Mind controls: Putting a light switch in the brain

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If only brain cells could be turned on and off as easily as a light switch. Now they can, thanks to the field of optogenetics. At the moment, the technique remains a research tool as it requires animals to be genetically modified before their brains can be stimulated. But the unprecedented level of control it gives over individual neurons arguably makes it the most exciting advance in neuroscience of recent years.

Optogenetics was born in 2004 when Karl Deisseroth and Ed Boyden at Stanford University in California investigated a molecule called channelrhodopsin-2, normally present in green algae. The molecule is an ion channel: in other words, the right trigger makes it change shape, opening up an internal channel that allows sodium ions to flow into an alga's eyespot. In the case of channelrhodopsin-2, the trigger is blue light, thus allowing algae to sense daylight.

The team inserted the gene that codes for channelrhodopsin-2 into rat neurons, and then grew them in the lab. As in algae, shining blue light on the neurons caused an influx of sodium ions, triggering electrical firing (*Nature Neuroscience* vol 8, p 1263).

To stop neurons from firing, the team turned to an ion channel called halorhodopsin, from a bacterium-like creature native to salt lakes in Egypt. When exposed to yellow light, halorhodopsin pumps chloride ions into cells, and this stops any electrical impulse. The team inserted the halorhodopsin gene into nematode worms, and managed to stop them in their tracks by bathing them in a golden glow.

Now these techniques are being used on mice by implanting fibre-optic cables to carry light deep into their brains. And last year the Stanford team showed a burst of yellow light could call a halt to electrical activity similar to that seen in an epileptic seizure in slices of mouse brain (*Proceedings of the National Academy of Sciences*, vol 106, p 12162).

There's also the potential to use light to get information from the brain. By inserting a gene that makes cells glow green when they fire, neural activity could be monitored through the same optical fibre that delivers light.

Could optogenetics ever be used on people? Right now, there's a lot of caution about gene therapy, as a few people died after receiving the therapy for other

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