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Conceptualizing a cyborg

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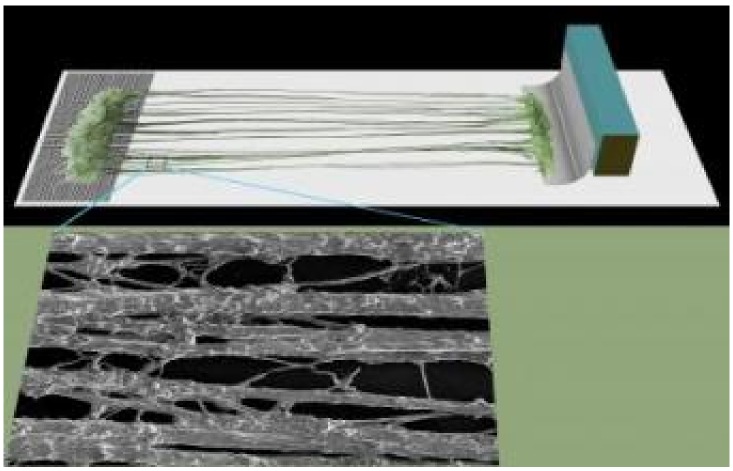

Schematic of stretch-grown axons, showing axons growing on electrodes on right and computer-controlled motor pulling axons to left. Blow-up is close-up of stretch-grown axons. Credit: Douglas H. Smith, MD, University of Pennsylvania School of Medicine

Investigators at the University of Pennsylvania School of Medicine describe the basis for developing a biological interface that could link a patient's nervous system to a thought-driven artificial limb. Their conceptual framework - which brings together years of spinal-cord injury research - is published in the January issue of *Neurosurgery*.

"We're at a junction now of developing a new approach for a brain-machine interface," says senior author Douglas H. Smith, MD, Professor of Neurosurgery and Director of the Center for Brain Injury and Repair at Penn. "The nervous system will certainly rebel if you place hard or sharp electrodes into it to record signals. However, the nervous system can be tricked to accept an interface letting it do what it likes - assimilating new nerve cells into its own network".

To develop the next generation of prosthetics the idea is to use regions of undamaged nervous tissue to provide command signals to drive a device, such as an artificial limb. The challenge is for a prosthesis to perform naturally, relaying two-way communication with the patient's brain. For example, the patient's thoughts could convert nerve signals into movements of a prosthetic, while sensory stimuli, such as temperature or pressure provides feedback to adapt the movements.

The central feature of the proposed interface is the ability to create transplantable living nervous tissue already coupled to electrodes. Like an extension cord, of sorts, the non-electrode end of the lab-grown nervous tissue could integrate with a patient's nerve, relaying the signals to and from the electrode side, in turn connected to an electronic device.

This system may one day be able to return function to people who have been paralyzed by a spinal-cord injury, lost a limb, or in other ways. "Whether it is a prosthetic device or a disabled body function, the mind could regain control," says Smith.

To create the interface, the team used a newly developed process of stretch growth of nerve fibers called axons, previously pioneered in Smith's lab. Two adjacent plates of neurons are grown in a bioreactor. Axons sprout out to connect the neuron populations on each plate. The plates are then slowly pulled apart over a series of days, aided by a precise computer-controlled motor system, until they reached a desired length.

For the interface, one of the plates is an electrical microchip. Because Smith and his team have shown that stretch-grown axons can transmit active electrical signals, they propose that the nervous-tissue interface - through the microchip - could detect and record real-time signals conducted down the nerve and stimulate the sensory signals back through the axons.

In another study, Smith and colleagues showed that these stretch-grown axons could grow when transplanted into a rat model of spinal-cord damage. The team is now is the midst of studies measuring neuronal electrical activity across newly engineered nerve bridges and the restoration of motor activity in experimental animals.

Source: University of Pennsylvania

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