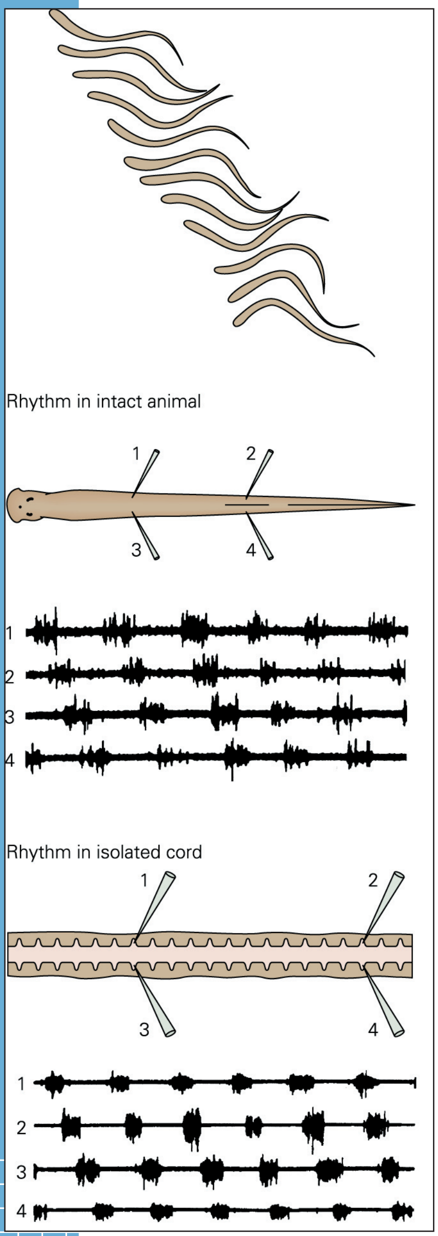
RESEARCHBRIEF

T H E I N S T I T U T E F O R S Y S T E M S R E S E A R C H

Spinal Cord Regeneration



Top to bottom: A swimming lamprey; the animal with electrodes positioned in it; recording from the muscles of the animal during swimming; the isolated spinal cord; recording from the motor output of the spinal cord by itself in a dish.

The potential

For many years, researchers have been searching for a cure to paralysis. According to an ISR research team, sometime within the next decade devices may be developed to help people who are paralyzed. A microchip could act as a neural prosthetic device for spinal cord injury patients. Robotic legs could be developed for amputees that would be controlled by their own spinal cord with the aid of the neural prosthetic microchip.

While preliminary work is underway, at present such benefits seem like a distant goal.

The challenge

Many challenges face spinal cord regeneration research. Lamprey eels, one primary source of spinal injury research, show varying levels of regeneration. The lamprey will regenerate its spinal cord to normal functioning if contained in a controlled environment at room temperature; however, if returned to its natural habitat of cold water its regeneration can be dysfunctional. This could hold serious implications for future human spinal cord regeneration. Currently, researchers are trying to understand why this discrepancy exists, and whether there is a remedy that would prevent dysfunctional regeneration in humans, for when we finally develop regenerative therapies.

Until that day comes, it would help to have alternative methods to activate and control locomotion in patients with spinal cord injuries. The problems that lampreys exhibit in regeneration imply that simply obtaining regeneration would be inadequate to produce healthy movement in humans, and could take considerably more time than people currently think. Thus, there is a push for a neuroprosthetic device to fill the gap until regeneration is fully operational, either in the absence of regeneration or in addition to partial regeneration. All the pieces needed to make the device work currently exist; research is now focused on making them work.

The research

Professor Avis Cohen (Biology/ISR) and her team of researchers in the Lab for Neural Control of Locomotion study locomotion and the regenerative process of the lamprey eel. The hope is that the organizational principles that Dr. Cohen and her team identify in the lamprey will be able to be applied to spinal cord injury patients in the future.

The lamprey is an extremely primitive vertebrate. When researchers remove its spinal cord, the cord continues to function.

One of the primary questions Dr. Cohen and her team seek to answer is how the nervous system generates the behavior. They are studying the spinal pattern generator for locomotion in both normal lampreys and lampreys with spinal cord injuries, using neurophysiology, immunohistochemistry, and computational and neuromorphic engineering.

A result of research with the lampreys thus far has been the development of a microchip, designed in collaboration with ISR-affiliated Associate Professor Ralph Etienne-Cummings (Johns Hopkins University), to help activate and regulate locomotion of limbs below the area of spinal cord injury. While the chip was initially intended to control locomotion in robots, it became clear that it also could be used as a neural prosthetic device for humans. A prototype of the chip is currently being tested in an autonomous biped robot (for more information, see the links for Dr. Anthony Lewis and Iguana Robotics at the end of this research brief).

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The chip acts as a controller. It's a smart system that receives feedback, for example, in the case of a partial leg amputee, from the extremities, joints and remaining muscles. The chip uses this feedback to gauge whether the robotic limbs are moving at the right strength and timing for the situation. If not, there needs to be an adjustment in the drive.

Cohen and her lab are observing the chip in conjunction with an isolated lamprey spinal cord in a Petri dish. They are seeking to achieve feedback in real-time. While Cohen believes this is possible, it has not yet been accomplished in this biological system.

As it is currently envisioned, the chip will not be appropriate for *all* types of spinal cord injury. It will be potentially most useful to individuals with thoracic injuries, allowing them to walk with little more more than a cane or a walker. Cohen believes that this technology will be a gateway for future advancements that will hold answers for more serious spinal cord-injured people.

Cohen is optimistic that testing the microchip in mammalian systems such as rats, and then in humans, could begin within a decade.

Support

This research has been funded primarily by the National Institutes of Health and the Christopher Reeve Foundation.

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Web links

Laboratory for Neural Control of Locomotion *www.life.umd.edu/biology/cohenlab/*

Iguana Robotics *www.iguana-robotics.com*

Dr. Anthony Lewis—Roboticist *www.iguana-robotics.com/people/tlewis/tlewis.html*