dle Tournaisian seed-like structure from Montagne Noire is described. These seeds consist of eight free integumentary lobes surrounding a thick-walled nucellus, which in turn contains one functional megaspore and an endosporic gametophyte. Unlike other Devonian and Early Carboniferous ovules, this specimen does not contain a pollen chamber, a feature which is considered characteristic of early seed plant reproductive biology (hydrasperman reproduction). This type of reproduction was previously thought to occur in all early gymnosperms and was used as evidence of monophylesis. Galtier and Rowe suggest that the new ovule can either be interpreted as an intermediate stage between pteridophytic and gymnospermous reproduction or as evidence of early gymnosperms. If the latter, then a monophyletic origin of gymnospermy may be in doubt.

Another important contribution to our understanding of fossil gymnosperms is the paper by Gao Zhifeng and B.A. Thomas on Lower Permian cycads from China (Review of Palaeobotany and Palynology, v. 60, p. 205-223). They describe several new cycad megasporophylls which provide evidence for evolutionary trends leading to the origin of the modern cycad megasporophyll.

Angiosperm origins were once again the subject of investigation and speculation, including examination of possible "precursor" plants. B. Cornet (Evolutionary Trends in Plants, v. 3, p. 25-51) described the pollen-producing (male-*Synangispadix*) and ovule-producing (female-*Axelrodia*) reproductive structures found associated with the leaf *Sanmiguelia* at the Upper Triassic Sunday Canyon site in Texas. He believes these fructifications represent very primitive angiosperms that combined both monocot and dicot features. K. Pederson, along with P.R. Crane and E.-M. Friis, described a well-preserved early bennettitalean reproductive structure (Review of Palaeobotany and Palynology, v. 60, p. 7-24), *Vardekloeftia*, from the Upper Triassic (early Rhaetian) of East Greenland. This reproductive organ includes less than 20 ovules embedded in numerous, interseminal scales. Each ovule contains a nucellus surrounded by an integument and a cupule. Pollen was found in the micropyles of some of the ovules and these authors speculate that pollination and dispersal were probably relatively unspecialized.

W. Martin, A. Gierl and H. Saedler (Nature, v. 339, p. 46-48) approached the question of the origin of the angiosperms in a different way — by comparing nucleotide sequence data from living angiosperms and applying the "molecular clock" principle to suggest the timing of diversification from gymnospermous ancestors. Their data place the monocot-dicot divergence at about 320 million years, or the mid-Carboniferous. These data clearly differ from paleobotanical data and the authors invoke the "upland origins" hypothesis espoused by Axelrod as one possible way to explain the lack of angiosperm fossils during the Paleozoic.

In paleobotany, there will always be those exciting discoveries that represent "firsts." For example, G.W. Rothwell and R.A. Stockey (American Journal of Botany, v. 76, p. 637-644) described the first megafossil assignable to the fern order Ophioglossales, a group that has been considered to include many primitive features. The specimens include vegetative and fertile fronds from the Paleocene of central Alberta and are assigned to the genus *Botrychium*. E. Flügel, B. Senowbari-Daryan and G.D. Stanley described the first dasycladacean alga (*Diplopora*) from North America (Journal of Paleontology, v. 63, p. 374-381). Their specimens occur within an accreted terrane in northeastern Oregon and are used as evidence of the far-traveled nature of this terrane. The genus was previously known only from the Upper Triassic of Europe. J.F. White and T.N. Taylor (Mycologia, v. 81, p. 634-646) detailed the first example of a fossil fungus assignable to the Trichomycetes (Zygomycotina) from the Triassic of Antarctica. Trichomycetes today are primarily endosymbionts living within the hind gut of arthropods. The fossil fungus occurs attached to the inner surface of an irregularly shaped structure that is interpreted as an arthropod cuticle. This discovery offers excellent evidence that the specialized relationship between trichomycetes and their arthropod hosts is a very old one.

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Vertebrate paleontology

The topic of mass extinctions continued to occupy vertebrate paleontologists in 1989. At the extinctions workshop held at the International Geological Congress in July in Washington, D.C., speaker after speaker gave compelling evidence refuting the prevalence of catastrophic mass extinctions. Especially hard hit was the proposed 26-million year periodicity in vertebrate mass extinctions. For example, the mid-Miocene "extinction event" actually represents a peak in diversification among land mammals in both North America and Asia. The late Eocene "mass extinction" is a gradual, climatically controlled event spanning almost 5 million years and peaking at the end of the middle Eocene. Several scientists advanced claims that non-avian dinosaurs survived into the Paleocene, not only in North America, but also in South America and China. There was no evidence for mass extinctions in the late Jurassic and early and mid-Cretaceous, and even the much-touted evidence for an impact of an extraterrestrial object at the end of the Triassic was equivocal.

The excellent Permo-Triassic vertebrate record shows no evidence of a catastrophic mass extinction. Much of the latest thought on the subject has been reviewed in S.K. Donovan's "*Mass Extinctions: Processes and Evidence*" (Columbia University Press).

At the second Snowbird Conference on mass extinctions, vertebrate paleontologists were definitely in the minority. Nevertheless, J.D. Archibald and L.J. Bryant presented evidence of a non-catastrophic extinction in terrestrial vertebrates across the Cretaceous/Tertiary boundary. This was documented in detail in a recent monograph by Bryant (University California Publications in Geology). Jaeger and others (Geology, v. 17, p. 316-319) reported new dates for the K/T boundary of about 65.7 million years, and showed that the terrestrial faunas in India afford no evidence of mass extinction at that time. Further, they argued that the Eurasian nature of these faunas shows that India was much closer to Asia in the late Cretaceous than had been thought, and that the collision between the two must have taken place much faster than traditional models of plate tectonics have suggested. At the Geological Society of America meeting in November in St. Louis, an entire session was held on periodic mantle volcanism as a possible source for environmental perturbations that could trigger extinctions.

A Penrose Conference on Eocene/Oligocene extinctions held in Rapid City, South Dakota, further corroborated these conclusions. More than 61 participants, representing both marine and terrestrial realms, presented evidence that the most severe diversity decline occurred at the end of the middle Eocene (Bartonian, Uintan), and not at the end of the Eocene, where most of the earlier attention had been focused. New argon/argon dates have revised radically the time scale for this interval, so that the Eocene/Oligocene boundary has crept up to about 34 millions years ago (from previous estimates of 36.5 or 38 million years). In terrestrial terms, these new dates show that the Chadronian land mammal "age" — long thought to be early Oligocene — is entirely late Eocene, which relegates the Orellan and Whitneyan to the early Oligocene. R. Stucky (Current Mammalogy, v. 2, p. 275-432) presented a detailed analysis of mammalian diversity and origination-extinction equilibria throughout the Cenozoic demonstrating the gradual nature of faunal turnover during that time.

Extinction was also a topic of interest at the annual meeting of the Willi Hennig Society, which was held last October at Cornell University. A half-day symposium considering the effects of extinction on

reconstructing the genealogical history of life was one of the high points of that meeting. Donoghue and others (Annual Review of Ecology and Systematics, v. 20, p. 431-460) concluded that to avoid globally unparsimonious results, all evidence from both fossil and Recent organisms should be taken into consideration when assessing phylogenetic relationships. Indeed, even incompletely known fossils can exert a profound influence on the outcome of phylogenetic analyses. Fossils may be especially relevant in sorting out ancient radiations by preserving relatively unmodified morphologies that have subsequently been transformed beyond recognition in extant forms.

This year was marked by some exciting new finds and studies of fish-like vertebrates. Papers by Cheng (Alcheringa, v. 13, p. 153-166) on the rostral tubuli of dipnoans and by P. Albergh (Zoological Journal, Linnean Society, v. 96, p. 119-166) on the appendicular appendages of porolepiforms were of general interest to morphologists. Biostratigraphic implications of ichthyofaunas were also discussed. A. Blieck and P. Janvier (Annales de Paläontologie, v. 75, p. 125-168) gave biostratigraphic correlations for the Lower Devonian of northwestern Europe based on a new agnathan fauna (pteraspidomorphs and cephalaspidomorphs) from Artois, France. And Z. Lewy and H. Cappetta (Neues Jahrbuch für Mineralogie, Geologie und Paläontologie, Mh., v. 1989, n. 4, p. 212-222) discussed the biostratigraphic implications of their discovery of Senonian neoselachian shark teeth from Israel.

A major event of 1989 was the gathering of about 50 paleontologists specializing in fish-like vertebrates in Tallinn, Estonia, for the Second International Colloquium on Middle Palaeozoic Fishes. "Fossils as Living Organisms" was the main theme of the symposium organized by T. Marss, E. Mark-Kurik and D. Kaljo.

B.G. Gardiner and B. Schaeffer (Zoological Journal, Linnean Society, v. 97, p. 135-187) have just produced a major review of the early actinopterygian phylogeny. And the phylogeny of two advanced actinopterygian groups were investigated during the last year: the Cretaceous/Tertiary crossognathiform teleosts by L. Taverne (Palaeontographica A, v. 207, p. 79-105) and the dercetid actinopterygians by Y. Chalifa (Journal of Vertebrate Paleontology, v. 9, p. 314- 328). The question of early sarcopterygian phylogeny, an ever controversial topic, has been reconsidered by P. Albergh (Zoological Journal, Linnean Society, v. 96, p. 119-166), and by J.A. Long (Journal of Vertebrate Paleontology, v.9, p. 1-17).

The American Society of Ichyologists and Herpetologists held their annual meeting in June in San Francisco. J. Musik and M. Bruton organized a one day symposium on the "Evolution and Biology of the Coelocanths." The resulting symposium volume will be published in *Environmental Biology of Fishes*.

The First World Congress of Herpetology was held last year in Canterbury, England. Two symposiums discussed issues related to paleontology: "Palaeoherpetology — impact on neoherpetology," and "The interrelationships of primitive tetrapods: the fossil evidence."

Of general interest is J.-C. Rage and Z. Rocek's (Palaeontographica, Abt. A, v. 206, p. 1-16) redescription of the Early Triassic salientian, *Triadobatrachus*. The authors also reconsidered the issue of saltatorial adaptations as an impetus to the evolution of frogs.

Synapsid amniotes received the usual interest in 1989. S.S. Sumida discussed new information on the postcranial skeleton of the early synapsid, *Lupeosaurus*. *Colobomycter*, once thought to be an early synapsid, was reviewed recently by M. Laurin and R. Reisz (Canadian Journal of Earth Sciences, v. 26, p. 544-550), who thought reptilian relationships were more likely, although the evidence is scant. G.M. King's long-awaited monstergraph on the so- called "anomodont" therapsids appeared at the end of 1988 (Handbuch der Paläoherpetologie, 17C, 174 p.), but is of such significance that it must be mentioned in this year's review. Dicynodonts were again in the news as indicators of faunal affinities between North Africa and South America in the late Triassic (J.M. Dutuit, C.R. Academie Sciences II, v. 309, p. 1267-1270).

The Fifth International Theriological Congress was held in late August in Rome. Symposiums were held on the Great South American Interchange, new data from molecules and morphology on the phylogeny of mammals, on proboscidean evolution and conservation. A session on mammalian evolutionary paleoecology stimulated an international exchange of ideas, not only about methods, but also about community evolution from the local to the continental scale.

L. Kristalka and R.K. Stucky recently reported a specimen of the primate *Notharctus* showing that all earlier reconstructions were inaccurate (Journal of Vertebrate Paleontology, v. 9, p. 28A). The new skull removes notharctids from close relationships with either anthropoids or lemuriforms, and refutes old arguments that adapids were closer to lemuriforms than they are to anthropoids. M.C. Maas and others (Paleobiology, v. 14, p. 410-431) examined the proposition that rodents competitively excluded the plesiadapidorm primates — as they apparently did to the multituberculates — during the Eocene, and found that all of the available evidence was consistent with that hypothesis. R.F. Kay reported a new giant tamarin monkey from the early Miocene (Sanacrucian) of Colombia: it was apparently a diurnal fruit eater, about twice the size of living callithricids (Journal of Vertebrate Paleontology, v. 9, p. 28A). This is consistent with the idea that acallithricids arose as larger monkeys, and that the living forms are dwarfed.

R.L. Bernor and others (Journal of Vertebrate Paleontology, v. 8, p. 427-452) analyzed hipparionine horses from the Vienna Basin, and found that they appeared more than one million years later than the "*Hipparion* datum" elsewhere in Europe; thus, they are not the ideal biochronological indicators that they have been purported to be, nor are they necessarily the indicators of savanna habitats. V.L. Roth (Paleobiology, v. 15, p. 165-179) showed that elephant dentitions are highly affected by stresses during their development, and this results in many dental anomalies. As a consequence, many elephant taxa based on slight dental differences may just be aberrant individuals. S. Stuenes (Journal of Vertebrate Paleontology, v. 9, p. 241-268) straightened out the taxonomy of the dwarf hippopotami of Madagascar: there are only two valid species, one of which was aquatic and the other more terrestrial.

K. Padian and D.J. Chure's Dinosaur Short Course, held during the GSA meeting last November in St. Louis, was a great success, and the accompanying volume, *The Age of Dinosaurs* (Short Courses in Paleontology #2, S.J. Culver, editor, Paleontological Society, 210 p.) is already available. Also of interest to the dinosaurologist was the publication of S.G. Lucas and A.P. Hunt's "Dawn of the Age of Dinosaurs in the American Southwest" volume (New Mexico Museum of Natural History Press, 414 p.), D.J. Chure and J.S. McIntosh's "A Bibliography of the Dinosauria (Exclusive of the Aves) 1677-1986" (Museum of Western Colorado Press, 226 p.), J.O. Farlow's "Paleobiology of the Dinosaurs" (GSA Special Paper 238, 100 p.), D.D. Gillette and M.G. Lockley's "Dinosaur Tracks and Traces" (Cambridge University Press, 448 p.), and Dale Russell's eye-popping "An Odyssey in Time: Dinosaurs of North America" (NorthWord Press Inc., 239 p.).

Lepidosaurs received less attention this year. Of special interest was S.E. Evans and A.R. Milner's determination that the ancient "lizard" *Fulengina* was actually a juvenile sauropodomorph dinosaur (Palaeontology, v. 32, p. 223-230). N.C. Fraser and M.J. Benton's (Zoological Journal, Linnean Society, v. 96, p. 413-445) review of rhynchocephalian lepidosaurs gives further corroboration for our understanding of the broad outlines of the Mesozoic history of that once diverse group.

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