Algal protein in worm neurons allows remote control of behavior by light

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By introducing expression of a special green-algae gene into neurons of the tiny, transparent nematode C. elegans, researchers have been able to elicit specific behavioral responses by simply illuminating animals with blue light. The work paves the way for better understanding of how neurons communicate with each other, and with muscles, to regulate behavior in intact, living organisms. Generally speaking, detailed information about the activity and function of specific neurons during particular behaviors has been difficult to achieve in undissected animals.

The new findings are reported by Alexander Gottschalk and colleagues at Goethe-University Frankfurt and at the Max Planck Institute for Biophysical Chemistry, also in Frankfurt.

In their new study, the researchers employed a light-sensitive protein from the green alga Chlamydomonas reinhardtii. This protein, channelrhodopsin-2 (ChR2), sits in cell membranes, where it gates the flow of certain ions from one side of the membrane to the other. Such so-called channel proteins play central roles in the activities of neurons and muscle cells, and while some channel proteins are sensitive to chemicals or electrical signals, ChR2 and its relatives are controlled directly by certain wavelengths of light, making them ideal for remote control in the laboratory.

In their experiments, the researchers took advantage of the light sensitivity of the algal channel protein by introducing expression of a modified form of ChR2 in specific C. elegans neurons and muscle cells.

The researchers found that when this form of ChR2 was expressed in muscle cells, blue-light activation of the protein was sufficient to cause strong contraction of the muscle. They found that muscle contraction was simultaneous with light exposure.

The researchers went on to show that expression of the engineered ChR2 in mechanosensory neurons, which respond to touch by activating a reflex that causes worms to back up, was sufficient to prompt the backing behavior in response to blue-light exposure. In fact, the ChR2 expression in mechanosensory neurons allowed the backing behavior to occur (in response to light) even in mutant worms that lacked the C. elegans ion channel that normally mediates backing behavior in response to touch.

The researchers performed electrophysiological experiments to show that the effects they observed were indeed due to the inward flow of ions caused by activation of the ChR2 protein by light; this inward ion flow persisted for the duration of blue-light exposure.

Future work may include studies using forms of ChR2 or related proteins that are sensitive to different wavelengths of light; by allowing remote-control activation of different neurons and muscle cells within an individual animal, such approaches could aid in understanding the circuitry and control of complex behaviors.

Source: Cell Press

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