

TMM 42452-1 represents a new species of hadrosaur. This species is referable to *Kritosaurus*, as shown by the presence of a recurved narial crest, failure of the prefrontal and premaxillary articulations to contact on the lateral surface of the nasal, and penetration of the nasals between the frontals on the skull roof. The dentary symphysis of TMM 42452-1 is unusual, in that it is formed by rostrorodorsally directed processes of each dentary, resulting in a w-shaped union of the mandibles (as restored) in rostral view. The skull and mandibles are correspondingly wider transversely than in other *Kritosaurus*. The restructuring of the rostrum in TMM 42452-1 may be functionally similar to the structure of the rostral dentaries in *Edmontosaurus copei*. Recognition of the unique structure of the rostral mandibles in these two species may constitute the first documentation of an unequivocal trophic specialization within Hadrosauridae.

The lower shale member of the Aguja Formation is stratigraphically lower than the upper shale member, the main fossiliferous horizon of that unit. However, the temporal relationships between the two are not entirely clear. There is no evidence of common upper shale member taxa such as *Chamososaurus nariscalesis* in the lower shale, and the new hadrosaur species does not occur in the upper shale member of the Aguja Formation. Although the lower shale member of the Aguja has not been extensively prospected, it may harbor a unique (earliest Middle Campanian) fauna.

MICROTUS PINETORUM AND M. OCHROGASTER FROM THE WAPSIPINICON LOCAL FAUNA, JONES COUNTY, IOWA

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The Wapsipinicon Local Fauna consists of several faunules collected from a fossiliferous fissure complex within the Dutch Creek valley of Wapsipinicon State Park, Jones County, Iowa. Excavations have yielded over 3000 microvertebrate remains including: the endemics *Microtus pinetorum* (pine or woodland vole) and *M. ochrogaster* (Prairie vole); the boreal indicators *Phenacomys inermis* (heather vole), *Synaptomys borealis* (northern bog lemming), and *Clethrionomys gapperi* (southern red-backed vole); the taiga indicator *Microtus xanthognathus* (yellow-cheeked vole); and the tundra indicators *Dicrostonyx torquatus* (colored lemming), *Microtus miurus* (singing vole), and *Lemmus sibiricus* (brown lemming). The presence of *Mus musculus* (house mouse) suggests a degree of contamination at the site, however AMS radiocarbon dates ranging between 13,460 ± 120 and 25,470 ± 350 yr B.P. have been obtained from individual mandibles of *Microtus xanthognathus*. This site represents yet another fauna indicative of boreal and tundra-like conditions in the upper Mississippi Valley during the Late Pleistocene.

Separation of the lower first molars (m1s) of *Microtus pinetorum* from those of *M. ochrogaster* has been problematic due to similar occlusal morphology. Although traditional techniques (i.e. isthmus width, shape and orientation of the 6th and 7th re-entrant angles, etc.) separate most specimens, morphologic overlap typically leads to some unidentified specimens or misidentification. Morphometric analysis of landmark data (21 2-D landmarks) and schmelzmuster (enamel microstructure) discriminate these two taxa consistently (nearly 100%). Both morphometric analyses and schmelzmuster provide independent tests to support or refute identifications (using traditional means) of problematic specimens.

NEW SPECIMENS OF MERYCOBUNODON (ARTIODACTYLA, OROMERYCIDA) FROM THE EARLY UINIAN OF SAN DIEGO COUNTY, CALIFORNIA

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Merycobunodon littoralis was originally described on the basis of two maxillary fragments from the middle Eocene Friars Formation. Numerous specimens of the upper and lower dentition have since been collected from the Friars by SDSNH personnel, and a new small species of *Merycobunodon* may also be present in this formation, represented by partial skulls and associated dentaries. SDSNH 47877, previously referred by the author to *cf. Lophiohyus* sp., is re-identified as a large individual of *M. littoralis*. It consists of L + R dentary fragments with well-worn cheek teeth and partial anterior dentitions, a well-worn M3, and some fragmentary postcrania.

Important features of the lower jaw of *M. littoralis* include: symphysis rugose; mental foramen below p2; incisors unknown; long diastema between caniniform c1 and large, caniniform p1; long diastema between p1 and 2-rooted p2; long diastema between p2 and p3; p4 simple, with small metaconid but without paraconid; molars with labial cingulids, weak crests, weak metastylids, and without paraconids; m3 hypoconulid lobe with large central cusp and smaller lingual cusp but without U-shaped basin. Diastemata in the anterior dentition are shorter in dentaries of younger individuals of *M. littoralis*, suggesting ontogenetic variation. SDSNH 47877 also displays a strongly fused radius and ulna and a medio-laterally compressed astragalus.

The dentary and cheek teeth of *Merycobunodon* are similar to those of Bridgerian *Helohyus*, and especially "*Lophiohyus*" *alticeps*, differing mainly in the loss of the paraconid, presence of weak metastylids, and presence of a weakly bifurcated protocone on the upper molars. The latter character was previously used to assign *Merycobunodon* to the Oromerycidae. While this assignment seems correct, *Merycobunodon* may be too derived to be ancestral to other oromerycids such as *Protolyopus*, which lacks significant diastemata in the

anterior dentition, has a smaller p1 with a shorter, triangular crown, and shows only partial fusion of the radius and ulna in old individuals.

FLESHING-OUT TRICERATOPS: ADDING MUSCLE AND SKIN TO THE VIRTUAL TRICERATOPS

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We present fully fleshed-out reconstructions of the horned dinosaur *Triceratops* based on the new posture and skeletal mount developed recently at the Smithsonian Institution's National Museum of Natural History. A wide variety of different, three-dimensional views were used as a basis for adding the primary musculature to the skeleton of *Triceratops*, and then placing the skin and other components on top of that layer. This was done fully in digital form starting with different views generated from the Virtual *Triceratops*, the three-dimensional computer model of the skeleton, that were exported as graphics files. These were then imported directly into the software used for the painting of the new image, for the subsequent addition of the muscles, skin and other components. Subtle points of attachment for the muscles could be checked interactively using the virtual model directly, and the results applied to the views being fleshed-out. The resulting files were then used for many different applications, and especially as the graphics used in the new Horned Dinosaur section of the Smithsonian's Dinosaur Hall. Hard-copy was generated for yet other applications, especially for use in publications and marketing. This is the first dinosaur reconstruction done in this way and points to the great potential for making far more accurate fleshed-out reconstructions of dinosaurs by starting with the basic skeletons that are reconstructed in a form that can be manipulated easily for use by the artist. The virtual model especially made it possible to view the potential muscle attachments in great detail from all angles, and even allowed all non-involved elements to be temporarily hidden to allow concentration on the attachments of interest, and then, of course, revealed to make sure they do not obstruct the inferred muscle path.

BIRD FEATHERS, INSECTS, AND PLANT FOSSILS FROM LOWER CRETACEOUS LACUSTRINE BEDS IN THE CENTRAL GOBI DESERT, MONGOLIA

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Specimens of feathers were found in Lower Cretaceous beds at Abdrant Nuru in the central Gobi Desert, which had been known as an Upper Cretaceous vertebrate locality based on its dinosaur fauna and its ichnofauna. The Lower Cretaceous beds are separated from the Upper Cretaceous continental red beds by an angular unconformity. The lithology of the Lower Cretaceous is dark-gray mudstone, hard siliceous and marly mudstone, fissile paper shale, and fine-grained sandstone, indicating a lacustrine sedimentary environment. The beds dip to the northwest at an angle of about 18 degrees in a monoclinical structure, and strike SW-NE. The total measured thickness of the Lower Cretaceous beds is about 120 m. Plant and arthropod fossils are abundant in these beds.

During an intensive excavation in six quarries, three specimens of possible bird feathers were found in the paper shale lithofacies. The feathers show slightly asymmetrical width of the vanes on either side of the rachis. Their calamus is not preserved. The plumaceous parts of the feathers are not visible. They are considered to be contour feathers. Although at present there is no clear feature that allows us to assign these feathers to birds rather than dinosaurs, the discovery of such remains of external parts of vertebrates indicates high potential for discovery of skeletal remains of such taxa in the Lower Cretaceous paper shale lithofacies. A specimen of a fish scale was also collected.

The geologic age of these fossiliferous beds is poorly known. The arthropod fauna contains Dipteran larvae, Hemiptera, Orthoptera (roaches), and many species of Coleoptera. The megafossil flora includes cycads, gymnosperms, bennettitaleans, ferns, and rare angiosperms. The Khukhshirin and Andakhuduk Formations are possibly correlated with the fossiliferous section at Abdrant Nuru.

THE EVOLUTION OF VERTEBRAL PNEUMATICITY IN THE SAUROPODA

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The vertebrae of sauropod dinosaurs are characterized by complex architecture involving laminae, fossae, and internal chambers of various shapes and sizes. These structures are interpreted as osteological correlates of an intricate system of pneumatic diverticula similar to that of birds. In primitive sauropods, including *Jobaria* and *Haplocanthosaurus*, pneumatic features are limited to fossae. Although these fossae are morphologically simple, lacking the elaborate subdivision of pneumatic chambers observed in more derived taxa, the absence of similar fossae in the axial skeletons of ornithischians suggests that they are pneumatic in origin and not simply adaptations for mass reduction. A well-developed system of vertebral laminae was already present in primitive sauropods and also supports the interpretation of certain

vertebral characters as products of pneumatization. Camerate and camellate are internalized pneumatic chambers independently acquired in neosauropods and some Chinese forms. The polycamerate and camellate vertebrae of higher neosauropods are characterized by internal pneumatic chambers of considerable complexity. The independent acquisition of these derived morphologies in *Mamenchisaurus*, advanced diplocoids, and most titanosauriforms is strongly correlated with increasing size and neck length.

The presacral vertebrae of primitive sauropods were probably pneumatized by diverticula of cervical air sacs similar to those of birds. Although pneumatic characters in sauropods are most extensive and complex in presacral vertebrae, the sacrum was also pneumatized in most neosauropods. Pneumatization of the proximal caudal vertebrae was achieved independently in diplocoids and titanosaurids, in birds, the synsacrum is pneumatized via abdominal air sacs which function primarily in lung ventilation. The presence of pneumatized sacral and caudal vertebrae in neosauropods indicates that abdominal air sacs may have been present in at least some sauropods. The hypothesis that sauropods had thoracoabdominal air sacs is also supported by certain aspects of their paleobiology, especially the observed rapid growth rates.

3D HISTOLOGICAL TAPHONOMY: BARBECUING CAMPANIAN DINOSAURS LEAVES ITS MICROSCOPIC MARK!

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Gross morphology indicates that some fibro-lamellar bone of specimen CMC VP7122, from incinerated Campanian dinosaurs (Wegweiser, 2000) burned at temperatures ranging from 800°C to an excess of 1200°C. Scanning electron microscopy (SEM) suggests evidence of microstructural changes that occurred in the dinosaur bones during burning, principally alterations within the Haversian canal systems. Osteocyte lacunae are still visible in some specimens. These fine-scale microscopic changes corroborate the macroscopic color change evidence of burning at high temperatures. Three-dimensional (3D) scanning electron microscopic images are presented to provide a different perspective of the Haversian canal system found in Campanian dinosaur bone.

During incineration, histological changes occur in several ways as temperature increases over time. First, dehydration and densification of the burning bone occurs between temperatures of 105° to 600°C. Decomposition then occurs at temperatures between 500° to 800°C. Next, inversion of the burning bone material occurs at temperatures of 700° to 1100°C. There are few additional microscopically observable changes during the temperature rise from 1100° to 1600°C. However, at approximately 1600°C the bones begin to melt, accompanied by a general fusion of the material as the temperature exceeds 1600°C. The dinosaur bones examined in this investigation displayed evidence for changes occurring under 1600°C. These and other morphological changes as evidenced by scanning electron microscopic observation of these transformations are presented in this report. This is the first time microscopic histological changes found in burned dinosaur bone is described.

FIRST DESCRIPTION OF THE SKULL OF *MENISCOEISSUS ROBUSTUS* EXPANDS KNOWN MORPHOLOGICAL DIVERSITY OF MULTITUBERCULATA AND DEEPENS PHYLOGENETIC MYSTERY

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Preliminary description of the first skull of a cimolodontan multituberculate from the Late Cretaceous of North America (NSM-PV 20436) reveals it to be different from those of Mongolia, supporting the hypothesis that the Djadochtheria are endemic to Asia. Yet the skull of *Meniscoeissus robustus* possesses a unique mosaic of characters inconsistent with placement in either Ptilodontidae or Taeniolabidae.

The affinities of the Cimolomyidae, to which *Meniscoeissus* belongs, have been a mystery unsolvable on the basis of dental data, and cimolomyids are usually placed in Cimolodonta incertae sedis. *Meniscoeissus* does not belong in Djadochtheria: the enamel of the lower incisor is not restricted; its frontal-parietal suture is clearly V-shaped; it has a larger incisive foramen than any djadochtherian; and the head is shaped like that of other North American cimolodontans, with an anteriorly flared zygomatic arch and a flat profile that does not taper substantially towards the muzzle.

Meniscoeissus resembles Djadochtheria, however, in having sharply pointed frontals that separate the nasals posteriorly, and in having the lacrimal exposed on the cranial roof, precluding contact of the frontal with the maxilla. These two characters make it unique among North American multituberculates for which the skull is known. Its postorbital process is unique among all described multituberculates in that the frontal and parietal both participate via a deeply elaborate suture.

Meniscoeissus resembles *Taeniolabis* in lacking palatal fenestrae, in the anterior origin of the zygomatic arch dorsal to P4-M1, and in position of the posterior edge of the palate. Before cimolomyids can be considered ancestral to Taeniolabidae, however, additional research is

needed to distinguish phylogenetically informative characters from those that vary allometrically. Thus far, the skull of *Meniscoeissus* is as equivocal as its teeth.

PELVIS MORPHOLOGY OF TEXAS RAUISUCHIANS

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Rauisuchians were a fascinating group of archosaurs that dominated the predatory niche of terrestrial ecosystems during the Middle to Late Triassic Period. However, there is much confusion regarding the phylogeny of rauisuchians. In the Triassic of Texas there appears to have been three distinct morphotypes of rauisuchian well represented in rocks of Carnian and Norian age. The three rauisuchians present in Texas are *Postosuchus*, "*Chatterjeea*", and poposaurids. The illia of rauisuchians are very distinctive and may indicate relationships within the group. *Postosuchus* may be distinguished from the other two groups by the horizontal tilting of the ilium such that the acetabulum faces ventrolaterally and possessing a small supra-acetabular buttress located dorsal to the acetabulum. The pubic peduncle is positioned anteroventrally. The illia of poposaurids and "*Chatterjeea*" were positioned vertically with a large supra-acetabular crest that developed into a forward projecting flange that extends anteriorly to the preacetabular blade. The pubic peduncle faces more anteriorly than in *Postosuchus*. All three groups lived contemporaneously within the Dockum of Texas and show adaptation to a fully erect gait.

CONVERGENT EVOLUTION OF THE MAXILLA-DENTAL COMPLEX IN CARNIVOROUS ARCHOSAURS

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Archosaurs first appeared in the Late Permian, and during the subsequent Mesozoic Era they evolved several different clades of carnivores, all of which can trace their origins back to a primitively carnivorous form. Three aspects of the maxillary teeth of carnivorous archosaurs were investigated for potential functional correspondences with the form of their associated maxillary bone: mean and maximal tooth lengths; medio-lateral and antero-posterior tooth bending strengths; and total external surface area of teeth. A fourth investigation looked at the depth of the skull relative to its length for any potential functional correspondence with total tooth area or mean maxillary tooth length. All linear and areal dimensions were normalized to correct for size-related factors.

A good correspondence was found between long teeth and teeth with high bending strengths and the amount of bone in the ventral region of the maxilla; and this condition was observed to have evolved independently in rauisuchians, crocodylomorphs, and at least three times in theropod dinosaurs. No plausible relationship was found between the total surface area of the teeth and maxillary form. Working under the assumption that larger predators will generally attack and dismember larger prey, the observed changes in maxillary form are interpreted as a biomechanical response for increasing support of the teeth during a phylogenetic increase in body size, and the concomitant increase in the size of prey.

A strong correlation also exists between normalized maxillary tooth lengths (mean tooth length divided by skull length) and skull aspect ratios (mean skull depth divided skull length). It is proposed that increases in the length of teeth, and the presumed increase in the depth of penetration by the teeth, are associated with an increased resistance to sagittal (dorso-ventral) bending of the skull for all sizes of carnivorous archosaurs.

DIVERSITY AND TURNOVER IN EASTERN AFRICAN PLIO-PLEISTOCENE CARNIVORA

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Studies of African mammalian diversity have focused on the turnover-pulse hypothesis, which suggests that a major turnover event occurred in African land mammals 2.8-2.5 Ma. Although carnivore diversity should correlate with patterns of climatic diversity due to effects on prey species, carnivores have not been included in previous studies. We present analyses of diversity and turnover in eastern African carnivore taxa from 4.5 to present.

Turnover in eastern African carnivores is the opposite of that predicted by the turnover-pulse hypothesis. Our research indicates a distinct pattern with high turnover between 4.5-3 Ma, low turnover between 3-2 Ma and renewed high turnover after 2 Ma. Reduction in turnover around 3 Ma and the increase at around 2 Ma are both statistically significant. Elimination of sites with large, dominant faunas did not change this pattern substantially. Absence of correlation between number of localities and number of taxa in each interval indicates that the key interval from 4-1 Ma is not significantly affected by sampling effort.

Our examination of carnivore faunas around the world suggests the following. An extinction event occurred in eastern African carnivores near the Miocene-Pliocene boundary. The early peak in relative turnover was triggered by local diversification of some groups (e.g., sabertooths, otters, hyaenids). Later stages of the early high turnover interval are characterized by a dispersal event into eastern Africa of taxa such as *Canis*, *Megantoneon* and small mustelids from the north and *Hyaena* from the south. Diversity peaks at 3.5-3 Ma. After this event, last appearances dominate first appearances. After about 2 Ma, there is decimation of