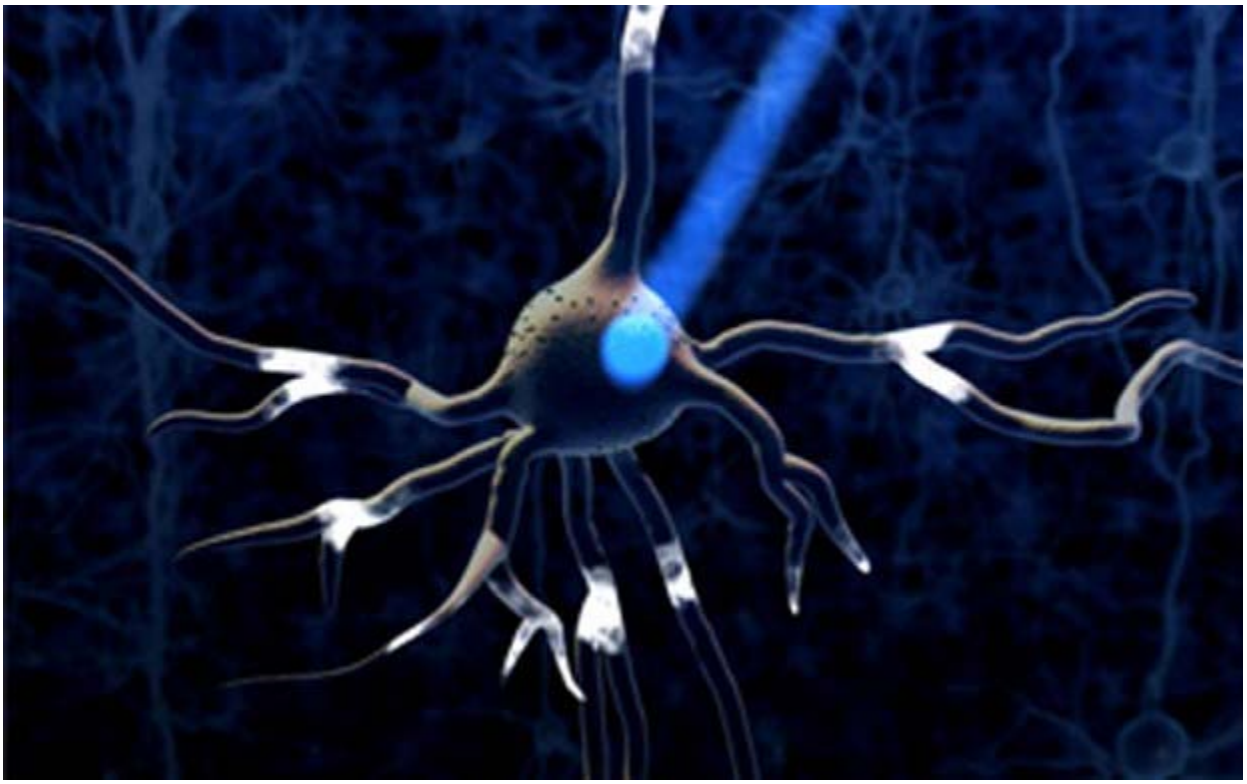
Scientists use light to control brain with flick of a switch

Implants that deliver pulses of light into the brain could lead to new treatments for diseases such as epilepsy and Alzheimer's Disease.



Optogenetic molecular reagents enabling control of targeted neurons and biological functions with light

By Richard Gray, Science Correspondent

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It is an area of science that has the power to control the human mind with the flick of a light switch.

Scientists have developed a way of using pulses of light to turn the brain cells that control our everyday actions and thoughts on or off at will. It provides a way of controlling the brain that has never been possible before.

The researchers have already conducted tests in monkeys, our closest relatives, using light to send them to sleep. They now hope to develop the techniques further for use in humans.

The technology promises to provide revolutionary new treatments for diseases that are notoriously difficult to control such as epilepsy, Alzheimer's Disease and psychiatric illnesses. It could even help people make new memories.

But like many scientific advances, it is likely to divide the public, scientists and the medical community as it combines three already controversial technologies.

First, cells in the brain itself must be genetically altered so they react to light. Such genetic modification of human cells is still an emerging science and the long term effects are still largely unknown.

An implant must also be placed directly into the brain, requiring an operation, so that it can deliver light to the brain cells using tiny optical fibres similar to those that carry broadband signals around the UK.

Drawing on the growing scientific knowledge of how our brains work, this opens up the ability to control behaviour – something that will alarm the more paranoid free rights campaigners.

Yet despite the obvious ethical dilemmas such research will throw up, the benefits could be profound.

"As a therapy, this could help tackle diseases which are difficult or unlikely to be treated by other means," said Dr Edward Boyden, a biological engineer at the Massachusetts Institute of Technology, who is at the forefront of research in this area, known as optogenetics.

"We have conducted the first tests of optogenetics in non-human primates and shown it to be safe. We are still some way from doing this in humans, but the potential is exciting."

His group have built a prototype implant that can shine light onto specific areas of the brain and even single cells in an attempt to develop new therapies for neurological diseases.

The technology exploits the discovery of light sensitive molecules that are found in algae and some bacteria. Algal cells use these molecules to help move towards sources of light, which they need to help them grow.

The molecules work by allowing a flow of electrical activity through the cell. Neurons in the brain also rely on similar pulses of electrical activity to send messages in the brain and through out the body.

Dr Boyden found that it was possible to use genetically engineered viruses to introduce these light sensitive algae molecules into mammalian brain cells, or neurons as they are also called.

The virus inserts a gene from the algae into the animal cells – giving them the instruction manual they need to produce the light sensitive molecules themselves – and within days the molecules begin to appear on the surface of the neurons.

When light hits these altered brain cells, they turn on or off, depending on the gene that has been inserted.

Dr Boyden and his colleagues have also developed a wireless implant that uses thousands of tiny optical fibres to deliver light to the parts of the brain where it is inserted. This means they can switch brain cells on or off in any sequence they desire.

Working with scientists from around the world, Dr Boyden has have been able to send mice and primates to sleep using beams of light with this technology.

In newly published research they have also turned mice into "light addicts" by putting the algae molecules into cells found at the part of the rodents' brain that deals with reward and pleasure.

It meant that a mouse would return to a light switch over and over again to get a dose of light, which would turn on the cells in its brain to give a pleasurable sensation.

Such technology, if it is ever used in humans, would give doctors the potential to control people's behaviour. Using molecules that turn off brain cells when exposed to light, it may be possible to help people who are suffering from addiction.

Patients with mental health disorders could also be given new treatments as neuroscientists learn more about how the brain malfunctions to lead to conditions such as depression, schizophrenia and bipolar disorder.

It could also be used to help patients with spinal cord injuries to help alleviate pain or restore movement by using light to bypass the damage to the nerves in the spine.

Dr Boyden said: "In epileptic seizures, part of the brain becomes overactive. With the prosthetic implants we are developing, it is possible to turn off the area of the brain that is overactive for a brief period of time.

"In cases where people have lost part of their brain due to stroke or injury, or due to neurodegenerative diseases such as Alzheimer's, there is a growing interest in stimulating brain cells to change the way brain works.

"Some groups are also trying to directly enter information into the brain to help people form new memories."

Brain implants are not new and have been used for years in deep brain stimulation and cochlear

implants for deaf patients. In these, however, electricity is used to stimulate a part of the brain and can often create side effects as surrounding brain tissue is also activated.

By using light, however, Dr Boyden believes it will be possible to be more targeted and believes single brain cells could be controlled, which opens up the possibility of fine tuning the brain and even helping high level processes such as memory creation.

Currently they can pack several hundred to a thousand of these on a single implant less than a third of an inch across, but they hope to squeeze hundreds of thousands if not millions to allow them to target individual brain cells.

Other groups, including scientists at Imperial College London, are also working on using similar implants to restore sight to blind patients who have suffered damage to their retina at the back of their eyes.

Andrew Malloy, publisher of the Institute of Physics' *Journal of Neural Engineering*, said optogenetics was seen as one of the most exciting areas of science to have emerged recently.

He said: "Optogenetics provides a toolkit that will enable dramatic advances in our understanding of the circuitry of the brain and potentially provide better treatments for neurological and psychiatric disorders such as Parkinson's disease and schizophrenia."