Military-funded scientists have already made impressive, high-tech strides toward better fake limbs.
The next step: Prosthetic arms and legs powered by spinal fluid. Photo: US Air Force
The prostheses of the future will be powered by spinal fluid.

At least that's the idea of one group of MIT researchers, who are working with Pentagon funding to create fluid, lifelike, neurally mediated prosthetic limbs. They've already designed the brain-implant portion of such a prosthesis, which is meant to interface with the brain's neurons and communicate those signals to the artificial limb. Now they've come up with novel new fuel cells to power that implant ... by squeezing energy out of the patient's own spinal fluid.

The team, whose research is partly funded by the Office of Naval Research and Darpa, this week published a paper that describes a prototype of its spinal-fluid-sucking strategy.

“We see this as the 'holy grail' of implants,” Dr. Rahul Sarpeshkar, the effort’s lead researcher, tells Danger Room. “Something that uses energy from its surroundings, instead of needing recharges or replacements. You just eat some food, and the energy is ready and waiting.”

The energy he’s referring to is glucose. Cerebrospinal fluid, found in the spinal canal and certain brain regions and used by the body to protect neural tissues, is actually a particularly rich source. It’s also a savvy spot to implant a foreign object, in this case a fuel cell that powers a brain implant. Because cerebrospinal fluid contains few immune cells, it’s less likely than other regions of the body to reject an invading entity. The fluid is also low in proteins, which, in other regions of the body, threaten to trigger biofouling — a process whereby proteins stick to an implant, causing infections and rejection.

Before Sarpeshkar and co. designed the fuel cells, they came up with brain implants that need extremely small doses of energy. Other models of brain implants for prostheses, including one by a Pentagon-funded venture at Johns Hopkins, need a lot of power to run. Sarpeshkar’s, as Wired magazine noted earlier this year, require a mere 100 microwatts of energy — an estimated 100 times less than other brain implants, according to Sarpeshkar. Meaning that a glucose fuel cell — which provides a very small sum of energy — has enough oomph to operate them.

The fuel cell itself, and its mechanism of action, are actually quite simple. The team designed the cell using a silicon chip, combined with two electrodes separated by an ion-specific membrane, inside a bio-compatible platinum shell. The fuel cell would be implanted amid the brain’s cerebrospinal fluid, and it would catalyze the oxidation of glucose molecules swimming through the fluid. Of course, the body oxidizes glucose for energy all the time. But that process is extremely complicated, and strips glucose of all 24 of its electrons to maximize energy yield. Sarpeshkar’s fuel cell performs a simpler, less efficient oxidation, stripping each molecule of only two electrons.

Still, the energy yielded by the fuel cell is “entirely adequate” to power the brain implant designed by his team of scientists, Sarpeshkar says. And the method solves an important problem where the design of next-generation prostheses are concerned: Their brain implant portion will need a steady, long-lasting supply of energy. Because most existing implant designs use relatively higher quantities of energy, scientists have typically relied on batteries — either implanted in the brain or external to the body — to power the devices.

But that approach is laden with downsides, namely that batteries — even rechargeable ones — inevitably require replacement. “You can only recharge something so many times,” Sarpeshkar says. “And if a battery needs replacement every five years, you don’t necessarily want to be implanting that inside the brain.”

Spinal-tapping fuel cells, on the other hand, would boast a constant source of energy, no need for recharging and little risk of bodily rejection. Which means they might very well stay inside a patient’s brain for decades, or even an entire lifetime.

Of course, this potential holy grail is still a ways off. For one, scientists have yet to perfect the neural interfaces necessary for a fluid, fully functioning bionic limb. Plus, Dr. Sarpeshkar and his team still need to try their prototype on an animal model — not to mention find human test patients willing to tap into their spinal fluid for the sake of science.

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2IDSgt • 15 days ago

Hell, if these things get much more advanced, losing a limb might not be such a big deal anymore. "Don't worry son, we'll get you fixed up with a new leg here and you'll be back with your unit in less than a week."

Joey • 14 days ago

Wonder if the power level on those limbs goes up to eleven...I mean when you are humping a hill in Afghanistan and you need a little more out of your leg you lost on one of your four tours to Iraq...I just think you should get an extra boost.

Pb • 14 days ago

Wait, I thought it was blood that powered the muscles. Nothing could go wrong with this idea, though..

Jason Faulkner • 14 days ago • parent

Blood is a complex mix of substances that does all kinds of things. Blood does power muscles, by bringing the glucose they need to operate and by carrying away the waste products. Red blood cells bring the oxygen, but that's not so much fuel as it is a catalyst. The bottom line fuel for all muscles in the body is glucose.

Starshiprarity • 15 days ago

I heard about this in a sci-fi comic but had no idea it was as realistic as this. As long as you don't lose too many limbs, this could be a flawless powersource. Of course I'm sure of the required energy demands vs production, but whatever demands are, the body will just produce more glucose as needed so there's probably not a threat to other functions.

PeteEllis • 15 days ago

I wonder how much power it actually takes to run a prosthetic leg?
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http://www.wired.com/dangerroom/2012/06/prosthetics-spinal/