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Nature, nurture, or physics? Researchers answer question about nematode behavior

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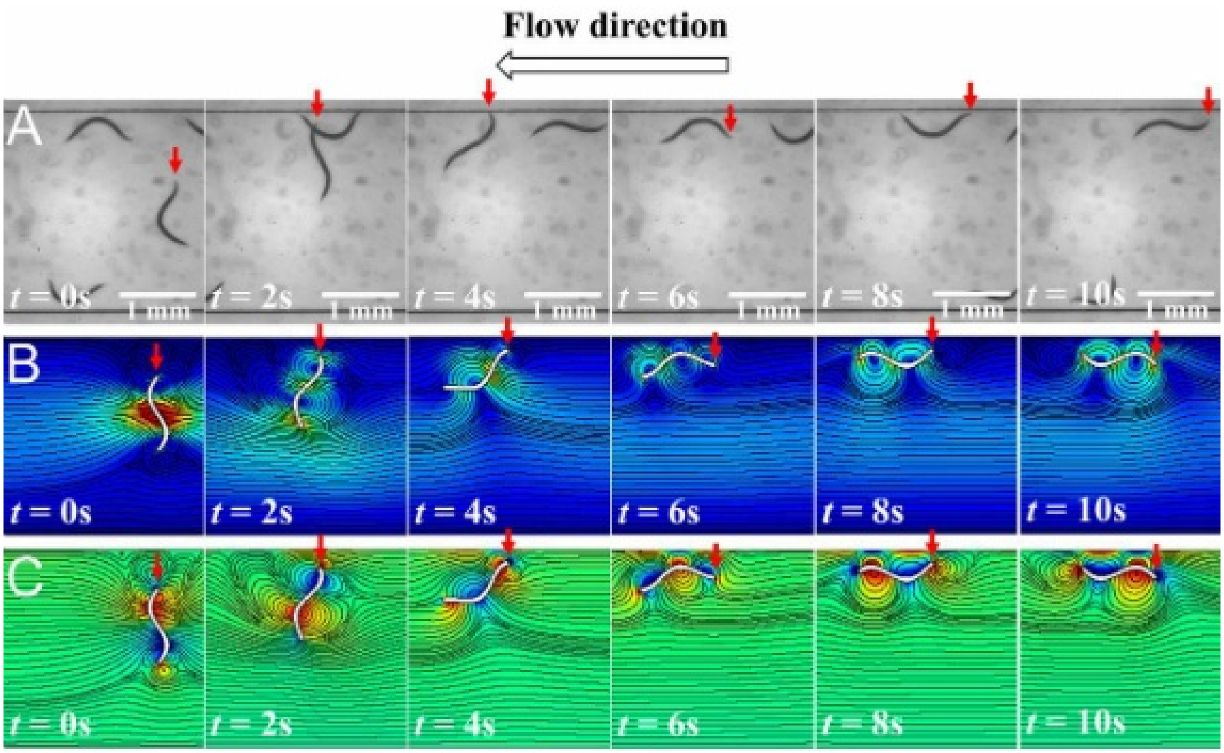

Comparison of experimentally observed and computer-simulated change of orientation of an undulatory swimmer

Nature versus nurture is an age-old question in biology, centering on whether a given trait is determined by an organism's genes or by its environment. Most times the answer is "both," but research at the

University of Pennsylvania has found one trait in particular that is not easily described by either.

This trait, whether or not the common model organism C. elegans will swim upstream, is best explained by physics.

Haim Bau, professor in the Department of Mechanical Engineering & Applied Mechanics in the School of Engineering and Applied Science, and graduate student Jinzhou Yuan, along with David Raizen, assistant professor in the Department of Neurology in Penn's Perelman School of Medicine, published their study in the *Proceedings of the National Academy of Science.*

C. elegans, a nematode or roundworm, is one of the most commonly used animal models in biological research. Nematodes are valuable models for the role genetics plays in behavior because researchers can screen hundreds or thousands of worms for a specific behavior and then determine which genes have an influence on it.

This type of study, however, is predicated on the assumption that the traits they see are truly behaviors: things that the worms actively choose to do, rather than things that passively influence them. Such a distinction is not always clear.

For example, under certain conditions, nematodes will swim upstream but under other circumstances will not. The origins of this upstream swimming behavior, also known as "positive rheotaxis," is an open question, but understanding it is critical to the way high-throughput experiments with the organism are run. For example, most experiments are done with thousands of worms, and researchers need to be able to sort the worms into different populations, such as which worms are weaker, or which worms have a specific mutation.

The Penn researchers found that in the presence of external flow only the nematodes that swam near a solid surface, like a wall, were facing upstream. The nematodes that swam far away from surfaces did not have a preferred direction of motion. With this controlled experiment, they were able to identify exactly what determines this directional motion.

"Near a solid, stationary surface," said Yuan, "the nematodes experience a short-range hydrodynamic effect that rotates the animal's head toward the surface and the tail away from the surface. We call this phenomenon surface-attraction or bordertaxis"

This means that, in the presence of water flow parallel to the solid surface, the part of the worm closer to the surface moves slower than the part farther away from the surface.

"As a result," Yuan said, "the external flow rotates the body of the animal to face upstream."

In other words, Yuan found that rheotaxis is a passive behavior, independent of genotype.

"These results will help guide the design of new sorting devices," Yuan said.

The results may also help scientists understand the life cycles of the nematode and perhaps why it might be beneficial for them to swim upstream.

In particular, scientists have reported that parasitic nematodes tend to swim against the flow in agriculture settings.

"This rheotaxis mechanism," Yuan said, "might help the worms stay next to crops, so, when it rains, the worms aren't washed deep into the soil where they have no food. This mechanism may help them to swim against the flow caused by rainfall to stay near the surface of the soil where their food source is."

"One of the most interesting findings," Bau said, "is how passive forces, forces that are exerted by the environment, can impact the life cycle without requiring deterministic decisions by the worms themselves."

More information: "Propensity of undulatory swimmers, such as worms, to go against the flow." *PNAS* 2015 112 (12) 3606-3611; published ahead of print March 9, 2015, DOI: 10.1073/pnas.1424962112

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