Researchers Look to Nature for Design Inspiration

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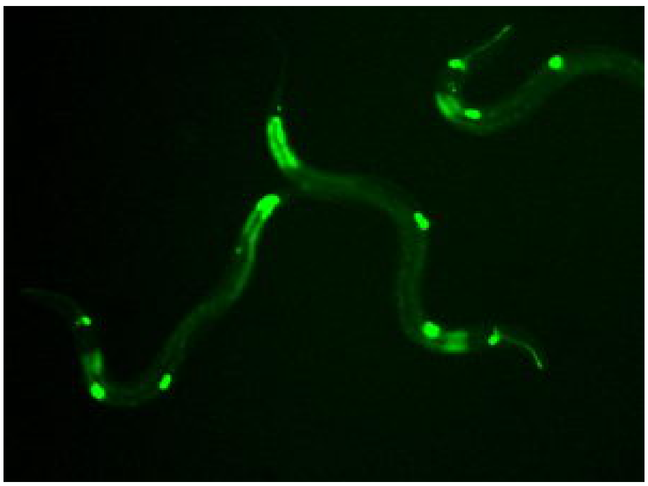

With glowing green neurons, Hang Lu is studying how sensory- and memory-related genes are expressed and regulated in tiny micro-sized worms (about 50 microns in diameter).

Georgia Tech researchers studying nature's masterful and time-tested design techniques to find answers for some of science's toughest design challenges presented their research May 11 and May 12 at the International Symposium for Biologically-inspired Design and Engineering at Georgia Tech.

Here are several highlights of Georgia Tech research presented at the symposium:

In an effort to create brain-inspired sensors and gain new insight into how memories are formed in the human brain, Hang Lu, an assistant professor in the School of Chemical and Biomolecular Engineering and a researcher with the Center for Biologically Inspired Design and Engineering (CBID) at Georgia Tech, is studying how sensory- and memory-related genes are expressed and regulated in tiny micro-sized worms by observing the worms' behavior on an equally micro-sized chip.

Hang Lu, an assistant professor in the School of Chemical and Biomolecular Engineering, holds a micro-sized chip designed to carefully control the types of stimuli the microscopic worms receive.

"Nature has evolved a very efficient sensing system for the worms. The worms are very good at finding mates, finding food, avoiding predators and finding a good home. We're hoping we can learn a lot from this highly evolved sensing system," Lu said.

The key is deciphering how the very small worms (about 50 microns in diameter, much smaller than the diameter of a human hair, and with only 302 neurons altogether) integrate their keen sensory information about their environment into their brain. A certain stimulus, such as the presence of undesirable bacterial food, triggers changes in sensory neurons that stimulate other neurons to give rise to an avoidance behavior, and can also create a memory imprint in the worm's brain.

In order to figure out which neurons are activated for a particular behavior, Lu and her team use a laser beam to operate on worm neurons and then study the behavior after the lesion forms. A genetic technique is used to make certain neurons produce jellyfish's green fluorescent protein, and the laser beam then targets the green neurons.

Since the worms and their neurons are so small, appropriate micro-sized devices have to be created to study them. By carefully controlling the types of stimuli the microscopic worms are exposed to via an intricate micro chip with stimulus delivery systems, Lu and her team can decipher what new sensory information is triggering which neurons that then produce proper behavior and form worm memory as a result.

Steve DeWeerth and Lena Ting, faculty members in the Wallace H. Coulter Department of Biomedical Engineering at Georgia Tech and Emory University, are working to create better control of legged robots and human prostheses using biological inspiration. Their research centers on better understanding how the nervous system communicates with joints and muscles for movement and balance and then designing systems that closely replicate the naturally fluid movement of animals and humans. The research group's goal is to help build robots with better mobility and prosthetics with natural movement more similar to a real limb.

One experiment involves a small robot that closely replicates the balance and movement of a cat to help the team determine how the body communicates to joints and muscles to help withstand sudden jolts or changes in footing. The little robot takes bumps and ground shakes while researchers gather data on how it avoids falling and what kind of pressures trigger a loss of balance.

Another project combines a real frog's muscle with a virtual robotic leg. Force impulses simulating an outside stimulus (such as a sudden bump) are sent to the frog muscle by a computer and motor. The muscle then sends a signal back to the computer, and the virtual model translates the reaction. The biological/computer fusion creates an electrical and mechanical information loop that provides researchers with a better idea of how the muscle reacts to certain mechanical stimuli.

And in research that could lead to novel strategies for tissue engineering, repair and replacement, Georgia Tech biologist J. Todd Streelman is looking at the jaws of different species of cichlid fish to better understand the mechanical properties of jaws and teeth under stress.

Some species of cichlids crush hard prey, like snails, while others do not. Streelman's team is generating three-dimensional X-rays of the jaws to allow them to compare species and see the microscopic architecture that reinforces the jaws while the fish crush their prey. Using a technique commonly used by engineers to model mechanical properties, Finite Element Analysis, the team is able to determine which parts of the jaws are the most important in withstanding these extreme compressive forces.

Source: Georgia Institute of Technology

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