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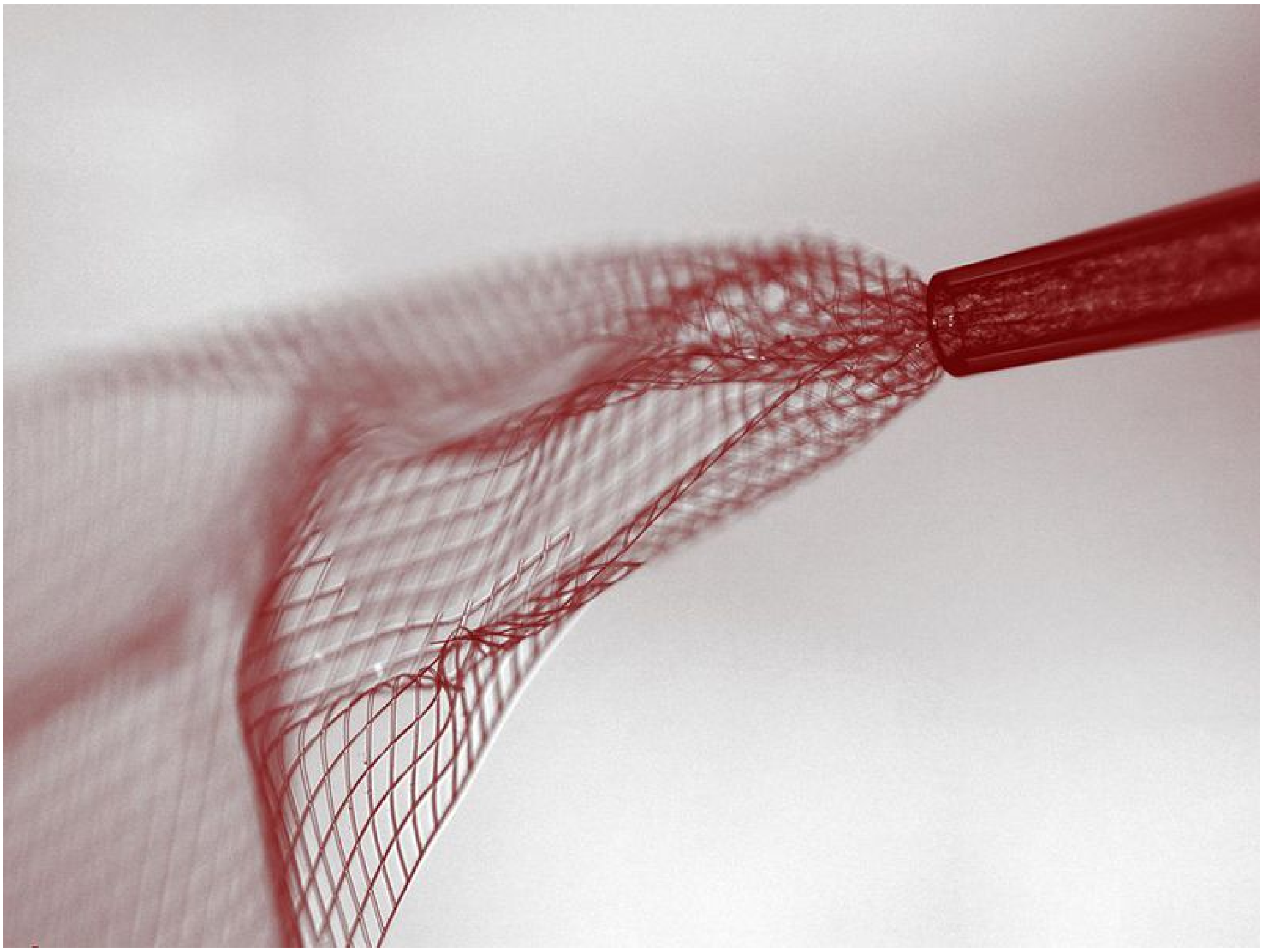
A Flexible Circuit Has Been Injected Into Living Brains

Tested on mice, the rolled mesh fits inside a syringe and unfurls to monitor brain activity



The rolled electronic mesh is injected through a glass needle into a water-based solution. (Lieber Research Group, Harvard University)

By Devin Powell
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What if the next gadget for sending messages to your friends wasn't a watch strapped to your wrist or a phone stuffed in your pocket—but an electronic device embedded in your brain? Now, a new kind of flexible circuit has brought us one step closer to this science fiction future. Implanted via injection, a grid of wires only a few millimeters across can insinuate itself with living neurons and eavesdrop on their chatter, offering a way for electronics to interface with your brain activity.

"We're trying to blur the distinction between electronic circuits and neural circuits," says Charles Lieber, a nanotechnologist at Harvard University and co-author of a study describing the device this week in *Nature Nanotechnology*.

So far the tech has been tested only in the heads of live mice. But Lieber hopes to ultimately wire it up to humans. His backers include Fidelity Biosciences, a venture capital firm interested in new ways to treat neurodegenerative disorders such as Parkinson's disease. The military has also taken an interest, providing support through the U.S. Air Force's Cyborgcell program, which focuses on small-scale electronics for the "performance enhancement" of cells.

Neural electronics are already a reality for some people. Those suffering from severe tremors or uncontrollable muscle spasms can find relief via electric shocks, which are delivered by long wires threaded deep into the brain. And quadriplegics have learned to control prosthetic limbs using chips embedded in the brain or electrodes laid on the brain's surface.

But these technologies can only be used in severe cases because they require invasive procedures. "Previous devices have relied on large incisions and surgeries," says Dae-Hyeong Kim, a nanotechnologist at the Seoul National University in South Korea.

What makes the new approach different is the circuit's exceptional pliability. Made from strands of metal and plastic woven together like fishing net, the circuit is a "hundred thousand times more flexible than other implantable electronics," says Lieber. The net can be rolled up so that it can easily pass through a syringe needle. Once inside the body, the net unfurls of its own accord and becomes embedded in the brain.

Autopsies of injected mice revealed that the wires had woven themselves into the tangled fabric of neurons over the course of weeks. Tight connections formed as plastic and brain matter knitted together with seemingly little negative impact. This compatibility is perhaps because the net was modeled after three-dimensional scaffolds used by biomedical engineers to grow tissues outside of the body.

A 3-D microscope image shows the mesh injected into a region of the brain called the lateral ventricle. (Lieber Research Group, Harvard University)

The neurons' activities could be monitored using microscopic sensors wired into the circuit. Voltage detectors picked up currents generated by individual brain cells firing. Those electrical signals were relayed along a wire running out of the head to a computer.

"This could make some inroads to a brain interface for consumers," says Jacob Robinson, who develops technologies that interface with the brain at Rice University. "Plugging your computer into your brain becomes a lot more palatable if all you need to do is inject something."

For neuroscientists interested in how brain cells communicate, this sensitive tool offers access to parts of the nervous system that are difficult to study with traditional technologies. Three months ago, for instance, a colleague of Lieber's injected some of his nets into the eyes of mice, near nerve cells that gather visual information from the retina. Probing those cells typically requires cutting out a chunk of the eye. Signals collected by the injected nets have remained strong so far, and the mice remain healthy.

To be useful for humans, though, Lieber's team will need to prove that the nets have even greater longevity. Previous neural electronics have suffered from stability problems; they tend to lose signal over time as cells near the rigid intruders die or migrate away. But the team is optimistic that Lieber's mesh will prove to be more brain-friendly, since cells encountering it so far seem to cuddle up and grow into its gaps.

Listening in on brain activity may be only the beginning—as with everyday circuits, different components can be added for different tasks. In another experiment, Lieber's team injected circuits outfitted with pressure sensors into holes inside a soft polymer. When the polymer was squeezed, the sensors measured changes in pressure inside the cavities. That could be useful for investigating pressure changes inside the skull, such as those that occur after a traumatic head injury.

Further down the line, the net may be studded with feedback devices that deliver electrical stimulation or release packets of drugs for medical treatment. Add in a few microscopic RFID antennae, and the circuit could go wireless. And sci-fi fans should salivate at the thought of installing memory storage devices—similar to the RAM inside computers—to improve their own memories.

"We have to walk before we can run, but we think we can really revolutionize our ability to interface with the brain," says Lieber.

About Devin Powell

Devin Powell is a freelance writer based in New York. He has also contributed to publications such as *Nature, National Geographic, The Washington Post* and *New Scientist*.