ELECTROCHEMISTRY

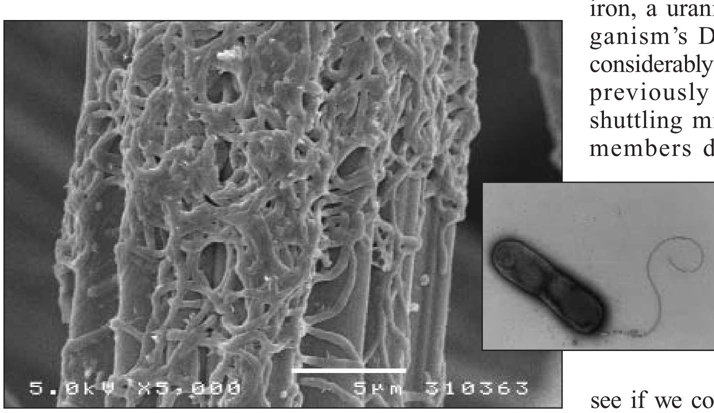
Microbes Sweet on Making Power

Alternative energy is already a big business. Power plants that turn agricultural waste into electrical power, for example, produce 37 billion kilowatt-hours of electricity in the United States each year, enough to supply the entire state of Colorado. Even so, the process used in most "biomass" power plants—burning wastes to produce steam, which drives electricity-generating turbines—converts only 20% to 40% of the energy in plant debris to electricity. Now a pair of Massachusetts-based researchers say that a radically different approach may do better.

In the September issue of *Nature Biotechnology*, microbiologist Derek Lovley of the University of Massachusetts, Amherst, and his postdoc Swades Chaudhuri report that they've created a microbe-based fuel cell that harvests up to 83% of the available electrons in sugar molecules and passes them directly to an electrode. That efficiency is "very noteworthy," because it's far higher than previously reported in microbe-based fuel cells, says Leonard Tender, an electrochemist and microbial fuel cell specialist at the Naval Research Laboratory in Washington, D.C. What's more, the microbes in the new fuel cells munch happily on a variety of sugars, including glucose, fructose, and xylose, which are the building blocks of most plants. Although sugars are just one ingredient in plants, they make up a sizable fraction of some crops. "That represents a huge accessible biomass" that can be used with the technology, Tender says. Still, Lovley and others caution that the technique is still far from becoming an industrial technology. One hurdle it must clear is speed: Although the bugs efficiently strip sugars of their electrons, they do it slowly.

Like all fuel cells, microbe-based cells work by plucking electrons from fuel molecules and passing them to a battery or wire without burning the fuel. That makes the cells clean and efficient. But past microbe-based systems have been either too inefficient or too finicky to have a shot at producing power on a large scale anytime soon. In 2001, for example, a team led by Byung Hong Kim of the Korea Advanced Institute of Science and Technology in Seoul reported that a species of *Clostridium* bacteria could siphon electricity directly from sugars, but the microbes converted a meager 0.04% of the available electrons in glucose to electricity.

Lovley and Chaudhuri discovered their latest electron-shuttling bacteria by accident. While probing an aquifer in southeastern Virginia for bugs that might help remove uranium from groundwater below old nuclear weapons labs, researchers in Lovley's lab stumbled on a bacterium called *Rhodoferax ferrireducens* that passed electrons to iron, a uranium stand-in. The organism's DNA appeared to be considerably different from that of previously known electron-shuttling microbes. So the team members decided to see what types of substrates it would eat and were surprised to find that it happily downed a variety of sugars. "From there, it was an easy decision to see if we could feed it sugars and generate electricity," Lovley says.



Sugar high. *Rhodoferax* bacteria could harvest enough energy from a sugar cube to power a cell phone for 4 days.

CREDITS: D. LOVLEY AND S. CHAUDHURI/UNIVERSITY OF MASSACHUSETTS, AMHERST

Lovley and Chaudhuri placed a culture of *Rhodoferax* in one side of a two-chambered water tank. In each chamber they placed a solid graphite electrode connected by a wire. When fed glucose and other sugars, the *Rhodoferax* grew and multiplied, completely coating the positively charged anode to which they passed the electrons they liberated from the sugars. Although the *Rhodoferax* proved remarkably efficient at reaping electrons, "there is plenty of room for improvement," Lovley says. The team has already shown that simply replacing the solid graphite electrodes with electrodes made from either porous graphite or graphite felt—both of which have far more surface area—can boost power output as much as threefold.

Lovley hopes to use *Rhodoferax* to make more-efficient marine batteries for powering remote instruments. But in the long run, Tender says, the real potential is replacing biomass-burning with bugs. Says Tender: "It really simplifies the prospects of using waste streams and biomass as a fuel source."

–ROBERT F. SERVICE

ScienceScope

Afghan Gold Resurfaces

A trove of 20,000 gold ornaments that had vanished during Afghan unrest is safe in a vault in Kabul.

Soviet archaeologists uncovered the spectacular artifacts in 1978 from a hill called Tilya Tepe in Afghanistan. But researchers feared that the important collection—a rich melding of Western and Eastern styles from the first century B.C.—was melted down in the 1990s (*Science*, 8 November 2002, p. 1199). Senior Afghan officials now say that the collection is intact deep in a vault in the presidential palace.

Palace staff members refused to give the Taliban the codes necessary to open the vault, they said, despite physical threats and beatings. "Everything is safe and in its place," President Hamid Karzai told reporters late last month. Because the National Museum remains without a roof or security systems, however, the gold is likely to stay hidden from public and scholarly sight for the foreseeable future. Still, its recovery is "a major confidence boost to all those who love and respect Afghanistan's history," says archaeologist Robert Knox of the British Museum in London.

–ANDREW LAWLER

Scientists Plan Global Forum

The annual World Economic Forum in Davos, Switzerland, gives corporate and government celebrities a chance to exchange ideas on weighty issues before hitting the ski slopes. Now, researchers hope to create a similar invitation-only event on global science policy.

This week an international group led by officials from Japan and the United States announced plans for the first Science and Technology for Society Forum next year in Kyoto. The forum is needed to spark "open, informal discussions" of thorny issues such as global warming and human cloning, says Koji Omi, Japan's former science minister and a member of parliament. "The purpose is to create a dialog with the larger society," adds Bruce Alberts, head of the U.S. National Academy of Sciences.

Planners expect to invite about 100 scientists, plus dozens of executives, politicians, and reporters. Japan is picking up most of the tab for the first meeting, scheduled for 14 to 16 November 2004. But planners hope to attract corporate support for what they say could become an annual affair.

–DAVID MALAKOFF