

It's Sensitive. Really.



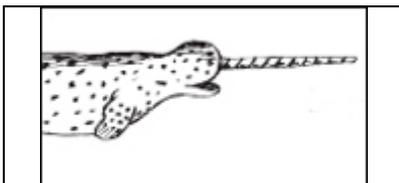
NORTHERN EXPOSURE
A male narwhal shows his tusk, spiraling counterclockwise,
in the waters of northwestern Greenland.

Bryan & Cherry Alexander, Photo Researchers Inc.

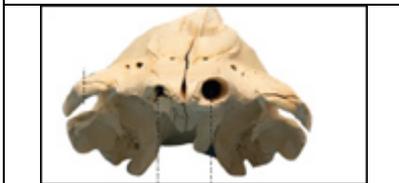
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A Long History



Riddle Solved

For centuries, the tusk of the narwhal has fascinated and baffled.

Narwhal tusks, up to nine feet long, were sold as unicorn horns in ages past, often for many times their weight in gold since they were said to possess magic powers. In the 16th century, Queen Elizabeth received a tusk valued at £10,000 - the cost of a castle. Austrian lore holds that Kaiser Karl the Fifth paid off a large national debt with two tusks. In Vienna, the Hapsburgs had one made into a scepter heavy with diamonds, rubies, sapphires and emeralds.

Scientists have long tried to explain why a stocky whale that lives in arctic waters, feeding on cod and other creatures that flourish amid the pack ice, should wield such a long tusk. The theories about how the narwhal uses the tusk have included breaking ice, spearing fish, piercing ships, transmitting sound, shedding excess body heat, poking the seabed for food, wooing females, defending baby narwhals and establishing dominance in social hierarchies.

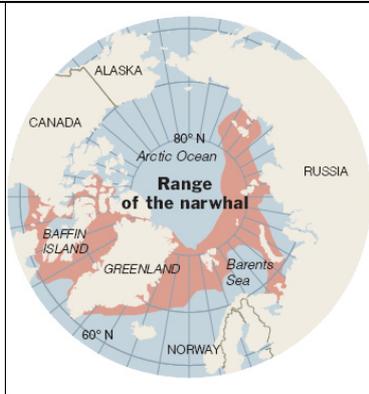
But a team of scientists from Harvard and the National Institute of Standards and Technology has now made a startling discovery: the tusk, it turns out, forms a

sensory organ of exceptional size and sensitivity, making the living appendage one of the planet's most remarkable, and one that in some ways outdoes its own mythology.



**Bryan & Cherry Alexander
Photo Researchers, Inc.**

A double-tusked narwhal, top, is a rarity. Like other whales, narwhals surface to breathe air, middle. Martin T. Nweeia, a research team leader, measures tusks at the Zoological Museum in Copenhagen.



**Enlarge This Image
The New York Times**

The find came when the team turned an electron microscope on the tusk's material and found new subtleties of dental anatomy. The close-ups showed that 10 million nerve endings tunnel from the tusk's core toward its outer surface, communicating with the outside world. The scientists say the nerves can detect subtle changes of temperature, pressure, particle gradients and probably much else, giving the animal unique insights.

"This whale is intent on understanding its environment," said Martin T. Nweeia, the team's leader and a clinical instructor at the Harvard School of Dental Medicine. Contrary to common views, he said, "The tusk is not about guys duking it out with sticks and swords."

Today in San Diego, Dr. Nweeia is presenting the team's findings at the 16th Biennial Conference on the Biology of Marine Mammals, sponsored by the Society for Marine Mammalogy.

James G. Mead, curator of marine mammals at the Smithsonian Institution in Washington, where Dr. Nweeia is a research associate, said the exposed nerve endings appear to be unparalleled in nature.

"As far as I can see, it's a unique thing," Dr. Mead said in an interview. "It's something new. It just goes to show just how little we know about whales and dolphins."

He noted that no theory about the tusk's function ever envisioned its use as a sensory organ.

In the Canadian wilds, the team recently conducted a field study on a captured narwhal, fitting electrodes on its head. Changes in salinity around the animal's tusk, Dr. Nweeia found, produced signs of altered brain waves, giving preliminary support to the sensor hypothesis. The unharmed whale was then released.

With the basics now in hand, the team is working to understand how the narwhal uses the information. One theory is that the tusk can detect salinity gradients that tell if ice is freezing, a hazard that has killed hundreds of narwhals. Tusk readings may also help the whales track environments that favor their preferred foods.

"It's the kind of discovery," said Dr. Mead of the Smithsonian, "that opens up a lot of other questions."

Little about the narwhal's appearance or behavior offers clues to the tusk's sensory importance. The whale has eyes, though small ones. It also has a thick layer of blubber and no dorsal fin so it can swim easily under the ice. Like any whale, it must surface periodically to breathe air. And as in dolphins, its mouth is set in a permanent smile.

The word narwhal (pronounced NAR-wall or NAR-way-l) is said to derive from old Norse for "corpse whale," apparently because the animal's mottled, splotchy coloring recalled the grayish, blotched color of drowned sailors.

Though shy of humans, the animals are quite social. They often travel in groups of 20 or 30 and form herds of up to 1,000 during migrations.

Males weigh up to 1.5 tons, grow about 15 feet long and are conspicuous by their tusks, which can grow from six to nine feet in length. A few females have tusks and, in rare cases, narwhals can wield two of the long teeth. Though often ramrod straight, the tusks always grow in tight spirals that, from the animal's point of view, turn counterclockwise.

The long ivory tusk "looks like a cross between a corkscrew and a jousting lance," Fred Bruemmer, an Arctic explorer, wrote in "The Narwhal" (Swan Hill Press, 1993).

Narwhals live mainly in the icy channels of northern Canada and northwestern Greenland, but they are found eastward as far as Siberia.

The whale's close cousin, the snowy white beluga, thrives in captivity. The shy narwhal tends to die.

Arctic explorers have often observed them at a distance because narwhals frequently raise their heads above the water, their tusks held high. Jens Rosing, in his book "The Unicorn of the Arctic Sea" (Penumbra Press, 1999), tells of seeing them during expeditions off Greenland. There the whales would frolic and apparently mate.

"Over a hundred can be seen at once," he wrote. "They often rise vertically out of the water, lifting themselves with strong movements of their tail fin so that half their body is above water."

Mr. Rosing added: "There is great confusion of movement - both females and males take part. Often one can see a male and female shoot up from the water, trembling, belly to belly."

When luxuriating on their backs in the water, narwhals often turn their heads so their tusks point straight up. Dr. Nweeia of Harvard said the Inuit, the indigenous peoples of the Arctic, who know the narwhal intimately, have a name for the whale that translates as "the one that is good at curving itself to the sky."

Around A.D. 1000, the narwhal tusk debuted in history as a profitable lie. Historians say people in the far north learned of narwhals from Norsemen or perhaps from finding animal bodies occasionally washed up on northern shores. It is known that the Vikings hunted the narwhal and acquired tusks from Arctic natives.

Unscrupulous traders passed them off as one of the most prized objects of all time: unicorn horns.

The ancient Chinese, Greeks, Romans and other peoples had accepted the unicorn as real, and the arrival of the beautifully spiraled objects seemed to prove the animal's existence. The supposed horns sparked huge interest because they were said to have the power to cure ills and neutralize poisons.

Kings and emperors, eager to foil assassins, had cups and eating utensils made of the precious horns. A London doctor advertised a drink made from powdered tusks that could cure scurvy, [ulcers](#), dropsy, gout, consumption, coughs, heart palpitations, fainting, rickets and melancholy.

The horns became an icon of power, both earthly and divine, in part because of their religious associations. In medieval times, the unicorn was seen as a symbol of great purity and of Christ, the motif common in religious art. The fantastic beast appeared in many thousands of images, Mr. Bruemmer wrote, and "All carry a horn that is unmistakably a narwhal tusk, the only long, spiraled horn in all creation."

Churches put small pieces of "unicorn horn" in holy water, giving ailing commoners hope of miracle cures. Meanwhile, the bishops of Vienna carried staffs made of the precious ivory, while St. Mark's Basilica in Venice displayed a horn wreathed in purple velvet.

By the 17th century, the deception began to falter amid the expansion of New World exploration and multiplying reports of bizarre whales that bore long tusks. Ole Wurm, a Danish zoologist, investigated the matter and in 1638 exposed the horn's true origins in a public lecture.

As the unicorn myth died a slow death, the reputation of the narwhal grew larger than life. Explorers claimed its tusk could punch holes in thick ice, and that males battled with their long tusks for supremacy. In 1870, Jules Verne told how a narwhal could pierce ships "clean through as easily as a drill pierces a barrel."

Dr. Nweeia, a general dentist in Sharon, Conn., with an interest in dental anthropology, developed a taste for exotic investigations while doing research on Indian tribes in the Amazon and children in Micronesia. He lectured on how animal and human teeth differ, and eight years ago he began to wonder about narwhals and their odd tusks.

"They defied most of the principles and properties of teeth," he recalled. Many narwhal reports proved contradictory, he found, and "my interest spiraled like the tooth."

In 2000, Dr. Nweeia decided to investigate the animal closely and first trekked to its icy habitat in 2002, going to Pond Inlet, a tiny settlement at the northern tip of Baffin Island. There he met David Angnatsiak, an Inuit guide who agreed to help. Under international agreement, the Inuits are allowed to hunt narwhals, which they eat and harvest for their tusks.

During expeditions in 2003 and 2004, aided by the Canadian Department of Fisheries and Oceans, Dr. Nweeia was able to gather head and tusk specimens, which he brought back for analysis. He and his colleagues tracked a clear nerve connection between the animal's brain and tusk, finding the long tooth heavily innervated. But why it should be so remained a mystery.

The investigators zeroed in on the riddle with sophisticated instruments at the Paffenbarger Research Center of the National Institute of Standards and Technology, a federal organization in Gaithersburg, Md. The American Dental Association finances the research center.

Rough deposits of calcified algae and plankton coated the outside of the tusks Dr. Nweeia brought back. The scientists decided to remove them in an acid bath to get down to the surface of the tooth before viewing it under an electron microscope. First, however, they decided to give the uncleaned tusk a cursory microscopic examination.

It was a shock. There, contrary to all known precepts of tooth anatomy, they found open tubules leading down through the mazelike coating to the tooth's inner nerves and pulp.

"That surprised us," recalled Frederick C. Eichmiller, director of the Paffenbarger Research Center. "Tubules in healthy teeth never go to the surface."

Extrapolating from a count of open tubules over one part of the tooth's surface, the team estimated that the average narwhal tusk had millions of openings that led down to inner nerves.

"No one knew that they were connecting to the outside environment," Dr. Nweeia said. "To find that was extraordinary."

His collaborators include Naomi Eidelman and Anthony A. Giuseppetti of the Paffenbarger Research Center, Yeon-Gil Jung of Changwon National University in South Korea and Yu Zhang of New York University.

Increasingly, the investigation centers on how the whales use their newly observed powers. One central unanswered question is how sensory abilities in males might relate to herd behavior and survival.

The scientists, noting that the males often hold their tusks high in the air, wonder if the long teeth might sometimes serve as sophisticated weather stations, letting the animals sense changes in temperature and barometric pressure that would tell of the arrival of cold fronts and the likelihood that open ice channels might soon freeze up.

Dr. Nweeia noted that the discovery does not eliminate some early theories of the whale's behavior. Tusks acting as sophisticated sensors, he said, may still play a role in mating rituals or determining male hierarchies.

He added that the nerve endings, in addition to other readings, undoubtedly produce tactile sensations when the tusk is rubbed or touched, and that these might be interpreted as pleasurable.

This tactile sense might explain why narwhals engage in what is known as "tusking," where two males gently rub tusks together, Dr. Nweeia said. He added that the Inuit seldom report aggressive contact, undermining ideas of ritualized battle.

Dr. Nweeia said that gentle tusking might also be a way that males remove encrustations on their tusks so tubules stay open, allowing them to better function as sensors. "It may simply be their way of cleaning or brushing teeth," he said.

He called the basic discovery mind boggling, especially given the freezing temperatures of the Arctic.

"This is one of the last places you'd expect to find such a thing," Dr. Nweeia said of the large sensory organs. "Cold is one of the things that tubules are most sensitive to," as people sometimes discover when diseased gums of human teeth expose the tubules.

"Of all the places you'd think you'd want to do the most to insulate yourself from that outside environment," he said, "this guy has gone out of his way to open himself up to it."