LIFE THROUGH TIME VERTEBRATES

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In 2001, vertebrate paleontologists reported a number of important discoveries. The most significant concerned specimens that cast new light on the origin of two groups of marine mammals: whales and sirenians (sea cows or manatees and dugongs).

It has long been known that whales descended from the ungulates, or hoofed mammals, and the traditional paleontological view was that their closest relatives were the large carnivorous hoofed mammals known as mesonychids (J.H. Geisler, *American Museum Novitates*, v. 3344, p. 1). However, molecular studies suggested that whales are most closely related to the even-toed ungulates, or artiodactyls; some studies even place whales *within* the artiodactyls as a sister-group of the hippopotamus (united as a group called the "Whippomorpha" by molecular biologists).

In the fall of 2001, skeletons of at least three different Eocene whales were reported, having the distinctive double-pulley ankle bones unique to the Artiodactyla (J.G.M. Thewissen and others, *Nature*, v. 413, p. 277; Gingerich and colleagues, *Science*, v. 293, p. 2239). These specimens remove the old objection that whales lacked key artiodactyl features and seem to place them firmly within that order. Which artiodactyl group is their closest sister-taxon is still under debate.

The second key specimen was the discovery of *Pezosiren*, a nearly complete skeleton of a sirenian from the Eocene of Jamaica (D. P. Domning, *Nature*, v. 413, p. 625). Although it has the classic sirenian skull, jaws, teeth, and even the dense pachyostotic ribs, it still had fully functional limbs with well-developed toes, not flippers. Clearly it could walk on land, but many features showed it was primarily aquatic, yet without the tail propulsion or flippers seen in living sirenians. It is a perfect example of a "transitional form" whose existence the creationists keep denying.

Other phylogenetic problems within the Mammalia continue to show surprising developments. Several different molecular studies (O. Madsen et al., *Nature*, v. 409, p. 610; W.J. Murphy et al., *Nature*, v. 409, p. 614; W.J. Murphy, *Science*, v. 294, p. 2,348) have argued that the molecular and mitochondrial DNA cluster mammals into five supraordinal groups: marsupials, xenarthrans (edentates), Afrotheria (African insectivores, elephant shrews, plus aardvarks and tethytheres), Euarchontoglires (rodents, rabbits, primates, colugos and tree shrews), and the Laurasiatheria (whales, artiodactyls, perissodactyls, carnivores, pangolins, bats and insectivorans). These groups are still controversial and contradict numerous other molecular and morphological arrangements, but they do seem to cluster animals with an originally Gondwanan distribution (marsupials, Afrotheria and Xenarthra) and Laurasian distribution (Laurasiatheria plus Euarchontoglires). Consistent with these studies was the first report of a Cretaceous marsupial from Madagascar (D.W. Krause, *Nature*, v. 412, p. 497), which places the pouched mammals on another Gondwanan landmass (Australia, South America, Antarctica and now Madagascar) in the Late Cretaceous.

Courtesy of Julia Clarke, American Museum of Natural History

***Apsaravis ukhaana* is a transitional bird fossil found last year that supplies more evidence that birds descended from dinosaurs.**

Widely reported in the news are the spectacular specimens of feathered dinosaurs from the Jurassic-Cretaceous lake beds of Liaoning Province, China (Xu X. and others, *Nature*, v. 410, p. 200; M.A Norell, *Natural History*, v. 6, p. 110; S.A. Perkins, *Science News*, v. 160, p. 106) as well as additional important transitional bird fossils from the same deposits (M.A. Norell and J.A. Clarke, *Nature*, v. 409, p. 181). These specimens conclusively show that birds descended from dinosaurs, since true feathers appeared in dinosaurs long before they became flying creatures. Further corroborating this conclusion is the reinterpretation of the fingers in birds and dinosaurs (F. Galis, *Trends in Ecology and Evolution*, v. 16, p. 16) which shows how their fingers were changed by a homeotic mutation and removes the old objection that bird and dinosaur hands had different digits and were not homologous.

In addition to the spectacular bird and dinosaur specimens from the Jurassic and Cretaceous of Liaoning Province, these same lake deposits yield important new specimens of frogs that rearrange their phylogeny (Gao K.Q. and Wang Y., *Journal of Vertebrate Paleontology*, v. 21, p. 460) plus complete sets of specimens of both larval and adult salamanders (R. Carroll, *Nature*, v. 410, p. 534).

Other widely reported discoveries among the dinosaurs include a bizarre new theropod (S.D. Sampson and colleagues, *Nature*, v. 409, p. 504) and a new sauropod (K.C. Rogers and C.A. Forster, *Nature*, v. 412, p. 530) from the Late Cretaceous of Mongolia. Several functional analyses of dinosaurs reached interesting conclusions. Analyses of the skull of *Allosaurus* (G.M. Erickson, *Nature*, v. 409, p. 987; E.J. Rayfield and others, *Nature*, v. 409, p. 1033) suggested that it had a relatively weak bite. Another analysis proposed that sauropods couldn't lift their heads high or rear up due to blood pressure constraints (E. Powell, *Discover*, v. 22, p. 10). Larry Witmer argued that dinosaur nostrils have been misinterpreted (L.M. Witmer, *Science*, v. 293, p. 850).

Finally, an analysis of the soft-bodied fossils from the Cambrian (N.D. Holland and J. Chen, *BioEssays*, v. 23, p. 142) gives us surprising new insights into the origin of the vertebrates.

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