Nanobots: Where Science Fiction Meets Medicine

by LISA JAFFE HUBBELL

Itty bitty robots soon could make giant LEAPS in health care.

Robots conjure up thoughts of C3PO, or the “Lost in Space” machine warning “Danger, Will Robinson!”—or maybe that Roomba buzzing around your living room. In terms of cutting-edge health care, however, think smaller: nanobots. At one micron in diameter, they are tiny—for comparison, a human hair is about 100 microns in diameter—but their potential in health care is limited only by imagination.

Current potential uses under investigation include drug delivery, infection detection, and damage repair. But it’s a mistake to think of nanorobots as microscopic versions of Star Wars characters swimming through your body on some incredible voyage. Lose that hokey idea, says Harry Stephanou, PhD, professor and director of automation and robotics, and professor of electrical engineering at the University of Texas at Arlington.

Instead, think of robotics as an array of sensors, actuators and processors.

“We are planning devices you swallow that will assemble in your stomach and conduct procedures,” says Harry Stephanou, PhD, professor and director of automation and robotics, and professor of electrical engineering at the University of Texas at Arlington.

“Robotics used to be about making small things that are used in health care,” Stephanou says. “But now we are planning (devices) you swallow that assemble in your stomach and conduct procedures. They have some level of autonomy.”
The Biomask: Rebuilding a Face

Among the most exciting projects drawing Stephanou’s focus is one known as the biomask, a technology that began as a military application for soldiers with extreme facial trauma. In the past, soldiers with extensive burns and other injuries often died from their wounds. Though body armor and advances in patient care have improved outcomes and saved lives, these wounded warriors sometimes survive with horrific facial injuries that often result in extensive scarring and impaired mobility.

“Losing your face is like losing your identity,” Stephanou says. “Some of these men have had dozens of surgeries and are at the point of giving up.” What the future may bring is a nanorobotic scaffolding that will allow the creation of new, healthy tissue in situ. It is similar to what others are working on with three-dimensional copiers that may someday create entire body parts or organs one layer at a time. The prototype is called a biomask.

The loss of these patients’ other body parts, which limits material for tissue donation to help burns and other facial injuries heal, was one of the impetuses for the development of the biomask technology, says Joseph Rosen, MD, a plastic surgeon at Dartmouth Hitchcock Medical Center in Hanover, N.H., and an adjunct professor in engineering at the college.

“Some of the need was filled with conventional surgery,” he says. “Some was filled with face transplantation. But there was also a need to regenerate lost tissue.” Doing it outside the patient, in vitro, is made difficult by the very structure of the face, Rosen says. “The face is complex … because it moves and it feels. You have to create some kind of grid with small unit sizes that can deposit what you need, where you need it, when you need it.”

Each of the grid tiles in the biomask is less than a millimeter in length and width. They are bioreactors that can change shape, apply suction to a wound, deposit medications or fluids, measure oxygenation or pH levels, and deliver bioreactive agents or cells. This grid could become the scaffolding on which the parts of the face, from bone to skin, are regrown on the patient over time. These units can clean up the damaged parts of a wound or burn so that new tissue is grown on a clean surface. The various tiles can be programmed and timed to deposit bone, skin, muscle or nerves as necessary.

Dr. Harry Stephanou says scientists one day will be “manufacturing body parts.”

Some surfaces, like the eye, are beyond what even Rosen thinks the biomask can do.
“This is for simple tissues with simple devices,” he says. Even the most simplistic form of the mask is still years away.

Currently, Rosen notes scientists have created some of the components—microfluidic parts that control delivery and removal of fluids and some sensory systems—but the mask hasn’t been assembled. Then there will be animal trials, human trials, and the FDA must weigh in. “This is a challenging task, but doable,” he says.

The layered and flexible nature of the biomask makes it potentially useful in other areas of the body, Rosen says. In particular, he thinks it will be of use to people with hand injuries, where healing in conjunction with continued movement is imperative if the patient wants to have meaningful mobility and use from the appendage.

**Accelerating Development**

Nanorobotics in health care project to expand beyond the bounds of healing to prevention. “They have shown in the military that a large percentage of soldiers are disabled due to injuries to the bone structure of the foot, knee and spine from the heavy loads they carry,” Stephanou says. The Department of Defense is working to create a lightweight, web-like suit with actuators and sensors to protect the body from injury while allowing for flexibility and complete range of motion.

Spurred by injuries to soldiers in Iraq and Afghanistan, doctors are producing nanorobotic scaffolding upon which the parts of the face can be regrown.

Nanorobotic technology isn’t just for soldiers, says Stephanou. Patients impacted by car or industrial accidents, injured in fires, or maimed by dog bites will also find help from this technology when it is approved for use. Could it also be utilized to create organs? Maybe, Rosen says. The technology hasn’t reached that point yet, but it could happen.

Even the advancements closest to reality remain years away, though Stephanou thinks with “the right investment” you could see healthcare applications of nanorobotics in hospitals within a couple of years. Other applications may take longer, but Rosen says innovations have a way of accelerating in development. The mask he is working on would have seemed unfathomable before the wars in Afghanistan and Iraq. The impetus of those conflicts has spurred development and put pressure on people like Rosen and his colleagues to work faster in bringing these inventions to market.

The brave new world of medicine is starting to look like what was promised in old-time science fiction. “Somewhere down the road,” Stephanou surmises, “they will be manufacturing body parts in factories.”
Rosen says that all this was made possible in part through virtual reality and the ability to imagine things and then create the software to build prototypes. How far will it go? “If you can imagine it, maybe you can build it,” he says.