Medical Xpress

Why animals don't have infrared vision

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On rare occasion, the light-sensing photoreceptor cells in the eye misfire and signal to the brain as if they have captured photons, when in reality they haven't. For years this phenomenon remained a mystery. Reporting in the June 10 issue of *Science*, neuroscientists at the Johns Hopkins University School of Medicine have discovered that a light-capturing pigment molecule in photoreceptors can be triggered by heat, as well, giving rise to these false alarms.

"A photon, the unit of light, is just energy, which, when captured by the pigment rhodopsin, most of the time causes the molecule to change shape, then triggering the cell to send an electrical signal to the brain to inform about light absorption," explains King-Wai Yau, Ph.D., professor of neuroscience at Johns Hopkins and member of its Center for Sensory Biology. "If rhodopsin can be triggered by light energy," says Yau, "it may also be occasionally triggered by other types of energy, such as heat, producing false alarms. These fake signals compromise our ability to see objects on a moonless night. So we tried to figure it out; namely, how the pigment is tripped by accident."

"Thermal energy is everywhere, as long as the temperature is above absolute zero," says neuroscience research associate Dong-Gen Luo, Ph.D. "The question is: How much heat energy would it take to trigger rhodopsin and enable it to fire off a signal, even without capturing light?" says Johns Hopkins Biochemistry, Cellular and Molecular Biology graduate student Wendy Yue.

For 30 years, the assumption was that heat could trigger a pigment molecule to send a false signal, but through a mechanism different from that of light, says Yau, because it seemed, based on theoretical calculations: that very little thermal energy was required compared to light energy.

But the theory, according to Yau, was based mainly on the pigment rhodopsin. However, rhodopsin is mainly responsible for seeing in dim light and is not the only pigment in the eye; other pigments are present in red-, green- and blue-sensitive cone photoreceptors that are used for color and bright-light vision. Although researchers are able to measure the false events of rhodopsin from a single rhodopsin-containing cell, a long-standing challenge has been to take measurements of the other pigments. "The electrical signal from a single cone pigment molecule is so small in a cone cell that it is simply not measurable," says Luo. "So we had to figure out a new way to measure these false signals from cone pigments."

By engineering a rod cell to make human red cone pigment, which is usually only found in cone cells, Yau's team was able to measure the electrical output from an individual cell and calculate this pigment's false signals by taking advantage of the large and detectable signals sent out from the cell.

As for blue cone pigment, "Nature did the experiment for us," says Yau. "In many amphibians, one type of rod cells called green rods naturally express a blue cone pigment, as do blue cones." So to determine whether heat can cause pigment cells to misfire, the team, working in the dark, first cooled the cells, and then slowly returned the cells to room temperature, measuring the electrical activity of the cells as they warmed up. They found that red-sensing pigment triggers false alarms most frequently, rhodopsin (bluish-green-sensing pigment) triggers falsely less frequently, and blue-sensing pigment does so even less.

"This validates the 60-year-old Barlow's hypothesis that suggested the longer wavelength the pigment senses—meaning the closer to the red end of the spectrum—the noisier it is," says Yau. And this finding led the team to develop and test a new theory: that heat can trigger pigments to misfire, by the same mechanism as light.

Pivotal to this theory is that visual pigment molecules are large, complex molecules containing many chemical bonds. And since each chemical bond has the potential to contain some small amount of thermal energy, the total amount of energy a pigment molecule could contain can, in theory, be enough to trigger the false alarm.

"For a long time, people assumed that light and heat had to trigger via different mechanisms, but now we think that both types of energy, in fact, trigger identical changes in the pigment molecules," says Yau. Moreover, since longer wavelength pigments have higher rates of false alarms, Yau says this may explain why animals never evolved to have infrared-sensing pigments.

"Apart from putting to rest a long-standing debate, it's a wake-up call for researchers to realize that biomolecules in general have more potential thermal energy than previously thought," says Luo.

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