Planet's nitrogen cycle overturned by 'tiny ammonia eater of the seas'

September 30 2009, by Hannah Hickey

(PhysOrg.com) -- It's not every day you find clues to the planet's inner workings in aquarium scum. But that's what happened a few years ago when University of Washington researchers cultured a tiny organism from the bottom of a Seattle Aquarium tank and found it can digest ammonia, a key environmental function. New results show this minute organism and its brethren play a more central role in the planet's ecology than previously suspected.

The findings, published online today in the journal *Nature*, show that these microorganisms, members of ancient lineage called archaea, beat out all other marine life in the race for ammonia. Ecologists now assume that ammonia in the upper ocean will first be gobbled up by phytoplankton to make new cells, leaving very little ammonia for microbes to turn into nitrate.

"Our data suggests that it's the other way around," said co-author Willm Martens-Habbena, a UW postdoctoral researcher. "Archaea are capable of stealing the ammonia from other organisms and turning it into nitrate. Then it's the phytoplankton that take up that nitrate once again."

Ammonia is a waste product that can be toxic to animals. But plants, including phytoplankton, prize ammonia as the most energy-efficient way to build new cells.

The new paper also shows that archaea can scavenge nitrogen-containing ammonia in the most barren environments of the deep sea, solving a longrunning mystery of how the microorganisms can survive in that environment. Archaea therefore not only play a role, but are central to the planetary nitrogen cycles on which all life depends.

"Bacterial nitrifiers were discovered in the late 19th century. One century later this other group of nitrifiers is discovered that is not a minor population, it turns out to be the major population," said co-author David Stahl, a UW professor with appointments in the departments of civil and environmental engineering and microbiology. "We have to revise our basic understanding of the nitrogen cycle."

In the tree of life, archaea occupy their own branch. Archaea were discovered only about 30 years ago and were first thought to exist only in extreme environments, such as hot springs or hydrothermal vents. They are now known to be more widespread.

In the early 1990s scientists collecting seawater found strands of genetic material that suggested at least 20 percent of the ocean's microbes are archaea, and circumstantial evidence suggested they might live off ammonia. Stahl's group in 2005 was the first to isolate the organism, which they got from a tropical tank in the Seattle Aquarium, and demonstrate that it can, in fact, grow by oxidizing ammonia. His lab and others have since found the organism in many marine environments, including Puget Sound and the North Sea. The microbe is likely ubiquitous on land and in the seas, they say.

The new experiments show that the organism can survive on a mere whiff of ammonia - 10 nanomolar concentration, equivalent to a teaspoon of ammonia salt in 10 million gallons of water. In the deep ocean there is no light and little carbon, so this trace amount of ammonia is the organism's only source of energy.

"What Willm's work has shown is that these archaea can grow at the vanishingly low concentrations of ammonia found in the ocean," Stahl said. "Until we made the measurements, no one thought it would be possible that an organism could live on these trace amounts of ammonia as a primary energy source."

That finding has two important implications for ocean ecosystems. Scientists knew that something was turning ammonia into nitrate in the deep ocean, but could not fathom what organism might be responsible. Now it appears archaea are those mysterious organisms.

And in the sun-dappled upper ocean waters, it appears that archaea can out-compete phytoplankton for ammonia. The same may be true in soil environments, the researchers say.

The archaea in question are small even by the standards of single-celled organisms. At 0.2 micrometers across, about 8 millionths of an inch, the only life forms smaller are viruses. Martens-Habbena speculates that archaea's size could explain how they are able to survive on such a scant energy supply. The strain used in these experiments is named Nitrosopumilus maritimus, which means "tiny ammonia-oxidizer of the sea."

A better understanding of archaea's lifestyle and role in nitrogen cycles not only would rewrite ecology textbooks. It could also have practical applications, such as devising natural ways to boost a soil's nitrogen content without needing to use chemical fertilizers, or designing sewage treatment plants that employ microbes to remove nitrogenous waste more efficiently, or understanding which microbes produce global-warming gases such as nitrous oxide.

The new findings will also affect the equations used in global climate models, researchers say. Computer models use global cycles of nitrogen and other chemicals to estimate how much carbon dioxide the oceans will absorb and ultimately sink to the bottom of the sea. The new findings suggest that most of the nitrate in the surface water comes from recycling of biomass, and not from the deep water as currently assumed.

"Our data suggest that the carbon pump is weaker than currently assumed, so current climate models may overestimate how much carbon can be absorbed by the oceans," Martens Habbena said.

Source: University of Washington (news : web)

Citation: Planet's nitrogen cycle overturned by 'tiny ammonia eater of the seas' (2009, September 30) retrieved 9 April 2024 from https://phys.org/news/2009-09-planet-nitrogen-overturned-tiny-ammonia.html

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.