UC SANTA BARBARA
THE Current

May 20, 2015
Julie Cohen

Seeing Without Eyes

The octopus has a unique ability. It can change the color, pattern and even texture of its skin not only for purposes of camouflage but also as a means of communication. The most intelligent, most mobile and largest of all mollusks, these cephalopods use their almost humanlike eyes to send signals to pigmented organs in their skin called chromatophores, which expand and contract to alter their appearance.

A new study by UC Santa Barbara scientists has found that the skin of the California two-spot octopus (Octopus bimaculoides) can sense light even without input from the central nervous system. The animal does so by using the same family of light-sensitive proteins called opsins found in its eyes — a process not previously described for cephalopods. The researchers' findings appear in the Journal of Experimental Biology.

"Octopus skin doesn't sense light in the same amount of detail as the animal does when it uses its eyes and brain," said lead author Desmond Ramirez, a doctoral student in the Department of Ecology, Evolution and Marine Biology (EEMB). "But it can sense an increase or change in light. Its skin is not detecting contrast and edge but rather brightness."

As part of the experiment, Ramirez shone white light on the tissue, which caused the chromatophores to expand and change color. When the light was turned off, the chromatophores relaxed and the skin returned to its original hue. This process, Ramirez noted, suggests that light sensors are connected to the chromatophores

and that this enables a response without input from the brain or eyes. He and his co-author, Todd Oakley, an EEMB professor, dubbed the process Light-Activated Chromatophore Expansion (LACE).

In order to record the skin's sensitivity across the spectrum, Ramirez exposed octopus skin to different wavelengths of light from violet to orange and found that chromatophore response time was quickest under blue light. Molecular experiments to determine which proteins were expressed in the skin followed. Ramirez found rhodopsin — usually produced in the eye — in the sensory neurons on the tissue's surface.

According to Oakley, this new research suggests an evolutionary adaptation. "We've discovered new components of this really complex behavior of octopus camouflage," said Oakley, who calls cephalopods the rock stars of the invertebrate world.

"It looks like the existing cellular mechanism for light detection in octopus eyes, which has been around for quite some time, has been co-opted for light sensing in the animal's skin and used for LACE," he explained. "So instead of completely inventing new things, LACE puts parts together in new ways and combinations."

Octopuses are not the only marine mollusks whose skin can sense light, but scientists don't know yet whether the skin of those other animals contains the light-sensitive opsins. If they do, Ramirez wants to understand how these two groups are related."Do they all come from the same ancestral source or did they evolve multiple times?" he asked. "What kind of behaviors do the different groups share and what kind of behaviors does the skin sensing light underlie?"

Ramirez and Oakley are conducting new experiments that will seek to answer those questions and more.

About UC Santa Barbara

The University of California, Santa Barbara is a leading research institution that also provides a comprehensive liberal arts learning experience. Our academic community of faculty, students, and staff is characterized by a culture of interdisciplinary collaboration that is responsive to the needs of our multicultural and global society. All of this takes place within a living and learning environment like no other, as we draw inspiration from the beauty and resources of our extraordinary location at the

edge of the Pacific Ocean.