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ENVIRONMENT

The Tiniest Power Plants

Scientists are seeing a host of possibilities in electricity produced by microbes

Leonard M. Tender had a little demo in his office at the Naval Research Laboratory in Washington that could wow visitors. His computer screen showed air and water temperature data transmitted from a buoy in the nearby Potomac River. The surprise was the power source for the buoy's electronics: microbes. Bacteria in the river bottom gobbled up organic matter and sent electricity flowing into an electrode Tender put in the riverbed. If thawing ice in the river hadn't dragged the buoy downstream early this year, the no-maintenance system would have run indefinitely. "It worked flawlessly, making as much power the last day as the first," Tender says.

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In nature, the electrochemist explains, the bugs hand off extra electrons to iron-rich minerals in the surrounding sediment. But such minerals can be rare, he says, so "the microbes are starved for a place to put the electrons." When scientists bury an electrode in sediment and connect it in a circuit, the bugs glom on to it and happily supply electricity. The result is one of the world's most unlikely power plants.

Tender hopes to turn these microbes into power supplies for sensors and instruments in lakes and oceans. That will be a boon for researchers and military sleuths whose sensing devices, in harsh or remote aquatic settings, are limited by battery life.

Scientists who wish to harness such power from microbes are also thinking big. They envision robots that find and eat organic matter to generate their own power, wastewater treatment plants that produce electricity, and biological refineries where bugs turn sunlight and carbon dioxide into automobile fuel. Pioneering gene sequencer J. Craig Venter suggests that microorganisms could even weaken the grip of oil-producing nations by providing alternatives. The research "is at a very, very early stage, but the potential is huge," says Patrick L. Brezonik of the National Science Foundation.

At the University of Massachusetts at Amherst, microbiologist Derek R. Lovley has figured out how these bugs work. To prove their potential, he has designed microbial cells powerful enough to drive toy SUVs and other devices.

FILAMENT FLOW

Lovley recently made an important discovery. Some species of electricity-producing microbes, such as Geobacter, have long, wispy filaments extending out from their cells. At one of his son's soccer games, Lovley broached the "crackpot" idea with another dad that the filaments could be natural wires. The talk led to experiments proving that electrical current flowed down the filaments. "It's still quite amazing to me," says Lovley.

The find has important practical implications. Lovley and others had thought that microbes could make electricity only when snuggled up against the electrodes. The natural wires, however, mean that they can connect from a greater distance. Billions of bugs can thus funnel electricity to a single electrode, providing 10 to 15 times more power than expected. This compounding factor helped attract the attention of companies such as Toyota Motor Corp. (TM), which is exploring microbial fuel cells as a potential power source. "Eventually we may be able to drive a car with one of these things," says Lovley.

What's more, the versatile microbes can be coaxed into making hydrogen instead of electricity. "We've demonstrated that it will work. Now we have to show feasibility at a larger scale," explains Stephen Grot, president of Ion Power Inc., which is working on the process.

Some scientists believe the biggest improvements will come from tinkering with biology itself. Researchers at Venter's company, Synthetic Genomics Inc. in Rockville, Md., and at Lawrence Berkeley National Laboratory (LBL) are trying to genetically engineer cells to make hydrogen or other fuels directly from sunlight or wastes. The current state of microbial energy "is like the early days of the electronic explosion, when we had a handful of design components, such as transistors, capacitors, and resisters," Venter says.

Learning how to put the right genes together could transform energy production. "In this new era of synthetic biology, organisms can be redesigned to do what you want them to do," says LBL researcher Antón Vila-Sanjurjo. And it can be done relatively quickly. "Trust me. In 15 years, there should be a product," says Venter.

One sci-fi-like possibility would be vast megawatt-producing microbial colonies on the ocean bottom. More likely are myriad small devices. Microbes could make enough electricity in a septic tank for a house, or they could convert farm waste into liquid fuel. GreenFuel Technologies Corp. in Cambridge, Mass., is already using algae to turn nitrogen and carbon dioxide from smokestack gases into biodiesel fuel. "There is a lot of excitement about biologically inspired approaches to tough problems like energy," says venture capitalist Steve T. Jurvetson, who has invested in GreenFuel and Synthetic Genomics.

Plus, microbial energy could turn agricultural regions of the world into fuel exporters. "There is no single 'next big answer,'" concludes Bruce E. Logan, microbial fuel cell researcher at Pennsylvania State University. "There is a portfolio of sources that we have to develop, and this is one of them."

By John Carey

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