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Computer Modeling of Microbes Will Yield Improved Clean-Ups

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Description
Strategies that use microbes to clean up polluted sites are becoming more refined as scientists merge advances in gene sequencing methods, culture techniques and computer modeling. This approach is allowing scientists to better pit microbial muscle against environmental offenders such as uranium and petroleum with unprecedented precision.

Newswise — Strategies that use microbes to clean up polluted sites are becoming more refined as scientists merge advances in gene sequencing methods, culture techniques and computer modeling, says University of Massachusetts Amherst microbiologist Derek Lovley. This integrated approach is allowing scientists to better determine which pollution fighting species to use and when to use them, pitting microbial muscle against environmental offenders such as uranium and petroleum with unprecedented precision.

"If we know how the organisms will behave, and we know the site's hydrology and geochemistry, we'll actually be able to engineer the ideal conditions for clean-up," he says. Lovley will discuss his research on Tuesday, Oct. 18, at 8:30 a.m. at the three-day, annual Soils, Sediments and Water Conference at the Murray D. Lincoln Campus Center at UMass Amherst. The work will also appear in an upcoming issue of the journal *Applied and Environmental Microbiology*.

Cleaning up polluted groundwater is a daunting task that is often exacerbated by substances that continue to leach from surrounding soils, re-polluting the site. In recent years scientists have tried combating such contamination by taking advantage of microorganisms that live naturally in soils and waterways. While they go about their daily business, many of these microbes change nearby contaminants into less toxic forms, or versions that are easier to remove.

Known as bioremediation, this approach could be less expensive, more effective and more environmentally friendly than the current "muck, suck and truck" strategy whereby contaminants are merely dug or pumped up and carried away. But difficulties in extracting the pertinent microbes from the environment and uncertainty about their relevance when grown in a lab have hindered the development of consistently successful bioremediation efforts, says Lovley.

Now science is hurdling many of the factors limiting bioremediation's potential, he says. Advances in molecular techniques can let researchers get a read on what organisms have which genes turned on at the height of clean-up activity. Integrating this information with genome sequencing data and lab culture studies is shedding light on microbial metabolic and regulatory pathways. And now scientists can incorporate all this information into computer models. This systems approach will let scientists run simulations of microbial behavior on computers, compare the models' predictions with lab and field data, and ultimately, says Lovley, accurately predict who should be sent in to clean up which mess.

For the past few years Lovley has been exploring this approach at a uranium contaminated site in Rifle, Colo., near the Colorado River. Hoping to stimulate any sleepy microbial populations that were present, Lovley's team set up a tank that dripped acetate—a harmless, naturally occurring, vinegar-like substance that some microbes use for food—into the soil. Sure enough, measurements of the amount of uranium in the groundwater above the acetate drip compared to below the drip revealed that now well-fed, microbes in the soil had gotten busy and were converting the uranium to an easy to clean-up version.

Lovley then compared microbial DNA he sampled from the site to a database of DNA sequences. Such databases now house thousands of entries and since scientists tend to examine the same section of a gene for groups of organisms, unknown DNA samples can be matched bar code style to a known sequence in the database.

It turned out that the Colorado site was dominated by a handful of Geobacter species, a microbe first isolated from the Potomac River in 1987. In Geobacter, scientists noticed for the first time that the organism was using metals in the soil to conserve energy, much the way that animals use oxygen, a trick now thought have evolved in several microbial families. In Colorado, the microbe was using uranium the same way, turning the element into a form that was no longer water soluble.

Lovley's team began growing pure cultures of Geobacter in the lab. They picked apart its metabolic pathway and tackled sequencing more of its genome. The team sampled the Rifle site's clean-up zone for the microbes' mRNA. Cells make mRNA when they are actively turning genes on, and sampling it would tell Lovley which genes were being used during peak clean-up hours.

This Geobacter expos? has revealed a wealth of information including which nutrients the microbe prefers, which genes are linked to its metabolic rate and how the bacteria behave when they run out of uranium. But the real value comes from integrating all these data into computer models, says Lovley. With these in silico models scientists can run thousands of experiments to determine the likely physiological response of a given microbe at a given site. Modeling could make some aspects of environmental engineering drastically more informed, efficient and cost-effective, he says.

"This detailed work we've done at the Colorado site is one thing, but we don't have the luxury of doing that kind of study at every site," says Lovley. "The modeling aspect has tremendous potential to improve remediation strategies and our overall understanding of microbiology."
