN ECUADOR

WILLIAMS, Susan, Athens, OH; RYBCZYNSKI, Natalia, Canadian Museum of Nature, Ottawa, ON, Canada; RAMÓN, Jose-Luis, ALBUJA V., Luis, Escuela Politécnica Nacional, Quito, Ecuador

Until the mid-1980s, the pre-Pleistocene vertebrate fossil record of Ecuador was remarkably sparse. In 1922, Anthony reported the discovery of a Pleistocene caviomorph rodent *Drytomomys aequatorialis* from the Nabón region in southern Ecuador. Fifty-five years later a fragmentary upper third molar of a toxodontid was reported from the Cuenca region. Starting in 1985 and continuing for almost a decade, several intermontane sedimentary basins of southern Ecuador were prospected with some success. These efforts substantially increased the Miocene vertebrate fossil record from this region and uncovered a diverse plant flora as well. While continued efforts by paleobotanists have greatly expanded the plant fossil record, vertebrate paleontological research in the region has virtually halted.

Recently, we conducted a one-week reconnaissance to determine the viability of renewing fieldwork in the intermontane basins of southern Ecuador. We relocated some of the Miocene localities in the Cuenca and Nabón basins. These localities are of particular interest because they are of known ages. Although a definitive bone layer in the Cuenca basin has yet to be established, fragmentary toxodontid dental enamel and other unidentifiable bone fragments were recovered by surface prospecting. At Nabón, additional toxodontid dental material was collected from Miocene sediments. Besides enamel for stable isotope analysis, fossilized brood balls from scarabid beetles were also collected and appear promising for phytolith analysis to permit paleodietary reconstruction of the local herbivores. Continued fieldwork and systematic paleontology in southern Ecuador holds promise for the recovery of vertebrate fossils. The dietary composition and evolution of equatorial faunas from South America can address hypotheses about community structure and response to local climate change, in particular Andean uplift.

Poster Session I

FIRST OCCURRENCE OF *GLASBIUS* (MAMMALIA, METATHERIA) NEW MEXICO AND A LANCIAN AGE (LATE CRETACEOUS) FOR THE NAASHOIBITO MEMBER, KIRTLAND FORMATION

WILLIAMSON, Thomas, New Mexico Museum of Natural History, Albuquerque, NM; WEIL, Anne, Oklahoma State Univ. Center for Health Sciences, Tulsa, OK; BECENTI, Lavina, Univ. of New Mexico, Albuquerque, NM

The definition of the Lancian Land-Mammal "Age" is problematic, largely because of difficulties in designating a first occurrence datum to mark its onset. However, three mammal taxa, *Batodon*, *Glasbius*, and *Essonodon*, that uniquely occur in the Lancian have been proposed as the best candidates for this. Here we report on the occurrence of one of these taxa, *Glasbius* from NMMNH locality 4005, in the Naashoibito Member, Kirtland Formation.

NMMNH L-4005 is located approximately 10 m above the base of the Naashoibito Member in Willow Wash, within the Bisti/De-na-zin Wilderness area of the San Juan Basin, New Mexico. It has yielded a diverse vertebrate microfauna including the teeth of lizards (e.g., *Peneteius*), dinosaurs (e.g., Titanosauridae indet., cf. *Tyrannosaurus rex*, *Richardoestesia isosceles*, *Troodon* sp.) and mammals. The mammals include several Multituberculata, including *Essonodon*, and at least one identifiable therian mammal. These are considered to be part of the Alamo Wash local fauna. Two specimens can be confidently referred to *Glasbius*. NMMNH P-46380 is a right m2 or m3. P-46381 is a right m4. It is possible that both specimens are from a single individual. Both teeth are larger than those of *G. intricatus* from the Lance Formation of Wyoming. They are approximately the size of *G. twitchelli* from the Hell Creek Formation of Montana, and are tentatively referred to that species. The m4 is much smaller than the m2 or 3. The m2 or 3 and m4 both have a labial cingulid with a cuspid anterolabial to the hypoconid. The presence of *Glasbius* in the Naashoibito Member gives additional support for a Lancian age for the Alamo Wash local fauna.

3D Imaging Symposium, Friday 9:45

DIETARY PREFERENCES OF MULTITUBERCULATES: PRELIMINARY INFERENCES FROM DENTAL MORPHOLOGICAL COMPLEXITY PATTERNS IN MUROID RODENTS

WILSON, Gregory, Denver Museum of Nature & Science, Denver, CO; EVANS, Alistair, JERNVALL, Jukka, FORTELIUS, Mikael, Univ. of Helsinki, Helsinki, Finland

Mammalian tooth shape can be used to reconstruct dietary preferences in fossil taxa and track patterns of morphological evolution through time. However, quantifying tooth shape has been hampered by several methodological limitations. Methods, like geometric morphometrics, that rely upon shared homologous landmarks restrict the taxonomic and morphologic scope of comparisons. They also neglect the shape information that is not captured by the configuration of landmarks.

We recently developed a method that addresses these limitations. It uses Geographic Information Systems software to analyze slope orientation of three-dimensional tooth surface data. We used the number of distinct orientation patches on a tooth surface as a measure of tooth surface complexity. In a sample of living muroid rodents and carnivores with known dietary preferences, "orientation patch complexity" differentiates between feeding ecologies independent of phylogeny, increasing from faunivores to omnivores to herbivores.

We used the modern dataset and this new method to estimate dietary preferences in a sample of Late Cretaceous and Paleocene multituberculates. Multituberculates are a group of long-extinct mammals that have been particularly challenging for dental functional morphologists because their molars are highly complex and lack homologous features with therian molars. GIS analyses capture this complexity and allow for direct comparisons with the morphologically similar sample of modern muroid rodents. Some previous studies have suggested that multituberculates were herbivorous, whereas other recent studies have suggested they were omnivorous. Our preliminary results provide a range of orientation patch complexity values that suggest that multituberculate diets ranged from more herbivorous taxa, like the Late Cretaceous *Bubodens*, to more omnivorous taxa, like the Cretaceous and Paleocene *Mesodma*.

Wednesday 11:15

LATEST CRETACEOUS REPTILES FROM THE HASHEMITE KINGDOM OF JORDAN

WILSON, Jeffrey, Univ. of Michigan, Ann Arbor, MI; MUSTAFA, Hakam, Yarmouk Univ., Irbid, Jordan; ZALMOUT, Iyad, Univ. of Michigan, Ann Arbor, MI

The paleobiogeographic relationships between Africa and neighboring landmasses during the Cretaceous remain a major question, due to differing paleocoastline reconstructions and the uneven distribution of fossiliferous sediments on southern landmasses. South America is the only region of Gondwana with good representation of vertebrates from both Lower and Upper Cretaceous sediments. Vertebrates of Africa and Australia are best known from Cenomanian and older horizons, whereas those of India, Antarctica, and Madagascar are best known from latest Cretaceous sediments. These latter share a common latest Cretaceous fauna that has not yet been documented on Africa, a pattern that has been interpreted to reflect Early Cretaceous biogeographic isolation of Africa from the rest of Gondwana.

Africa and Arabia maintained a broad geographic connection until rifting of the African and Arabian Plates and opening of the Red Sea ~34 Ma and the relatively recent collision between the Arabian Peninsula and Eurasia ~10 Ma. Jordan forms the northwestern part of the Arabian Peninsula, which was ringed by seas that received erosional products from the continent throughout the Phanerozoic. Recent field exploration in Cretaceous deposits in southern Jordan has uncovered major new Santonian and Maastrichtian localities that preserve diagnostic fossil reptiles. Santonian fossils include the recently described bothremydid side-necked turtle *Karkaemys arabicus*, which is closely related to *Zolhafah bella* from the Maastrichtian of Egypt. Maastrichtian fossils include the first diagnostic dinosaur from the Arabian Peninsula and partially articulated cranial and postcranial remains of the azhdarchid pterosaur *Arambourgiania philadelphiae* (wingspan 6-7 m). The dinosaur is a titanosaur sauropod that is characterized by extreme camellate pneumaticity, a posteriorly inclined neural spine, absence of hyposphene-hypantrum articulations, and features linking it to the Early Cretaceous *Malawisaurus dixeyi* from central Africa. These preliminary discoveries suggest that the Cretaceous of Jordan contains diagnostic vertebrate fossils that provide insights into African paleobiogeography.

Wednesday 11:45

COMPARATIVE TAPHONOMY AND PALEOECOLOGICAL RECONSTRUCTION OF TWO MICROVERTEBRATE ACCUMULATIONS FROM THE HELL CREEK FORMATION (MAASTRICHTIAN), EASTERN MONTANA

WILSON, Laura, Museum of the Rockies, Bozeman, MT

Microvertebrate accumulations are often used for paleoecological reconstructions, but taphonomic characteristics of specimens included in assemblages are rarely considered prior to population analysis. Taphonomic and taxonomic structures from one fine-grained and one coarse-grained facies bearing non-isotaphonomic assemblages of the Maastrichtian Hell Creek Formation were compared. Specimens were quarried to collect high-resolution distribution data permitting positioning of each specimen in three-dimensional space. Taphonomic signatures of an assemblage and subsequent relative abundance of taxa are directly correlated to the hydraulic indicators (i.e., grain size, sedimentary structures) of the depositional facies. Statistical analyses show size, shape, abrasion, and taxonomic compositions vary significantly between assemblages. Despite potential difference in time-averaging, comparison of hydraulically equivalent elements (e.g., ornithischian teeth or caudate vertebrae) between the two deposits does not show sub-populations of the assemblages to be significantly different. Results demonstrate that portions of the assemblages can be analyzed for population structure, most notably relative abundance of hydraulically equivalent skeletal elements from morphologically similar organisms, regardless of accumulation in non-isotaphonomic deposits. Only after detailed taphonomic analyses and comparison of taphonomically similar elements can the population structure represented within an assemblage be assessed.

Preparators Symposium, Thursday 11:00

COLLECTION AND HANDLING PROTOCOL FOR MOLECULAR AND CHEMICAL ANALYSES OF WELL PRESERVED FOSSIL SPECIMENS

WITTMAYER, Jennifer, SCHWEITZER, Mary, North Carolina State Univ., Raleigh, NC
The chemical and molecular characterization of soft tissues and cells preserved in fossil bone presents many technical challenges, not the least of which is detecting artifact induced

by collection and handling procedures. Here we discuss a series of experiments designed to determine the extent of interference caused by these common practices and protocols. Results showed that some analytical analyses, such as FTIR, are disproportionately affected by, for example, the application of standard field consolidants, while the results of other methods are not affected by these same procedures.

We present an overview of analytical methods most appropriate for fossil analyses, and suggest standard protocols for collection and handling fossil specimens for future chemical and molecular characterization. In particular, we emphasize the role of the field crew assigned to the original recovery of fossil remains, and the preparators who are first to observe exceptionally preserved fossils that may hold promise for future analyses. Although we do not propose the elimination of common field practices, such as application of consolidants to stabilize fossil remains, we encourage collectors and preparators to consider the effect these handling methods have upon analytical analyses of fossil tissues, and to set aside untreated representative specimens. For this reason, we propose a simple method, and describe components of a kit, for field collection of well-preserved fossil specimens potentially appropriate for future molecular analyses.

Saturday 2:45

DEDUCTIVE VIRTUAL SYNTHESIS OF A SAUROPOD SKULL

WITZEL, Ulrich, GÖSSLING, Rainer, Ruhr-Univ. Bochum, Bochum, Germany

The measurement of strains in real skulls is an inductive method that yields information about the stresses occurring in the a priori existing shape. In contrast, the approach taken here to determine the relationship between skull function and skull shape applies Wolff's law through a deductive technique of structure synthesis. This paper describes the application of this method in the exact virtual synthesis of a sauropod skull, e.g., *Camarasaurus*.

An unspecific homogeneous solid is first constructed, giving the stresses ample volume to spread between points of force application and constraint. The FE-software ANSYS 10 is used to form 10-noded tetrahedral finite elements with a maximum of 129,000 nodes. The initial conditions are the functional spaces for the eye openings, muscle forces, and placement of the dental arcade, including assumed bite forces. Enforcing equilibrium of forces, the primary 3D stress flows in each load case are summarized by a physiological superposition, which accumulates the highest value of stress in each finite element. If the stress free parts are eliminated and the summarized stress flows are maintained, a reduced model appears, which is very similar to the real skull. This reduction of shape can be repeated iteratively and leads to a more exact form. The final FE-model is presented by using the CAD-software CATIA V5.

Changes in the form of the dental arcade, its position relative to the braincase, the origins of muscles, or the height of the skull lead to models that clearly resemble morphological differences between genera. The deductive virtual synthesis of a skull of *Camarasaurus* using the finite-element structure synthesis (FESS) demonstrates the direct correlation between functional loading and the biological structure and shape and can be used to test hypotheses regarding the relationship between structure and function during skull evolution.

Saturday 11:15

EVOLUTION OF THE SCALATION PATTERN IN TEMNOSPONDYLS

WITZMANN, Florian, Berlin, Germany

The presence of ossified dermal scales is a plesiomorphic feature of basal tetrapods. In most Paleozoic temnospondyls, thin round-oval scales covering the flanks and the back of the trunk can be distinguished from ventral, elongate gastral scales arranged en chevron that protected the belly during crawling on the bottom. The investigation of an extensive growth series of the Permo-Carboniferous temnospondyl *Scleerocephalus* reveals that the morphology of the gastral scales in small larvae corresponds to the round-oval scales of the rest of the body. During further ontogeny, the gastral scales differentiate and reach a spindular morphology. The tapering end of each spindular gastral scale fits into a dorsal groove on the medial adjacent scale. This arrangement allowed telescoping of the scales and thus provided a high degree of flexibility during flexion of the body. In the ontogenetically most advanced specimens of *Scleerocephalus*, the gastral scales are distinctly thicker and attain a rhomboid outline by accelerated growth in the posterior direction. The articulation between neighbouring gastral scales by well-defined facets has reduced the flexibility between them. Outgroup comparison shows that the stem-tetrapod *Greererpeton* and many anthracosaurs possess corresponding rhomboid gastral scales. In most temnospondyls, however, the gastral scales do not attain the adult rhomboid condition but retain the juvenile spindular or even the larval round-oval shape, which can be interpreted as paedomorphic traits. This suggests that the different types of gastral scales in temnospondyls as well as the scales of the back and the flanks can be traced back to the same Anlage of round-oval scales that differentiated early in ontogeny. In the Mesozoic, a complete reduction of dermal scalation occurred independently in distinct dissorophoid, capitosauroid, and trematosauroid temnospondyls. This reduction was probably caused by several factors that are different for each group, like cutaneous respiration especially in small forms, the demand for greater mobility, and the decreased importance of belly protection in fully aquatic temnospondyls.

Saturday 1:30

EVOLUTIONARY STASIS IN THE FUNCTIONAL DENTAL SHAPE OF *ECTOCION*, A "CONDYLARTH" LINEAGE SPANNING THE PALEOCENE/EOCENE BOUNDARY

WOOD, Aaron, ZELDITCH, Miriam, GINGERICH, Philip, Univ. of Michigan, Ann Arbor, MI

Past studies of evolutionary mode in fossil mammalian lineages have often been limited to univariate traits (e.g. molar crown area). It is reasonable to assume that tooth shape, a multivariate trait, reflects more of the functional portion of the tooth; the part that is more likely to experience selective pressures. Previously, we studied the tooth margin shape and cusp configuration in the lower dentition of *Ectocion*, a phenacodontid "condylarth" from the Paleocene/Eocene (P/E), using geometric morphometric techniques. Our results indicated stasis in tooth margin shape and cusp configuration over the sampled time interval spanning the P/E boundary. Admittedly, these aspects of tooth shape in *Ectocion*, the most herbivorous of phenacodontids, may not contain the true shape differences resulting from selective pressures on the full masticatory abilities of the lower dentition.

Here we present the results of a new geometric morphometric study of the shearing crest shape of the lower dentition (p4, m1, m3) of *Ectocion osbornianus* and *E. parvus*. Teeth with little to no wear were sampled over a 1.5 million year interval. Principal cusps were used as landmarks, and semi-landmarks were digitized along the highest edge of the shearing crests. Principal components analyses showed no separation between time intervals at all temporal resolutions. Multivariate tests characterize the crest time series as consisting of counteracting changes with less change (i.e. stasis) than expected under a random walk. Permutation F-tests show that the shape variation within each biozone is not significantly different than variation for the entire sampled interval, providing further proof of stasis.

Currently, these methods are being extended to the Eocene perissodactyl genus *Hyracotherium*. Chronospecies of *Hyracotherium* show distinct molar sizes during the early Wasatchian with the smallest species, *H. sandrae*, occurring during the Paleocene/Eocene Thermal Maximum. The purpose of the new study is to study change in the functional tooth shape and tooth wear shape between the *Hyracotherium* chronospecies.

Wednesday 3:30

A NEW "MIDDLE" CRETACEOUS ZALAMBALESTID MAMMAL FROM NORTHEASTERN CHINA

WOOD, C.B., Providence College, Providence, RI; ZAN, Shuqin, Geol. Mus. China, Beijing, China; CHEN, Jun, Jilin Univ. Geol. Mus, Changchun, China; ROUGIER, Guillermo, Univ. Louisville School Med., Louisville, KY; SCHAFF, Charles, Museum of Comparative Zoology, Cambridge, MA

Fossils from a new mid-Cretaceous locality near Gongzhuling City in Jilin Province, China, include two incomplete dentaries, which represent a newly described genus and species (*Zhangolestes jilinensis*) referable to the eutherian family Zalambdalestidae. Both dentaries possess an enlarged, procumbent first incisor combined with an interesting mosaic of both plesiomorphic and derived dental characters compared to the early zalambdalestid *Kulbeckia kulbecke*. For example, the new specimens appear to show five premolars (including an almost fully molariform ultimate premolar) combined with only three incisors and a low but single-rooted canine. The trigonids on p5 and m1 are relatively open and not as compressed as in later zalambdalestids. *Kulbeckia*, from Turonian deposits in Uzbekistan has four premolars, and other than the typical procumbent incisor its anterior dentition is different in detail (e.g., four incisors plus double-rooted canine) compared to the Chinese material. Cenomanian *Bobolestes* (now including *Otlestes*) has an almost fully molariform ultimate premolar but no sign of enlarged incisors. Other early eutherians such as *Eomaia*, *Prokennalestes*, and *Montanalestes* have a trenchant, non-molariform ultimate premolar. *Zhangolestes* may therefore extend the range of certain, presumably derived eutherian characters to an earlier time than previously known.

More work is needed on interbasinal correlation, but at present it seems unlikely that *Zhangolestes* could be younger than Cenomanian. The locality is in basin-margin outcrops of the Quantou Formation, which is widespread in the subsurface of Songliao Basin and which has been assigned ages ranging from Aptian to Cenomanian. Songliao Basin is tectonically and sedimentologically distinct from the smaller but more numerous basins in western Liaoning. The Gongzhuling locality is likely to emerge as an important source of new information on "middle" Cretaceous vertebrates as additional mammalian, dinosaurian, and other specimens already collected are described from it.

Poster Session III

A STUDY OF *CAMARASAUROUS*' (DINOSAURIA: SAUROPODA) TORSO AND ITS BIOMECHANICAL IMPLICATIONS

WOOD, Jacqueline, Univ. of New Orleans, New Orleans, LA

This project examined the torso shape through articulating casts of both dorsal vertebrae and ribs and its biomechanical implications of the well-known sauropod *Camarasaurus*. The project resulted in a new curve in the dorsal vertebrae series, a torso which is more narrow and volumetrically smaller than previous models, the first attempt in reconstructing intercostal musculature, and a scapulocoracoid angle of 20-30° based upon scapular facets.

Background knowledge for the reconstruction was gained through dissection of *Alligator mississippiensis*, *Iguana iguana*, and *Gallus domesticus*. The dorsal vertebrae were articulated based on the position of the zygapophyses and centrum spacing. The dorsal ribs were articulated onto the vertebrae based upon the tuberculum/diapophysis, capitu-

lum/parapophysis articulations, and the flat lateral edge of the ribhead. The results are not consistent with published models, however they are consistent with the information obtained in dissections.

Saturday 9:30

USING LIMB CIRCUMFERENCE AND BODY MASS TO ESTIMATE SAUROPOD DINOSAUR GROWTH RATES

WOODWARD, Holly, Montana State Univ., Bozeman, MT; LEHMAN, Thomas, Texas Tech Univ., Lubbock, TX

Sauropod dinosaurs were the largest terrestrial animals and their growth rates remain a subject of debate. Based on counting growth lines in histologic sections and relating bone length to body mass, it has recently been estimated that *Apatosaurus* attained its adult body mass of about 25,000 kg in as little as 15 years, with a maximum growth rate of 5,466 kg/yr. This rate exceeds that projected for a precocial bird or eutherian mammal of comparable estimated body mass. Using an alternative method of estimating limb circumference and body mass for each growth line, and fitting the resulting age/mass data to the von Bertalanffy growth equation, a revised growth curve suggests that *Apatosaurus* adult mass was reached by 70 years with a maximum growth rate of 520 kg/yr. This alternative method for growth rate determination was also applied to histological studies of two titanosaurid sauropods. At only about half the mass of *Apatosaurus*, *Janenschia* took between 20 and 30 years to attain its adult size (~14,029 kg). This result is supported by independent evidence of estimated bone apposition rates. Despite having an adult body mass greater than *Apatosaurus*, the titanosaurid *Alamosaurus* attained a mass of about 32,663 kg within 45 years and a maximum growth rate of 1,090 kg/yr. Titanosaurids may have been the fastest growing of all sauropods. Even so, the growth rate estimates produced using the von Bertalanffy equation for all three sauropods fall within the interval between those projected for reptiles and those for birds or mammals of equivalent projected body mass. These results are comparable to those found for smaller dinosaurs, and suggest that sauropods grew at rates similar to other dinosaurs in spite of their great size.

Wednesday 2:45

EARLIEST KNOWN BIRD TRACKS FROM THE CEDAR MOUNTAIN FORMATION, UTAH

WRIGHT, Joanna, Univ. of Colorado, Denver, Denver, CO; KIRKLAND, James, Utah Geological Survey, Salt Lake City; FOSTER, John, Museum of Western Colorado, Grand Junction, CO; DEBLIEUX, Donald, Utah Geological Survey, Salt Lake City, CO; GASTON, Robert, Gaston Design, Fruita, CO

The earliest known bird, *Archaeopteryx*, is known from the Upper Jurassic deposits of Solnhofen in Germany but all other fossil bird remains are Early Cretaceous or younger. Similarly, the oldest known fossil bird tracks are Early Cretaceous in age, with the possible exception of some bird-like tracks reported from the Triassic of South America.

The Cedar Mountain Formation of western Colorado and eastern Utah is renowned for producing diverse Early Cretaceous terrestrial fossils, and several tracksites have also been reported. However, these are the first bird tracks reported from the Cedar Mountain Formation. The tracks are preserved in the Yellow Cat Member, which is probably Barremian in age.

These bird tracks were discovered in summer 2005 by JRF and RG on a fallen sandstone block. Further investigation of the site turned up two further blocks, found by JIK and JLW respectively. A ripple-marked fourth slab preserves two small theropod tracks. All the tracks are preserved in concave epirelief on a thin medium-grained sandstone layer at the top of a meter thick erosional-based coarser sandstone with a rippled top surface, which may be of crevasse splay origin. This lithology is very distinctive and it was therefore possible to definitively locate it in the measured cliff section, although no tracks were found *in situ*.

The tracks are 35-45mm in length and have pace lengths of 130-150mm. Some preserve faint phalangeal pads and small claw marks but there are no traces of interdigital webbing. Several preserve a hallux impression. The divarication angle of digits II-IV is 105-115 degrees. The tracks are toed-in about 15 degrees. Approximately 50 tracks are preserved on the three slabs and there are several short trackways. We believe these to be the earliest known bird tracks in the world.

Saturday 3:45

A REVIEW OF THE EVIDENCE FOR A HUMAN ROLE IN THE EXTINCTION OF AUSTRALIAN MEGAFUNA AND AN ALTERNATIVE INTERPRETATION

WROE, Stephen, Univ. of New South Wales, Sydney, Australia; FIELD, Judith, Univ. of Sydney, Sydney, Australia

Arguments that megafaunal extinctions in Australia were anthropogenically mediated have focused on establishing terminal appearance ages. This approach has been underpinned by three principle tenets: (1) if megafauna disappeared before significant climate change, but after human colonisation, then it can be inferred that extinctions were human mediated; (2) climate change within the last glacial cycle was unremarkable relative to previous cycles; and (3) all or most Pleistocene megafauna were present when people arrived on the continent. We review the evidence for human causation and note mounting evidence suggesting that the last 400-300 ka in Australia has been characterised by escalating aridity and climatic variability, culminating in the breach of a hydrological threshold within the last glacial cycle. Only 21 species (35%) of megafauna whose disappearance has been attributed to human activity are known to have persisted after the Penultimate Glacial Maximum (c. 130

ka), a time of undoubtedly severe climate change. Thus, 39 species of megafauna (65%) cannot be reliably placed within 80,000 years of firm evidence for human arrival at c. 50-43 ka. At most eight species (13%) were clearly present at this time. Four or more persisted until the onset of full glacial conditions at c. 30 ka. We argue for a falsifiable model of staggered extinction in which most megafaunal extinctions predated human arrival and with the influence of people as a minor superimposition on broader trends in train since middle Pleistocene times.

Friday 10:30

A NEW CERATOPSIDIAN DINOSAUR (ORNITHISCHIA) FROM THE UPPER HORSESHOE CANYON FORMATION, ALBERTA, CANADA

WU, Xiao-chun, Canadian Museum of Nature, Ottawa, ON, Canada; BRINKMAN, Donald, EBERTH, David, Royal Tyrrell Museum of Palaeontology, Drumheller, AB, Canada

Southern Alberta is uniquely famous for its richness of dinosaurian and other fossil vertebrates in the late Cretaceous. ceratopsians, or horned dinosaurs, are one of the best represented dinosaur groups in the region and one of the last non-avian dinosaur groups to become extinct. Ceratopsians are well represented in the Lower Horseshoe Canyon Formation (Upper Campanian) and Lower Scollard Formation (Upper Maastrichtian, roughly equivalent in age to the Frenchman Formation of southern Saskatchewan and the Hell Creek and Lance Formations of USA), but are rare in the Upper Maastrichtian Upper Horseshoe Canyon Formation and its equivalent deposits in neighboring areas. A new ceratopsian dinosaur skeleton was collected from the Upper Horseshoe Canyon Formation in the Dry Island-Buffalo Jump Provincial Park, southern Alberta in the field season of 2001. Although dinosaurs have been collected from this interval for approximately a century, this is the first associated specimen of vertebrate fossils found within the top 20 m of the Horseshoe Canyon Formation.

The new ceratopsian is diagnosable primarily on the basis of a combination of features in the premaxilla, nasal horn core, squamosal frill, and epijugal. The most striking of those features include an extremely dorsoventrally broadened narial process of the premaxilla, a rostrally positioned premaxillary process extending into the interpremaxillary fenestra, the presence of greatly elongate epoccipitals of the squamosal frill, a deep fossa on the rostroventral surface of the squamosal frill, the epijugal sharply triangular in lateral view, and the presence of a transverse and an oblique vascular trace on the rostral surface of the nasal horn core. Our preliminary study suggests that the new form is a chasmosaurine and nested within a clade including *Triceratops*, *Diceratops* and *Torosaurus*, which are all from the late Maastrichtian deposits. The new ceratopsian fills the stratigraphical/chronological gap that currently exists between the late Campanian and the late Maastrichtian ceratopsian dinosaurs.

Saturday 10:45

NEW CERATOSAURS FROM THE JURASSIC SHISHUGOU FORMATION OF WESTERN CHINA

XU, Xing, Beijing, China; CLARK, James, George Washington Univ., Washington, DC

From 2001 through 2005, our excavations in the Middle-Upper Jurassic Shishugou Formation in the Junggar Basin, Xinjiang Uighur Autonomous Region, western China have yielded numerous vertebrate specimens covering several major vertebrate groups. Four specimens in this collection are here identified as two new species of ceratosaurian theropod (=neoceratosaurian theropod), which represent the earliest known species of the group. Ceratosaurians represent a large radiation of theropod dinosaurs mainly in the Cretaceous of the southern hemisphere. Although current phylogenetic hypotheses predict their presence deep in the Jurassic, there are only two unquestionable Jurassic ceratosaurians, which hinders our understanding of their origin and early evolution. Recent phylogenetic analyses posit ceratosaurians either as the sister group to coelophysoids or to tetanurans, hypotheses that have profound effects on the timing and pattern of the basal splitting of theropod dinosaurs. The two new ceratosaurians from the Late Jurassic part of the Shishugou Formation display an unusual combination of character states. While similar to other ceratosaurians in many derived character states, they share a number of derived cranial and limb characters with tetanurans and also a few salient cranial and pelvic features with coelophysoids, which shortens the morphological gaps between the three major theropod groups. Our phylogenetic analyses support a monophyletic Cetosauria-Tetanura clade and character distributions on the recovered tree indicate that some tetanuran, coelophysoid, and ceratosaurian diagnostic features now have broader distributions and characterize much more inclusive clades. These new ceratosaurians also represent the first record of the group in Asia and have implications on the paleobiogeographical reconstructions of Middle-Late Jurassic time period. Our analysis suggests that Asia remained connected to other major landmasses at least until the Late Jurassic and more intense prospecting in outcrops of this time period promises to provide further support for a close-relationship of Asian dinosaur faunas and those of other continents.

Poster Session II

THE CHRONOLOGIC AND STRATIGRAPHIC SEQUENCE OF MAMMALIAN ASSEMBLAGES DISTRIBUTED IN THE WIND BLOWN DUSTY DEPOSITS OF THE CHINESE LOESS PLATEAU SINCE 8.0 MA B.P.

XUE, Xiangxu, ZHANG, Yunxiang, YUE, Leping, Northwest Univ., Xi'an, China; LI, Xiaochen, Shaanxi Normal Univ., Xi'an, China

By collecting and correlating the fossil mammalian faunas and their bearing beds of the eolian Neogene red clay and Quaternary loess profiles, the sequences of twelve stratigraphic units (U) and ten mammalian assemblages (M), proceeding from older to younger, have been established. They are: **1.** MU1, Lamagou assemblage (assemb.) contained in the 1st unit, the middle of the upper Miocene, 8.0-7.0 Ma; **2.** MU2, Taohuapo assemb. in the 2nd unit, the upper of the upper Miocene, 7.0-6.0 Ma; **3.** MU3, Miaoliang assemb. in the 3rd unit, the uppermost of the upper Miocene, 6.0-5.3 Ma.; **4.** (?M)U4, which fossil assemblage hasn't been found yet in the 4th unit, the lower Pliocene, 5.3-4.0 Ma. But the other climatic indicators show that the climate of this period might have been warmer and humid. We'd like to reserve it as a separate unit and wish to collect more fossils in the future; **5.** MU5, Renjiapo assemb. in the 5th unit, the lower of the upper Pliocene, 4.0-3.2 Ma; **6.** (?M)U6 is the same as (?M)U4. The 6th unit is the upper of the upper Pliocene, its age is 3.2-2.6 Ma; **7.** MU7, Longdan assemb. in the 7th unit, the lowest of lower Pleistocene, 2.55-1.8 Ma; **8.** MU8, Bajiazui assemb. in the 8th unit, the middle of the lower Pleistocene, 1.8-0.78 Ma; **9.** MU9, Gongwangling and Yanguo assemblages. in the 9th unit, the upper of the lower Pleistocene, 1.15-1.2 Ma; **10.** MU10, Chenjiawo assemb. in the 10th unit, the middle Pleistocene, 0.78-0.13 Ma; **11.** MU11, Rouyuan assemb. in the 11th unit, the Upper Pleistocene, 0.13-0.01 Ma; **12.** MU12, Banpo assemb. in the 12th unit, the recent loess deposits, 0.006 Ma. MU1-MU6 might be corresponded to those of European land mammal ages MN11-MN17 respectively. The character of mammalian assemblages contained in each unit was analyzed and the corresponding paleo-climatic environments were deduced. The main reasons causing the changes of paleo-climate were also discussed.

Saturday 8:00

LANZHOU SAURUS MAGNIDENS FROM THE LOWER CRETACEOUS OF GANSU PROVINCE, CHINA: THE LARGEST-TOOTHED HERBIVOROUS DINOSAUR IN THE WORLD

YOU, Hai-lu, JI, Qiang, Institute of Geology, Chinese Academy of Geological Sciences, Beijing, China; LI, Da-qing, Fossil Research and Development Center of the Third Geology and Mineral Resources Exploration Academy of Gansu Province, Lanzhou, China

Lanzhousaurus magnidens is an iguanodontian dinosaur recently discovered in the Lower Cretaceous Hekou Group of Gansu Province, northwestern China, which possesses the largest teeth of any herbivorous dinosaur yet discovered. The holotype is represented by a partial skeleton of a single individual including the mandible (missing predentary, right coronoid and right articular), isolated maxillary teeth, isolated right and complete, in situ left dentary teeth, a series of fourteen vertebrae (six cervicals and eight dorsals), both sternal plates, ribs, and both pubes.

Lanzhousaurus differs from all other iguanodontians in possessing large individual teeth and a small tooth count per tooth row, with a mere 14-4 cm-wide tooth families preserved in a single dentary tooth row of the 1 m long lower jaw. Based on a cladistic analysis, *Lanzhousaurus* is firmly situated as a member of the Styrcosterna by virtue of a suite of derived features, such as the relatively narrow, lozenge-shaped maxillary teeth with mammilliform marginal denticles, hatchet-shaped sternal plates, and pubis with expanded cranial blade and short caudal ramus. Among members of the Styrcosterna, the closest taxon to *Lanzhousaurus* is the Nigerian iguanodontian *Lurdusaurus*, and they together may represent a previously unrecognized, massively-constructed quadrupedal lineage in the evolution of ornithomimid dinosaurs. Both *Lanzhousaurus* and *Lurdusaurus* are less derived than the Iguanodontioidea, which evolved derived features such as more than 20 teeth per tooth row, one or two prominent ridges on the dentary crown, and closely appressed metacarpals II-IV.

Wednesday 3:00

DENTAL MORPHOLOGY AND EUTHERIAN PHYLOGENY: SIGNAL AND NOISE

ZACK, Shawn, Baltimore, MD

Dental remains constitute the bulk of the mammalian fossil record and often provide the only available means of inferring phylogenetic relationships. Mammalian dentitions are morphologically complex and highly diverse, and thus dental morphology should provide a rich source of character data for investigating the phylogeny of Eutheria. However, in most recent studies of the higher-level interrelationships of eutherian mammals, dental morphology has been de-emphasized as a source of characters in favor of cranial and postcranial morphology. This is due largely to concerns that the primary signal in dental morphology is functional rather than phylogenetic, making dentitions too homoplastic to permit phylogenetic inferences at the highest levels of eutherian phylogeny.

To test the utility of eutherian dental morphology in analyses of higher-level phylogeny, a broad sample of dental characters was scored across a diversity of eutherians, primarily Paleocene and Eocene genera, which are closer in time to the initial radiation of eutherians than are modern taxa (the focus of most higher-level studies), and a few modern representatives of orders that lack clear early Tertiary relatives. Phylogenetic analysis of the resulting matrix generally supports groupings that have enjoyed broad support in other morphological studies. Superordinal taxa such as Archonta are recovered as either clades or grades,

despite the inclusion of other taxa with presumably similar dietary adaptations, indicating that there is a phylogenetic signal in eutherian dental morphology apart from the overriding dietary signal. However, the impact of homoplasy is substantial, particularly in the case of genera and families such as Arctostylopidae that are strongly distinct at the time of their first appearances. Such taxa are unstable and are often resolved at unexpected positions near taxa that fall into a broadly similar dental category (e.g. lophodont) but differ substantially in detail, suggesting that the phylogenetic signal in dental morphology is rapidly masked by convergence if sampling is not denser, in some cases denser than is currently possible.

Poster Session II

BLANCAN WOODRATS (RODENTIA: CRICETIDAE) FROM THE MEADE BASIN SOUTHWESTERN KANSAS

ZAKRZEWSKI, Richard, Fort Hays State Univ., Hays, KS

Three species of woodrat are known from Blancan deposits in the Meade Basin of southwestern Kansas. *Neotoma quadruplicata* was described from the Rexroad 3 local fauna (l.f.) and subsequently identified at six other sites in the basin. *N. sawrockensis* was described from the Saw Rock Canyon l.f. and *N. taylori* from the Borchers l.f. R.A. Martin and colleagues have recovered woodrats from 16 additional sites.

The study sample included 30 specimens of each molar from Rexroad 3 and all molars from the other sites. Two of the variables measured were greatest length and width of the molars. Those sites (7) at which $N = \text{or} > 8$ were analyzed using Student's *t*-test, with $P < 0.05$ as the level of significance. *N. leucopetrica* from the White Rock l.f. of north-central Kansas served as an outgroup.

Significant results indicate that molars from XIT 1B are shorter than from the other sites, except for the M1 at Borchers. The M3 and m3 are narrower, except for the m3 from Borchers. The M2 from Rexroad 3 and Wendell Fox and m1 from White Rock are wider than the sample from XIT 1B. At Wendell Fox the M3 is wider than from Borchers and the m1 is also wider than from Borchers and Rexroad 3. The M1, M2, m1, and m2 from Wendell Fox are longer than from Borchers and Rexroad 3. The length of m1 and m2 and the width of m1 from Wendell Fox are smaller than from White Rock.

These data suggest the presence of two additional woodrats in the basin; a small taxon at XIT 1B that may be in a lineage with *N. sawrockensis* and *N. taylori* and a larger taxon at Wendell Fox that may be in a lineage with *N. leucopetrica*.

Poster Session A

REDUCTION OF THE EOCENE SIRENIAN PELVIC GIRDLE: WHO WAS WALKING AND WHO WAS SWIMMING?

ZALMOUT, Iyad, GINGERICH, Philip, The Univ. of Michigan, Ann Arbor, MI; DOMNING, Daryl, Howard Univ., Washington, DC

Reduction and loss of hind limbs are progressive adaptations in several groups of marine mammals. Sirenians are a typical example of such adaptation for life in coastal and off-shore environments.

Preserved pelvic girdles belonging to three Eocene sirenian families (Prorastomidae, Protosirenidae, and Dugongidae) from Caribbean and Tethyan deposits show that there was a gradual reduction in their size with loss of some features associated with hind limb functions. The Caribbean late early Lutetian *Pezosiren* has a terrestrially adapted pelvic girdle. Middle to late Eocene *Protosiren* from Egypt and Pakistan shows intermediate characteristics between semiaquatic and terrestrial forms in having a single sacral vertebra with elongated transverse processes, an innominate with a shallow acetabulum and reduced obturator foramen, and a femur with an oval femoral head and anteroposteriorly compressed femoral shaft. Late Eocene *Eosiren* and *Eotheroides* have the most reduced pelvic and femoral features, including: reduced length of the ischium and ilium, a diminutive obturator foramen, and unfused and distinctly separated left and right pubic bones that must have been connected to one another by ligaments or cartilage, presaging the complete loss of function in hind limbs.

Reduction in length of the innominate is associated with reduction in the diameter and depth of the acetabulum and obturator foramen, and there is also a notable reduction in the diameter of the femoral head associated with shortening of femoral length. This general reduction in size is progressive over time. By the latest Eocene, sirenians had their hind limbs inside their body wall and were fully aquatic. This dramatic transition to aquatic life in sirenians was phased differently from that of contemporaneous archaeocete whales.

Poster Session I

ECOLOGY AND PHYSIOLOGY OF WHITE RIVER MAMMALS BASED ON STABLE ISOTOPE RATIOS OF TEETH

ZANAZZI, Alessandro, KOHN, Matthew, Univ. of South Carolina, Columbia, SC; MacFADDEN, Bruce, Florida Museum of Natural History, Gainesville, FL

To characterize the ecology and physiology of common late Eocene to early Oligocene White River mammals, we analyzed $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ of tooth enamel carbonate for five of the most abundant taxa: the perissodactyls *Brontops* (brontothere), *Mesohippus* (equid), and *Subhyracodon* (rhino); and the artiodactyls *Merycoiodon* (oreodont) and *Leptomeryx* (leptomerycid). Excepting *Brontops*, which became extinct by the Orellan, teeth include Chadronian and Orellan specimens. $\delta^{13}\text{C}$ values of M2s, M3s, and premolars range from -13.1‰ to -7.7‰ (V-PDB), consistent with expected pure C3 diets. In the Chadronian, *Mesohippus*, *Merycoiodon*, and *Leptomeryx* show indistinguishable average $\delta^{13}\text{C}$ values ($\sim 10\text{‰}$). However, *Brontops* and *Subhyracodon* exhibit lower (-11.2‰) vs. higher (-9‰)

values, respectively, indicating a preference for denser forests/wetter conditions (*Brontops*) vs. more open habitats/drier conditions (*Subhyracodon*). Orellan compositions are similar, except that *Leptomeryx* shows higher average $\delta^{13}\text{C}$ values, perhaps indicating a different habitat preference for the new Orellan species *L. evansi*. Chadronian $\delta^{18}\text{O}$ values are indistinguishable for *Mesohippus*, *Merycoiodon*, *Leptomeryx*, and *Subhyracodon* ($\sim 25\text{‰}$, V-SMOW) whereas *Brontops* shows a statistically lower $\delta^{18}\text{O}$ (23‰). Only *Leptomeryx* exhibits a different Orellan $\delta^{18}\text{O}$ value (24‰). Because hind-gut fermentation in perissodactyls requires high water turnover, whereas foregut fermentation does not, the indistinguishable $\delta^{18}\text{O}$ values of perissodactyls (except *Brontops*) and artiodactyls suggest that foregut fermentation had not yet developed, at least in these taxa.

Friday 2:30

ONTOGENY AND LIFE HISTORY OF *FALCARIUS UTAHENSIS*, A PRIMITIVE THERIZINOSAURID FROM THE EARLY CRETACEOUS OF UTAH

ZANNO, Lindsay, Utah Museum of Natural History, Univ. of Utah, Salt Lake City, UT; ERICKSON, Gregory, Florida State Univ., Tallahassee, FL

The type locality of the recently named basal therizinosaur *Falcarius utahensis* is known as the Crystal Geyser Quarry (CGQ)—a dense, paucispecific bonebed within the Cedar Mountain Formation that is notable for being the largest known maniraptoran mass death assemblage. To date over 2000 elements have been recovered from the CGQ, representing individuals of a minimum of five growth stages. Recent excavations at the site have generated novel elements from the smallest known size class (estimated to belong to a minimum of one individual of approximately 0.5 m in length) as well as previously unknown elements from individuals of intermediate growth stages (i. e. smaller than 4 m in length). Recovered juvenile specimens include dorsal, sacral, and caudal vertebrae, an ischium, pubis, femur, fibula, astragalus, proximal scapula, proximal humerus, metacarpals, and multiple phalanges. Thus far less than five percent of the CGQ has been excavated and only a small amount of the bones removed from this area have been prepared. The MNI based on femora is eight, therefore extrapolation of this value suggests an MNI for the quarry of approximately 300.

Falcarius bones from the CGQ are excellently preserved, displaying well-developed LAGS. From the femoral and fibular ontogenetic series thus far recovered, we are generating the first detailed histological analysis for this clade. This study aims to: 1) characterize the microstructure of major long bones for use in phylogenetic analyses; 2) construct a growth curve for comparison with other non-avian dinosaur taxa; and 3) identify possible physiological and/or metabolic changes correlated with modification of the therizinosaur diet. Initial results are promising, offering a nearly complete LHC from hatchling to adult.

Poster Session B

LOCOMOTORY BEHAVIOR IN THE LAMBEOSAURINE HYPACROSAURUS STEBINGERI

ZELÉNITSKY, Darla, Calgary, AB, Canada; THERRIEN, Francois, Royal Tyrrell Museum of Palaeontology, Drumheller, AB, Canada; CURRIE, Philip, Univ. of Alberta, Edmonton, AB, Canada; HENDERSON, Donald, Royal Tyrrell Museum of Palaeontology, Drumheller, AB, Canada; HORNER, John, Museum of the Rockies, Bozeman, MT

In order to investigate the locomotory behaviour in lambeosaurines, we CT-scanned humeri and femora from an ontogenetic series (embryonic to adult individuals) of *Hypacrosaurus stebingeri*. These elements were scanned at approximately 65% down the length of the bone, below either the deltopectoral crest or the fourth trochanter. Cortical bone distribution and cross-sectional properties were quantified from the CT scan data. Cortical bone area (CA) and second moment of area (I) were determined from CT slices with ImageJ software, and each parameter was plotted against bone length in logarithmic space. Plots reveal that these biomechanical properties scale nearly identically between the humeri and femora (CA is positively allometric and I is isometric), which indicate that both forelimbs and hindlimbs are subject to the same loading regime throughout ontogeny. We interpret these results as evidence that *Hypacrosaurus* used its forelimbs during locomotion at all growth stages, although the extent to which they were quadrupedal cannot be determined. Our results differ from those obtained previously for *Maiasaura* for which the biomechanical properties of the forelimbs scaled differently from those of the hindlimbs, indicating a transition from bipedal to quadrupedal locomotion during ontogeny. If the conclusions reached for *Hypacrosaurus* and *Maiasaura* can be extrapolated to their respective subfamilies, such a difference in locomotory behaviour between hadrosaurines and lambeosaurines could help explain the larger hatchling size, the larger egg size, and the more robust humeri of lambeosaurines.

Poster Session B

A LATTICE-LIKE PATTERN OF OSSIFIED TENDONS IN PSITTACOSAURUS (DINOSAURIA: CERATOPSIA)

ZHOU, Chang-Fu, Peking Univ., Beijing, China; FOX, Richard, Univ. of Alberta, Edmonton, AB, Canada; GAO, Ke-Qin, Peking Univ., Beijing, China

Ossified tendons are important in studying the musculoskeletal system and behaviors of dinosaurs. Since Dollo's description of dinosaur ossified tendons in 1886, the pattern of ossified epaxial tendons is best known in iguanodonts and hadrosaurids. In this study, an ossified tendon lattice is described in *Psittacosaurus* from the Lower Cretaceous Yixian Formation in Liaoning Province, China, furnishing new information on epaxial musculature evolution in archosaurs.

In *Psittacosaurus*, the epaxial tendons are well developed in tight bundles along dorsal and sacral regions of the vertebral column. As in iguanodontoids, the tendons form a three-layered lattice. The mid-layer is formed by posteroventrally-oriented tendons, and both outer and inner layers by posterodorsally-extending tendons. A similar pattern is known for the neoceratopsian *Chasmosaurus*. Recent studies show that the lattice in Iguanodontoidea, *Chasmosaurus*, and avians, has lost the innermost, *M. multifidus*, layer, a derived character for Dinosauria; these clades, retain the more lateral *M. spinalis* and *M. semispinalis* components of *M. transversospinalis* in crocodylians and lepidosaurs. These findings in *Psittacosaurus* extend the epaxial tendon lattice among Ceratopsia, strengthening the hypothesis that the similar epaxial musculature in Cerapoda is derived for Dinosauria.

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