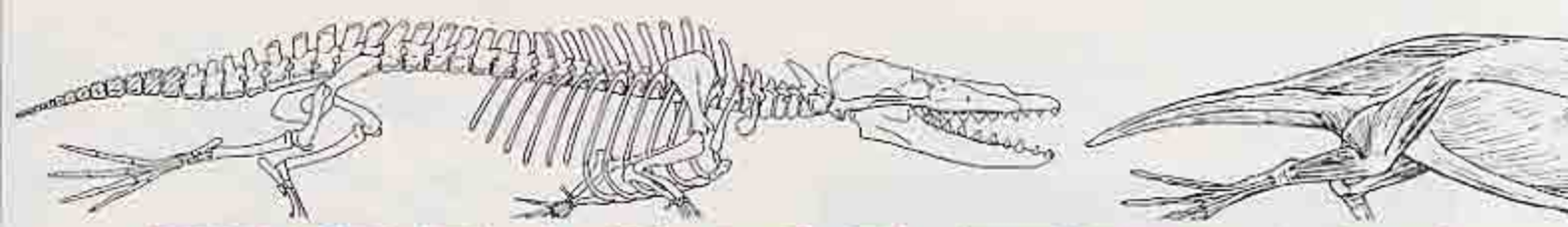


WHALES THAT WALKED

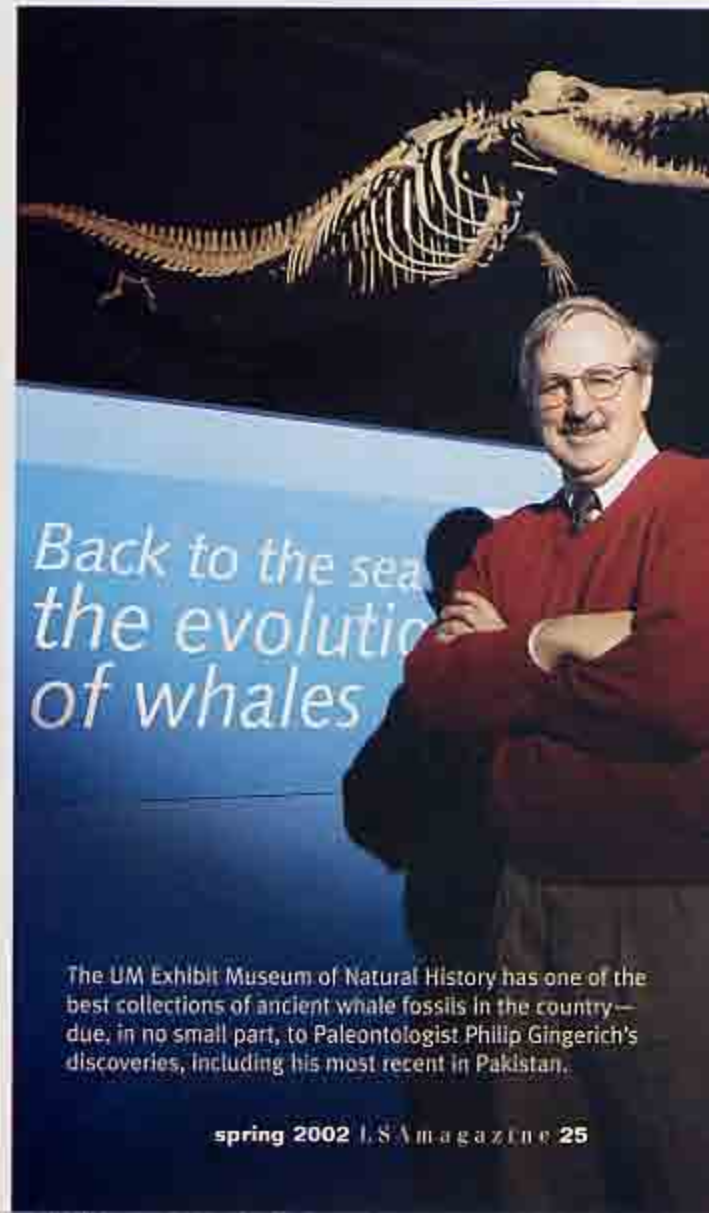
UM Paleontologist Discovers Two New Ancient Species That Fill Gaps in the Evolutionary Record of Leviathans

BY PHILIP D. GINGERICH

Whales have long fascinated us, and remain popular today, I think, because we somehow see ourselves in them. We see the mystery of our intelligence in the mystery of their intelligence. We see the mystery of our origin in the mystery of theirs. Whales are interesting too because they are literally "extraterrestrials." Ancestral mammals moved from the sea to the land, but then early whales left the land and moved back to the sea.

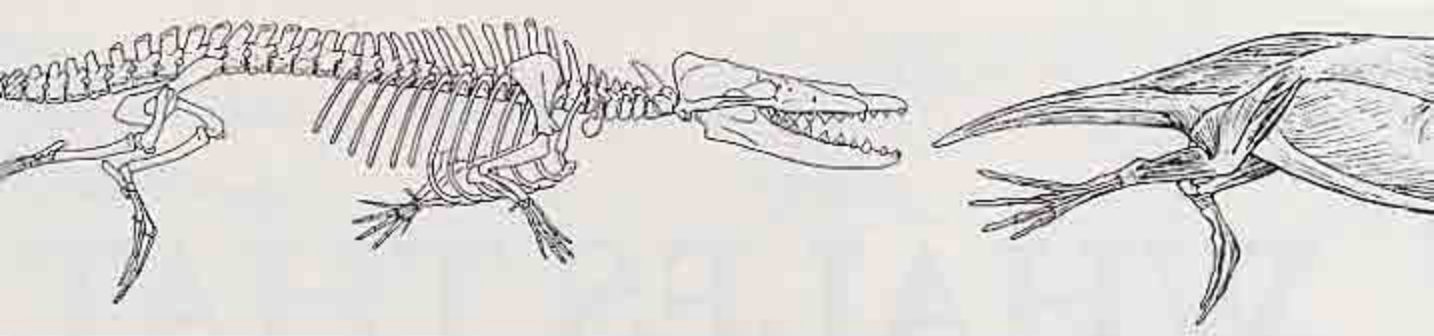
The genealogy of living whales, including dolphins, can be traced back to a point some 35 million years ago, to the time when modern ocean patterns of circulation, heat transport, and nutrient-rich upwelling provided new opportunities leading to diversification of the modern whales. I study archaic whales that lived before this period of diversification of modern whales, and whose fossils can be found in the "Eocene strata"—layers of rock and sediment that formed from 35 million years to 55 million ago. These creatures lived in a sea called Tethys that mostly disappeared when the Indo-Pakistan subcontinent closed against the rest of Asia and merged to form one continent. Fossiliferous strata, including marine animal skeletons, deposited at the time, are now folded into the foothills of the modern Himalaya Mountains. Exposed fossil beds are best in the desert mountains of Pakistan, bordering Afghanistan, and it was here in the summer of 2001 that my team of fellow paleontologists discovered what came to be two new species of ancient whales.

Before describing our find, let me explain more about "Eocene whales." They were first discovered in the early 19th century. One, *Basilosaurus*, is the fossil whale of *Moby-Dick*. Eocene whales are the ones that made the still-poorly known transition from land to sea, approximately 50 million years ago.



The UM Exhibit Museum of Natural History has one of the best collections of ancient whale fossils in the country—due, in no small part, to Paleontologist Philip Gingerich's discoveries, including his most recent in Pakistan.

PHOTO BY MARTIN VLOET OF UM PHOTO SERVICES



Got Fur?

He says that 75 percent of his work is "sure" and 25 percent is "speculative."

"The fur's more speculative," says John Klausmeyer, an exhibit preparator at the UM Exhibit Museum, of his painting of *Rhodocetus balochistanensis* that appears here and also graced the cover of the prestigious journal *Science* on September 21, 2001.

Klausmeyer sketched treatments of this extinct whale ancestor—bone structure, musculature, and finally skin and fur (see above)—based upon the fossilized skeleton discovered by paleontologist Philip Gingerich. The well-preserved skeleton gave Klausmeyer a good sense of the animal's muscle configuration, such as the powerful jaw muscles. But a 47-million year old skeleton tells nothing of a creature's flesh. "Jowly or not?" Klausmeyer asks. "We don't know." "Color of skin? Don't know that either."

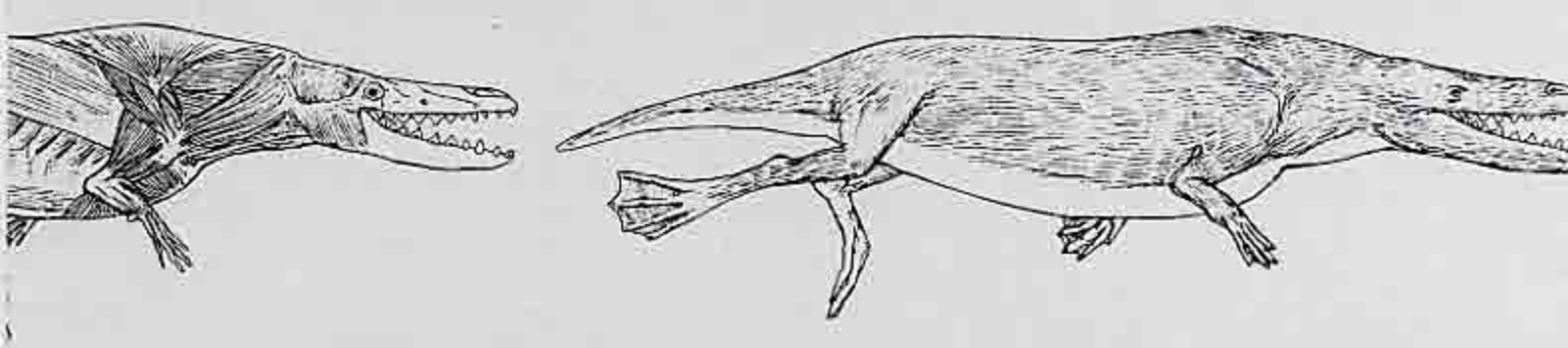
Nevertheless, Klausmeyer's "paleo-reconstructions" of dinosaurs and prehistoric mammals, among others, at the Museum for the last 17 years have impressed experts and visitors alike. Not only does Klausmeyer draw and paint, but he sculpts, builds models and exhibits, and writes exhibit text. He also teaches a class in exhibit work. Originally a medical illustrator (with a B.F.A. and M.S. from UM), Klausmeyer switched from human anatomy to animal because he wanted more variety to his work.

So what about the fur on *Rhodocetus balochistanensis*? Gingerich and Klausmeyer decided that this creature probably was lightly furred like today's sea lions since it spent part of its time in the ocean and part on land. As the species gradually evolved into solely aquatic creatures, its fur, as with modern whales, vanished.

John A. Kinch

PAINTING AND DRAWINGS BY JOHN KLAUSMEYER

John Klausmeyer's painting of *Rhodocetus balochistanensis* appeared on the cover of *Science* magazine last fall.



and these are the ones that later gave rise to modern whales. The problem of understanding the origin of whales has always been that whales changed so much, evolving from land to sea, and that they now retain very little that is distinctive about their land-mammal ancestry.

Biochemists first tackled the problem of whale relationships in the 1950s by studying cross-reactivity of the immune system. They found a tie to artiodactyls and nothing else. Artiodactyls include all of the familiar even-toed or split-hoofed, plant-eating mammals, such as today's cows, deer, pigs, camels, and hippopotami. Paleontologists interpreted these immunological tests as meaning that an extinct group of meat-eating scavenging land mammals called mesonychids was intermediate.

However, in recent years, biologists studying DNA sequences have reinforced the connection of whales to artiodactyls—but not to the branch of mesonychids—and argued even more confidently for a close relationship to hippos within the artiodactyls. Their work stemmed from DNA comparisons of modern hoofed mammals and whales. I knew of this idea but did not take it very seriously because mesonychids seemed the only evolutionary bridge we had in the fossil record. We had not discovered any skeletal remains to prove that mesonychids were not an "evolutionary step" for modern whales.

Of course, in a whale fossil, certain bones are telltale clues as to what you have before you. The most distinctive bone of an artiodactyl skeleton is the "double-pulley" astragalus that forms a double hinge in the ankle, and marks artiodactyls as artiodactyls back to the very beginning of their history. Mesonychids, in contrast, have a normal 'single-pulley' astragalus like most mammals, including ourselves. Whales today don't have an astragalus because they don't have ankles anymore.

Whale astragalus bones were not known until our field work in Egypt in the 1980s, when we showed that Basilosaurus retained legs and feet. These were small though and uninformative because the legs and feet were already too reduced in Basilosaurus (we were astonished that they had feet at all). Nevertheless, the Egyptian fossils hinted at the possibility of an older ancestor that also might have astragalus bones. So, in 1992, I started a series of expeditions in Pakistan to find and study older whales and look for the astragalus bones in them.

This proved extremely difficult, but finally late last summer, on the first morning of our field work, graduate student Iyad Zalmout found the first skeleton with an astragalus! Initially, small fragments of weathered bone were scattered across a gently sloping hillside. Iyad traced these like breadcrumbs, working slowly up the slope until the scatter of fragments converged at their source. Here much of a skeleton was entombed in the rock. Later in our field work Munir ul-Haq of the Geological Survey of Pakistan found another skeleton with complete hands and feet.

At the first fossil site, I fit two pieces together to make a complete astragalus and was astonished to see how perfectly this resembled the distinctive "double-pulley" of artiodactyls rather than "single-pulley" of mesonychids. At that moment, the evidence was clear: Whales evolved directly from artiodactyls without an intermediate mesonychid stage. The skeleton with complete hands and feet surprised me too in resembling anthracotheres, the "coal beast" artiodactyls thought to have given rise to hippos. Thus the evidence now seems clear that whales arose from the base of the hippo branch of artiodactyl evolution.

The taxonomic names for the new species we found are *Artiocetus clavis* and *Rhodocetus balochistanensis* (pictured opposite). As with other ancient whales, these species lived part of the time in water, and part on land, hitching themselves ashore as modern sea lions do. They were up to nine to 10 feet and we estimate weighed as much as a half-ton. They would have shared the earth with early forms of horses, elephants, primates, bats, and the now-extinct condylarths and creodonts.

Last fall, I wrote a cover story for the journal *Science*. The scientific and popular press picked up our find, and our work was featured in *The New York Times* and *National Geographic* magazine, among many others. We're pleased with our discovery. It is an important, satisfying result, capping years of field and laboratory work of many paleontologists, especially at the University of Michigan.

But there's more work to be done. We're eager to pin down just when and how land-living, plant-eating artiodactyls over millions of years became sea-dwelling, fish-eating whales. We have yet to find a full set of intermediate species skeletons linking the two groups.

The war in Afghanistan postponed our field work in 2001. But we hope to return soon to the arid mountains of Pakistan again in search of whales.

Philip D. Gingerich is the E.C. Case Collegiate Professor of Paleontology, Professor of Geological Sciences, and Director of the Museum of Paleontology.

LSA EXTRA

More about whales at magazine.lsa.umich.edu