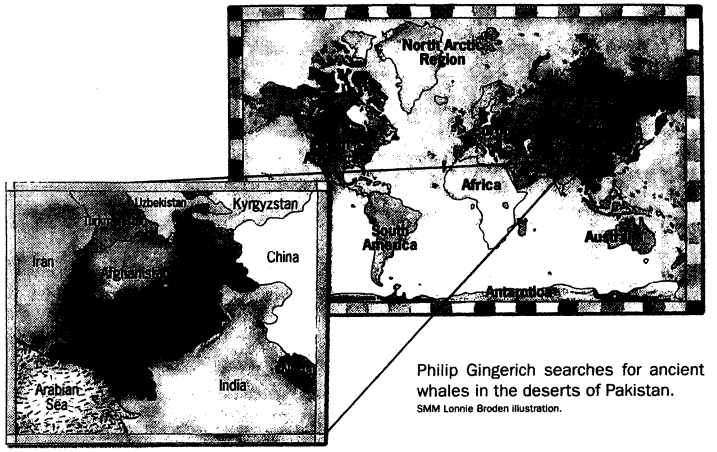
Activity 7

WHALES:
Walking Into the Past

Whales with knees and toes? Incredible as it seems, whales once walked on legs and lived on land. Millions of years of biological change have erased the whale's legs from its body. But a faint trace remains. Hidden inside the streamlined body of many modern whales are tiny hip and leg bones. The story of how the whale—marvel of the oceans—evolved from a four-legged mammal is an amazing one. So far, it provides one of the best examples of how organisms change over time. And like whales, the story is still evolving.

Just about everything to do with whales was once a big puzzle, even what kind of animal it was. Fish or mammal? Scientists had trouble deciding. From the small dolphin to the enormous grey whale, these animals look and live like fish. They can't survive out of water—but on the other hand, they can drown in water. Every 15 minutes or so they have to swim to the water's surface to breathe. Like all mammals, whales are warm-blooded, give birth to babies rather than lay eggs, and nurse their young with milk. They even have a belly button.

Philip Gingerich, paleontologist at the University of Michigan, digs for fossil whales.
Photo courtesy University of Michigan Museum of Paleontology.



Philip Gingerich searches for ancient whales in the deserts of Pakistan.
SMM Lonnie Broden illustration.

So, if whales are mammals, how did they come to live like fish? Could their ancestors have been land mammals that gradually took to the oceans? When scientists first asked these questions, there was little fossil evidence to provide answers. Until, that is, paleontologist Philip Gingerich discovered a bone in the desert of Pakistan.

Many of the great scientific discoveries happen by accident, if the scientist is open to surprises. Philip Gingerich wasn't looking for whales when he arrived in Pakistan in 1977 with a team of international scientists. Dr. Gingerich was an expert on extinct land mammals. So he was disappointed to find that the first place he had targeted to look for fossils was an ancient seashore. The rocks were filled with fossilized snails and other shellfish—not the best place to find the bones of a land mammal.

Like kids in a giant sandbox, Gingerich and his team went to work anyway. After a week of scouring the exposed rocks, they found a few pieces of bone that looked promising: They could make out part of a pelvis and a backbone. Gingerich recalls joking with his team about finding a "walking whale" with hips and legs, but back then it was just a joke. The team assumed that the fossils were bits and pieces of an ancient elephant ancestor, a land mammal that had drifted out to sea after death.

But on a December day in 1979, the team found a specimen that was not so easy to explain. Embedded in rock as hard as cement, it was a curious fossil skull. Gingerich took the skull home to his lab. When the fossil was cleaned up, Gingerich could see that it was no bigger than a wolf's skull and had many wolf-like features. The teeth were a mix of canines and molars, and the nostrils were set close to the snout. But attached to the skull was a set of tiny thickened ear bones. The only animals on Earth, living or extinct, that have ear bones thickened this way are the whales.

Gingerich named the creature *Pakicetus* (pack-eh-SEA-tus), Whale of Pakistan. It lived about 48.5 million years ago. Based on the land mammal-like features of the skull, Gingerich hypothesized that this whale probably went into the water to

feed but came out on land to rest and to give birth. After the unexpected discovery of *Pakicetus*, Gingerich began to hunt for whales in earnest. Whale fossils are large, and they are relatively easy to find in the desert. Sometimes the wind lends a hand by scouring away the sands and shales, leaving entire skeletons exposed. One valley in Egypt was especially rich in whales. On a series of visits starting in 1983, Gingerich and his team found virtually a whale a day. The final tally came to 379 whales. He found some with hipbones, but Gingerich also hoped to find legs and feet.

In 1989 Gingerich was mapping the spine of a well-preserved 50-foot-long skeleton of *Basilosaurus* (bah-sill-oh-SOAR-us), a fossil whale that lived about 10 million years after *Pakicetus*. Two-thirds of the way down the spine he found a small round bone standing vertically. This seemed out of place, and the top was weathered away. When the rest was excavated, the bone proved to be an upper leg bone with the knee joint preserved. No one had ever seen the knee of a whale before.

Counting down the spine, this bone was near the 48th vertebra. The whole team went to work brushing sand away from this part of all the *Basilosaurus* that had been mapped so far. Soon they found, astonishingly, not only more hips and upper legs, but also lower leg bones, anklebones, and finally, one by one, the bones of three tiny toes. These were the first hind limbs and feet ever found with a fossil whale skeleton.

Basilosaurus was a huge ocean-going whale, with retracted nostrils forming a blowhole halfway up its four-foot-long skull. Its body was equipped with legs, but they were too small to support the animal's weight on land.

Gingerich predicted that scientists would unearth many more missing links between land and sea whales. He wasn't disappointed. Some of the most important finds were yet to come. In the 1990s J. G. M. Thewissen and Gingerich discovered two whales that were almost as old as *Pakicetus*. Both had legs larger than *Basilosaurus*, even though the skeletons were only 10 to 12 feet long. One was named *Ambulocetus natans* (am-bue-low-SEA-tus-NAY-tans) and the other *Rodhocetus kasranii* (row-deh-SEA-tus-kaz-RAN-nee-eye). Like *Pakicetus*, both of these whales found their food in water and were good swimmers, but both still hitched their way ashore to rest and to give birth.

Some crucial parts of the *Rodhocetus* skeleton were still missing. The hands, feet, and tail were poorly known. But Gingerich persevered, and eventually his team found

Rodhocetus, "the barely walking whale."
John Klausmeyer illustration.

a complementary *Rodhocetus* skeleton with hands and feet intact. He named this one *Rodhocetus balochistanensis* (bah-low-CHIS-stan-en-sis), after the province in Pakistan where it was found. This discovery brought new surprises. The middle three fingers of each hand retained a tiny hoof. And the anklebones proved to be the kind that belonged only to hoofed mammals known as artiodactyls (arty-oh-DAK-tils). Artiodactyls include cows, goats, pigs, and hippos. *Rodhocetus* combined features of an aquatic whale with features of a hoofed mammal all in the same skeleton.

Scientists doing DNA studies had already claimed that the whale's closest living relatives were artiodactyls like the hippopotamus, and here was confirmation. The fossil record and DNA evidence were now saying the same thing. *Rodhocetus* was like an arrow pointing backward to a hoofed ancestor and forward to an ocean-dwelling dolphin.

In this activity you'll have a chance to meet *Rodhocetus*, the barely walking whale, excavate and sort some "fossils" of your own, and learn how to read bones like a paleontologist to understand the whale's remarkable transition from land to sea.