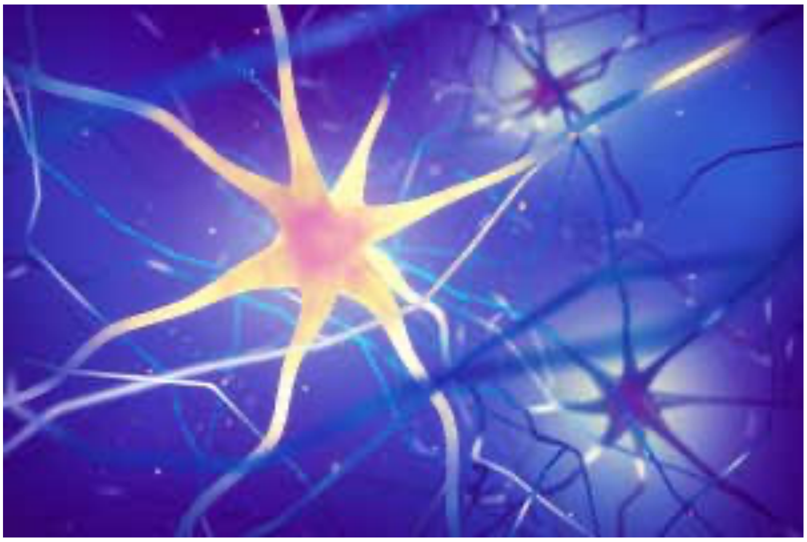
Living electrodes for linking brains to computers tested in rats



Artist's impression of human neurons

"Living electrodes" made of nerve cells genetically modified to respond to light have been successfully implanted in the brains of animals. The hope is that they will provide a better and longer-lasting way to link brains with computers than conventional electrodes.

"It allows our technology to be speaking the language of the nervous system, instead of electrical jolts, which is what is done now," says Kacy Cullen at the University of Pennsylvania. "When our implanted neurons are activated, the deeper part of the brain they are connected to then becomes activated by a natural synaptic mechanism."

Electrodes implanted in the brain have been used since the 1950s for everything from treating Parkinson's disease to helping people who are paralysed to communicate, move and even sense things. "There have been some fantastic successes," says Cullen.

But there are problems with conventional electrodes. Putting a foreign object in the brain provokes an immune response that can cause scarring, making the performance of the electrode change or degrade. Electrodes also affect all adjacent neurons, not just the target ones, which can lead to unwanted effects.

Cullen's approach instead relies on optogenetics: genetically modifying neurons so they respond to light signals. A clump of about 10,000 cells is then placed at the top of a dissolvable gel cylinder just twice the diameter of a human hair.

The axons of the neurons – the living wires – grow along the cylinder and out of the end.

When 1.5-millimetre-long cylinders containing modified rat neurons were implanted in the visual cortex of rats, many of the implanted cells survived and their axons grew down into the cortex and made connections with the cells there. “If we have a problem, it’s too many connections rather than too few,” says Cullen.

The challenge now is to show that desirable connections can be reinforced and unwanted ones pruned, so that implants can achieve specific effects, such as preventing epileptic seizures.

The implanted neurons can be of a type that activate the cells they connect to, or that dampen down activity, or a mix of both types. By modifying the cells to fluoresce when activated, implants should be able to monitor brain activity as well as controlling it.

For treating patients, Cullen envisages generating neurons from matched cells stored in stem cell banks, to avoid immune rejection. It would be prohibitively expensive to generate neurons from each individual’s own cells, he says.

To control the neurons, an LED array would be implanted on the brain surface, just above the upper end of the implanted nerves. “Being on the brain surface, we don’t expect that they will elicit the same immune reaction as penetrating electrodes,” says Cullen.

Anthony Hannan at the University of Melbourne says it is possible that living electrodes will be better for some applications than conventional ones. “However, they do not yet have evidence that it would be far superior to any other type of electrode,” he says.

And using living electrodes also brings a whole new set of challenges, such as preventing infections and achieving consistent results, says Hannan.

Cullen has set up a company called Innervace to help commercialise the technology. However, he stresses that the work is still at an early stage. “It is still at a fairly basic level, and several years away from clinical applications.”