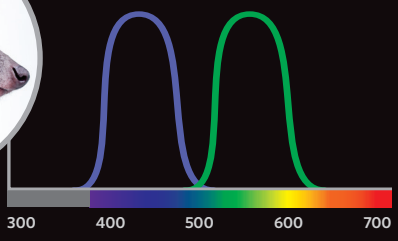
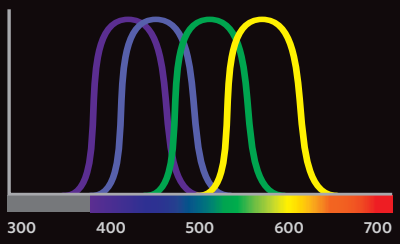
ANIMALS' DIVERSE PALETTES

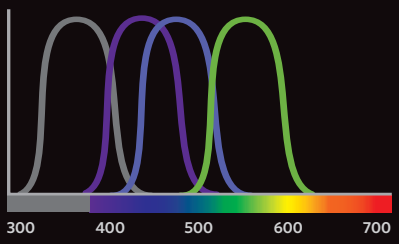
Most mammals, such as dogs, express just two types of opsins in the distal ends of their eyes' cone cells, which are responsible for color vision. Humans and some primates have three. Other animals, including birds, fish, and insects, have even more opsins, although insects don't have cones, but instead use other types of cells to detect color. Such diversity yields whole new worlds of color, with each opsin adding an order of magnitude more hues. Reconstructing the evolution of opsin genes, Shozo Yokoyama of Emory University and his colleagues have found that substitutions at only a couple dozen amino acid sites in opsin proteins account for this diversity of spectral tuning found among vertebrates.



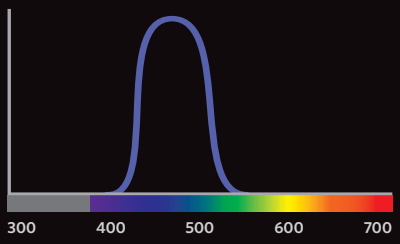
Like most mammals, dogs (*Canis familiaris*) see in color, just far fewer colors than other animals. From a behavioral study of two Italian greyhounds and a toy poodle, researchers figured out their limited color discrimination is due to dichromatic color vision (*Visual Neuroscience*, 3:119-25, 1989).



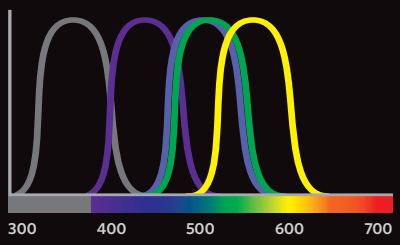
Chickens have four types of cone opsins (*PNAS*, 89:5932-36, 1992), and in some birds, the short-wavelength opsin is shifted to absorb in the ultraviolet. Bird cone cells also have an oil droplet that serves to filter or concentrate particular wavelengths of light.



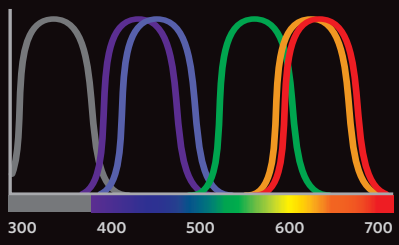
The eye of the American chameleon (*Anolis carolinensis*) has no rods and uses multiple cone opsins to detect color. The peaks here show the maximum absorption of the photopigments reconstituted in vitro (*Vision Research*, 38:37-44, 1998).



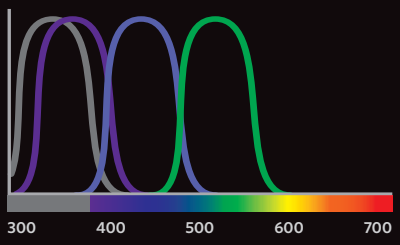
In its ocean habitat, the coelacanth (*Latimeria chalumnae*) receives only blue light. Correspondingly, its rod-enriched eyes absorb light in this range. The peak here represents the absorption maximum of the visual pigment in vitro (*PNAS*, 96:6279–84, 1999).



Like many fish, goldfish can see in the ultraviolet, thanks to a shift in their short-wavelength opsin. Using their long-wavelength opsin (yellow peak), they can also see red, likely an adaptation to their shallow aquatic environment, in which red light is not filtered out (*Genetics*, 153:919–32, 1999).



The small white butterfly (*Pieris rapae*) expresses four types of opsins but has at least six types of photoreceptors (*PLOS ONE*, 5:e15015, 2010). Filters in the eye adjust the spectral sensitivity of the photoreceptor cells. In males, the violet receptor is modified into a second blue one (not shown).



Repeated florets called ommatidia in the compound eye of the fruit fly (*Drosophila melanogaster*) are made of a central color-vision cell surrounded by six blue-light absorbing cells. Shown here are the absorption maximums for the opsins expressed in the central cell of the ommatidium (*J Neurosci*, 19:10716-26, 1999).