Illuminating research sheds new light on the evolution of light-response systems

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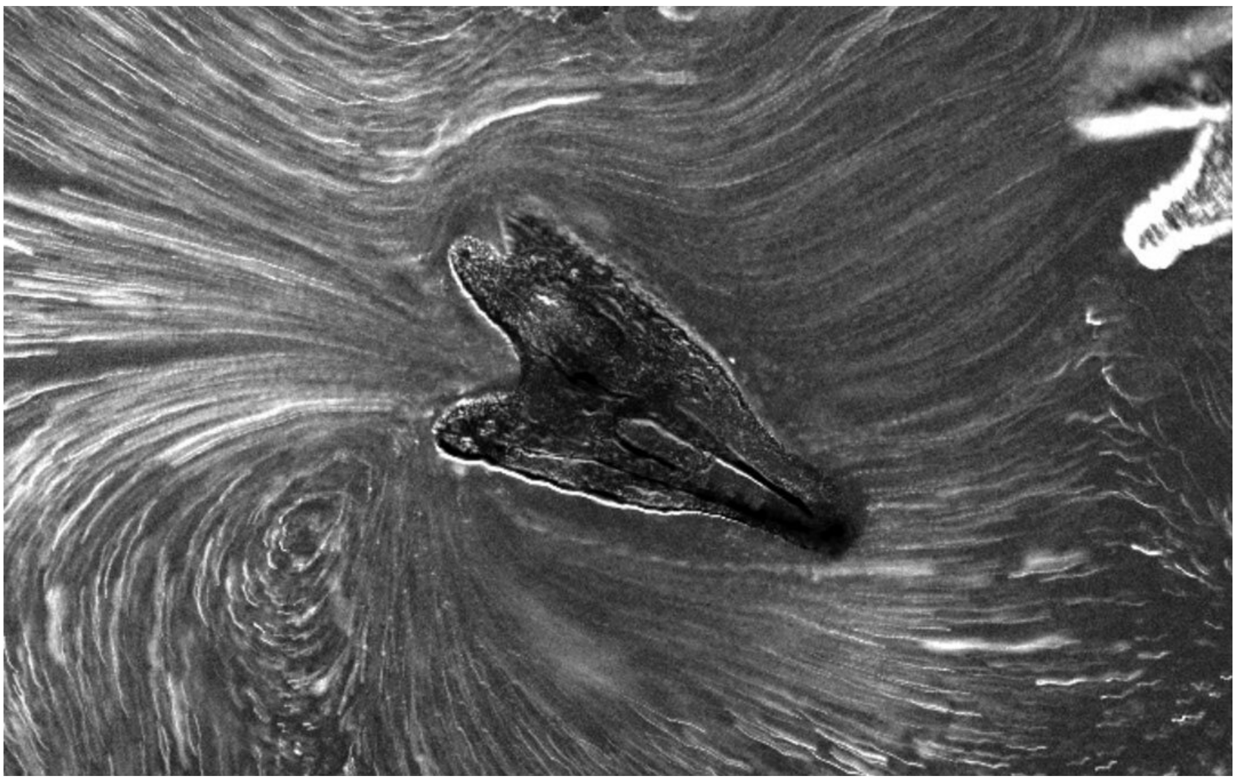

Researchers from the University of Tsukuba found that sea urchin larvae exhibited ciliary responses to strong photoirradiation by swimming backward. As ciliary responses are difficult to detect in deuterostomes because they may be masked by more obvious muscular activities, identifying cilia-based responses to light in sea urchins provides key information on the evolution and diversification of light-response systems in macroscopic animals. Credit: University of Tsukuba

Light is essential for most life on Earth, and single-celled or small multicellular organisms were most likely first to develop the ability to respond to light. But now, researchers from Japan have identified interesting behavior in sea urchin larvae that may provide insights into the evolution of light-responsive tissues/organelles in macroscopic animals.

In a study published this month in *PLOS Genetics*, researchers from the University of Tsukuba have revealed that sea urchin larvae reverse their swimming direction when exposed to strong photoirradiation (light) because of the impact of light on the neuron pathways that typically make them swim forward.

Light-response systems usually involve a combination of photoreceptors (cells in the retina that respond to light), nervous system components, and organs that respond to nerve impulses. These organs tend to be muscles in most macroscopic animals, and cilia (hair-like structures) play a role in microscopic aquatic organisms. The cilia-based response probably developed first, before being replaced by muscle-based responses during the evolution of deuterostomes, or more complex animals. However, ciliary responses are so subtle that they are difficult to identify.

"Cilia-based responses to light are poorly understood in deuterostomes, possibly because muscle activities are more obvious than ciliary activity," explains lead author of the study, Professor Shunsuke Yaguchi. "Sea urchins have free-living planktonic larvae that mainly move using cilia rather than muscles, so they offer a rare opportunity to investigate the presence and mechanisms of cilia-based responses in deuterostomes."

To do this, the researchers used a strong light source to irradiate larvae from different species of sea urchins in dishes of seawater and observed their behavior using a microscope. Before exposure to the light, the larvae had stayed mainly at the surface of the water.

"The results were intriguing," says Professor Yaguchi. "The larvae dropped from the surface immediately, and some of them swam backward. We observed similar behavior in several species, suggesting that the response is common among sea urchin groups."

To visualize and quantify the behavior, the researchers added diatoms, or single-celled algae, to the dishes. The movements of these diatoms reflect the water current changes caused by ciliary beating from the larvae, indicating that ciliary responses are present and functional in sea urchins.

Given that cilia are present on tissue cells and facilitate key functions in most organisms, including humans, the identification of this ciliary response in sea urchins may be key in understanding the mechanisms of human behavior or feelings in response to light. Revealing these signaling pathways in sea urchins thus sheds new light on the evolution and diversification of light-response systems.

More information: Shunsuke Yaguchi et al, Planktonic sea urchin larvae change their swimming direction in response to strong photoirradiation, *PLOS Genetics* (2022). DOI: 10.1371/journal.pgen.1010033

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