Forbes.com

Breakthroughs

Building Vessels For An Incredible Journey

Jonathan Fahey, 01.20.09, 12:00 AM ET

Hollywood is remaking that 1966 movie classic, *Fantastic Voyage*, in which a miniaturized submarine called Proteus navigates the body of a fatally ill genius to save him. But if the producers are planning to call it sci-fi, they'd better finish up soon.

Two independent teams of researchers recently debuted devices that, at least in the laboratory, show the possibility of cruising through the body and capturing errant cells.

Engineers at Australia's Monash University published on Tuesday the results of their efforts to build a motor measuring one-tenth of an inch wide, small enough to navigate human arteries. It's not ready for a cruise to a cerebellum, but they given it a telling name: Proteus."Our end aim is to make it possible to swim upstream in blood vessels in the brain," says James Friend, an associate professor of engineering and the lead researcher on the project.

At Johns Hopkins University, another team recently revealed an even tinier device: a tetherless microgripper, about the size of a piece of dust, which can grab and tear off a clump of tissue. (For pictures, see "Metadata: Perspective Of A Dustmote")

"In surgery in the old days, they just cut up your whole body. Now it's a tiny incision with a tube," said David Gracias, an assistant professor in the Department of Chemical and Biomolecular Engineering at Johns Hopkins, who supervised the project. "The obvious next step is a micromachine that you can swallow or inject."

Gracias' microgrippers are like tiny six-legged spiders with bodies made out of nickel and gold, and arms made from layers of chromium and copper. The arms are layered so as to create a tension that naturally pulls the arms closed. To keep them open until just the right moment, however, the arms are also coated with a heat-sensitive polymer.

Here's how they could work: Doctors could position the grippers using magnets (tracking their progress with scanners). Once the grippers are in the right spot, doctors use either heat or non-toxic chemicals to soften the polymer, and the grabbers' arms snap up dozens of cells within reach. Doctors would then use the magnets to pilot the grippers out of the body.

The power of the grippers comes from employing natural tension, like that in springs. That way, Gracias could skip using an electrical power supply and make the devices breathtakingly small. "If you use electricity, you need wires, and it's a pain," he says. "We've been trying to circumvent that problem. The real highlight [of our work] is that it's the first micromachine powered by chemicals."

Gracias has yet to send his microgrippers into a living creature. In the lab, Gracias' researchers grabbed dozens of live animal cells from a clump at the end of a tube the width of a capillary, without killing the cells. The grippers were also sent after a tough target to test their strength, bovine bladder tissue.

Gracias' microgrippers could be used for things like very minimally invasive biopsies, but he has much bigger--or, smaller--plans. He's working on devices powered by ATP, the molecule that energizes every living cell. He envisions unleashing millions of such micrograbbers in the bloodstream, triggered not by heat but by the presence of a particular pathogen.

"In the ultimate sense, we are looking for something that is autonomous like a biological machine," Gracias says.

But there are plenty of steps that Gracias needs to take first. For now, Gracias is simply trying to make his microgrippers let go. A version designed for industrial micro-assembly applications can open up again--but only in response to toxic chemicals.

In Australia, Friend attacked the problem of getting into the body from a different direction, namely by making a tiny motor that could propel another device--such as a camera. Trying to shrink a traditional electromagnetic motor is tricky because the power of the motor fades as it gets smaller. To get around this problem, Friend turned to a piezoelectric power source--crystals that produce electricity when under pressure. This is the same power source for things like quartz watches and kids' light-up sneakers.

Friend vibrates a lead zirconate titanate crystal, and those vibrations twist a spring-like element attached to a rotor. The spring untwists and extends, turning the rotor. It then lets go of the rotor and retreats before extending again. Friend compares the action to someone tossing pizza dough. The pizza tosser applies periodic twisting force spinning the dough, or rotor, always in the same direction.

There is a difference, though. "The motion for a pizza guy is about a foot, and he turns the dough once a second," says Friend. "The motion for us is one micron, an it happens a million times per second."

The rotor is attached to a flagellum, and, in his experiments, Friend measured enough force there to power the motor through the arteries in the brain.

He, too, however, has a long to-do list before the motor embarks on a maiden voyage: His current motor has a tether attached for power. Friend wants to power it wirelessly--and learn to control it so it won't get lost. Then he has to figure out what he's propelling. Attaching a camera would be a likely first step.

Or here's another possible payload for Friend's Proteus: A fleet of Gracias' microgrippers.

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