PREPARE TO MOVE

The brain as the command center for bodily movement was too simple an idea, thought the Russian physiologist Nicolas Bernstein some 60 years ago.

After studying human movements for years, Bernstein concluded in 1940 that the nervous system had to prepare the body in advance for what might happen next. Using computer technologies unavailable to their predecessor, Hillel Chiel, Case professor of biology, neurosciences, and biomedical engineering and his research group have provided direct evidence for Bernstein's conclusion.

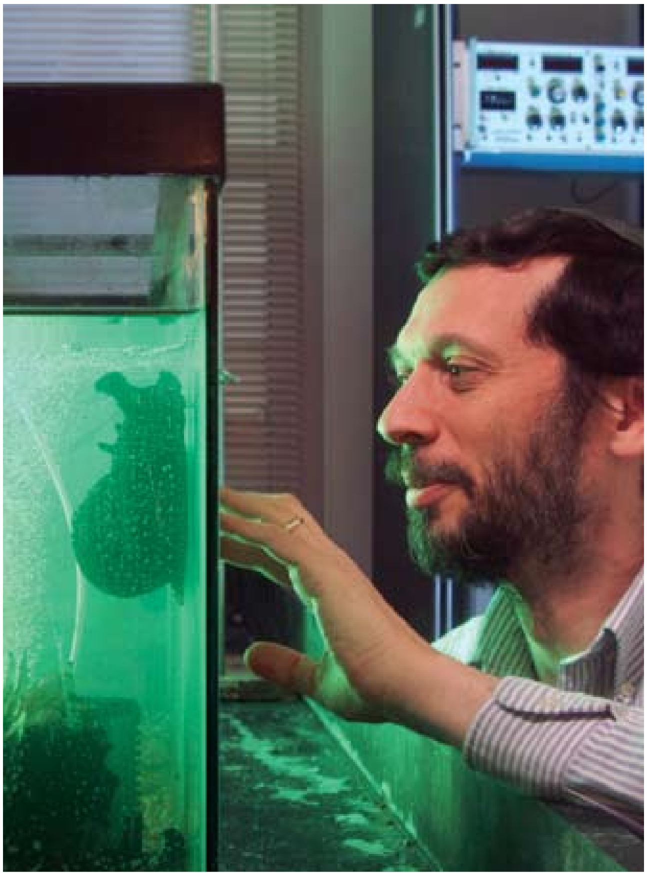
This research, which provides an understanding of how neurons trigger and interact with the muscles, will help in the development of new generations of robots that can move through water and through tube-like structures such as pipes, blood vessels, and the colon.

Reporting on their findings in the *Journal of Neuroscience* are Chiel, Hui Ye, Chiel's former graduate student who is currently a postdoctoral fellow at the Toronto Western Research Institute, and Douglas Morton, another former graduate student who is currently a radiologist at Premier Medical Imaging in Michigan.

To test Bernstein's hypothesis in animals, Ye, Morton, and Chiel studied the neural control of swallowing in the sea slug. These studies provide the first demonstration of Bernstein's hypothesis in a behaving animal, and indicate that the behavioral roles of motor neurons can change depending on how parts of the body are positioned.

"This study demonstrates the interconnectedness of the neurons and the muscles and how it is just as relevant in humans as it is in the less complicated system of the slug," says Chiel, who has patented robotic graspers based on the sea slug's behavior.

In stronger swallows, part of the neural output sets up feeding muscles so that they act in new ways. Specifically, a "grasper" muscle, controlled by motor neuron, acquires a new function: it not only grasps the food, but also pulls it in.



Hillel Chiel

Another muscle, called the "hinge," exerts no force in weak swallows and can pull the grasper back during strong swallows. This means that the motor neuron for the hinge affects behavior in one context, but not in another.

The Case scientists have previously applied their research findings to the creation of mechanical devices that mimic the interactions of an animal's neurons and muscles to produce movement.

SUSAN GRIFFITH

SIMULATED TOOLS PRODUCE REAL RESULTS

Virtual reality simulation tools are already revolutionizing the way dentists are taught at Case and if M. Cenk Cavusoglu has his way, simulation technology at Case will also train the world's brain and heart surgeons.

M. Cenk Cavusoglu

Cavusoglu, an assistant professor of electrical engineering and computer science at the Case School of Engineering, and his colleagues at Case and other institutions nationwide are applying engineering, computer science, and biomedical expertise to develop the technology and open architecture software necessary for simulation technology. They also are experimenting with soft tissue models and "haptics" technology that replicates the appearance and functions of the heart and brain to enable doctors to "feel" when they accomplish procedures correctly.

"Simulation is a popular training tool because it reduces the learning time and allows students to learn independently," says Cavusoglu.

Prior to joining Case in 2002, Cavusoglu helped to develop sophisticated laparoscopic and endoscopic tools in the Robotics and Intelligent Machine Lab at the University of California at Berkeley.

Laparoscopy and endoscopy enable doctors to treat diseased organs and tissue, and remove cysts and tumors through tiny rather than major incisions with local rather than general anesthesia.

The challenge now, he says, is to expand these minimally invasive techniques to complex surgeries.

"Laparoscopy requires a different skill set than open surgery," Cavusoglu explains. "Surgeons typically view patients from the outside in. When a laparoscopic camera is inserted, they see patients from the inside out. Hand/eye coordination is difficult to master. Practice on a simulator would allow surgeons to perfect their technique with no risk to patients."

Another undertaking, Cavusoglu's "robotic beating heart surgery" project, is also advancing surgical science. In a joint program with the University of California at Berkeley funded by the National Science Foundation, Cavusoglu and several Case doctoral students are building a prototype robot that will allow surgeons to routinely perform open surgery on a beating rather than a stopped heart, minimizing risk to the patient. Designed to stabilize and track the heart's motion, the robot would virtually eliminate the need for heart/lung machines.

"Traditional coronary artery bypass graft (CABG) surgery has undesirable side effects that range from cognitive loss to increased hospital stays that are believed to be related to artificial heart pumps," Cavusoglu says. "In this project, we believe that if the heart were able to beat freely during surgery, these pumps would not be needed and it is possible that these side effects might be lessened."

LAURA MASSIE