composite cast of a giant ground sloth *Megatherium americanum* (NHMUK 26540) on public display in the Natural History Museum, London.

Our 'alpha-shapes' predictive equation is characterised by a high correlation coefficient and low percentage prediction error (r^2 = 0.973, %PE = 12.3%). The mass of *M. primagenius* and *M. americanu* were estimated to be 3635 kg and the 3706 kg respectively, which match well with previous volumetric estimates of body mass. The application of alpha-shapes matches the predictive capacity of the convex hulling method but reduces the potential bias that segmentation of the skeletons may introduce. Future work should attempt to combine aspects of both convex hulls and alpha-shapes methods to provide a reliable mass estimation technique for complete fossil skeletons.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

BIOMECHANICAL ADAPTATIONS TO INCREASED BODY SIZE IN THE NEURAL SPINES OF THEROPOD DINOSAURS

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Theropod dinosaurs exhibit diversity in diet, lifestyle, cranial and body ornamentation, and body size, among other traits. However, the majority of theropods are characterized by a bipedal posture and locomotion. Unlike quadrupedal posture, which distributes weight across both fore- and hind limbs, bipedal posture distributes weight only on the hind limbs. This posture therefore generates bending moments in the vertebral column about the hips. Rugosities on the anterior and posterior aspects of neural spines are common in theropods. Histologic analysis of these spinal projections indicates that they are composed of metaplastic bone associated with the intervertebral ligaments. We hypothesize that these rugosities were a physiological adaptation to stresses incurred by bipedal posture in large-bodied species. This predicts the presence of rugosities in large-bodied theropods and the relative absence in small bodied theropods. We tested this hypothesis with a phylogenetic t-test to determine whether average body size differs between species with and without neural spine rugosities. We find strong support for this correlation ($p < 1.0e\text{-}^{10}$). Projecting rugosities also appear to vary between juveniles and adults of the same species, with juveniles either lacking them or exhibiting smaller rugosities. This limited ontogenetic evidence also supports our hypothesis. Metaplastic ossification of the interspinal ligament would likely affect the flexibility of the spinal column, increasing passive support for body weight. A stiff spinal column would also provide support for the primary hip flexors and therefor influence locomotor performance in large-bodied theropod dinosaurs.

Colbert Prize (Wednesday - Saturday, October 14-17, 2015, 4:15 - 6:15)

EARLY MIOCENE PALEOENVIRONMENTS OF RUSINGA ISLAND, KENYA: NEW DATA FROM FOSSIL MAMMALIAN TOOTH ENAMEL STABLE ISOTOPE COMPOSITIONS

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The fossil-bearing Early Miocene formations on Rusinga and Mfangano Islands, Kenya (ca. 17–20.5 Ma) preserve diverse mammalian faunas, including numerous catarrhine primates. These assemblages are key references for understanding the evolution and diversification of crown catarrhines, so placing the Rusinga vertebrate communities in a clear ecological context is crucial to resolving the ecology and behavior of early apes and Old World monkeys. Prior paleoenvironmental reconstructions have yielded a range of conflicting results from closed-canopy tropical rainforests to open and semi-arid environments. Our recent work has integrated multiple paleoenvironmental methods at individual localities in the Hiwegi Fm, including leaf margin and leaf area analyses of fossil leaves, paleosol micromorphology and geochemistry, and vertebrate taphonomy and paleoecology. Our results suggest more open, drier woodland habitats low in the Hiwegi Fm that transition to a dense, closed canopy forest up section. Notably, the same species of catarrhines are found in both intervals, indicating they habitually occupied both open woodlands and closed forests.

We present carbon isotope compositions ($\delta^{13}C$) of tooth enamel of proboscideans, suids, rhinocerotids, chalicotheres, anthracotheres, tragulids, hyracoids, and carnivores from a series of formations (Kiahera, Hiwegi, and Kulu) on Rusinga Island. While paleosols record environmental information averaged over hundreds to thousands of years at a single site, enamel $\delta^{13}C$ provides paleoenvironmental information over the short interval of tooth formation (months to years) and integrates the dietary signal over the foraging habitats of a consumer, which aids evaluation of temporal and spatial environmental variability. The sampled teeth (currently n=48) have $d^{13}C$ values that span the entire range of modern C_3 biomes. The majority of specimens fall within one standard deviation of modern mean C_3 vegetation, indicating most sampled animals foraged in C_3 environments with neither light/water stress nor closed canopies. Interestingly, numerous specimens have $\delta^{13}C$ values consistent with foraging in more open habitats in which plants experienced light/water stress. Only two specimens, both tragulids, have $\delta^{13}C$ values low enough to indicate foraging in a closed-canopy forest. Our results are broadly consistent with the reconstructions based on paleosols and fossil leaves for the Hiwegi Fm, but suggest high spatial variability in habitats throughout the Early Miocene succession on Rusinga Island.

Grant Information
Leakey Foundation; University of Minnesota; Baylor University; Evolving Earth Foundation; Geological Society of America; Society for Sedimentary Geology; Explorers Club

Technical Session VII (Thursday, October 15, 2015, 1:45 PM)

MACROEVOLUTIONARY TRENDS IN THE PREORBITAL SKULL REGION OF ORNITHOPOD (ORNITHISCHIA) DINOSAURS

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Hadrosauroid dinosaurs are some of the most derived megahebivorous tetrapods ever to evolve, typified by elongated preorbital skulls and large external naris that began as the opposite condition in more primitive ancestors such as *Lesothosaurus*, dating from the Early Jurassic. Though the evolution of the preorbital skull in ornithopod dinosaurs appears to be directional based on observation of primitive versus derived Late Cretaceous species, Late Jurassic and mid-Cretaceous ornithopods allow rigorous testing of this hypothesis by providing pivotal anatomical data throughout the ornithopod tree. The evolutionary modes and correlations of three features in the ornithopod skull-preorbital skull length, area of the antorbital fenestra, and area of the narial fenestra-were tested using a variety of phylogenetic comparative methods on 37 ornithopod taxa and 750 time-scaled trees to account for stratigraphic uncertainty in species occurrences. An evolutionary mode test in BayesTraits revealed no statistical difference between a random walk model and directional model in preorbital skull length evolution, either considering each of the traits singly or wholesale. Phylogenetic generalized least squares regression shows a strong degree of correlation between length of the preorbital skull and size of the naris (R^2 = 0.48), a weak correlation with preorbital skull length and size of the antorbital fenestra (R^2 = 0.18), and a moderate correlation between size of the naris and antorbital fenestra (R^2 = 0.33). These results do not support the hypothesis that ornithopod cranial evolution was on a directional path towards the hadrosaurid morphology. Much of the seeming randomness in skull evolutionary modes may be due to the inclusion of smaller bodied, mid- Late Cretaceous basal ornithopods/basal ornithischians such as *Orodromeus* and *Thescelosaurus*, yet excluding these taxa from analyses does not change the result that the preorbital region of ornithopod skulls generally evolved via Brownian processes. As such, there may be a larger array of cryptic dietary morphology among ornithopods than previously appreciated, a major consideration for future modeling of megaherbivorous dietary evolution across dinosaurs.

Technical Session IX (Thursday, October 15, 2015, 1:45 PM)

AN IN-DEPTH LOOK AT 'SHALLOW' DINOSAUR TRACKS

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An animal's foot can indirectly deform layers beneath the substrate's surface, leading to the creation of 'undertracks' that are frequently discovered in the fossil record. Despite the benefits of the undertrack model, its application to footprints formed by different mechanisms is not justified. For example, Mesozoic dinosaurs moving through soft, wet substrates sank to significant depths without transmitting deformation far below the foot. In taxa with relatively long toes, such as theropods and some ornithischians, the sediment collapsed and sealed shut behind each penetrating digit, leaving a V-shaped sulcus. Such slit-like tracks can be easily misinterpreted, particularly if only one surface is available for analysis.

We combine results from computer simulations with multi-slab specimens from the Hitchcock Ichnology Collection in the Beneski Museum of Natural History at Amherst College to illustrate four scenarios: 1) If sulci are fully prepared, tracks can be construed as shallow marks left by a thin-toed foot (often avian) or the product of swimming or scraping motions. 2) If sulci are incompletely prepared, remaining fill can give the illusion of a shallow track made by a wide-toed foot. 3) Sampling of incompletely exposed sulci at multiple levels yields a sequence (one of Hitchcock's "stony volumes") that appears to show a shallow track transmitting undertracks over long distances. 4) Finally, morphologically detailed undertracks are sometimes found below collapsed sulci, contrary to the popular conception that detail decreases with depth. Given that deep track surfaces are more likely to be encountered than very shallow track surfaces, we believe that these errors and similar mistakes may be quite common in studies of dinosaurs and other taxa. A more complete understanding of track formation dynamics is critical for correct interpretation of morphologies encountered in the field and collections.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

PALEOGENE XENARTHRA AND THE EVOLUTION OF SOUTH AMERICAN MAMMALS

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Recent studies show Xenarthra to be even more isolated systematically from other placental mammals than traditionally thought. The group not only represents one of four primary placental clades, but proposed links to other fossorial mammal taxa (e.g., Pholidota, Palaeanodonta) have been contradicted. No unambiguous Paleocene fossil xenarthran remains are known, and Eocene remains consist almost exclusively of isolated cingulate osteoderms and isolated postcrania of uncertain systematic provenance. Cingulate skulls are unknown until the late middle Eocene, and the oldest sloth and anteater skulls are early Oligocene and early Miocene age, respectively; there are no nearly complete xenarthran skeletons until the early Miocene. Ecological reconstructions of early xenarthrans based on extant species and the paleobiology of extinct Neogene taxa suggest the group's progenitors were myrmecophagous with digging and perhaps some climbing adaptations. The earliest cingulates were terrestrial diggers and likely myrmecophagous but soon diverged into numerous omnivorous lineages. Early sloths were herbivores with a preference for forested habitats, exhibiting both digging and climbing adaptations. We attribute the rarity of early xenarthran remains to low population densities associated with myrmecophagy, lack of durable, enamel-covered teeth, and general scarcity of fossil localities from tropical latitudes of South America. The derivation of numerous omnivorous and herbivorous lineages from a myrmecophagous ancestor is a curious and unique feature of xenarthran history and may be due to the peculiar ecology of the native South American mammal fauna. Further

progress in understanding early xenarthran evolution may depend on locating new Paleogene fossil sites in northern South America.

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Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

DID THE HUNT FOR EARLY MAMMALS IN ARIZONA CREATE A SIGNIFICANT SAMPLING BIAS?

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The completeness of the fossil record and biases in our collections of this record have been the subject of numerous previous studies. Most of these have focused on two main areas: the relative completeness of organisms or the overall body mass of the recovered organisms. This has resulted in a fairly good understanding of the completeness of the fossil record in what could be termed "normal" conditions; prospectors collecting specimens with no particular focus on clade collected or size of the organism. Overall, large-bodied organisms tend to be discovered and described soonest while smaller-bodied organisms are generally discovered later and tend to be less complete.

To test if this trend is robust, the Lower Jurassic (Sinemurian–Pliensbachian) Kayenta Formation of Northern Arizona was investigated. In the 1970s and early 1980s, intensive fieldwork was undertaken by crews from the Museum of Northern Arizona and Harvard's Museum of Comparative Zoology attempting to locate early mammals and stem-mammal synapsids. Based on this focus we hypothesized that a "rebound" would exist, with a greater number of small-bodied organisms being discovered before larger-bodied ones, reversing the "normal" trend. A review of the published literature suggested this hypothesis was supported.

A specimen-level analysis of the Kayenta Formation collections of the Museum of Northern Arizona was conducted to test these results from the literature review. Data collected included date of collection, least-inclusive clade, estimated body length, and a completeness index score. Analyses of these data did not support the rebound hypothesis. Declining trendlines for size over time have an R-squared value between 0.95 and 0.97, indicating a good fit to a standard "big first" model. This suggests a publishing bias may exist and literature-based studies of collection biases may be missing an underlying signal in collections themselves.

Poster Session I (Wednesday, October 14, 2015, 4:15 - 6:15)

THE IMPORTANCE OF SENSITIVITY ANALYSES FOR THE INFERENCE OF FUNCTION FROM STRUCTURE

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The inference of function from structure is a challenging aspect of vertebrate paleontology, yet provides fascinating paleobiological insights. For example, understanding the variability in temporal activity patterns is crucial for gaining insight into ecological interactions and resource partitioning in paleoecosystems. Recent studies have shown that the morphology of the scleral ring and orbit structures may prove to reliably distinguish between different activity patterns. Strong correlations between visual performance features and activity patterns among extant avians and squamates provide a basis for drawing inferences about the activity patterns of extinct saurians. However, several factors (e.g., taphonomic, allometric, polymorphic) may introduce potentially confounding noise in classifying extinct taxa.

In order to evaluate the robustness of such inferences, we performed a sensitivity analysis. We combined time-calibrated phylogenies with data from extant (n = 368, with known diel activity pattern) and extinct (n = 33) saurian species to devise a resampling and simulation approach.

First, we tested how sample size affects the estimation of optimal lambda, a tree transformation parameter that seeks to maximize the correlation between form and function. Optimal lambda is important for accurate functional classifications of fossil samples. Our resampling results demonstrated that optimal lambda estimates for datasets of less than 100 species are unreliable, with many false near zero estimates.

Second, we designed a simulation approach to explore the effects of measurement variability. On the basis of empirically derived proxies, we generated several measurement distributions that reflect variation in fossils, ranging from natural variation to geologic deformation. While functional classifications of many fossils (including, e.g., *Velociraptor*, *Confuciusornis*) remained robust across all traits when assuming natural variation, some were more labile for at least one trait (e.g., *Ornithomimus*, *Pterodasutro, Rhamphorhynchus*). When introducing a high degree of variation, representative of geologic deformation, all taxa were prone to be misclassified.

Our results have important implications for future comparative studies. In order to avoid inaccurate paleobiological inferences, datasets must be sufficiently large to avoid problems with statistical inference of model parameters, and effects of natural variation and geologic deformation should be explored.

Technical Session V (Wednesday, October 14, 2015, 1:45 PM)

NEW TECHNIQUES FOR REMOVING THE EFFECT OF MORPHOLOGICAL INTEGRATION ON PHYLOGENETIC ANALYSIS

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One of the assumptions of phylogenetic analysis is that all of the characters being assessed evolve independently of one another. However, morphological characters may be linked due to a shared developmental or epigenetic process, or because states are selected together because of shared functional or ecological pressures. The interdependence of characters is referred to as morphological integration and has been a major source of arguments against using morphology to construct phylogenetic hypotheses in favor of using molecular data instead. The most common method used to remove the effect of morphological integration has been for the investigator to identify a suite of correlated character changes, usually associated with a particular ecomorph, and then downweight or delete those characters to reduce their collective contribution to tree length. I have developed two techniques that remove potential investigator biases by allowing the covariance structure of the data to determine how each character ultimately contributes to the tree length or model of evolution. For the first time, the structure of the data is determined using a phylogenetically informed categorical factor analysis. This uses the tree structure and a mix of Pearson's, tetrachoric, polychoric, and polyserial correlations to integrate discrete and continuous data into the same covariance structure. It also allows the researcher to include data such as sex or environmental factors into the data structure without using them as characters in the phylogenetic analysis. For parsimony searches, my new technique uses the degree to which its state can be predicted by other characters' states to determine the appropriate reweighting scheme. Because the factor analysis is sensitive to the tree structure, I use an iterative process to gradually converge on the best re-weighting scheme and tree topology together. For maximum likelihood based searches, I use the factor structure to find the difference between the state of each character and the state predicted by the states of the other characters, similar to a phylogenetically informed size correction. For each tree in a search of tree-space, the model of evolution is estimated for each character that maximizes the likelihood of the observed residual. These new techniques allow researchers to use all available morphological data to construct phylogenetic hypotheses without the looming specter of morphological integration.

Poster Session III (Friday, October 16, 2015, 4:15 - 6:15)

A NEW DIVERSE SQUAMATE FAUNA FROM THE LATE MIOCENE OF NORTHERN GREECE

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Late Miocene microvertebrate faunas from Southeastern Europe are crucial for our understanding of the evolution, extinction events and biogeographic scenarios of Neogene squamates. However, the relative scarcity of such localities from this region and the overall interest of most researchers in micromammals have hindered the identification of squamate remains. Therefore, the majority of squamate specimens from these localities have not been properly identified and are, usually, only tentatively assigned up to the family level. New squamate material is here presented from the late Miocene locality of Ano Metochi. Located in the Serres Basin in Northern Greece, Ano Metochi is already well known for its rich micromammal fauna as also some important large mammal finds, which all have pointed with certainty a late Turolian age (MN 13). Squamates have only received minor attention, with only a few sporadic referrals of the existing finds. However, new undescribed material recovered from this locality indicates a highly diverse squamate fauna. Lizards are represented by numerous agamids, lacertids, scincids and anguids, as also some indeterminate forms. Much of the material consists of dentaries, maxillae, vertebrae, osteoderms and limb elements, permitting the identification of a multitaxic lizard fauna. Snakes are represented by a large number of isolated vertebrae, but also from cranial elements as well as fangs, allowing the identification of scolecophidians, natricine and non-natricine colubrids, and several indeterminate forms. The presence of a scolecophidian is rather important as it constitutes one of the few occurences in the Neogene fossil record of this group at a global level. Comparison with the adjacent and slightly coeval locality of Maramena, also from the Serres Basin, reveals the notable absence of varanids, viperids and elapids from the Ano Metochi fauna. This absence should be attributed to preservation or collection biases, as Maramena has been more extensively investigated for microvertebrates, although a genuine absence of these groups due to ecological factors should not be ruled out. Deciphering the alpha taxonomy of the Ano Metochi lizards and snakes adds significantly to the known diversity of squamates from the Neogene of Southeastern Europe, contributing also to the knowledge of their ecology, evolution and biogeography.

Poster Session IV (Saturday, October 17, 2015, 4:15 - 6:15)

TAPHONOMIC DESCRIPTION OF THREE RECENTLY DISCOVERED *TROODON* CLUTCHES FROM EGG MOUNTAIN

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Troodon eggs are known from the Upper Cretaceous (Campanian) Two Medicine and Judith River Formations. Egg clutches document the reproductive behavior of this dinosaur and provide insight into the evolutionary transitions from non-avian dinosaurs to birds. Here we describe the taphonomy of three recently discovered *Troodon* clutches excavated during 2012, 2013, and 2014 at the Two Medicine Egg Mountain locality. These partial clutches consist of between 3 and 8 eggs in varying condition with associated eggshell debris. The 2012 clutch is the most heavily disturbed since the eggs lack the near-vertical posture typical of better-preserved clutches. In contrast, the less disturbed 2013 and 2014 clutches retain upright eggs leaning toward the clutch center. Because the eggs were partially buried in sediment after being laid, these clutches indicate autochthonous nesting. Sediment samples from the clutches indicate grey siltstones that are very poorly to moderately sorted. Orientation of associated eggshell from the 2012 and 2013 clutches favor concave down, n = 73 of 122 and, n = 118 of 225, respectively, whereas those from the 2014 clutch favor concave up (n = 30 of 56). Eggshell orientation from modern avian nesting sites and transport experiments may provide insight into the interpretation of these clutches. Eggshell orientations from all three clutches are inconsistent with transported assemblages. Eggshell orientations near the 2012 and 2013 clutches compare most closely with fragmentation caused by trampling by chicks after hatching. Orientations near the 2014 clutch more closely compare to fragmentation due to either hatching or predation. The 2012 (n = 11) and 2013 (n = 17) clutches preserve high numbers of shed *Troodon* teeth and may record feeding near the clutch or the lengthy brooding period. *Orodromeus* and small skeletal remains near these two clutches could be consistent with the former.