Life electric: microbes wire up to share energy

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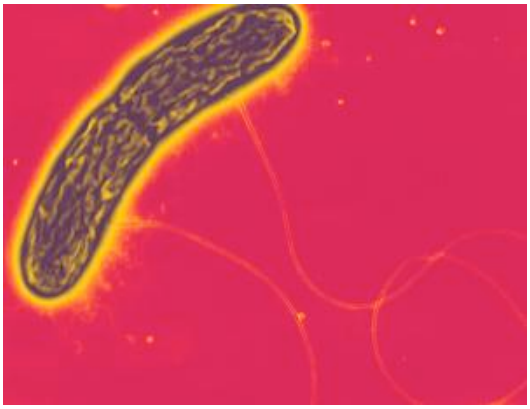
It's electrifying: bacteria, it seems, can share energy simply through touch.

In a lab in Massachusetts, researchers have evolved a very unusual colony of symbiotic bacteria. The bacteria, which belong to two different species, cannot live without each other and grow biological wires to share energy in the form of electrons.



G. metallireducens reaches out for its partner (Image: Derek Lovley/SPL)

"They can just wire themselves up to each other," says Derek Lovley, a microbiologist at the University of Massachusetts at Amherst. "I think it's probably one of the most surprising things I've seen working in microbiology."

Lovley and his team grew two strains of geobacter bacteria that needed each other to grow. *Geobacter metallireducens* breaks down ethanol to get energy, but can only do so if it has somewhere to dump spare electrons. *Geobacter sulfurreducens* can't break down ethanol but can accept electrons.

So Lovley and his colleague Zarath Summers put them together, started nine co-cultures, and waited. They expected the two species to team up and completely break down the ethanol, and that *G. metallireducens* would pass the spare electrons to *G. sulfurreducens* using hydrogen as a chemical shuttle.

Initially, the marriage went poorly and the bacteria consumed very little ethanol. But after several months, something strange happened. Red clumps formed in the liquid cultures. The bacteria had mutated and were now producing cytochrome, a red protein.

Cytochrome conducts electricity and is known to line fine hairs called "nanowires" that are produced by both bacteria.

It's a knock out

Suspecting that the *G. metallireducens* might be passing electrons directly to *G. sulfurreducens* without the hydrogen intermediate, the team "knocked out" a gene that helps it consume hydrogen, and started again. Had hydrogen been the electron messenger, both species would have died. Instead, the cytochrome mutation developed in the new colony in a matter of weeks. Hydrogen, it turned out, didn't matter much at all.

To seal their case for electron-only exchange, the team manipulated other genes. They knocked out the gene on *G. sulfurreducens* that produces cytochromes. The clumps failed to form and

the colonies could not break down the ethanol. They ramped up the cytochrome gene. The mutation again formed within a few weeks.

The team think the two species are living in electrical symbiosis. They each do part of the reactions necessary to break down their food, ethanol. In order to hook up and complete the reaction, they must share electrons. They do this by producing tiny electrical wires and connecting to each other.

The implications are far-reaching, says Ken Nealson, an environmental microbiologist at the University of Southern California in Los Angeles. For instance, are the cells in the human body wired like bacteria? And what would that mean for disease diagnosis and treatment? "Most of us believed the bacteria have mechanisms for talking to each other. Nobody ever thought that it could be electrical communication," Nealson says.

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