ANNIVERSARY ISSUE 67 WAYS TO REINVENT THE WORLD

DISCOVER

Science, Technology, and The Future

WHAT WILL FUEL THE FUTURE?

HOW SOLAR, ETHANOL, WIND, AND FUSION WILL REALLY WORK

HUMAN CYBORGS

RECYCLABLE CITIES

INSTANT DNA SCANS

ANTI-AGING PILLS

BEEF WITHOUT THE COW

FRAUDPROOF VOTING

MATTER HACKERS

OCTOBER 2008

$4.99 U.S.

PLUS Virtual Therapy, Hybrid Ships, Your Inner Zombie, Lunar Getaways, Cars With Legs, The Perfect Battery, Super-Yield Crops, and **NASA AT 50:** THE PHOTOS THAT CHANGED OUR UNIVERSE

RISE OF THE CYBORGS

BY **SHERRY BAKER**

The rapid response helped the monkeys use the robotic arm in a natural way, reacting quickly if they were about to drop a piece of food, for instance, and refining movements in real time.

Work like this lends credence to the cyborg-maker's long-sought goal: the possibility, in the not-too-distant future, of helping the paralyzed walk, reach, and grasp. Front and center in this effort is Northwestern University neuroscientist Lee Miller, who injects local anesthetic into a monkey's arm so that the limb is temporarily paralyzed. Then, instead of sending neural signals from the animal's brain to a robot, he shunts them back into the muscles of the paralyzed arm, thereby bypassing the spinal cord. "The signals are going to a stimulator that is electrically stimulating those same muscles," Miller explains. "So essentially it allows the monkey to use his arm again, flexing the wrist and playing a video game all entirely voluntarily, despite the fact that the arm is actually paralyzed."

MERGING MAN AND MACHINE

The spectacular successes of brain implants in primates has paved the way for new human trials, including one at Brown University, where neuroscientist John Donoghue is moving ahead with BrainGate, a minuscule array of tiny, spikelike electrodes implanted in the motor cortex. Candidates are quadriplegics, with all four limbs paralyzed due to ALS, spinal cord injury, or brain stem stroke. So far, three patients implanted with BrainGate can voluntarily modulate several dozen neurons sufficiently to type on a screen, move a prosthetic hand, or control a robotic arm.

"Our goal is to help restore communication and independence," says Donoghue's colleague Leigh Hochberg, a neuroscientist with the Department of Veterans Affairs. One patient, a 37-year-old with ALS, died 10 months into the trial after his respirator was inadvertently disconnected. His untimely death, and the progress he made while participating in the experiments, were especially moving to Hochberg. "He could demonstrate that his mental status was fully intact," Hochberg says. "He had great insight into his disease and the research we were doing and great humor as well."

Even with the limited number of subjects, the human research has already confirmed the monkey findings and answered important questions about how the brain works. "One thing we wondered was how a particular part of the brain functioned years after an arm and hand hadn't moved due to disease or injury," Hochberg says. "We found some insight thanks to one of our first participants, who had a spinal cord injury. He was paralyzed, but the moment he thought about using his hand, we saw changes in neural activity in the specific part of the motor cortex associated with hand movement. Different neurons fired at different rates depending on what he imagined performing."

What that means, Hochberg says, is that the brain signals that once controlled the subject's paralyzed hand and arm were still there and functioning—they just could not pass through the damaged spinal cord to allow the arm and hand to move. He hopes devices like BrainGate will circumvent such damage and allow the brain to communicate with a prosthetic limb or even the actual one, in the manner of Miller's research. "If we can take those natural signals and send them to a functional electrical stimulation system placed in and around the muscles and nerves of an arm or a leg," Hochberg says, "someone might be able to control their own limb again using neural technology rather than injured biology."

Another planned clinical trial involves a miniaturized neural electrode the size of a couple of kernels of corn, pioneered by neuroscientist Richard Andersen at Caltech. Hoping to accomplish what some have compared to mind reading, Andersen wants to implant his device in the brain's higher-level sensory-motor areas, including the parietal lobe and premotor cortex, the seats of personal preference and intent. From a practical perspective, the implant could empower patients to use their abstract thoughts and feelings to control a medical device—a nuanced form of biofeedback. On another level, it could help physicians interpret thoughts that would normally control the patient's body. "The first thing a doctor often asks is 'How are you feeling?'" Andersen says. "By looking at the decoded neural signals, the doctor could know."

SPEAKING HIS MIND

Even better, says Philip Kennedy, would be giving the locked-in the gift of actual voice—and he's getting close.

Erik Ramsey became the first subject for this research after he suffered a horrible car accident. Surgery repaired a host of broken bones and torn muscles, but Ramsey didn't seem to wake