Padian, K. and Olsen, P.E., 1989, Baird's two axioms of vertebrate paleoichnology. Abstract of Papers, Forty-Ninth Annual Meeting Society of Vertebrate Paleontology, Journal of Vertebrate Paleontology, Vol. 9, No. 3, Supplement., p. 34A-35A.

Numerous small vertebrate fossils have been recovered from the Twin Mountains and Paluxy formations of Erath, Hood, and Somervell Counties, Texas. Salamanders, frogs, and lizards are abundantly represented in the samples and indicate the presence of a diverse small tetrapod fauna. Salamander taxa recovered include *Prosiren elinorae* from the Twin Mountains and Paluxy formations, and other possible Caudata of unknown affinity are also present. Discoglossid-grade anurans were recovered from the Twin Mountains and Paluxy formations, although numerous frog elements in the sample are difficult to relate to modern anuran families. Lacertilians are also present in both the Twin Mountains and Paluxy formations, primarily represented by isolated jaws. Several specimens may be related to the Teiidae. Many of the Comanchean lizards may be reasonably compared to the paramacellodids. However, due to the fragmentary nature of the specimens and predominance of plesiomorphic characters, it is difficult to taxonomically define the small Comanchean tetrapod taxa at the familial level. The Early Cretaceous fossils illustrate the difficulty of relating small Mesozoic tetrapods to Cenozoic clades.

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## THE ORIGIN OF VERTEBRATE SCALES AND TEETH: CONODONTS AS THE FIRST CRANIATES

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Recently described soft body fossils reveal conodonts to be elongate, laterally compressed animals with a caudal fin and V-shaped body segments, leading to the resurrection of theories of a chordate affinity for these enigmatic fossils. The only chordate structures comparable to conodont elements are the horny tongue teeth of hagfish, that develop like vertebrate teeth and have enamel proteins in the outer cell layer. Conodont elements consist of an outer, ectodermally secreted, enamel-like part and an inner, mesodermally secreted, dentine-like part. Patterns of growth lamellae reveal that conodonts could regenerate broken cusps, indicating the probable presence of an epidermal covering as seen in vertebrate scales. Functional considerations suggest the presence of a horny covering as well, such as in modern hagfish teeth. The epidermal epithelium would have secreted phosphatic layers internally and produced a horny cusp externally. Vertebrates may have originated from conodonts that later evolved the ability to form phosphatized structures elsewhere in the body surface integument and emphasized mesodermally secreted calcium phosphate, while hagfish may be derived from conodonts which eventually lost all mineralization and retained only horny teeth.

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## LATE CRETACEOUS DINOSAURS FROM THE NORTH SLOPE OF ALASKA

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Vertebrate fossils from Ocean Point, Alaska, on the Colville River, were deposited in overbank as well as channel sediments of a Late Cretaceous floodplain. A paucispecific bone bed within the Kogosukruk Tongue, Prince Creek Formation (Campanian-Maestrichtian) is dominated by hadrosaurid remains, with *Troodon* and a small tyrannosaurid represented primarily by isolated teeth. Adult remains are rare in the deposit, and most of the hadrosaurid bones belong to juvenile or subadult individuals. Preliminary comparisons of isolated cranial elements indicate a close similarity to *Edmontosaurus saskatchewanensis*. The bone bed contains a mixture of isolated, associated, and articulated, well preserved fossils and small, worn, and coated bone fragments.

Adjacent channel deposits have yielded limited samples of these taxa as well as remains of teleosts, a possible crocodilian, the marsupial *Pediomys*, and the ceratopsian *Pachyrhinosaurus*. A partial femur of a very young, probably hatchling, hadrosaur was collected as float from the Rogers Creek Member of the Schrader Bluff Formation near Umiat.

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## A NEW ?EOCENE MAMMAL FAUNA FROM THE ANDEAN MAIN RANGE

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Post-Casamayoran, pre-Deseadan age mammalian faunas are very poorly known. Fragmentary mammalian remains were discovered within sediments of a 10,000+m thick volcanic, volcanoclastic wedge ("Porfirítica Fm"), a major unit of the south central Andes, near Termas del Flaco Chile (34° 55'S, 70° 20' W) in 1988. Work in 1989 led to the recovery of a rich fauna which promises to fill an important gap in South American mammalian history and to yield fundamental insights on the chronology of Andean tectonics. Several dozen jaws, skulls, and nearly complete skeletons have been collected from sediments tentatively referred to the uppermost member of this unit, the Farellones Fm. Preparation to date has revealed wide taxic diversity, including forms provisionally referred to: *Periphragnis*; Notostylopidae, gen. nov.; ?Groeberiidae, gen. nov.; Litopterna, *inc. sed.*; Dasypodidae, *inc. sed.*; *?Bryanpattersonia; Pseudhyrax;* Notohippidae, gen. nov.; *Polydolops*; and ?Borhyaeidae. Several of these are indicative of a Mustersan age, but some new forms are decidedly more "Deseadan" in aspect. Correlation with the enigmatic Divisaderan is not as yet indicated.

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## THE ARROYO FORMATION (LEONARDIAN: LOWER PERMIAN) AND ITS VERTEBRATES

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Studies of the Arroyo Formation from Baylor County south to Runnels County, Texas, trace changes in organisms and environments from the "classic" terrestrial beds of Baylor County to the fully marine sections to the south. Terrestrial vertebrate remains have been found only as far south as Haskell, Texas. Limestones have produced tetrapods to the level of Abilene, Texas. Among these are the commonest genera of the Arroyo, but *Captorhinus* is absent. Above the Lueders Limestone, the southern Arroyo section consists of four marine limestones alternating with beds of red mudstones, with increments of sandstones and conglomerates. The distributions of the limestones and the clastics indicate four major transgressions of the sea, with the land-sea borders forming an irregular coastline during the peaks of transgression. The limestones have yielded a wide variety of fish, including xenacanthid sharks, various other Chondrichthyes, and dipnoan and palaeoniscoid Osteichthyes. Special attention is paid to the systematics, distributions, and habitats of the fish, with emphasis upon scale histology in taxonomic studies.

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## BAIRD'S TWO AXIOMS OF VERTEBRATE PALEOICHNOLOGY

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Through a series of seminal works in paleontology, Donald Baird stimulated a large body of process-oriented studies in fossil vertebrate footprints. Much of his influence can be traced to two simple but essential axioms: 1) "A footprint is not a static record of morphology, but a dynamic record of an animal in contact with a particular substrate under particular environmental conditions"; and 2) "Typological analysis of isolated examples cannot be expected to yield zoologically significant information."

The first axiom has stimulated pioneering work in both locomotory and sedimentological aspects of footprint formation; the second has provided a justification for sensible taxonomic and paleobiological consideration of all fossil footprints and trackways. The formation and preservation of a footprint can usefully be seen as an

**interaction of anatomy, locomotion, and substrate conditions. In this way, much new progress has been made in interpreting trackways, the identity and locomotion of their trackmakers, and the paleoenvironmental conditions of their formation.**

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MORPHOMETRICS OF THE PTEROSAUR WING: ONE SHARP DIVISION, FEW TRENDS

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Skeletal wing shape for 10 genera of pterosaurs was examined using principal component analyses. As expected, pterodactyloids differed from the paraphyletic 'rhamphorhynchoids' in having relatively short wings with relatively long fourth metacarpals (MC4). Within the 'rhamphorhynchoids', *Rhamphorhynchus* had a relatively long wing constructed from a relatively short humerus and long wing-finger (in particular, phalanges 1 and 4); whereas *Dorygnathus*, *Peteinosaurus*, and *Scaphognathus* borea relatively long forearm on otherwise short wings. *Campylognathoides* was intermediate in skeletal wing shape.

Most of the diversity among pterodactyloid taxa involved the relative length of MC4, which is relatively short in *Germanodactylus*, *Pterodaustro*, *Pterodactylus antiquus*, and *P. kochi*. *Gallodactylus* was unique among the pterodactyloids studied here in having a relatively long wing-phalanx 4. Pterodactyloids, *Dorygnathus*, and *Scaphognathus* had relatively short wings with long middle segments (forearm + MC4) that may have been functionally similar; however, the middle segment was dominated by MC4 in the pterodactyloids and by the radius in *Dorygnathus* and *Scaphognathus*. With the exception of the sharp division between 'rhamphorhynchoids' and pterodactyloids, change in skeletal wing shape is not orthogenetic and does not appear to follow a broad phylogenetic pattern. Similarities in skeletal wing shape among pterosaur taxa are highly convergent and may reflect similarities in flight habits.

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NONMARINE MICROVERTEBRATES OF THE ELLISDALE LOCAL FAUNA: CAMPANIAN OF NEW JERSEY

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An estuarine deposit within the Marshalltown Formation contains a microfauna comparable to that of Campanian sites in western North America. A small species of *Opisthotriton* is particularly well represented, as are Pelobatidae, and scincoid, anguid, and teiid lizards.

The Marshalltown Formation correlates with the *Globotruncana calcarata* zone of planktonic foraminifera, the *Exogyra ponderosa* zone of Atlantic/Gulf usage, and presumably the *Baculites gregoryensis* Zone of the Western Interior. It is thus age-correlative with Judithian faunas of the Rocky Mountain region on the independent evidence of marine invertebrates.

The microvertebrate taxa (amphibian, reptile, and mammal) thus far recovered are nearly identical with those of western North America, giving no indication that eastern North America was a separate biotic province for such forms.

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NEURAL CREST AND THE EVOLUTION OF THE VERTEBRATE SKULL

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A persistent trend among the vertebrates has been the increase in size of anterior dermal elements of the skull at the expense of posterior elements (Romer 1941). In the transition from crossopterygian to amphibian, and in tetrapod evolution thereafter, the nasals, frontals, maxillae, and squamosals come to dominate the skull, while the parietals, post-parietals, and various temporal bones become restricted to the center of the back of the skull (and many minor elements are lost).

This trend may be explained by a shift in the relative contributions of the two embryonic tissues that form the skull: the paraxial mesoderm and ectodermal neural crest. Those elements that, among modern vertebrates, are derived from neural crest, are the ones which expand, while the mesoderm derivatives become restricted. Other neural crest derivatives (jaws, teeth, muscles of the jaw and aortic arches, cranial nerves, spinal ganglia, etc.) are all in some way related to a lifestyle of active locomotion and manipulation of food. Thus, the change in proportions of the bones of the skull may simply reflect an increase in the extent of neural crest-derived tissues in general, a trend related to pervasive selection for improved mobility and manipulation of food.

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FOSSIL VERTEBRATES FROM THE MARKS HEAD FORMATION (LOWER MIOCENE) OF SOUTHEASTERN GEORGIA

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Preliminary excavation of sediments from the Marks Head Formation (Hawthorne Group) at Porters Landing, Effingham County, Georgia, has yielded a small but highly significant terrestrial vertebrate fauna. At this locality, the Marks Head is 8 m thick and consists of interlayered clay and pebbly argillaceous sand. Over 500 kg of sediment has been washed and the concentrate picked for vertebrate remains. The majority of vertebrates recovered thus far are marine. The diverse fish fauna consists of 11 species of sharks and rays, and at least ten species of teleost fishes. Marine crocodilians, turtles, and odontocetes have also been recovered. The marine component of the fauna indicates that deposition occurred in a nearshore, subtropical marine environment. Terrestrial vertebrates include two species of heteromyid rodents, a cricetid, two species of insectivores, a moschid, and several lizards, indicating a Hemingfordian age. Because this fauna contains both marine and terrestrial vertebrates, it offers the possiblity for correlation between marine and non-marine biochronologies.

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NEW AR/AR DATES AND REVISED MAGNETOSTRATIGRAPHY OF THE CHADRONIAN THROUGH ARIKAREEAN LAND MAMMAL "AGES"

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Laser-fusion argon/argon dating of many of the ashes previously dated by Evernden et al. (1964) has produced dates that are much more reproducible than the old K/Ar dates, and in some cases differ radically from the old dates. For example, the old dates at Flagstaff Rim, Wyoming, ranged from 32.6 Ma (Ash J) to 36.1 (Ash B), but the new dates give a range of only 34.4-35.8 Ma. This much shorter time span requires revision of the magnetostratigraphic correlation, and it now appears that Flagstaff Rim spans C16N (at base) to the top of C13R. The long C12R reversed interval must match the long-reversed interval from the mid-Orellan to the late Whitneyan, and this is corroborated by the first dates on the Persistent White Layer and Lower and Upper Whitney Ashes. These changes will require another revision in the late Paleogene timescale but, for the moment, the spans of the land mammal "ages" are adjusted as follows: Chadronian, 37-34 Ma; Orellan, 34-31.5 Ma; Whitneyan, 31.5-29.5 Ma; Arikareean, 29.5-21 Ma. Combined with many new dates that are pushing the Eocene/Oligocene boundary to about 34 Ma, this means that the Chadronian is probably late Eocene, and the Orellan and Whitneyan are early Oligocene. Thus, the Terminal Eocene Event appears to be the Chadronian/Orellan event, not the Duchesnean/Chadronian transition as traditionally thought.