Secrets of Sea Bacteria

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Butler studies bioinorganic chemistry, the non-carbon side of life. It's a huge field, she says, and the biological roles of iron and other metals play key roles in it. Her main focus is on ocean water, where there are very unusual transition metal compositions. (Transition metals include such familiar elements as iron, manganese, copper, nickel, silver and gold.)
One thing that makes ocean water unusual is a seeming mismatch of supply and demand. There is almost no available iron but plenty of microorganisms that require it to survive. Butler studies the methods by which sea bacteria extract this scarce metallic nutrient. The knowledge she is gathering has possible applications not just in marine ecology but in medicine as well.

Like all bacteria growing aerobically (in the presence of free oxygen), sea bacteria make compounds called siderophores to convert insoluble iron into a form that they can use. The siderophores produced by ocean microbes are especially efficient, because they have to be with so little iron around. They come in two main varieties, photoreactive or amphiphilic (the latter soluble in either water or fat), and Butler studies both to see how they function? and whether they process only iron. ?Maybe they are going to make use of other metals and we haven?t discovered how,? she says.

The current research on siderophores in marine microbes grew out of experiments in the 1990s that tested the so-called ?iron hypothesis,? the idea that increasing the iron in sea water would stimulate the growth of micro-organisms (such as phytoplankton) that consume carbon dioxide. The hypothesis did pan out, but Butler doubts if it will be a practical way to sequester CO2 and fight global warming. So much iron would have to be added, she said, that it ?could wreak havoc on the natural environment.?

However, the experiments opened up other routes of inquiry by showing that heterotrophic bacteria (those feeding on carbon sources other than CO2) were very good at competing for the iron against other organisms. Could the chemistry that works so well for them at sea be put to other uses? Butler notes that a siderophore her lab discovered in the oil-eating bacterium Marinobacter hydrocarbonoclasticus was also just found to be produced by Bacillus anthracis, the bacterium that causes anthrax. So understanding how this compound works might help on two fronts, cleaning up oil spills and defending against bioterrorism. Amphiphilic siderophores also ?self-assemble into interesting structures,? Butler says, and thus might play a role in nanoscale materials engineering.
As a result of the importance of iron to microbial growth, many bacteria have evolved multiple pathways to acquire iron through specific energy-dependent receptor-mediated siderophore systems, FeHeme or FeHeme-hemophore systems and Fe(III)-transferrin or Fe(III)-lactoferrin systems.

The potential application on which Butler focuses most is medical. The bacteria she studies produce siderophores like those of mycobacteria, a genus that includes the microbes responsible for tuberculosis and leprosy, two highly drug-resistant diseases. "In understanding how marine bacteria produce siderophores," Butler says, "we will get an understanding of how we might disrupt the synthesis of siderophores in mycobacteria." Learning about the chemical lifeline of benign bugs, in other words, may make it easier to cut the lifeline in harmful ones.

Butler has been at UCSB since 1986, arriving here from a postdoctoral position at Caltech after earning her PhD at UC San Diego. Starting out in inorganic chemistry, she branched out into marine biology at UCSB's seaside campus. She has worked closely with Margo Haygood, a marine microbiologist on the faculty at Oregon Health & Science University. Among her UCSB collaborators are Matt Tirrell, Dean of the College of Engineering, Professor Joe Zasadzinski in Chemical Engineering, and Professor Cyrus Safinya in Materials and Physics. She says of bioinorganic chemistry, "It's one of the most exciting fields within inorganic chemistry? and adds, "Carbon is OK, but metals are essential!"

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