Feature

The pervasive presence of microbes

– Christopher O'Carroll

DEREK LOVLEY DID NOT START out wanting to be a microbiologist. As an undergraduate science major at the University of Connecticut in the 1970's, he had no notion that he would devote his career to expanding human knowledge about exotic critters too small to see with the naked eye. "I was not a microbiology major," he recalls. "I was mainly interested just in environmental science. I basically wanted to get a job working outdoors. That was the level of my sophistication at that age."

(photo by Ben Barnhart)

Today, Lovley heads the UMass microbiology department. He enjoys the opportunity to study microorganisms both in the laboratory and at a variety of outdoor sites far and near, and university administrators hail him as one of the top grant recipients on campus. Since he joined the faculty in 1995, his wide-ranging research projects have attracted millions of dollars in support from diverse funding agencies – civilian and military, government and private.

It was his interest in environmental studies that first turned Lovley toward the field in which he has established his stellar reputation. This planet's vast population of microscopic life forms includes creatures who have literally made our soil and water what they are today, and whose biological functioning is crucial to the continued health of the ecosystem. That reality came as a life-changing revelation to Lovley in his student days. He had previously tended to equate microbes with disease organisms and microbiology with medical research.

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Lovley: More images

"Most people think of microorganisms as pathogens, germs," he says. "Even a lot of microbiologists. I remember being in graduate school, there were still some professors who seemed to be amazed that microorganisms were important in the environment. But that's where 99.99 whatever percent of bacteria live, in natural environments. It's now being recognized that they live not only on the surface but also very deep in the earth."

In fact, Lovley says, if you were to weigh all the plant life that flourishes around the globe – the trees in all the forests and jungles, the crops on all the farms, the grasses and flowers in all the plains and meadows – that combined mass would not come close to equaling the mass of the planet's microorganisms. Single-cell life evolved relatively early in the planet's 4.5-billion-year history, so bacteria and archaea, the two great families of microbes, have had eons to diversify into thousands upon thousands of species and to assume key roles in every niche of the ecosystem.

For Lovley, it was microorganisms in the water supply that first sparked his youthful environmental-science imagination. "I was especially interested in aquatic environments," he says, "and most of the processing of materials in aquatic environments is not done by the fish or the insects, but by microbes living in the water and in the silt at the bottom. So I decided I would try to become a microbiologist. It seemed to be the facet of the ecosystem that had been the least investigated."

He went on to earn his Ph.D. in microbiology at Michigan State University and took a research job with the water resources division of the United States Geological Survey (USGS). "It was a really good 10 years," he says of his USGS career. "I was studying the quality of water. I was first brought in to work on Chesapeake Bay. There are a lot of pollution problems in Chesapeake Bay, but I pretty rapidly also got involved in groundwater studies. It turns out that microorganisms affect the groundwater significantly. They're just naturally there, interacting with the rocks and minerals affecting the groundwater chemistry. Also, if you have contaminated groundwater, the organisms can help clean up and remove contaminants."

Some of the discoveries Lovley made at the USGS laid the foundation for projects that he and his students and colleagues are pursuing today – projects with implications not only for environmental cleanup but also for such disparate fields as gold mining and the generation of electricity from biological sources.

Many of Lovley's discoveries deal with the ways in which microorganisms derive the energy they need. We humans, like other mammals, get our energy by inhaling oxygen and using it to break down organic molecules from our food. In a process that Lovley describes as "controlled combustion in your cells," oxygen captures electrons from, for example, sugar molecules, causing those molecules to release energy that our bodies can use.

Some microbes evolved in oxygen-rich environments and nourish themselves in a similar fashion, except that they can use oxygen to "digest" industrial pollutants that would be toxic to the human system. In one environmental cleanup project, Lovley developed a technique for stimulating some of these pollution-eating microorganisms to work in deep underground gasoline spill sites where the oxygen supply has been depleted.

Other microbes, which evolved in oxygen-poor subsurface environments, have developed the ability to use iron the way our cells use oxygen. These creatures take in particles of iron to capture electrons and cause the breakdown of energy-producing molecules. Lovely's research has shown that what these microorganisms can do with iron, they can also do with other heavy elements such as gold and uranium. Many bodies of water contain gold not in the form of electrically neutral atoms of metal but as ions – atoms that are missing a few electrons and thus have an electrical charge that causes them to interact with other particles in such a way that they become soluble in water. Iron-using microbes can take in these gold ions and use them in a digestive process that causes them to gain electrons and precipitate out of the water as atoms of insoluble metallic gold. Microbes can do the same thing with ions of uranium, a process that provides an efficient way to extract radioactive pollution from groundwater.

In addition, Lovley has studied microorganisms with the distinctive ability to pass electrons not only within their bodies, as we do in our cells, but also outside themselves. He has shown that this ability can be tapped to produce an electrical current from the biological activity of microbes consuming organic molecules in underwater silt. The Navy is interested in this discovery as a possible power source for sensing devices that could provide harbor security and perform other valuable functions.

Lovley admits that he has sometimes been surprised by the many different directions in which his research has taken him. And knowing how pervasive microbes are in every nook and cranny of the environment, he expects that there are many more surprises in store. When you're dealing with the oldest and most widely distributed life form on the planet, he says, "There are a lot of different avenues you can follow."

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