Live wires

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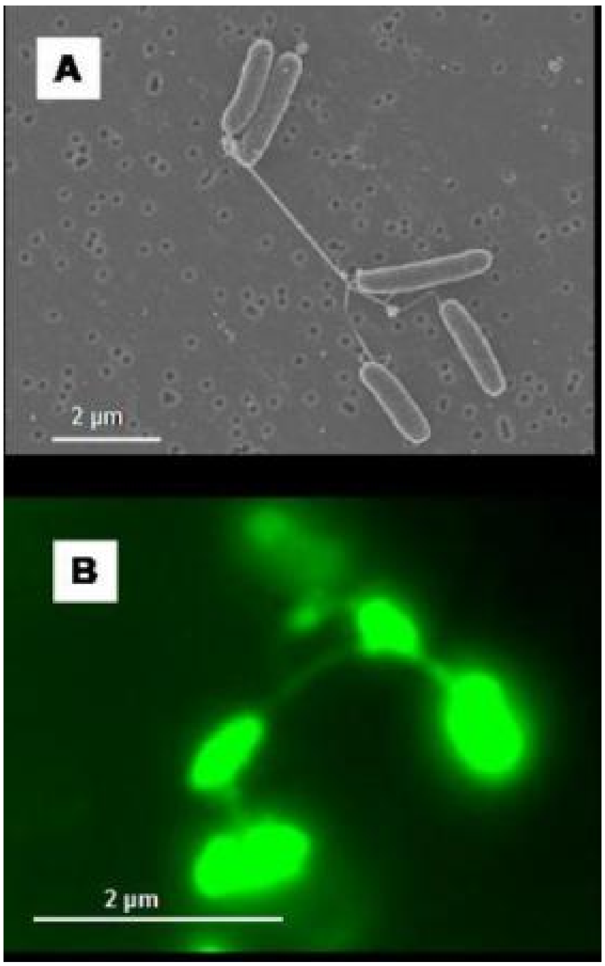

Bacteria, such as this strain of Shewanella, will under particular environmental conditions sprout nanowires that can shuttle electricity to its neighboring cells. (Top: scanning electron microscopic image; bottom: fluorescence-stained micrograph.) Credit: Pacific Northwest National Laboratory

When Yuri Gorby discovered that a microbe which transforms toxic metals can sprout tiny electrically conductive wires from its cell membrane, he reasoned this anatomical oddity and its metal-changing physiology must be related.

A colleague who had heard Gorby's presentation at a scientific meeting later reported that he, too, was able to coax nanowires from another so-called metal-reducing bacteria species and futher suggested the wires, called pili, could be used to bioengineer electrical devices.

It now turns out that not only are the wires and their ability to alter metal connected--but that many other bacteria, including species involved in fermentation and photosynthesis, can also form wires under a variety of environmental conditions.

"Earth appears to be hard-wired," said Gorby, staff scientist at the Department of Energy's Pacific Northwest National Laboratory, who documents the seeming ubiquity of electrically conductive microbial life in the July 10 advance online Proceedings of the National Academy of Science.

In a series of experiments, Gorby and colleagues induced nanowires in a variety of bacteria and demonstrated that they were electrically conductive. The bacterial nanowires were as small as 10 nanometers in diameter and formed bundles as wide as 150 nanometers. They grew to be tens of microns to hundreds of microns long.

The common thread involved depriving a microbe of something it needed to shed excess energy in the form of electrons. For example, Shewanella, of interest in environmental cleanup for its ability to hasten the weathering of toxic metals into benign ones, requires oxygen or other electron acceptors for respiration, whereas Synechocystis, a cyanobactetrium, combines electrons with carbon dioxide during photosynthesis.

Bereft of these "electron acceptors," bacterial nanowires "will literally reach out and connect cells from one to another to form an electrically integrated community," Gorby said.

"The physiological and ecological implications for these interactions are not currently known," he said, "but the effect is suggestive of a highly organized form of energy distribution among members of the oldest and most sustainable life forms on the planet."

In one clever twist, Gorby grew pili from mutant strains developed by collaborators that were unable to produce select electron transport components called cytochromes. Sure enough, the nanowires of the mutants were poor conductors.

"These implicate cytochromes as the electrically conductive components of nanowires, although this has yet to be conclusively demonstrated," Gorby said.

To measure currents as precisely as possible, Gorby and colleagues from the University of Southern California have built a microbial fuel cell laboratory at PNNL. The small bacteria-powered batteries, cultured under electron-acceptor limitations and fueled by lactate or light, now produce very little power, as measured by a voltmeter hooked to a laptop computer.

Co-author and PNNL scientist Jeff Mclean, who manages the microbial fuel cell laboratory, said that small changes in fuel cell design and culture conditions have already shown large improvements in the efficiency of the fuel cells. For example, so-called biofilms--a highly interconnected bacterial community--put out much more energy than other configurations.

Source: Pacific Northwest National Laboratory