Eyeless worms detect color
Roundworms discriminate color of toxic food despite a lack of eyes and opsin photoreceptor genes

By Lauren A. Neal and Leslie B. Vosshall

Animals use color vision to explore their environment, recognize mates, avoid predators, and guide feeding decisions. Color vision across the tree of life relies on specialized retinal photoreceptor cells and light-sensitive opsins with different spectral sensitivities. Caenorhabditis elegans is eyeless roundworms that dwell in rotting vegetation and compost heaps, feeding on a rich diversity of microbes (1). In its natural environment, C. elegans must traverse a complex microbial terrain while determining which food is safe for consumption. Some bacteria produce colorful toxins (2), making color discrimination a potentially life-or-death decision for the worm. On page 1059 of this issue, Ghosh et al. (3) demonstrate that C. elegans, despite lacking eyes and opsin genes, can discriminate between colors to guide foraging decisions. They identify two conserved stress-response genes that are required for color discrimination, revealing a new biology of color vision.

An estimated 80% of the bacteria naturally found in the C. elegans environment are beneficial to the organism, but the worm can encounter potentially harmful microorganisms while foraging for food (1). Pyocyanin, a blue-pigmented toxin secreted by the bacterium Pseudomonas aeruginosa, is known to generate tissue-damaging reactive oxygen species. This pigment is a major cause of pathogenicity because mutant P. aeruginosa that do not produce pyocyanin are less pathogenic to humans (2). When C. elegans encounters this colorful and toxic microbe, how does it recognize and avoid it?

Previous work demonstrated that C. elegans is sensitive to visible and ultraviolet light. lite-1 (high-energy light unresponsive protein 1) and gur-3 (gustatory receptor family protein 3) were identified as two components of a non-opsin phototransduction pathway that contributes to light-avoidance behavior (4–7). Ghosh et al. demonstrated that avoidance of toxic blue P. aeruginosa bacterial lawns by C. elegans on a Petri dish is enhanced in the presence of white light and requires the lite-1–gur-3 pathway. Adding pyocyanin to a culture of beneficial bacteria triggered repulsion by C. elegans in white light, yet solely illuminating beneficial bacteria with blue light in the absence of pyocyanin did not. The authors triggered avoidance of beneficial bacteria by adding a colorless chemical that produces reactive oxygen species and illuminating the environment with precise blue-amber wavelengths to mimic the color of pyocyanin. Moreover, this blue-amber light enhanced avoidance of nonpathogenic bacteria scented with an odor that worms find repellent. Therefore, pathogen avoidance is a multisensory experience that relies on both visual and chemical cues.

Ghosh et al. uncovered pronounced behavioral variation under blue or amber illumination in 59 wild strains of C. elegans. Some strains avoided pathogens only in blue light, and others were sensitive only to amber light. Several strains avoided these colors even without a repellent odor—a compelling demonstration that C. elegans detects and discriminates colors. The authors identified two genes that together strongly influenced color discrimination. The de-
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