Discovery of a simple mechanism for color detection

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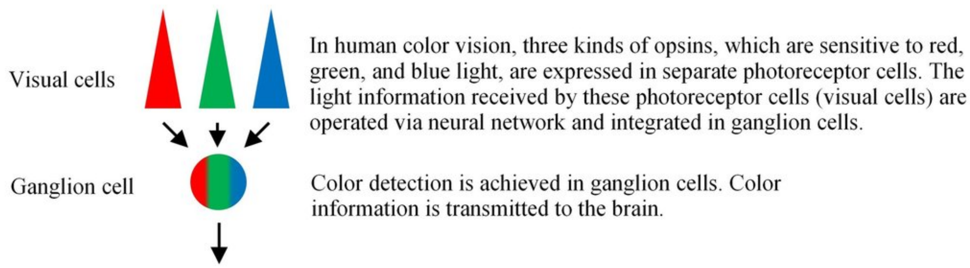
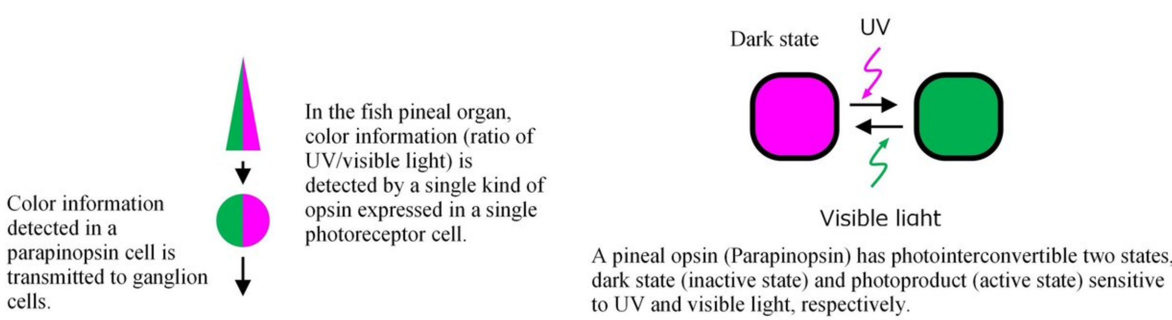


The mechanism of color detection in eyes. Credit: A. Terakita /Osaka City University

Color vision, consisting of ocular color detection, is achieved with complicated neural mechanisms in the eyes. Researchers from Osaka City University in Japan have found color detection with a simple mechanism in the fish pineal organ, an extraocular photosensitive organ on the brain surface. They have published their results in *Proceedings of the National Academy of Sciences*

"Human color vision involves red, green, and blue photosensitive molecules (opsins), which are expressed in different photoreceptor cells. So far, it has been believed that multiple kinds of color opsins are required to achieve color detection. However, we discovered that a super-simple mechanism based on a single kind of opsin in a single kind of photoreceptor cell achieves color detection, namely UV and visible light discrimination, in the fish pineal organ," said Akihisa Terakita, a professor at the Graduate School of Science at Osaka City University in Japan.

According to Terakita and his colleagues, Seiji Wada and Mitsumasa Koyanagi, assistant and associate professors at Osaka City University, the pineal organ of zebrafish employs a pineal UV-sensitive opsin called parapinopsin, which has a molecular property different from visual opsins in eyes. Both the pineal and visual opsins convert to a signaling active photoproduct (light state) upon light absorption, whereas their light states have different molecular properties. The light state of parapinopsin is highly stable and reverts to the original dark state (inactive state) upon visible light absorption, although the light state of visual opsin is unstable and rapidly decays. Because both of dark inactive and light active states of parapinopsin are stable, this feature is called "bistable nature."



The mechanism of color detection in the zebrafish pineal organ. Credit: A. Terakita /Osaka City University

"Two stable states of parapinopsin, which have different color sensitivity, UV- and visible light sensitivities for the dark and light active states, respectively is very important. It enables the fish to detect the color of light despite of one kind of opsin," Terakita said. "Environmental light contains all colors of light and its color composition varies depending on time and place. Because two states are photo-interconvertible, the mixture of the two states is formed under natural light. That is, parapinopsin alone behave like two kinds of light sensors."

The two states as two kinds of light sensors can act antagonistically to one another. UV-biased light causes the enhancement of signal. On the other hands, visible light-biased light causes the inhibition of signal. This biased color component appears in the late afternoon, when a sunny location contains abundant visible light, but a shady location contains abundant UV light. Parapinopsin alone detects such color component changes, according to Terakita.

The evolution of opsins suggests a very interesting possibility, according to Terakita, because ancestral opsins are considered to have a bistable nature.

"Taken together with the process of evolution of opsins, it is possible that bistable opsin has evolved into the current eye opsin. That is, because eyes and pineal organs have a common origin, it can be speculated that the emergence of a mechanism such as color detection by bistable opsin of fish pineal organ had been an important first step for vertebrates to acquire the complex function of color vision," Terakita said.

More information: Seiji Wada el al., "Color opponency with a single kind of bistable opsin in the zebrafish pineal organ," *PNAS* (2018). www.pnas.org/cgi/doi/10.1073/pnas.1802592115

Provided by Osaka City University