Cultural life of whales may cut diversity

Cultural heritage—traditions that affect behavior—may be a powerful force in whale evolution, much as it has been in human history, a biologist suggests.

Proposing culture to explain genetic diversity in species other than humans is perhaps unprecedented, notes Hal Whitehead of Dalhousie University in Halifax, Nova Scotia. Yet in the Nov. 27 SCIENCE, he suggests that whale traditions could explain a puzzle: why in some of their DNA, four whale species have only a tenth of the diversity that other whales and dolphins have.

"It's like the idea of guns," Whitehead says. Human cultural groups that made guns, rode horses, or sailed across oceans overran or outcompeted other people. As victors spread and losers perished, the original human diversity dwindled.

A similar force could steer whale evolution, Whitehead suggests. The species with skimpy diversity—killer, sperm, and the two pilot whale species—have unusual opportunities for developing powerful cultural influences. Whales are smart, live for decades, and pick up behaviors, such as songs, from family members. Unlike most other whales and dolphins, female relatives of these four species stay together for life in what is known as a matrilineal social structure. Males are far less social, although some pilot and killer whale males, too, stay with their parents.

"In one group, the females get a bright idea," Whitehead speculates. The change could improve anything from defense to baby-sitting. Whales with the improved technique would raise more young, who pick up the new trick. "Gradually, the ones with the bright idea take over the world, so to speak," Whitehead says.

In the SCIENCE paper, he reviews reports of 19 whale and dolphin species' diversity in the DNA passed from mother to offspring in cell structures called mitochondria. Other explanations for the low diversity among matrilineal whales have not satisfied Whitehead.

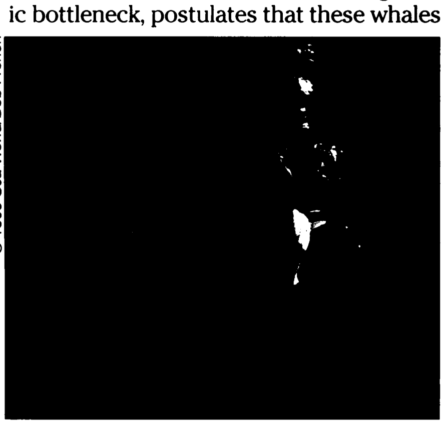
The most common scenario, the genetic bottleneck, postulates that these whales were once on the brink of extinction, leaving a small DNA pool for the renaissance of the species. Such models require population drops to about 1,000 whales for 1,000 generations, yet Whitehead sees no evidence for such disasters.

Other researchers have mused over whether low diversity could come from mass strandings on beaches, in which family groups vanish together. Some whales do this but not all the matrilineal ones, Whitehead points out.

Culture as an explanation for limited DNA variation seems a plausible hypothesis to Scott Baker of the University of Auckland in New Zealand, who has studied the genetics of humpback whales. He agrees with Whitehead that recent population declines for the matrilineal animals have not constituted a worldwide genetic bottleneck. However, Baker wonders whether ancient brushes with extinction might still be showing effects.

Marine ecologist Jim Estes of the University of California, Santa Cruz notes that learning from Mom can have profound effects that don't necessarily show up in mitochondrial DNA. The sea otters he has studied seem to pick up their mothers' specialty in food gathering, such as tackling sea urchins instead of abalones.

A specialist in cultural evolution, Peter J. Richerson of the University of California, Davis points out that "in recent years, evidence that social learning is important in nonhuman animals has been growing." —*S. Milius*



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The killer whale's low diversity in its mitochondrial DNA may come from its traditions and sociability.

Condensate divided? Quantum unity stands

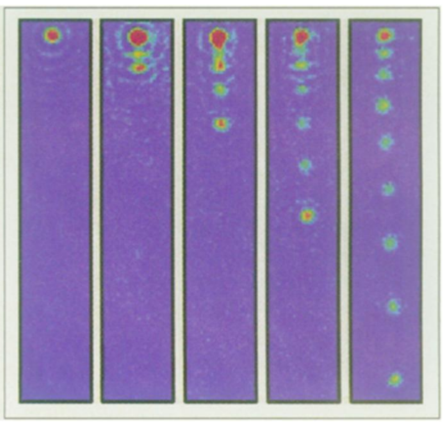
Atoms trapped in the remarkable form of matter known as a Bose-Einstein condensate share one quantum mechanical state, behaving collectively as a single superatom (SN: 7/25/98, p. 54). A new experiment demonstrates how robust, and possibly useful, that coherence can be, even when the superatom is minced into many parts, physicists say.

Although the first condensates were created in 1995 (SN: 7/15/95, p. 36), not until last year did physicists at the Massachusetts Institute of Technology prove they could manipulate a condensate as a coherent entity (SN: 2/1/97, p. 71). Taking a stopwatch to the phenomenon, experimenters at the University of Colorado and the National Institute of Standards and Technology, both in Boulder, reported in the Aug. 24 PHYSICAL REVIEW LETTERS that coherence can last surprisingly long—at least 100 milliseconds.

Now, Brian P. Anderson and Mark A. Kasevich at Yale University have split a condensate of ultracold rubidium atoms into roughly 30 parts without dashing their shared identity. "It's a beautiful and dramatic demonstration of what makes Bose-Einstein condensates so special—their coherence," says MIT's Wolfgang Ketterle.

In the Yale team's experiment, reported in the Nov. 27 SCIENCE, a vertical laser beam creates a standing wave, or series of peaks and troughs of light intensity, across the 15-micron-tall condensate. Acting as an "optical lattice," the laser wave nudges atoms to the nearest intensity peaks and suspends the condensate portions in layers "like a stack of pancakes," Anderson says.

Shutting off the magnetic fields that originally trapped the condensate, the researchers observe drips of about 1,000 atoms apiece that detach themselves all along the lattice and fall away. After about 10 such pulses, 1.1 milliseconds apart, the lattice runs out of atoms.



Anderson and Kasevich/SCIENCE

A Bose-Einstein condensate in an optical lattice (top circles) ejects falling pulses of atoms. The left-to-right sequence records repetitions of the same experiment imaged at progressively later times: 0, 3, 5, 7, and 10 milliseconds.

The formation of the regularly timed pulses shows that the layers within the lattice retain the original coherence of the condensate, the researchers maintain. Because of the wavelike behavior of coherent layers, the optical planes of the lattice can reflect them back when gravity pulls them downward. As the atoms rebound, a fraction of them are forced into a higher energy not allowed in the lattice, break free, and fall together as an atomic laser pulse.

The Yale researchers have also shown that they can precisely measure gravity by observing the rate at which the pulses fall.

The team interprets the oscillation within the lattice that creates the pulses as the first evidence in a condensate of a phenomenon called the Josephson effect. In the effect, previously seen in superconductors and superfluids and of wide use in electronics, an oscillating flow of particles passes through a barrier. In this instance, planes defined by the optical laser act as barriers to the motion of atoms. —*P. Weiss*