Understanding the brain and mind: Science's final frontier?

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The jelly-like tissue that is the brain is the most complicated object in the known universe. Credit: Dr Case/Flickr

The brain and the mind are two sides of the same coin. We have always wanted to understand how our minds work but, until recently, lacked the

tools to investigate the brain.

The jelly-like tissue that is the brain is the most complicated object in the known universe. Its 100 billion nerve cells (nearly 20 times the number of people on earth), are each connected to thousands of other nerve cells in a bewilderingly complex network.

Enormous strides have been made in understanding the chemical and electrical processes that nerve cells use to communicate with each other, but much remains to be discovered.

One of the greatest mysteries is the process by which this extremely complicated network generates conscious awareness, perception, behaviour, and emotions. And how it does this at the same time as processing sensory input and controlling muscles and all other organs.

How I got here

I decided to work in neuroscience in 1980 because of my interest in the causes of high blood pressure. Although hormones produced by the kidney, the adrenal gland, and other sites, can all modulate blood pressure, it was becoming increasingly clear that the brain was enormously important.

We began mapping sites in the brain where particular hormones might act to modulate body fluid and salt balance, and blood pressure. The results were very exciting and pointed to new ways that hormones and neurotransmitters could act in – and on – the brain.

Soon, my interest went way beyond blood pressure into the fascinating area of how the brain uses chemical transmitters.

When I started working in medicine in 1960, there was no way to image

the structure of the living brain; the skull represented a virtually impenetrable barrier to further understanding.

All this changed with the invention of the CT scanner in 1967 and the MRI scanner in 1973. MRI now routinely provides exquisitely detailed structural images, as well as images of brain function, which is known as fMRI.

Growing attention

Neuroscience has now become one of the most exciting and active areas of science. It encompasses medicine, psychology, and psychiatry, has strong links with biology, biochemistry, endocrinology and rests on behavioural physiology, chemistry, physics, and mathematics.

The brain's actions underlie all of our mental life, our thoughts, emotions, and beliefs. The explanations we create, and the way we process information, have a huge effect on our moods and behaviour.

We are beginning to understand how abnormalities in nervous transmission at synapses can cause diseases ranging from autism to schizophrenia, how levels of different transmitter chemicals can affect mood, anxiety, aggression and even love and commitment.

Understanding the enormously complicated brain network seemed an impossible task; each pathway seemed to use its own specific combination of chemical transmitters.

But by combining genomics and optics, it is now possible to monitor and modulate the activity of specific pathways in the living brain.

The changing brain

We used to believe the brain's network of intricate connections was fixed after early childhood. But we now know that the brain is highly plastic or changeable, and able to modify its structure and function in response to learning and memory.

Recovery from injury and response to disease depend to a large degree on this neural plasticity. Plasticity is most active in early childhood although it persists throughout life.

In young children, environmental influences can have profound and long-lasting effects on brain development. These effects can be negative when they face malnutrition, or deprivation of love and attention, mental and physical stimulation.

Conversely, the provision of these needs, and a rich cultural and intellectual environment can contribute to optimal development.

Becoming mindful

In parallel with these understandings in neuroscience at the cellular and network levels, there have been important discoveries about the mind. One of these is the development of cognitive behaviour therapy, which can alleviate anxiety and depression.

Another is the rediscovery in the West of meditation and mindfulness training, both of which can reduce anxiety and improve mental function and well-being.

We are in the midst of a flourishing of neuroscience. We can look forward to enormous advances in understanding how the normal brain works and how it malfunctions in brain disorders.

This will lead to radically new, more effective treatments and ultimately,

the prevention of the all-too-frequent brain disorders that plague our society.

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