The life aquatic: Why diurnal frog species kept genes adapted to night vision

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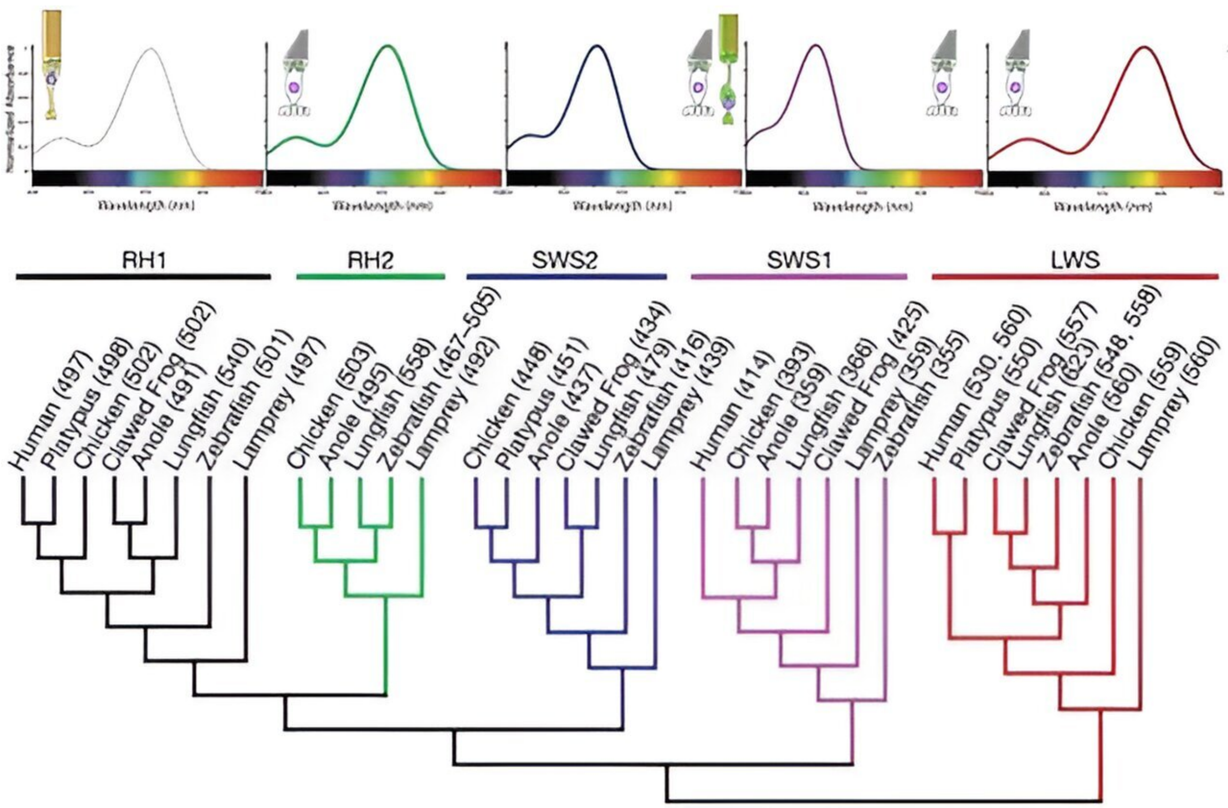

The ancestor of vertebrates had five distinct visual opsins: a rod-specific opsin, RH1, found in a single type of rod cell; and four cone opsins (LWS, RH2, SWS1, and SWS2), each present in a spectrally distinct class of cone. Most amphibians have an additional photoreceptor cell type, the blue-sensitive rods (also referred to as “green rods”), which express a cone visual pigment (SWS2).

The visual pigments formed by each of the different opsins absorb light maximally at different wavelengths (λmax), as illustrated by the representative absorbance plots, and even minor changes to the protein sequences can shift the sensitivity of the visual pigment and impact other aspects of visual pigment function. Cladogram of visual opsin relationships adapted from Davies et al. (2012). Pigment absorbances (in parentheses, nm) were estimated from in vitro expression with the exception of lungfish, which was measured with microspectrophotometry (MSP). Values retrieved from the following references: human (Yokoyama 2008; Davies et al. 2012), platypus (Yokoyama 2008; Davies et al. 2012), chicken (measurements shown are for pigeon; Yokoyama 2008), clawed frog (Darden et al. 2003; Yokoyama 2008), anole (Yokoyama 2008), lungfish (Hart et al. 2008), zebrafish (Yokoyama 2008), and lamprey (Davies et al. 2012). Humans and zebrafish have two copies of LWS that differ in absorbance. Zebrafish have multiple copies of RH2 that differ in absorbance (minimum and maximum values shown). Credit: *Molecular Biology and Evolution* (2024). DOI: 10.1093/molbev/msae049

Frogs display a remarkable diversity of species as a whole, but does the same hold true for their visual abilities? A new study led by York University's Faculty of Science has sought to answer this question by collaborating with researchers in Australia, Belgium, Brazil, Cameroon, Ecuador, Equatorial Guinea, French Guiana, Gabon, Seychelles, Sweden, United Kingdom and the United States, to get a sample of a diverse array of frogs to study the visual pigments found in their eyes.

"Through this large international collaborative effort, we were able to study the pigments of frogs from all over the world who have adapted to myriad environments, and for the most part, we found this diversity is 'reflected' in the pigments in frogs' eyes," says research lead and Assistant Professor in the Department of Biology Ryan Schott.

"We saw this pattern of visual evolution being driven by differences in species that are either aquatic as adults, or that are living on the ground, or trees. On the other hand, we didn't find much of a difference with the small groups of frogs that have adapted to daytime conditions as opposed to their nocturnal cousins."

The study, published today in *Molecular Biology and Evolution*, examined the frog visual system by looking at the visual pigments and other genes in the eyes of a diverse selection of frogs living in vastly different light environments. Visual pigments are the molecules in the photoreceptor cells of the retina that are responsible for detecting light and then sending signals to the brain to perceive that light.

"We humans, as well as many animals, have these pigments in our eyes that actually absorb and respond to light," explains Schott, also with the Centre for Vision Research at York and former research associate with the National Museum of Natural History at the Smithsonian Institution in Washington, D.C. "It's the differences in these pigments that allow us to see at night versus in the day, and allow us to perceive color differences. So, we were interested in how these pigments have evolved in these frogs in different light environments."

Schott, who studies the visual system of vertebrates in his lab located at York's Keele Campus, has previously looked at vision changes of southern leopard frogs as they metamorphose from aquatic tadpoles to frogs living on land, and found a lot of differences. However, the lack of difference between the diurnal and nocturnal frogs came as a surprise. While it is possible that differences were not captured in the method of research, Schott says their evolutionary heritage may provide an alternate explanation.

"Most frogs are nocturnal, and so ancestrally, they really have this visual system that's adapted to these nocturnal environments," he says. "This is probably suggesting that even the diurnal animals need these adaptations to survive because of course, they could say, get woken up in the night by a predator and then need to use their visual system to escape."

More information: Ryan K Schott et al, Diversity and Evolution of Frog Visual Opsins: Spectral Tuning and Adaptation to Distinct Light Environments, *Molecular Biology and Evolution* (2024). DOI: 10.1093/molbev/msae049

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