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Lizard’s ‘third eye’ sheds light on how vision evolved

A primitive third eye found in many types of lizards, used to detect changes in light and dark and to regulate the production of certain hormones, may help explain how vision evolved and how signals are transmitted from the eyes to the brain, according to new research by Rockefeller University scientists and colleagues at the Johns Hopkins University School of Medicine.

Several species of lizards, as well as some types of frogs and fish, have an organ known as a parietal eye located atop their heads. Consisting of primitive retina and photoreceptor cells similar to those found in the eyes of other vertebrates, these parietal eyes may serve as a window into how our more sophisticated image-producing eyes developed.

And now experiments conducted by researchers in the laboratories of Thomas P. Sakmar at Rockefeller and King-Wai Yau at Johns Hopkins, published this month in *Science*, show that the molecular mechanisms which underlie the parietal eye’s responses to light are similar to those that transmit responses from rod and cone cells in the eye to the brain. “We hypothesize that the parietal eye contains photoreceptor cells that are the evolutionary precursor of rod and cone cells,” says Sakmar, the Richard M. and Isabel P. Furlaud Professor and head of the Laboratory of Molecular Biology and Biochemistry at Rockefeller.

Vision works through a type of cell communication called G-protein-coupled signaling. When a photon of light enters the eye, it is captured by a receptor on the cell membrane and triggers a signaling cascade that activates a G protein. G proteins control enzymes that generate second-messenger molecules responsible for regulating the photoreceptor cells’ electrical potential and rate of synaptic firing — information necessary to transmit an image to the brain.

Normally, a G protein called transducin and a reddish pigment called rhodopsin are associated with vision processing in vertebrate photoreceptor cells, but neither were found in the parietal eye. Instead, the scientists found that a blue pigment, called pinopsin, and a new green pigment they named parietopsin couple through two unexpected G proteins. One, gustducin, is typically known for mediating bitter tastes in taste buds. The other, called Go, is normally associated with neurons and invertebrate photoreceptors. “Finding two distinct pigments and two G-protein pathways in the same cell was totally unexpected,” says Sakmar.

According to Sakmar and his colleagues, Go appears to be the most ancestral member of the family because it is found in both invertebrates and vertebrates and can be traced back to organisms called coelomates, from which both lizards and scallops evolved. Later, the ancestral photoreceptor acquired a second G protein, either transducin or gustducin, for chromatic antagonism and possibly various other purposes. The parietal photoreceptor evolved still later and retained these features while rods and cones, the scientists say, inherited only the gustducin/transducin-mediated pathway.

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