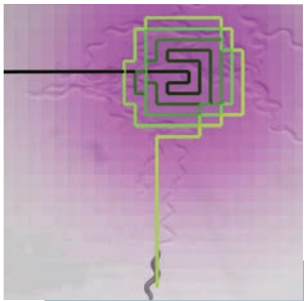

Tatyana Sharpee

Associate Professor
Computational Neurobiology Laboratory
Helen McLoraine Developmental Chair

The Problem

Biological systems—from a microscopic worm to a human brain—are incredibly complex. When this complexity becomes disorganized in humans, diseases like mental disorders, cancer, diabetes and others result. Rather than tackle each problem or disease piecemeal, some scientists are trying a broader approach. They are trying to understand the laws that govern biological systems at the fundamental level to develop theories of control in biological systems. Akin to the law of gravity or theory of evolution, such a framework for biological complexity would provide scientists a way to interpret data and connect knowledge from different systems in biology—and potentially yield unprecedented insights into behavior and disease.

The Approach

Tatyana Sharpee is developing a unifying theory of "biological control" to understand the universal principles of behavior. Specifically, she is uncovering how animals sense and adapt to their environment as well as make predictions and decisions. To do this, she applies mathematical strategies—like statistics and probability models—to chart the principles by which the brain's billions of neurons exchange energy and information. In particular, she uses information theory (a set of mathematical concepts commonly employed in communications and finance systems) to quantify the activity of neurons and, in one area of research, works to determine how features are organized within auditory and visual systems. Revealing the workings of these core senses would help lead to new treatments and brain-machine interfaces for patients with disruptions to these systems that can happen as a result of stroke, dementia or with schizophrenia. Ultimately, Sharpee hopes a unifying theory of biological control will provide guidance for innovative treatments and cures of biological disease and dysfunction, for everything from Alzheimer's to depression and anxiety.

The Innovations and Discoveries

- Sharpee's group recently showed how even simple organisms can implement maximally efficient strategies when searching for food. This theory offers clues into the basic mechanisms of decision-making: how we decide whether to continue with a project or start a new one, for example.
- Sharpee and collaborators have recently developed a theory that explains when it becomes advantageous for an organism to use new types of neurons. This theory could help catalogue and determine the number of separate neuronal types in the brain.
- She also discovered that, when the brain is trying to pick a shape out of a background, there's a trade-off between the complexity of the shape and the possible positions it can be in and still be recognized—a shape that's not very complex can still be picked out of the background by the brain even if it's upside down or sideways, for example.

For more information, please visit:
www.salk.edu/scientist/tatyana-sharpee

Computational Biology, Memory, Neurobiology, Neurological Disease, Systems Biology, Vision