

UC SANTA BARBARA

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Iron-Binding Compounds Produced By Marine Bacteria Have Important Implications For Marine Microbial Ecology

Structures of newly-discovered siderophores (the iron-carrying molecules secreted by bacteria to facilitate iron acquisition) described in the February 18 issue of *Science* by researchers at the University of California, Santa Barbara and other institutions, shed light on how marine bacteria acquire iron and raise provocative questions about the evolution of iron uptake by marine bacteria.

All bacteria need iron to grow, and in the ocean there is very little iron, explained Alison Butler, professor of chemistry and biochemistry at UC, Santa Barbara and co-author of the article.

"We wanted to know what molecular mechanisms control iron uptake," said Butler.

The article, "Self-Assembling Amphiphilic Siderophores from Marine Bacteria," describes the structures of the marinobactin and aquachelin siderophores which have polar peptidic head groups and hydrophobic fatty acid tails, explained Butler. "They have a hydrophobic portion and a hydrophilic portion," she said. "Like soap, they have a portion that dissolves in water and part that dissolves in grease."

The marinobactins are present as micelles (aggregations of molecules) and upon addition of iron, the micelles undergo a spontaneous phase change to form vesicles (bladder-like spheres).

When iron is added, it binds to the peptidic head, and then vesicles are formed.

"The transformation from micelle to vesicle upon iron coordination is the first example, to our knowledge, of such a metal-induced phase change in a biologically produced compound," said the authors. "The presence of this metal-induced switch raises questions about the physiological role for this transformation."

The authors were struck by the fact that different bacteria had the same 'strategy' for acquiring the iron. They state: "It is quite striking that these siderophores, whose distinctive properties hint at the possibility of a novel iron acquisition mechanism, are made by strains from two different genera within the gamma proteobacteria."

They conclude with a call for more study saying, "Whether the structural strategy represented by these siderophores constitutes a specific adaptation to the seawater environment and whether it is widespread among marine bacteria are important questions for further studies."

"We began this work hoping to discover some new and interesting chemistry and biology," said Margo Haygood, professor of marine microbiology at Scripps Institution of Oceanography, University of California, San Diego. "Bacteria in the ocean experience a very different environment than bacteria on land; we wondered whether they might have evolved special strategies for getting iron, the most critical trace element they need. Indeed, it appears they have."

Marine bacteria are just one of many different marine microorganisms, including phytoplankton (microscopic plants and animals), which compete for the limiting pool of iron in seawater.

According to the controversial 'iron hypothesis,' phytoplankton are said to assimilate more carbon dioxide -- a greenhouse gas -- from the atmosphere when the ocean is fertilized with iron. Tests in the Equatorial Pacific bear this hypothesis out, according to Butler. Marine bacteria compete successfully against phytoplankton, which is why studies of the molecular mechanisms of iron uptake are so important.

Scientists estimate that the oceans currently absorb a large fraction of the carbon dioxide produced by man's burning of fossil fuels. The rate of accumulation of man-made carbon dioxide responsible for climate change depends on how much carbon dioxide mankind emits, and how much of the excess is accumulated by plants and soil or is transported down into the ocean depths by plankton.

The authors of the article (in the order they appear) are: J.S. Martinez, G. P. Zhang and P. D. Holt, of the Department of Chemistry and Biochemistry, University of California, Santa Barbara; H.-T. Jung, Department of Chemical Engineering, University of California, Santa Barbara; C. J. Carrano, Department of Chemistry, Southwest Texas State University; M. G. Haygood, Scripps Institution of Oceanography, University of California, San Diego; and, Alison Butler, Department of Chemistry and Biochemistry, University of California, Santa Barbara.

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