SCIENCE NEWS of the week

Fossil Whale Feet: A Step in Evolution

Paleontologists digging in Pakistan have discovered the 50-million-year-old remains of a whale with legs and feet — a missing link in the evolutionary chain connecting aquatic cetaceans with their landlubbing forebears.

The new-found fossil, called *Ambulocetus natans,* is the first known ancient whale with large, functional hind limbs, says J.G.M. Thewissen of the Northeastern Ohio Universities College of Medicine in Rootstown. He and his colleagues report their find in the Jan. 14 SCIENCE.

Paleontologist Annalisa Berta of San Diego State University calls *Ambulocetus* "a very significant discovery. It shows us for the first time a whale that had well-developed hind limbs. It's very clear this animal was using its hind limbs in locomotion."

Researchers believe that modern whales descended from four-legged carnivorous mammals, somewhat like large wolves, that once roamed the continents. Sometime around the start of the Eocene period, 57 million years ago, these carnivores gave up their dry lifestyle for one under the waves, forcing their bodies to undergo a profound evolutionary transformation. Among the changes, ancient whales lost their legs and pelvises and developed the characteristic fluked tail that propels these modern leviathans through the seas.

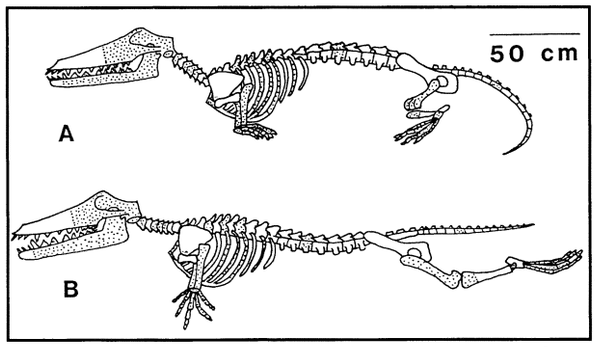
Living whales have no visible hind limbs, but some have internal finger-size bones that are vestiges of hips and legs, an indication that they evolved from land creatures. Three years ago, Philip D. Gingerich of the University of Michigan in Ann Arbor reported the discovery of a 40-million-year-old whale in Egypt that had external legs, although they were too small to help propel the animal (SN: 7/14/90, p.21). Gingerich suggested that this animal, called *Basilosaurus,* used its tiny hind limbs to grasp its partner during copulation.

While *Basilosaurus* most likely spent all of its time in water, Thewissen suggests that the sea-lion-size *Ambulocetus* led an amphibious lifestyle. *Ambulocetus* could walk on land, but the shape of its bones suggests it had weak hind limbs. It may have walked by dragging its body as sea lions do, Thewissen says.

In the ocean, *Ambulocetus* probably swam by flexing its back up and down, using the surface area of its big feet to push against the water, Thewissen suggests. Modern whales swim with the same undulating motion, but their broad tails provide the propulsion surface.

Berta argues that paleontologists will need to find more fossils to decipher how *Ambulocetus* swam. Because Thewissen did not unearth a pelvis with the rest of the bones, he cannot determine how the whale's legs attached to the rest of its skeleton, a critical factor in understanding the animal's locomotion.

The *Ambulocetus* discovery is one of several recent fossil finds that has spurred interest in early whale evolution. While in Pakistan in 1991 and 1992, Thewissen unearthed a well-preserved skull of *Pakicetus,* the oldest known whale species, which apparently spent much of its life on land.



Thewissen/SCIENCE

Ambulocetus *standing on land (A) and swimming (B).*

Researchers in Georgia are studying an as-yet-unnamed species of whale discovered in that state. The 40-million-year-old creature had a pelvis like that of a land mammal, suggesting that the whale had large hind limbs, says Richard C. Hulbert Jr. of Georgia Southern University in Statesboro.

Early cetaceans have captured the attention of paleontologists because the trek from land to sea provides a dramatic picture of evolution at work, Hulbert says. Throughout history, other animals have made the same voyage, but whales are the most recent group, giving scientists their best chance at documenting this transition. — *R. Monastersky*

Mars Observer: Piecing together the puzzle

Astronomers had hailed the mission as the first U.S. venture to Mars in 17 years. And for nearly 11 months, as the Mars Observer spacecraft hurtled through space to keep its planetary appointment, it seemed destined to explore the Red Planet in unprecedented detail. But last Aug. 21, three days before Mars Observer was to begin orbiting the planet, the craft mysteriously fell silent (SN: 9/4/93, p.149).

Now, a panel of independent investigators reports the likely cause of the craft's disappearance. Leaky valves probably allowed Mars Observer's oxidizer and fuel to mix and spontaneously ignite at exactly the wrong place: inside the system's fuel lines instead of at its rocket thrusters. Such premature ignition would have ruptured the fuel lines, causing fuel to spew out in all directions and spinning the craft out of control.

Several experts say that if the panel's conclusions are correct, NASA might have averted the catastrophe had it not decided, just months before launch, to delay pressurizing the craft until it reached Mars.

Panel leader Timothy Coffey, director of research at the Naval Research Laboratory in Washington, D.C., announced the investigation's results at a press conference last week. In their report, Coffey and his coauthors emphasize that their suggested scenario, though "probable," is not conclusive, since ground controllers had turned off the craft's transmitter just before the Observer was lost. As a result, says Coffey, the panel lacked a "smoking gun" that would indicate exactly what went wrong.

After evaluating some 60 explanations for the craft's loss, the panel eliminated all but a few possibilities and focused on flaws in the propulsion system. Tests revealed that a group of valves, known as check valves, were leakier than expected. Common in sprinkler systems, check valves ideally allow material to flow in only one direction.

Aboard the Mars Observer, two sets of check valves allowed high-pressure helium gas to rush through, pushing out from their respective tanks the desired amount of either the oxidizer nitrogen tetroxide (NTO) or the fuel monomethyl hydrazine (MMH). At the same time, the valves were designed to prevent the two liquids from flowing backward and thus inadvertently mixing and igniting in the fuel lines.

Experiments revealed that during the craft's 11-month journey, as much as 2 grams of NTO could have seeped through the check valves, condensing on the fuel lines' cold titanium tubing and setting the stage for disaster.

On Aug. 21, ground controllers took final steps in preparation for Mars Observer to fire its thrusters and enter an orbit around the Red Planet. Temporarily turning off the craft's transmitter as a

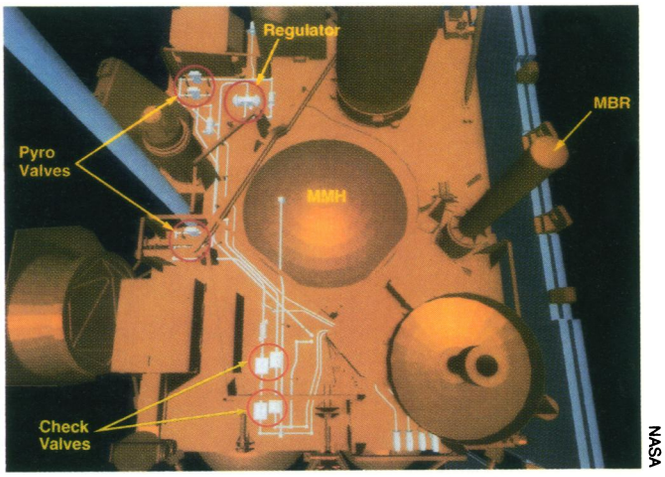
safety measure, they commanded the craft to blow open several pyro valves. With these rigid barriers out of the way, helium gas could flow though the check valves and pressurize the fuel and oxidizer tanks.

The absence of the pyro valves also meant that any NTO that had leaked through the check valves could mix with MMH, the panel conjectures. The enormous heat generated by the NTO-MMH mixture would have made titanium as soft as butter, rupturing the system and rendering the craft dead in space, Coffey says.

The panel charges that NASA's Jet Propulsion Laboratory (JPL) in Pasadena, Calif., which supervised the Mars Observer project, and its main contractor, Martin Marietta Astro Space, relied too heavily on designs for satellites orbiting Earth. Check valves function well, with little leakage, for short journeys in the warmer environment near Earth. But using them for a long interplanetary journey can prove problematic, says panelist Peter G. Wilhelm of the Naval Research Laboratory.

Indeed, NASA originally planned to rely on the check valves only for the first few days of the mission, says Mars Observer project manager Glenn Cunningham of JPL. The agency intended to pressurize the propulsion system five days into the flight rather than wait until the craft reached Mars 11 months later, when its thrusters had to be fired.

But those plans suddenly changed about six months before launch, Cunningham said. Scientists recalled that one of the Voyager spacecraft in 1976 had suffered a leaky regulator soon after its fuel system was pressurized, so they decided to hold off pressurizing Mars Observer until necessary.



NASA

Illustration shows propulsion system of the Mars Observer, including fuel tank of monomethyl hydrazine (MMH). A small transmitter, the Mars Balloon Relay (MBR), lies at right.

Had JPL officials gone with their original plan, the NTO leak would have been far smaller (five days' worth of seepage rather than 11 months' worth), and the craft might have survived, Wilhelm says.

Wilhelm adds that in the long run, debating the cause of the Observer's failure has less significance than ensuring that NASA addresses the myriad other problems found by the panel. If NASA doesn't, he cautions, "then the next time [they launch a similar craft], it will be something else that gets them."

—R. Cowen

Immune therapy stems diabetes' progress

Diabetic mice treated with a particular monoclonal antibody have regained the ability to regulate their blood sugar, leading researchers to hope that a similar treatment may one day stop insulin-dependent diabetes in humans.

Monoclonal antibodies are proteins produced to seek out and attach to specific molecules. The anti-CD3 monoclonal antibody homes in on the CD3 molecule, which sits in the membrane of immune-system cells called T-cells and serves as a docking site that helps these cells recognize their targets. Physicians use this monoclonal antibody to prevent and treat the rejection of organ transplants, with mixed success.

Up to now, researchers had demonstrated that they could use substances that interact with the immune system — including this anti-CD3 molecule — to stop the development of diabetes, but only if given before the autoimmune attack destroyed most of the pancreas' insulin-producing beta cells (SN: 11/6/93, p.292). Treatment early in the disease process with different monoclonal antibodies, as well as the immune-system-suppressing drug cyclosporin, can keep these mice diabetes-free.

"This is really the first treatment that has shown any ability to cause remission," says Joan T. Harmon of the National Institute of Diabetes and Digestive and Kidney Diseases in Bethesda, Md.

Lucienne Chatenoud and her colleagues at Necker Hospital in Paris tried the approach in adult, nonobese diabetic (NOD) mice. Many such mice lose the ability to regulate their blood sugar as they mature because their T-cells attack their insulin-producing cells.

Within a week of developing high blood sugar or signs of T-cell attack, the NOD mice were given either low doses of the anti-CD3 antibody for five days or hamster immunoglobulin as a control injection. In some experiments, the researchers also gave the mice the drug cyclophosphamide, which speeds the development of diabetic symptoms.

Researchers then monitored the distribution of different T-cells in these mice. They also implanted bits of NOD-mouse pancreas into the kidneys of treated mice or attached pieces of tail skin from a different mouse strain to see what transplants survived. Within a month, 64 to 80 percent of the anti-CD3-treated mice regained the ability to regulate their blood sugar, the team reports in the Jan. 4 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES.

T-cells still seemed to infiltrate the pancreas, but they stopped attacking beta cells. Also, these mice rejected the skin grafts but not the pancreas implants, indicating that the treatment quelled the T-cell attack but did not totally destroy immune-system function, says Chatenoud. The anti-CD3-treated mice remained diabetes-free for at least four months.

A study by Chatenoud's colleague Jean-Francois Bach had shown that this same anti-CD3 monoclonal antibody causes side effects too severe to make it a useful treatment in people, she notes. But she hopes that an anti-CD3 antibody fragment, which also halted diabetes in mice, will prove beneficial to people without causing side effects.

However, "it's a long way before we know whether a similar method will work in humans," Harmon cautions.

Important differences exist between human and mouse diabetes and between the immune systems of these two organisms.

"It's easier to manipulate the disease in the NOD mouse than in humans," says George S. Eisenbarth, an endocrinologist at the University of Colorado Health Sciences Center in Denver. "In man, it might be too late to intervene when [we] see the high blood sugar."

Nevertheless, the French work "suggests there is an injury mechanism that is reparable," says C. Garrison Fathman of Stanford University School of Medicine. Autoimmune diseases often progress in fits and starts: Many diabetics go through a "honeymoon" period after their first signs of high blood sugar and seem to recover temporarily.

This study indicates that a one-time intervention with some immune-system regulator during this period may prevent the development of full-blown diabetes, he adds.

—E. Pennisi