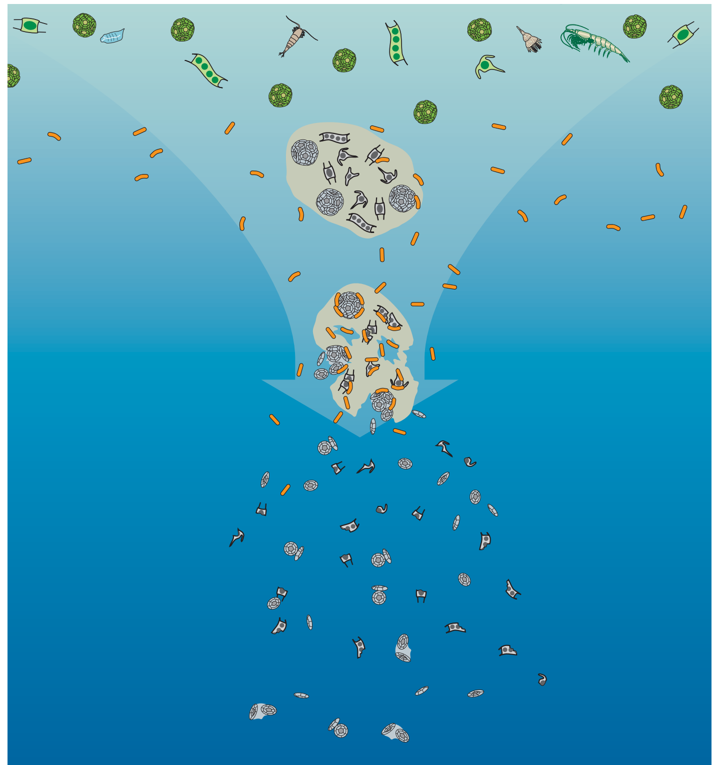
Bacterial 'conversations' have impact on climate

It's wondrous how the vast and the infinitesimal combine to make our planet work. Scientists at Woods Hole Oceanographic Institution have found that bacteria in the ocean, gathering in "microbial block parties," communicate and cooperate with each other to have a significant impact on how carbon dioxide is transferred from the atmosphere to the deep sea.

In this newly discovered mechanism, bacteria coalesce on tiny particles of carbon-rich detritus sinking in the ocean. They send out chemical signals to discern if other bacteria are in the neighborhood. If enough of their compadres are nearby, the bacteria en masse commence sending out enzymes that break up the particles into more digestible bits.

As a result, a substantial amount of carbon does not sink to the depths, which affects both the marine food web and the planet's climate. The re-released carbon can be reused by marine plants, and less carbon dioxide, a heat-trapping greenhouse gas, is drawn out of the air into the ocean. In addition, less carbon is effectively transferred to the bottom of the ocean, where it remains sequestered from the atmosphere.

The finding represents the first evidence that bacterial communication plays a crucial role in Earth's carbon cycle. It was reported Feb. 22 at the American Geophysical Union's Ocean Sciences meeting in Portland, Ore., by WHOI marine biogeochemists Laura Hmelo, Benjamin Van Mooy, and Tracy Mincer.



When marine plants die or are eaten, detritus is created. It is sticky and it agglomerates into particles that are heavy and start to sink. But then marine bacteria move in to break apart the particles (see below).

Illustrations by Jack Cook, WHOI

The carbon cycle works like a planetary conveyor. Carbon is spewed into the atmosphere in the form of carbon dioxide gas—naturally and gradually over geological time from volcanoes and plants, but much more rapidly in recent history from smokestacks and cars. The gas is absorbed by photosynthetic plants, which convert it into bigger organic carbon molecules that they use as food and building blocks for their cells.

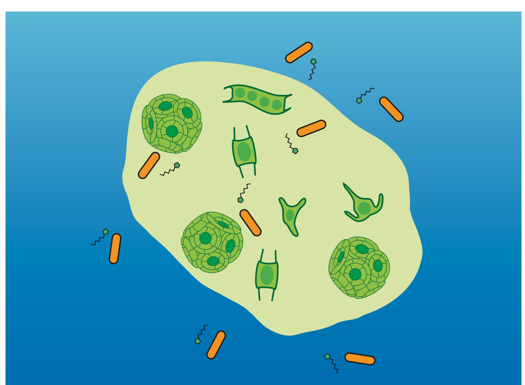
The oceans harbor multitudes of marine plants; the detritus created when they die or are eaten is sticky and it agglomerates into particles that are heavy and start to sink. These particles, raining into the deep, are sometimes visible and often called "marine snow."

Marine bacteria see food in these particles and begin to colonize them. But the carbon- and nitrogen-rich material is in the form of complex molecules too big to get through bacterial cell membranes. "A protein is too big," Hmelo said. "The bacteria want one amino acid."

The bacteria can manufacture enzymes to break down the molecules, but here's the catch: It costs precious energy to make the enzymes, and a lone bacterium doesn't stand a chance.

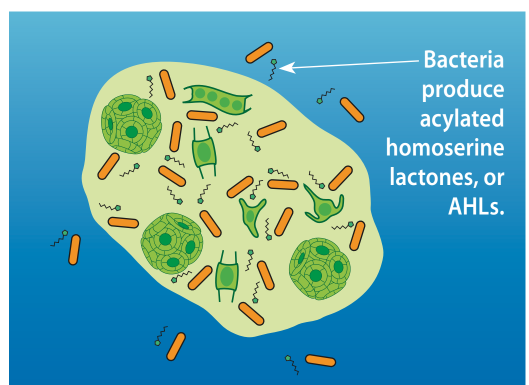
"For any one bacterium to engage in this, there's a risk that it wouldn't get a return on their investment," Van Mooy said. "It would have to send out enzymes and hope that they hit something and blow it up so they can get something to eat out of it."

Instead, the bacteria conserve their resources by making other



1. Colonization

Searching for food, bacteria colonize particles of marine detritus.



2. Proliferation & communication

Bacteria send out chemicals (AHLs) to sense if other bacteria are in the vicinity—a microbial equivalent of sending out Tweets to organize a block party.

chemicals, called acylated homoserine lactones, or AHLs, which cost much less energy to produce, Hmelo said. They send these AHLs into the environment to see if any other bacteria are around.

If no other AHL-producing bacteria are in the vicinity, the AHLs will diffuse away and quickly degrade, and bacterial “silence” will prevail. But if enough AHL-producing bacteria are nearby, the concentration of AHLs outside the bacteria will eventually rise. That’s the chemical signal to each bacterium that it’s got a lot of buddies in the area. In this way—a process called quorum sensing—the bacteria sense that they have achieved a quorum, in this case a sufficient density to begin to make and release enzymes. You might think of it as the microbial equivalent of sending out Tweets to organize a block party.

The scientists investigated this unexplored mechanism by using mesh traps to collect particles of marine snow sinking in Clayoquot Sound off Vancouver, Canada, where fjords extend into the ocean. Tides go back and forth over the shallow bottoms of the fjords, stirring up nutrients that spark blooms of marine algae.

Back in the lab at WHOI, the scientists incubated the collected particles and confirmed the presence of AHLs in the marine snow. They also added AHLs to samples and found that the chemical signals stimulated bacteria to make enzymes that broke apart the particles—confirming that bacteria “talk about it” before launching a coordinated assault.

In the natural world, Van Mooy said, only about 10 percent of particles make it all the way to the ocean depths; the scientists theorize that this quorum-sensing mechanism plays a key role in disaggregating most of the particles before they sink.

“So microscopic bacteria buffer the amount of carbon dioxide in the atmosphere through their ‘conversations,’ ” he said. “I think it’s amazing that there are an infinite number of these conversations going on in the ocean right now, and they are affecting Earth’s carbon cycle.”

—Lonny Lippsett

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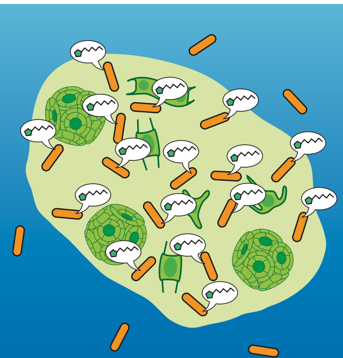
Rose Kantor, WHOI Summer Student Fellow

Scientists used sediment traps to collect specimens of particles of “marine snow” sinking in Clayoquot Sound off Vancouver Island.



3. Threshold population

Bacteria begin to proliferate. The concentration of AHLs rises.

4. Coordinated degradation

AHL levels reach a threshold signaling that the bacteria population has grown large. The bacteria begin to release digestive enzymes.

5. Disaggregation

The enzymes break down particles into bits that disperse into the water. As a result, less carbon sinks to the ocean depths and less heat-trapping carbon dioxide is drawn out of the atmosphere.