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Ancient Walking Whales Shed Light on Ancestry of Ocean Giants

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Scientists have found fossil skeletons of two new species of primitive whales with well-developed limbs, fingers, and toes—supporting genetic evidence that hippos are the closest modern land-dwelling relatives to the giants of the sea.

It has long been known that whales are mammals that moved to the sea about 50 million years ago. But how they are related to other mammals is a controversial issue.

"Whales are warm-blooded animals like we are—that has been known for a long time," said University of Michigan paleontologist Philip D. Gingerich. "Yet they're so different from other warm-blooded, furry things that it's been a mystery both how they came to live in the sea and what ancestors they might have come from on land."

Gingerich, University of Michigan graduate student Iyad Zalmout, and researchers from the Geological Survey of Pakistan and the University of New Hampshire are co-authors of a paper in the September 21 issue of the journal *Science* that resolves some of the mystery. Their discovery of fossils of walking whales reveals important clues about how these animals got around and what they had in common with living and extinct land-living animals.

Some researchers use morphology (the study of an animal's structure and form) to suggest that whales are descended from mesonychians, an extinct group of meat-eating animals that resembled hyenas with hooves. Others use DNA, molecular, and genetic techniques to suggest that whales and hippos are more closely related to one another than either of them is to any other species.

The fossils found in Pakistan last year add weight to the second theory: that whales descended from the group of animals known as artiodactyls, whose members include sheep, cows, pigs, camels, deer, and hippos. Artiodactyla (Greek *artios,* entire or even numbered, and *dactylos,* finger or toe) are named for the even number of fingers and toes (two or four) found on each hand and foot.

The fossils found by Gingerich and the others are the first and only known specimens that have sheep-like ankle bones and archaic whale skull bones in the same skeletons. Some of the ankle bones have signature features that place the whales in the artiodactyls group.

Certain ankle bones show specialized features typically associated with adaptation to running. Such features are unique to artiodactyls, living and extinct.

The presence of artiodactyl-like ankles in the primitive whales strongly suggests common heritage rather than convergent evolution, said Kenneth D. Rose of the Program for Functional Anatomy and Evolution at Johns Hopkins University School of Medicine in Baltimore, Maryland. Convergent evolution is the process by which different groups of organisms may evolve similar characteristics in response to particular environmental requirements.

"While ankles from primitive ancient whales have been discovered before, these are the first that are well-preserved enough to provide clues about whale ancestry," Rose said in a related article published in the same issue of *Science.*

Better Clues to Whales' Ancestors

Gingerich's discovery goes a long way toward resolving the conflict about the ancestry of whales, Rose said. "The fossils provide compelling morphological evidence," he said, "that whales are not just related to, but descended from, artiodactyls rather than mesonychians, thus bringing the morphological evidence into accord with molecular data."

Gingerich has been searching since the late 1970s for evidence that would clear up the confusion about the ancestry of whales. Other whale fossils he found in Pakistan in the late 1990s were nearly complete but lacked the critical hand and foot bones.

"Over and over again, we'd get the same backbones, but the parts we needed were gone," says Gingerich, who speculates that ancient sharks scavenged those parts before the bones became fossilized.

Finally last October, on their first morning at a new field site in Pakistan, Gingerich's team found a whale ankle bone that could answer the artiodactyl question.

The bone was so clearly like that of an artiodactyl that Gingerich—who previously had embraced the view that whales evolved from *mesonychid condylarths*—struggled for months to make sense of it, finally concluding without question that whales had artiodactyls' ankles.

"Now I even admit the possibility that hippos are a side line of artiodactyls that might be closer to the whales than any other living animals," he said.

Gingerich said the legs and feet of the primitive whales were not designed for walking long distances.

"It's clear that these animals could hitch their way out of water and back in, like sea lions do today, but they were more aquatic than I realized," Gingerich said. The size and shape of their bones suggest that they had webbed hands and feet and probably also used their tails to propel themselves through the water.

Gingerich hopes to return to Pakistan soon to continue looking for whale fossils, and he expects that other researchers will take a closer look at fossils of hippo-like animals to better understand the hippopotamus family tree.

Boost for DNA Studies

In addition to helping resolve the confusion about whale evolution, the recent discoveries should also lend more credibility to molecular, genetic, and immunological approaches to understanding evolutionary relationships, Gingerich said. "In the last few years, 15 or 20 DNA studies have come out supporting this artiodactyl connection," said Gingerich. "Those weren't taken very seriously, but this finding shows that they need to be.

"If the studies are done well, the DNA that animals carry in their bodies today gives us a better picture of the past than we might have thought it did. If we can make reliable inferences from animals that are living today, we can learn a lot about the past much faster.

"These techniques will never replace paleontology," he said, "but they will complement it and expand on what we can competently infer."

Despite this evidence that cetaceans (whales, dolphins, and porpoises) evolved from artiodactyls, substantial discrepancies remain, Rose said. "If cetacaeans belong to artiodactyls," he said, "then similarities in the cranial and dental morphologies of mesonychians and cetaceans must be the result of convergent evolution or must have been lost in artiodactyls.

"Well-preserved ankles of the earliest ancient whales are now needed to confirm that the traits seen in the new skeletons are indeed inherited from early artiodactyls and not a result of convergent evolution," Rose said.

The skeletons found by Gingerich and his associates are about 47 million years old, and come from the eastern part of Balochistan Province in Pakistan. The researchers have classified one, *Rodhocetus balochistanensis,* as a new species of an existing genus, and the other, *Artiocetus clavis,* as a new species and new genus. The skeleton of *Artiocetus* was located after pieces of ankle bones were found on the ground.

The early part of Gingerich's work was supported by a grant from the National Geographic Society's Committee for Research and Exploration.