Creature hiding in California lake reveals evolutionary secrets from 650 million years ago

Researchers have identified a microscopic organism in this extreme environment of Mono Lake that could illuminate the early evolution of life

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JOSHUA SHAVIT Published Jan 23, 2025

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Mono Lake, nestled in California's Eastern Sierra Nevada, is a haven for unique life forms. Its iconic tufa formations and thriving populations of brine shrimp and alkali flies showcase an ecosystem adapted to the lake's hypersaline, alkaline waters.

What does the word *Hypersaline* mean?

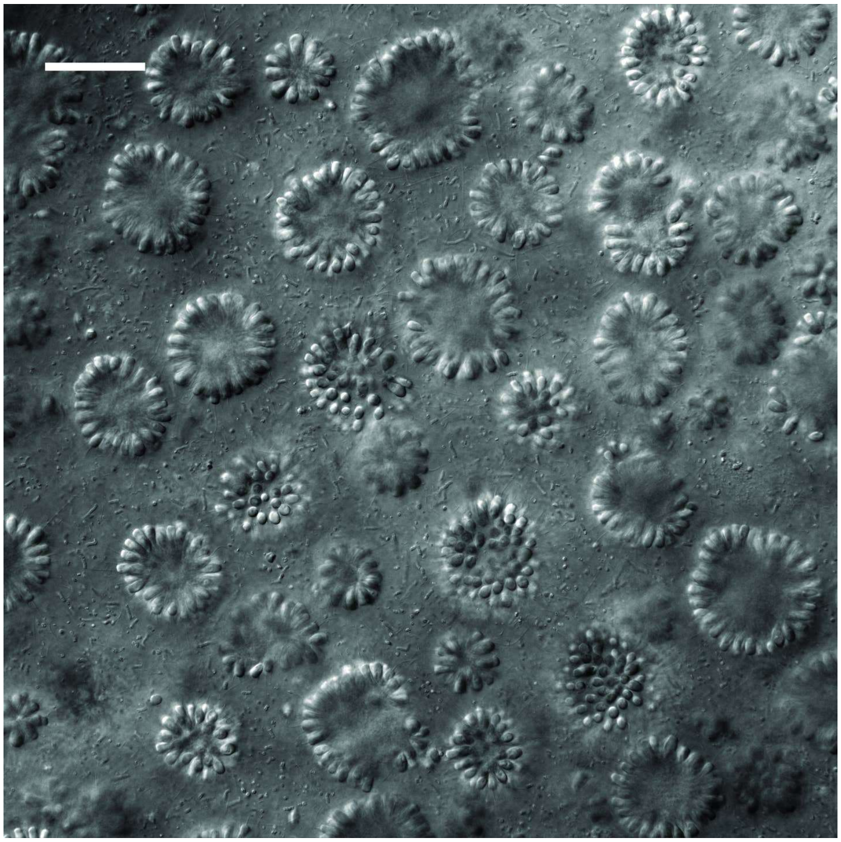
Now, researchers from the University of California, Berkeley, have identified a microscopic organism in this extreme environment that could illuminate the early evolution of life.

The discovery is a single-celled organism called a choanoflagellate, a group that holds special significance in the study of evolution. Although not animals themselves, choanoflagellates are the closest known living relatives of animals. Their biology offers vital clues about the transition from single-celled to multicellular life.

What must be true for a creature to be called an animal?

What sets this particular species apart is its microbiome. Unlike other choanoflagellates, which typically consume bacteria, this species forms a stable, physical association with its bacterial partners.

This makes it the simplest known organism to host a microbiome, providing researchers with an unprecedented opportunity to study how early interactions between single-celled organisms and bacteria influenced the evolution of complex life, including animals.



Globular colonies of the choanoflagellate B. monosierra seen under a microscope. As indicated by the 50-micron scale bar, these colonies are at the limit of what's visible to the naked eye.

"Very little is known about choanoflagellates, and there are interesting biological phenomena that we can only gain insight into if we understand their ecology," says Nicole King, a professor of molecular and cell biology at UC Berkeley and an investigator for the Howard Hughes Medical Institute.

King and her team study choanoflagellates as models for ancient life forms that once inhabited early oceans.

Their findings offer a window into the evolutionary processes that eventually gave rise to multicellular organisms.

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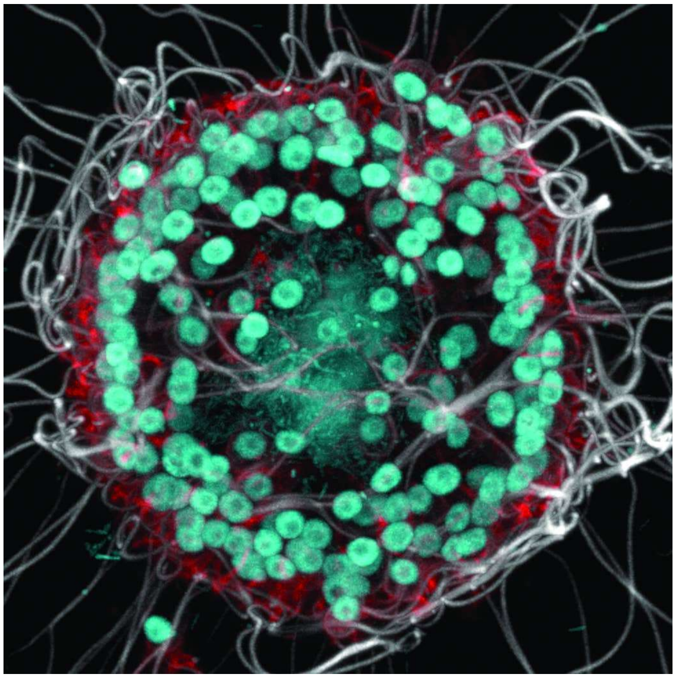
Dubbed *Barroeca monosierra*, this choanoflagellate demonstrates how early life forms not only survived in harsh conditions but also developed symbiotic relationships with bacteria. These relationships may have been pivotal in shaping the complex microbiomes that are now integral to animal life, including humans. This discovery underscores the ecological and evolutionary significance of Mono Lake's unique ecosystem, revealing new layers of complexity in the story of life's origins.

What is a symbiotic relationship?

The choanoflagellate was first discovered nearly a decade ago, when Daniel Richter, then a UC Berkeley graduate student, brought back a vial of water from a climbing trip to the Eastern Sierra Nevada. Under the microscope, the water teemed with life, particularly large, beautiful colonies of choanoflagellates. These colonies, composed of nearly 100 identical cells, formed a hollow sphere that twirled and spun as the individual cells used their flagella for movement.

King noted the similarity between these colonies and a blastula—a hollow ball of cells that forms early in the development of animal embryos. "One of the things that's interesting about them is that these colonies have a shape similar to the blastula," she said. However, it wasn't until years later that the research team realized the full significance of the colony's structure.



A colony of choanoflagellates stained to show its features. Cyan indicates DNA — the doughnut-shaped DNA of the choanoflagellate cells and a cloud of bacterial DNA inside the colony — while flagella are white and microscopic hairs (villi) on each cell are red.

Please see original article posted on Clark's website to view a 3-d Rendering of the

Graduate student Kayley Hake revived the choanoflagellates from a freezer and discovered something unexpected: DNA was present inside the hollow sphere, where there should have been no cells. After further investigation, she identified this DNA as bacterial, marking the first time bacteria had been observed living inside a choanoflagellate colony rather than being consumed by it.

Hake's work uncovered not just bacteria, but also a network of extracellular matrix structures inside the colony. These structures appeared to be secreted by the choanoflagellates and could serve as a habitat for the bacteria. This was a major breakthrough because no one had ever documented a choanoflagellate forming a stable, symbiotic relationship with bacteria.
Jill Banfield, a UC Berkeley professor and pioneer in the field of metagenomics, collaborated with King's team to identify the bacterial species found both in Mono Lake water and inside the choanoflagellate colonies. Metagenomics allows scientists to sequence all the DNA in an environmental sample and reconstruct the genomes of the organisms living there.

Banfield's lab identified several bacterial species in the lake's water, and Hake determined which of these were also inside the choanoflagellates. The bacterial populations inside the colonies were distinct, suggesting that some bacteria thrive better than others within the oxygen-poor interior of the colony.

While it's still unclear whether the bacteria are being farmed by the choanoflagellates for consumption or simply taking refuge from the harsh environment of Mono Lake, King believes future research will reveal more about the interactions between these organisms. "Much of this is speculation," King admitted, but she is hopeful that the findings will provide important clues about the evolution of life on Earth.
Previous studies in King's lab have already shown that bacteria can influence choanoflagellate behavior, including stimulating mating and encouraging the formation of colonies. *Barroeca monosierra* will likely serve as a new model system

for studying the interactions between eukaryotes (organisms with complex cells) and bacteria, as well as the role bacteria played in early animal evolution.

Despite these promising findings, Mono Lake's choanoflagellate colonies are elusive. During a recent visit, only six out of 100 water samples contained the choanoflagellates. Nonetheless, King remains excited about the future of this research. "I think there's a great deal more that needs to be done on the microbial life of Mono Lake because it really underpins everything else about the ecosystem," she said.
King's work, along with that of her colleagues, could help answer fundamental questions about the relationships between early life forms and their microbial companions—relationships that likely paved the way for the human microbiome and the complex interactions between animals and bacteria that we see today.

Nicole King and Josean Reyes-Rivera were doing field work near Mono Lake to collect choanoflagellates when they heard that their paper had been accepted by mBio.

In addition to King and Banfield, other contributors to the research include graduate student Kayley Hake, former doctoral student Patrick West, electron microscopist Kent McDonald, and postdoctoral fellows Josean Reyes-Rivera and Alain Garcia De Las Bayonas. Their work is supported by the Howard Hughes Medical Institute and the National Science Foundation.