The Overselling of Whale Evolution

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Conventional wisdom among evolutionists, at least at the popular level, is that whales descended from Mesonychidae, an early and diverse family of land mammals that were well adapted for running.[1] It is hypothesized that some mesonychid species began feeding on creatures inhabiting shallow waters and that over many generations the selective pressures created by this change of diet transformed one or more of the species into an amphibious archaeocete. The selective pressures of amphibious living in turn generated a variety of archaeocetes and eventually transformed one or more of the species into a fully marine archaeocete. Marine existence then shaped further adaptations to produce the 75 to 77 living species of whales, porpoises, and dolphins.[2]

Some evolutionists believe the fossil record has established this claim beyond a reasonable doubt. One writer went so far as to pronounce that "the evolutionary case is now closed."[3] The purpose of this article is to suggest that the fossil evidence for the mesonychid-to-whale transition is not persuasive, let alone conclusive.

Mesonychids to Archaeocetes

The first claim in the evolutionists' scenario is that archaeocetes descended from a mesonychid species. The ancestral status of Mesonychidae was first proposed by Leigh Van Valen in 1966 on the basis of certain dental similarities between the mesonychid *Dissacus navajovius* (which is *Dissacus carnifex* of Cope) and some archaeocete specimens. His rather cautious statement of the claim is worth recalling:

To my knowledge the family of Mesonychidae is one of the relatively few groups of mammals (and even of reptiles) that has not been specifically suggested as ancestral to the whales, but in my opinion the preceding argument establishes them as at least the most likely candidate. . . . *Dissacus navajovius* is possibly directly ancestral, but little is known of the early history of the mesonychids, especially outside North America.[4]

In a more extensive analysis published three years later, Frederick Szalay suggested that both hapalodectines (which was then considered a mesonychid subfamily) and archaeocetes probably "derived from either early or middle Paleocene mesonychids, *species more primitive than known mesonychines*" [emphasis mine].[5] In other words, Szalay concluded that both *Dissacus* and *Ankalagon*, the only middle Paleocene mesonychids known at that time, were too derived (evolutionarily advanced) to be in the archaeocete lineage.[6] He saw them as "sister groups" of the archaeocetes, not as actual ancestors.

Since publication of the Szalay article, three more genera of middle Paleocene mesonychids have been identified in Asia (*Dissacusium*, *Hukoutherium*, *Yangtanglestes*), but none is known from anything more than fragmentary crania.[7] Information on *Hukoutherium*, the best known of the three, is limited to a crushed and broken skull with lower jaws.[8] No one has nominated any of these genera for ancestor of the archaeocetes, and thus mesonychids continue to be classified in the more technical literature as a "sister group" to the archaeocetes.[9]

> To acknowledge, as Robert Carroll did recently, that "[i]t is not possible to identify a sequence of mesonychids leading directly to whales," is to understate the problem.[10] It is not even possible to identify a single ancestral species. All known mesonychids are excluded from the actual chain of descent by the evolutionists' own criteria.

The reason evolutionists are confident that mesonychids gave rise to archaeocetes, despite the inability to identify any species in the actual lineage, is that known mesonychids and archaeocetes have some similarities. These similarities, however, are not sufficient to make the case for ancestry, especially in light of the vast differences. The subjective nature of such comparisons is evident from the fact so many groups of mammals and even reptiles have been suggested as ancestral to whales.

In the case of mesonychids, the relationship to archaeocetes is based on the most general of similarities. As Van Valen acknowledged in the original article proposing mesonychid ancestry:

> [M]any features of the skull of *Protocetus* [an early archaeocete - AC] are not similar to those of either the Hyaenodontidae or the Mesonychidae (or to any other terrestrial mammal known to me) and probably represent to a considerable extent a reorganization of the skull, the chain of effects resulting from adaptation to hearing, feeding, locomotion, and other functions in an aquatic existence.[11]

This point was later echoed by Edwin Colbert: "In general this [archaeocete] skull appears as if it might have been derived from a mesonychid type, but there is little beyond certain general resemblances to support such a relationship."[12] Others have likewise noted that the cited similarities in skull and dental characters "are not all clear-cut."[13] One need only compare the reconstructed skull of the late Paleocene *Sinonyx jiashanensis* to that of an early archaeocete to appreciate these remarks.[14]

Amphibious Archaeocete to Fully Marine Archaeocete

The second claim in the evolutionists' explanation of the origin of whales is that an amphibious archaeocete evolved into a fully marine archaeocete. It is believed that this transformation is documented by a sequence of intermediate forms, what one writer called the "sweetest series of transitional fossils an evolutionist could ever hope to find."[15] This series, which spans 10-12 million years of the Eocene, includes *Pakicetus* *inachus*, *Ambulocetus natans*, *Rodhocetus kasrani*, *Indocetus ramani*, *Protocetus atavus*, and *Basilosaurus isis*.[16]

It is important to understand that, in calling these creatures a "series of transitional fossils," the evolutionist does not mean that they form an actual lineage of ancestors and descendants. On the contrary, they readily acknowledge that these archaeocetes "cannot be strung in procession from ancestor to descendant in a *scala naturae*."[17] What they mean is that these fossils show a progressive development within Archaeoceti of certain features found in the later, fully marine forms such as *Basilosaurus*. (The specific features relate mainly to the middle ear and the appendicular skeleton.) This progression of features is believed to correspond to changes that were occurring in the actual basilosaurid lineage.

Whether the early archaeocetes form a series or sequence of intermediate forms depends, of course, on their morphology and their stratigraphic position. The claim is that, for each of these fossils, the degree of evolutionary advancement corresponds to the stratigraphic position. In other words, the older the fossil the less advanced its features; the younger the fossil the more advanced its features. It is this correspondence of form and position (age) that provides the impression of directional transformation through time.

The generally accepted order of the archaeocete species, in terms of both morphological (primitive to advanced) and stratigraphical (lower/older to higher/younger) criteria, is *Pakicetus*, *Ambulocetus*, *Rodhocetus*, *Indocetus*, *Protocetus*, and *Basilosaurus* (see note 16). One problem for this tidy picture is that the stratigraphical relationships of most of these fossils are uncertain.

In the standard scheme, *Pakicetus inachus* is dated to the late Ypresian, but several experts acknowledge that it may date to the early Lutetian.[18] If the younger date (early Lutetian) is accepted, then *Pakicetus* is nearly, if not actually, contemporaneous with *Rodhocetus*, an early Lutetian fossil from another formation in Pakistan.[19] Moreover, the date of *Ambulocetus*, which was found in the same formation as *Pakicetus* but 120 meters higher, would have to be adjusted upward the same amount as *Pakicetus*.[20] This would make *Ambulocetus* younger than *Rodhocetus* and possibly younger than *Indocetus* and even *Protocetus*.[21]

In the standard scheme, *Protocetus* is dated to the middle Lutetian, but some experts have dated it in the early Lutetian.[22] If the older date (early Lutetian) is accepted, then *Protocetus* is contemporaneous with *Rodhocetus* and *Indocetus*. In that case, what is believed to have been a fully marine archaeocete was already on the scene at or near the time archaeocetes first appear in the fossil record.[23]

Given the significance evolutionists have attributed to these fossils in their battle with creationists, one cannot help but wonder whether their stratigraphical arrangement in the standard scheme has been influenced by their morphology. One committed to evolution would tend to be less critical of dates that placed these fossils in a morphological sequence and more critical of dates that disrupted that sequence.[24] As the diversity and shifts of expert opinion indicate, stratigraphical correlation is more an art than is commonly appreciated.

Based on the foregoing, it is reasonable to believe, even from within an evolutionist framework, that all the early archaeocetes were essentially contemporaries. *Basilosaurus isis*, on the other hand, was a gigantic marine archaeocete dating to the early Bartonian.[25] Evolutionists suspect that basilosaurids descended from the earlier Protocetidae (which includes the archaeocetes discussed above), but specialists admit there is a "lack of clear ancestor to descendant relationships."[26] Indeed, the tremendous size difference between Basilosaurinae and protocetids casts doubt on that hypothesis. All protocetids were less than ten feet long, whereas *Basilosaurus cetoides* was over 80 feet in length, and *Basilosaurus isis* was over 50 feet.[27] It has been calculated that, even in a rapidly evolving line, changes in size are usually on the order of only 1-10% per million years.[28]

Lacking a cogent argument that *Basilosaurus isis* actually descended from protocetids, evolutionists claim it is transitional in the sense that it exhibits features between the earlier protocetids and the later cetaceans. If *Protocetus* was fully marine, as some experts now believe, it is questionable whether and to what extent the features of *Basilosaurus* can be characterized as more "advanced." But more importantly, if *Basilosaurus* did not descend from protocetids and was not ancestral to cetaceans (see below), what does the presence of intermediate features in *Basilosaurus* establish? It seems the most one could say is that it indirectly supports the claim of descent with modification by showing a creature similar to the creature hypothesized to be in the actual lineage. Creationists find this too weak to carry the extraordinary claim of cetacean evolution.

Archaeocetes to Modern Cetaceans

The third claim in the evolutionists' chain of events is that archaeocetes gave rise to modern cetaceans. This is sometimes asserted as a fact, but the relationship between these suborders has long been debated.

There are major differences between the archaeocetes and cetaceans (e.g., body shape, thoracic fin structure, and skull arrangement) which have led many experts to deny that archaeocetes gave rise to odontocetes or mysticetes.[29] As George Gaylord Simpson concluded:

> Thus the Archaeoceti, middle Eocene to early Miocene, are definitely the most primitive of cetaceans, but they can hardly have given rise to the other suborders. The Odontoceti, late Eocene to Recent, are on a higher grade than the Archaeoceti and, on the average, lower than the Mysticeti, middle Oligocene to Recent, but apparently were not derived from the former and did not give rise to the latter.[30]

The point was reiterated two decades later by A. V. Yablokov, who wrote, “It is now obvious to most investigators that the Archaeoceti cannot be regarded as direct ancestral forms of the modern cetaceans.”[31] This was the consensus opinion until relatively recently.[32]

The current leaders in the field believe that archaeocetes were ancestral to modern whales, but there is no agreement on which family of archaeocetes was involved. In fact, all three families (Protocetidae, Remingtonocetidae, and Basilosauridae) have been proposed.[33] This is particularly revealing when one considers how radically different Remingtonocetidae is from the other archaeocetes.[34]

In addition, no chain of descent from archaeocetes to modern whales has been identified. The phylogenetic relationships among major lineages within the Cetacea continue to be “very poorly understood,” which is why recent phylogenies are dominated by dead ends, broken lines, and question marks.[35] As for *Basilosaurus isis*, it is generally recognized that Basilosaurinae was an isolated subfamily that had nothing to do with the origin of modern whales.[36]

Endnotes

[1] E.g., Stephen Jay Gould, “Hooking Leviathan By Its Past,” *Natural History* (April 1994): 12; Carl Zimmer, “Back to the Sea,” *Discover* (January 1995): 83; Elizabeth Culotta, “It’s A Long Way From *Ambulocetus*,” *Pacific Discovery* (Winter 1996): 16. Szalay and Gould divided Mesonychidae into three subfamilies: Mesonychinae, Hapalodectinae, and Andrewsarchinae. Frederick S. Szalay and Stephen Jay Gould, “Asiatic Mesonychidae (Mammalia, Condylarthra),” *Bulletin of the American Museum of Natural History* 132 (1966): 156. However, “mesonychids are now often given ordinal rank as either Mesonychia or Acreodi.” Maureen A. O’Leary and Kenneth D. Rose, “Postcranial Skeleton of the Early Eocene Mesonychid Pachyaena (Mammalia: Mesonychia),” *Journal of Vertebrate Paleontology* 15, no. 2 (1995): 402. Current thinking is that Hapalodectinae should be placed in its own family. Xiaoyuan Zhou, Renjie Zhai, Philip D. Gingerich, and Liezu Chen, “Skull of New Mesonychid (Mammalia, Mesonychia) From the Late Paleocene of China,” *Journal of Vertebrate Paleontology* 15, no. 2 (1995): 387, 396-98. **[RETURN TO TEXT]**

[2] The scenario is sketched in Keith Banister and Andrew Campbell, eds., *The Encyclopedia of Aquatic Life* (New York: Facts on File Publications, 1985), 294-296. See also Culotta, 16. The order Cetacea includes the whales, porpoises, and dolphins. The 75 to 77 living species are divided into 13 or 14 families and two suborders: Mysticeti (baleen whales) and Odontoceti (toothed whales, dolphins, and porpoises). The extinct suborder Archaeoceti is a wastebasket group that includes all ancient toothed Cetacea that lack the cranial features of Odontoceti and Mysticeti. It is comprised of three extinct families: Protocetidae, Remingtonocetidae, and Basilosauridae. The family Protocetidae includes the extinct subfamily Pakicetinae. The family Basilosauridae is comprised of two extinct subfamilies: Dorudontinae and Basilosaurinae. See, R. Ewan Fordyce and Lawrence G. Barnes, “The Evolutionary History of Whales and Dolphins,” *Annual Review of Earth and Planetary Science*, 22 (1994): 419, 427-31. **[RETURN TO TEXT]**

[3] Zimmer, 84. **[RETURN TO TEXT]**

[4] Leigh Van Valen, “Deltatheridia, A New Order of Mammals,” *Bulletin of the American Museum of Natural History* 132 (1966): 92. **[RETURN TO TEXT]**

[5] Frederick S. Szalay, "The Hapalodectinae and a Phylogeny of the Mesonychidae (Mammalia, Condylarthra)," *American Museum Novitates* 2361 (1969): 25; for application of statement to archaeocetes, see figure 19, p. 24. **[RETURN TO TEXT]**

[6] Szalay and Gould, 169-170 lists *Dissacus* as the only middle Paleocene mesonychid known at the time. *Dissacus sensu* Szalay and Gould was later divided into *Dissacus* and *Ankalagon* (type species being *Dissacus saurognathus*, which is *Dissacus carnifex* of Osborn and Earle). Leigh Van Valen, "*Ankalagon*, New Name (Mammalia: Condylarthra)," *Journal of Paleontology* 54, no. 1 (1980): 266. *Microclaendon*, which was not listed by Szalay and Gould, is now generally classified with triisodontines rather than mesonychids. Philip D. Gingerich, "Radiation of Early Cenozoic Didymoconidae (Condylarthra, Mesonychia) in Asia, With a New Genus From Early Eocene of Western North America," *Journal of Mammalogy* 62, no. 3 (1981): 535. It is noteworthy that the skull of neither *Dissacus* nor *Ankalagon* has been recovered. These genera are known from jaws, teeth, and rather limited postcrania. **[RETURN TO TEXT]**

[7] Discoveries of *Dissacusium* and *Hukoutherium* were first published in 1973; discovery of *Yangtanglestes* was first published in 1976. Li Chuan Luei and Ting Su-Yin, "The Paleogene Mammals of China," *Bulletin of Carnegie Museum of Natural History* 21 (1983): 1-93. *Dissacus* and *Ankalagon* are the only Paleocene mesonychids for which postcrania have been described. O'Leary and Rose, 401. **[RETURN TO TEXT]**

[8] Zhou, et al., 388. *Dissacusium* and *Yangtanglestes* are so poorly known that Zhou, et al. omitted them from their cladistic analysis. Ibid., 395. **[RETURN TO TEXT]**

[9] Malcolm C. McKenna, "Toward a Phylogenetic Classification of the Mammalia," in W. Patrick Luckett and Frederick S. Szalay, eds., *Phylogeny of the Primates* (New York: Plenum Press, 1975), 39; Donald E. Savage and Donald E. Russell, *Mammalian Paleofaunas of the World* (London: Addison-Wesley Publishing, 1983), 123; Robert L. Carroll, *Vertebrate Paleontology and Evolution* (New York: W. H. Freeman & Co., 1988), 521 (implicit in his statement "early mesonychids were almost certainly *close* to the ancestry of whales" [emphasis mine]); J. G. M. Thewissen, "Phylogenetic Aspects of Cetacean Origins: A Morphological Perspective," *Journal of Mammalian Evolution* 2, no. 3 (1995): 174. **[RETURN TO TEXT]**

[10] Robert L. Carroll, *Patterns and Processes of Vertebrate Evolution* (Cambridge: University Press, 1997), 329. **[RETURN TO TEXT]**

[11] Van Valen, (1966): 92. **[RETURN TO TEXT]**

[12] Edwin H. Colbert, *Evolution of the Vertebrates* 3rd ed. (New York: John Wiley & Sons, 1980), 329. **[RETURN TO TEXT]**

[13] Banister and Campbell, 295. **[RETURN TO TEXT]**

[14] *Sinonyx jiashanensis* can be found at Zhou, et al., 391. For a reconstruction of the skull of *Rodhocetus kasrani*, see Philip D. Gingerich, S. Mahmood Raza, Muhammad Arif, Mohammad Anwar, and Xiaoyuan Zhou, "New whale from the Eocene of Pakistan and the origin of cetacea swimming," *Nature* 368 (1994): 845. **[RETURN TO TEXT]**

[15] Gould, 10. **[RETURN TO TEXT]**

[16] The standard scheme is depicted in Carroll (1997), 331. *Pakicetus inachus* is known from only the back portion of a skull, jaw parts, and a few teeth. Philip D. Gingerich, Neil A. Wells, Donald E. Russell, and S. M. Shah, "Origin of Whales in Epiconti- nental Remnant Seas: New Evidence from the Early Eocene of Pakistan," *Science* 220 (1983): 403-406. **[RETURN TO TEXT]**

[17] Michael J. Novak, "Whales leave the beach," *Nature* 368 (1994): 807. [RETURN TO TEXT]

[18] The Eocene epoch is divided into early (Eocene 1), middle (Eocene 2), and late (Eocene 3) subepochs. Eocene 1 corresponds to the Ypresian stage, and Eocene 3 corresponds to the Priabonian stage. Eocene 2 is divided into the Lutetian and Bartonian stages. The Ypresian is dated from 56.5 to 50 mya, the Lutetian from 50 to 42.1 mya, the Bartonian from 42.1 to 38.6 mya, and the Priabonian from 38.6 to 35.4 mya. W. Brian Harland, Richard L. Armstrong, Allen V. Cox, Lorraine E. Craig, Alan G. Smith, and David G. Smith, *A geologic time scale 1989* (Cambridge: Cambridge University Press, 1990), 172. As for the uncertainty in the dating of *Pakicetus*, see R. Ewan Fordyce, "Cetacean Evolution and Eocene/Oligocene Environments" in Donald R. Prothero and William A. Berggren, eds., *Eocene-Oligocene Climatic and Biotic Evolution* (Princeton: Princeton University Press, 1992), 368, 370, 372, 376; M. J. Benton, ed., *The Fossil Record 2* (London: Chapman & Hall, 1993), 760-61; and Fordyce and Barnes, 430-31. [RETURN TO TEXT]

[19] *Rodhocetus kasrani* is known from a skull, lower jaws, vertebrae, pelvic bones, and a femur. Philip D. Gingerich, et al., (1994): 844-47. Gingerich dates the Ypresian-Lutetian boundary between 48-49 mya. See, ibid., 845. Thus, if *Pakicetus* is moved to the early Lutetian, by Gingerich's dating it would be at or under 48 mya. Gingerich has, on at least one occasion, estimated *Rodhocetus* to be "about forty-eight million years old." Philip D. Gingerich, "The Whales of Tethys," *Natural History* (April 1994): 88. [RETURN TO TEXT]

[20] *Ambulocetus natans* is known from a skull, ribs, vertebrae, and significant portions of fore and hind limbs. J. G. M. Thewissen, S. T. Hussain, and M. Arif, "Fossil Evidence for the Origin of Aquatic Locomotion in Archaeocete Whales," *Science* 263 (1994): 210-12. [RETURN TO TEXT]

[21] Carroll (1997), 333 says *Ambulocetus* is about two million years younger than *Pakicetus*. Thus, if *Pakicetus* is moved to about 48 mya (Gingerich's early Lutetian date), that would push *Ambulocetus* to about 46 mya. *Rodhocetus* and *Indocetus* are nearly contemporaneous fossils from the early Lutetian of the Domanda Formation in Pakistan (whereas *Pakicetus* and *Ambulocetus* are from the Kuldana Formation). *Indocetus ramani* is known from a skull, pelvic bones, vertebrae, and parts of hind limb bones. A. Sahni and V. P. Mishra, "Lower Tertiary Vertebrates from Western India," *Monograph of Paleontological Society of India* 3 (1975): 1-48; P. D. Gingerich, S. M. Raza, M. Arif, M. Anwar, and X. Zhou, "Partial Skeletons of *Indocetus ramani* (Mammalia, Cetacea) from the Lower Middle Eocene Domanda Shale in the Sulaiman Range of Punjab (Pakistan)," *Contributions from the Museum of Paleontology of the University of Michigan* 28 (1993): 393-416. [RETURN TO TEXT]

[22] Protocetus atavus is known from a well-preserved skull and from vertebrae, ribs, a tooth, and part of a second skull which have been referred to it. Lawrence G. Barnes and Edward Mitchell, "Cetacea" in Vincent J. Maglio and H. B. S. Cooke, eds., *Evolution of African Mammals* (Cambridge, MA: Harvard University Press, 1978), 585. Gingerich and others place it in the middle Lutetian, but the holotype was collected from the basal portion of the lower Mokattam Formation in Egypt, which some experts date to the early Lutetian. Ibid.; Benton, 760-61; see also, Fordyce, 370. [RETURN TO TEXT]

[23] *Protocetus* was found in deep-neritic deposits. Gingerich argues that *Protocetus* was completely aquatic and that its lumbocaudal trunk was flexible like that of modern whales. Gingerich, et al., (1994): 844-845. [RETURN TO TEXT]

[24] This is not to suggest any conscious manipulation on the part of these scientists. It is simply an acknowledgement that evidence that fits expectations is more readily received. [RETURN TO TEXT]

[25] This gigantic marine archaeocete reportedly possessed small but functional hind limbs that have been interpreted as copulatory guides. Philip D. Gingerich, B. Holly Smith, and Elwyn L. Simons, "Hind Limbs of Eocene *Basilosaurus*: Evidence of Feet in Whales," *Science* 249: 154-157 (1990). [RETURN TO TEXT]

[26] Fordyce, 376. **[RETURN TO TEXT]**

[27] Carroll, (1988), 523-24; Gingerich, et al., (1990): 250. **[RETURN TO TEXT]**

[28] Ernst Mayr, *Animal Species and Evolution* (Cambridge, MA: Harvard University Press, 1963), 238 (citing the work of J. B. S. Haldane). See also, Robert Wesson, *Beyond Natural Selection* (Cambridge, MA: MIT Press, 1991), 53. In this regard, it is noteworthy that the skull of *Pakicetus* was only one-half the size of the skulls of *Ambulocetus*, *Rodhocetus*, and *Indocetus*. Gingerich, et al., (1994): 844-845. **[RETURN TO TEXT]**

[29] This fact is noted in G. A. Mchedlidze, *General Features of the Paleobiological Evolution of Cetacea*, trans. from Russian (Rotterdam: A. A. Balkema, 1986), 91. **[RETURN TO TEXT]**

[30] George Gaylord Simpson, "The Principles of Classification and a Classification of Mammals," *Bulletin of the American Museum of Natural History* 85 (1945): 214. **[RETURN TO TEXT]**

[31] A. V. Yablokov in "Convergence or parallelism in the evolution of cetaceans," *International Geology Review* 7 (1965): 1463. **[RETURN TO TEXT]**

[32] Lawrence G. Barnes, "Search for the First Whale," *Oceans* (March 1984): 22. The old consensus has been broken, but the dispute remains unsettled. "Relationships of Mysticeti and Archaeoceti are uncertain, with insufficient fossil evidence to demonstrate close relationships." Edward Mitchell, "A Phylogeny of Cetacea," *American Zoologists* 15, no. 3 (1975): 824. "Debate has continued without resolution as to whether the Archaeoceti were ancestral to the Odontoceti, the Mysticeti, or both." Barnes and Mitchell, 595. "The fossil record of cetaceans is incomplete and has not provided unequivocal evidence on whether archaeocetes gave rise to one, both, or neither suborder of living whales." Michel C. Milinkovitch, Axel Meyer, and Jeffrey R. Powell, "Phylogeny of All Major Groups of Cetaceans Based on DNA Sequences from Three Mitochondrial Genes," *Molecular Biology and Evolution* 11, no. 6 (1994): 939. **[RETURN TO TEXT]**

[33] Fordyce and Barnes, 426. **[RETURN TO TEXT]**

[34] Fordyce and Barnes, 420, 431. They label remingtonocetids as "bizarre." Elsewhere Barnes calls them "a radically divergent group of archaeocetes" and describes them as having "almost crocodilelike skulls and teeth." Lawrence G. Barnes, "Whale" in *McGraw-Hill Yearbook of Science & Technology 1993* (New York: McGraw-Hill, 1993), 484. **[RETURN TO TEXT]**

[35] Quote from Andre Wyss, "Clues to the origin of whales," *Nature* 347 (1990): 428-29. Banister and Campbell likewise remark, "The origins of present-day cetaceans are poorly known." Banister and Campbell, 294. Regarding phylogenies, see Barnes and Mitchell, 594; Barnes, (1984): 21; Lawrence G. Barnes, Daryl P. Domning, and Clayton E. Ray, "Status of Studies on Fossil Marine Mammals," *Marine Mammal Science*, no. 1 (1985): 17; Barnes, (1993): 483. **[RETURN TO TEXT]**

[36] "It is now clear that several derived archaeocetes, such as *Basilosaurus*, did not give rise to modern taxa." Thewissen, 173. **[RETURN TO TEXT]**