Iron surprise: Algae absorb carbon dioxide

In a politically charged experiment, an international team of researchers turned a patch of the Pacific Ocean green with plankton by adding trace amounts of iron to the water. The study demonstrated that fertilizing ocean plants with iron can spur them to absorb vast amounts of carbon dioxide from the air, but the scientists warned against using this technique to combat global warming.

"It's safe to say that there is nobody associated with this experiment who would advocate adding iron to the ocean," says chief scientist Kenneth Coale of Moss Landing (Calif.) Marine Laboratories.

Coale and his colleagues performed the experiment to test a hypothesis proposed by the late John Martin, an oceanographer at Moss Landing who sought to explain why plants fail to thrive in certain nutrient-rich areas of the sub-Arctic, Antarctic, and equatorial Pacific Oceans. Martin proposed that an iron deficiency in these waters prevented algae from making use of the abundant nitrates. According to the hypothesis, higher iron concentrations during the ice ages enabled algae to absorb carbon dioxide from the atmosphere, thereby helping to cool Earth.

The results of the experiment, completed last month, run counter to findings from a trial 2 years ago, when Coale and his coworkers first tried to seed the Pacific with iron. In the fall of 1993, the team added 480 kilograms of dissolved iron to a 64-square-kilometer region near the Galapagos Islands. The extremely dilute iron solution stimulated plankton growth enough to result in a fourfold increase in chlorophyll. But the iron had only an anemic impact on carbon dioxide concentrations in the water.

This year, the scientists produced a much stronger effect, even though they used less iron than last time. According to preliminary calculations, the experiment yielded a 30- to 40-fold increase in chlorophyll and caused enough plankton growth to absorb 350,000 kg of carbon dioxide from the seawater. "The ocean turned green for miles around," says Coale.

Instead of giving the ocean one large shot of iron, as they had in 1993, the scientists split the dose into three infusions administered over a week. This technique mimicked iron's natural means of getting to the open ocean, through windblown dust particles. Coale suspects that the smaller doses improved the plankton's access to the fertilizer by preventing dissolved iron from forming heavy particles and dropping out of the surface layer where plants live.

Natural conditions also helped boost the potency of the iron supplement. In the earlier experiment, a front of low-salinity water moved into the region, forcing the iron-doped water to sink. This time, the treated water stayed at the surface throughout the experiment. As the plants grew, they absorbed dissolved carbon dioxide from the water, thereby reducing the amount of gas released into the atmosphere by the ocean.

The experiment's success strongly supports the theory that iron controls the rates at which plants grow and absorb carbon dioxide in certain ocean areas, says Coale. "It further strengthens the hypothesis that iron may control the transition from glacial to interglacial climates," he adds.

Scientists involved in the experiment fear their results will encourage proponents of geoengineering, who have suggested seeding the ocean with iron to reduce global carbon dioxide concentrations. Large-scale additions of iron would alter the ocean's food web in unpredictable ways and might cause increased release of methane, an even more potent greenhouse gas, says oceanographer Sallie W. Chisholm of the Massachusetts Institute of Technology, who rejects iron as a quick fix.

François M.M. Morel of Princeton University calls the study's results exciting and humbling. "This is a minute amount [of iron] and it had a tremendous effect. It says it is a little scary to be playing with nature." — *R. Monastersky*

Artificial RNA enzymes: Big and fast

RNA, the molecular middleman that translates DNA into proteins, has long been like the comic Rodney Dangerfield: It just didn't "get no respect."

That scientific disdain evaporated in the last decade as researchers discovered that RNA can perform an important duty many considered the province solely of proteins. Certain RNA molecules, called ribozymes, act like enzymes, substances that enable specific chemical reactions to go forward. That discovery even led to the bold hypothesis that early life was composed only of RNA that could build copies of itself as well as other molecules.

For such an RNA world to exist, there would have to be an impressive array of ribozymes to drive all the chemical reactions needed for life. Yet investigators looking for ribozymes in nature have found only a small variety.

To help establish the feasibility of an RNA world, some researchers are striving to construct ribozymes with new functions. They argue that if they can make a ribozyme that performs an important function, such as copying itself, then that ribozyme might once have existed, only to have disappeared as evolution proceeded. "The idea is that protein [enzymes] replaced RNA and we are left with few remnants of the RNA world," says David P. Bartel of the Whitehead Institute for Biomedical Research in Cambridge, Mass.

In 1993, Bartel and Jack W. Szostak, both then at Massachusetts General Hospital in Boston, reported that they had sifted through more than 1,000 trillion different lab-made RNA molecules, each a random sequence of 220 nucleotides, the basic building blocks of RNA. They were looking for RNA molecules that could chemically attach themselves to a specific target RNA molecule that they provided. They identified 65 novel ribozymes that could perform this chemical reaction.

The two then subjected these RNA molecules to 10 generations of so-called test-tube evolution, a molecular survival-of-the-fittest strategy (SN: 8/7/93, p.90). In each cycle of this process, they created copies of the preceding generation but introduced small errors in the RNA sequences. They then selected out the ribozymes that could best attach themselves to their target RNA and sent them through another round.

In the July 21 Science, Bartel, Szostak, and Eric H. Ekland, also of the Whitehead Institute, discuss further experiments with these ribozymes. After grouping the most efficient descendants of the original 65 into seven families, the researchers determined each family's catalytic domains—the nucleotides that help the ribozyme to bond chemically to the target RNA. These domains speed the joinings but don't include the specific nucleotides that bind to the target RNA. By creating an RNA molecule composed only of a particular domain, the scientists created a smaller ribozyme that can join RNA strands more than once.

One of the most interesting ribozymes Bartel and his colleagues found had a catalytic domain 93 nucleotides long. That's a surprisingly complex domain to emerge randomly from a 220-nucleotide-long molecule, asserts Bartel.

This particular ribozyme is also speedy, they report. Through further test-tube evolution, they identified its fastest version: a ribozyme that could join RNA strands a billion times faster than they would normally join. This reaction rate, more than once a second, is faster than any other ribozyme-mediated reaction and comparable to reactions aided by protein enzymes.

"That's impressive. People have always regarded RNA enzymes as slugs compared to proteins," says Gerald F. Joyce of Scripps Research Institute in La Jolla, Calif. — *J. Travis*