Introduction: The Human Brain

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The brain is the most complex organ in the human body. It produces our every thought, action, memory, feeling and experience of the world. This jelly-like mass of tissue, weighing in at around 1.4 kilograms, contains a staggering one hundred billion nerve cells, or neurons.

The complexity of the connectivity between these cells is mind-boggling. Each neuron can make contact with thousands or even tens of thousands of others, via tiny structures called synapses. Our brains form a million new connections for every second of our lives. The pattern and strength of the connections is constantly changing and no two brains are alike.

It is in these changing connections that memories are stored, habits learned and personalities shaped, by reinforcing certain patterns of brain activity, and losing others.

Grey matter

While people often speak of their "grey matter", the brain also contains white matter. The grey matter is the cell bodies of the neurons, while the white matter is the branching network of thread-like tendrils - called dendrites and axons - that spread out from the cell bodies to connect to other neurons.

But the brain also has another, even more numerous type of cell, called glial cells. These outnumber neurons ten times over. Once thought to be support cells, they are now known to amplify neural signals and to be as important as neurons in mental calculations. There are many different types of neuron, only one of which is unique to humans and the other great apes, the so called spindle cells.

Brain structure is shaped partly by genes, but largely by experience. Only relatively recently it was discovered that new brain cells are being born throughout our lives - a process called neurogenesis. The brain has bursts of growth and then periods of consolidation, when excess connections are pruned. The most notable bursts are in the first two or three years of life, during puberty, and also a final burst in young adulthood.

How a brain ages also depends on genes and lifestyle too. Exercising the brain and giving it the right diet can be just as important as it is for the rest of the body.

Chemical messengers

The neurons in our brains communicate in a variety of ways. Signals pass between them by the release and capture of neurotransmitter and neuromodulator chemicals, such as glutamate, dopamine, acetylcholine, noradrenalin, serotonin and endorphins.

Some neurochemicals work in the synapse, passing specific messages from release sites to collection sites, called receptors. Others also spread their influence more widely, like a radio signal, making whole
brain regions more or less sensitive.

These neurochemicals are so important that deficiencies in them are linked to certain diseases. For example, a loss of dopamine in the basal ganglia, which control movements, leads to Parkinson's disease. It can also increase susceptibility to addiction because it mediates our sensations of reward and pleasure.

Similarly, a deficiency in serotonin, used by regions involved in emotion, can be linked to depression or mood disorders, and the loss of acetylcholine in the cerebral cortex is characteristic of Alzheimer's disease.

Brain scanning

Within individual neurons, signals are formed by electrochemical pulses. Collectively, this electrical activity can be detected outside the scalp by an electroencephalogram (EEG).

These signals have wave-like patterns, which scientists classify from alpha (common while we are relaxing or sleeping), through to gamma (active thought). When this activity goes awry, it is called a seizure. Some researchers think that synchronising the activity in different brain regions is important in perception.

Other ways of imaging brain activity are indirect. Functional magnetic resonance imaging (fMRI) or positron emission tomography (PET) monitor blood flow. MRI scans, computed tomography (CT) scans and diffusion tensor images (DTI) use the magnetic signatures of different tissues, X-ray absorption, or the movement of water molecules in those tissues, to image the brain.

These scanning techniques have revealed which parts of the brain are associated with which functions. Examples include activity related to sensations, movement, libido, choices, regrets, motivations and even racism. However, some experts argue that we put too much trust in these results and that they raise privacy issues.

Before scanning techniques were common, researchers relied on patients with brain damage caused by strokes, head injuries or illnesses, to determine which brain areas are required for certain functions. This approach exposed the regions connected to emotions, dreams, memory, language and perception and to even more enigmatic events, such as religious or "paranormal" experiences.

One famous example was the case of Phineas Gage, a 19th century railroad worker who lost part of the front of his brain when a 1-metre-long iron pole was blasted through his head during an explosion. He recovered physically, but was left with permanent changes to his personality, showing for the first time that specific brain regions are linked to different processes.

Structure in mind

The most obvious anatomical feature of our brains is the undulating surface of the cerebrum - the deep clefts are known as sulci and its folds are gyri. The cerebrum is the largest part of our brain and is largely made up of the two cerebral hemispheres. It is the most evolutionarily recent brain structure, dealing with more complex cognitive brain activities.

It is often said that the right hemisphere is more creative and emotional and the left deals with logic, but the reality is more complex. Nonetheless, the sides do have some specialisations, with the left dealing with speech and language, the right with spatial and body awareness.

Further anatomical divisions of the cerebral hemispheres are the occipital lobe at the back, devoted to vision, and the parietal lobe above that, dealing with movement, position, orientation and calculation.
Behind the ears and temples lie the temporal lobes, dealing with sound and speech comprehension and some aspects of memory. And to the fore are the frontal and prefrontal lobes, often considered the most highly developed and most "human" of regions, dealing with the most complex thought, decision making, planning, conceptualising, attention control and working memory. They also deal with complex social emotions such as regret, morality and empathy.

Another way to classify the regions is as sensory cortex and motor cortex, controlling incoming information, and outgoing behaviour respectively.

Below the cerebral hemispheres, but still referred to as part of the forebrain, is the cingulate cortex, which deals with directing behaviour and pain. And beneath this lies the corpus callosum, which connects the two sides of the brain. Other important areas of the forebrain are the basal ganglia, responsible for movement, motivation and reward.

Urges and appetites

Beneath the forebrain lie more primitive brain regions. The limbic system, common to all mammals, deals with urges and appetites. Emotions are most closely linked with structures called the amygdala, caudate nucleus and putamen. Also in the limbic brain are the hippocampus - vital for forming new memories; the thalamus - a kind of sensory relay station; and the hypothalamus, which regulates bodily functions via hormone release from the pituitary gland.

The back of the brain has a highly convoluted and folded swelling called the cerebellum, which stores patterns of movement, habits and repeated tasks - things we can do without thinking about them.

The most primitive parts, the midbrain and brain stem, control the bodily functions we have no conscious control of, such as breathing, heart rate, blood pressure, sleep patterns, and so on. They also control signals that pass between the brain and the rest of the body, through the spinal cord.

Though we have discovered an enormous amount about the brain, huge and crucial mysteries remain. One of the most important is how does the brain produces our conscious experiences?

The vast majority of the brain's activity is subconscious. But our conscious thoughts, sensations and perceptions - what define us as humans - cannot yet be explained in terms of brain activity.

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How Does Brain Work?

Theories about how the brain works remain a topic of debate. It is agreed, though, that the hippocampus, a part of the brain, is undeniably important for memory. When we experience something, the information is sent via our senses to the hippocampus, where it is processed. Scientists believe that brain cells called neurons first transform the sensory stimuli we experience into images in our immediate memory. Then, these images are sent to the hippocampus and stored temporarily in short term memory. In the hippocampus information is organized, and it is during this process that parts of the image of our experience fade away. Finally, certain information is then transferred to long term memory in a section in the frontal lobe of the brain known as the cerebral cortex. Scientists think this process may happen while we are sleeping, but exactly how the information is transferred from one area of the brain to another is a mystery.

1. This passage is mainly concerned with ----.
   ○ A) how to improve our memory
   ○ B) why some of the information in short term memory fades away
   ○ C) illness that results in severe memory loss
   ○ D) how human brain processes and stores information
   ○ E) the importance of neurons in transferring sensory stimuli

2. According to the passage scientists ----.
   ○ A) know that information is sent from the long term memory to the hippocampus
   ○ B) have found out why some of the information is lost in the hippocampus
   ○ C) don't know exactly how the information is transferred from one area of the brain to another
   ○ D) agree on how the brain works
   ○ E) still debate whether the hippocampus is important for memory

3. It is pointed out in the reading that ----.
   ○ A) the brain was not considered as a highly complex organ in the past
   ○ B) damage to hippocampus doesn't cause memory loss
   ○ C) all of the information stored in the short term is transferred to long term memory
   ○ D) hippocampus is in the frontal lobe of the brain
   ○ E) scientists agree that the hippocampus is important in processing information