The Biology of . . . Batteries

Socket to Me

Slowly but surely, microbiologists are learning to unleash the Edison within

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Even if you haven't seen *The Matrix* or its sequels, you most likely know the basic premise of the movie: It's the distant future, and intelligent machines rule the world, having learned to harness an omnipresent and previously underutilized source of electrical power—humans. The machines "grow" people in vast industrial farms and siphon off the small current of electricity generated by the bodies. You, me—we are battery.

Photograph by Grant Delin

At the University of Massachusetts at Amherst, bacteria consume vinegar and convert it to energy with an efficiency rate of 80 percent. Together, the jars generate enough current to run a calculator.

Thankfully, civilization hasn't advanced quite so far. But there's a scrap of truth to this scenario: Living cells and their multicellular conglomerates (people) do generate a slight electric current. Only now are scientists figuring out how to plug into this resource. The advantages are tantalizing. A biological fuel cell could generate electricity directly, without the polluting by-products associated with fossil-fuel combustion, and at safe body temperatures. A biological battery also holds the promise of being very small in size, a boon in an age of ever-shrinking electronic devices. "If you compare the fuel we use with the devices we have, we're very limited," says Leonard Tender, an electrochemist at the Naval Research Laboratory in Washington, D.C. "We can look at how microbes do it and use them as a model."

Whether they choose to eat sugar, sunlight, or filet mignon, cells ultimately derive their energy by shuffling electrons, the negatively charged particles that flitter in atoms and molecules. Some molecules, with minor prompting, will readily give up an electron or two. Likewise, other molecules are greedy for stray electrons and will relinquish some energy when they get them. Cells ply the middle ground between supply and demand. Aided by specialized enzymes, a yeast bacterium cracks open a sugar molecule, harvests a couple of electrons, then introduces them to nearby oxygen molecules. The reaction generates water, some carbon dioxide, and a little burst of energy, which the bacterium pockets. It's a subatomic economy, running on a currency of electrons.

An electric current, meanwhile, is nothing more than a steady flow of electrons. A man-made battery is a miniature electron factory, powered by chemicals that react within the battery's walls. Batteries are handy because their electrons flow through an electrode (that nub at the top of a dry-cell battery) and from there are easily channeled into MP3 players, flashlights, toys, smoke detectors, and so on. If microbes could be convinced to do the same—to donate their electrons to an electrode rather than to random panhandling molecules—they, too, could supply us with electricity.

One persistent obstacle has been the membrane surrounding the cell. Most microbes conduct electron transactions deep in their own recesses, where the enzymes are; as a consequence, the organisms tend to seek out soluble

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