Our ‘a closer look’ series of factsheets looks at some subjects in greater technical detail. Here we look at neurones – the cells that make up the brain – what they look like, what they do and how they communicate to send messages around the body.

**what is a neurone?**
The human brain is made up of four different lobes. Each lobe has a different function, but they are all made up of individual brain cells called neurones. There are about 100 billion neurones in the human brain. Neurones in different areas are different shapes because they have different functions.

See our factsheet *a closer look – the brain*

**what do neurones do?**
Neurones are a particular type of cell that carry information messages or signals to and from the brain and the rest of the body. The connections from groups of neurones form nerves, a bit like telephone wires from a telephone exchange. The messages they send are called ‘nerve impulses’ or ‘action potentials’. As all these messages are sent around the body by nerves, this is how we get the name nervous system.

**the nervous system**
The nervous system is made up of two different parts. The brain and the spinal cord make up the central nervous system, which is like the body’s “control centre”. The brain sends and receives messages, which the spinal cord helps to relay. The other part of the nervous system is the peripheral nervous system, which contains all the nerves for the rest of the body.

**what do neurones look like?**
The size and shape of neurones varies depending on where in the body they are, but most of them share the same general features and structure. The structure of a neurone is similar to a tree.

Every neurone has an outside coating or wall called a cell or plasma membrane. This membrane has an important role in how neurones communicate.

The neurone has a type of “control centre” called the cell body. This contains the nucleus of the cell, which is like the cell’s “brain”, helping to make sure the rest of the neurone is working. This is like the top of the tree trunk.

Spreading out from the cell body are short branches called dendrites. These are the part of the neurone that receives messages from other cells. Each dendrite may have many branches, which can look like the big and small branches of the tree.

The axon of the neurone is like the trunk of the tree. It usually stretches out from the cell body, and the point where this happens is called the axon hillock. While the size of the dendrites and cell body tend to be fairly constant, the length of the axon varies. This part of the cell carries the messages away from the cell body, to the next cell.

At the end of the axon is the synaptic terminal, like the roots of the tree. This is the part of the neurone that connects to and communicates with the next cell, often the dendrites of another neurone. Where these two cells connect is called the synapse. Each neurone can connect to many other cells. The messages from one neurone, which can be either a chemical or an electrical message, pass through this synapse from one cell to another. The synaptic terminal contains a number of small sacs, called synaptic vesicles. These vesicles contain neurotransmitters, which are used in this communication.

Neurones can be grouped together depending on their function, and whether they send or receive information. There are three types, which altogether make up the circuits of the nervous system.

- Receptor or sensory neurones receive information from the senses (e.g. the ears, eyes, nose and skin) and respond by sending this information to the brain.
- Effector or motor neurones carry messages from the brain to muscles and glands in the body. These messages cause something to happen in the muscles or glands, which is how the body moves and functions.
- Interneurones send and receive information from sensory, motor or other interneurones. They form a link between the sensory and motor neurones.
how do neurones send messages?
The brain and nervous system work by sending messages around the body, from one neurone to another. These messages, called ‘nerve impulses’ or ‘action potentials’, are received by one neurone and carried along its length to its end. Once the message gets to the end of one neurone, it passes to the next neurone, or to another cell in the body.

Looking more closely at how neurones communicate, involves a lot of different things happening. To make this simpler, we can break this communication down into two stages. The first stage is how messages are carried along a neurone, and the second stage is how messages are passed from one neurone to another.

Ions are chemicals found in the human body, which have an electrical charge. Although there are lots of different ions in the body, the important ones when looking at how neurones work are sodium, potassium, and calcium. These ions all have an electrical charge that is positive. Some ions, such as chloride, have an electrical charge that is negative.

ions and the neurone
Messages are sent around the body as action potentials carried along the neurones. The action potential usually starts at the axon hillock and then moves down the axon, like a message moving along a telephone wire. This movement happens due to changes in the balance of electrical charge inside and outside the cell, at points along the axon.

The amount of electrical charge at any point along the axon depends on the amount of ions inside and outside the cell. Ions can pass through the cell membrane, and into or out of the cell, through ion channels (like gateways). The cell membrane controls what ions can pass through at any time by opening and closing the channels.

stage 1 – how messages are carried along a neurone
The amount of electrical charge of a cell also depends on how easily ions can flow over the cell membrane. Because of their electrical charge, ions try to balance themselves inside and outside the cell. But some ions can pass through the cell membrane more easily than others, and so they do not become balanced.

Action potentials are events that cause the cell membrane of the neurone to depolarize and repolarize. This is because they change the amount of ions inside and outside the cell, which then change the electrical charge of the cell. This is how messages travel along a neurone.

The ‘resting potential’
The ‘resting potential’ is the normal electrical state of a neurone when no message is being sent or received. In this state the neurone is polarised or ‘electrically charged’. The inside of the cell is negatively charged and the outside of the cell is positively charged. In this state there are more sodium ions outside the cell than inside it, and more potassium ions inside the cell than outside it.

The ‘action potential’
The action potential is the message that is carried along, like an electrical wave, down the neurones axon to its end.

When a message is received by a resting neurone, the cell responds by moving ions through the cell membrane. This happens at the point on the axon where the message was received, which becomes ‘depolarized’, and sets up the action potential.

Depolarization happens because sodium ion channels in the cell membrane open and allow sodium ions to flow into the cell from outside it. Sodium ions are positively charged and because they flow into the cell, the inside of the cell becomes more positive. Depolarization only lasts for a very short time because the sodium ion channels soon start to close.

Just before the sodium ion channels close, channels that allow potassium to flow out of the cell start to open. Potassium ions are also positively charged and as they flow out of the cell, the amount of positive ions left inside the cell gets lower. This causes the cell to become ‘repolarized’ – the cell briefly goes through a stage of being inactive and then goes back to its resting potential.

This sequence of changes (from resting potential to action potential and depolarized to repolarized) happens at a series of points along the axon, one point passing the message to the next, which is how the message spreads along the axon.
stage 2 – how messages are passed from one neurone to another

Where two neurones connect is called a synapse. When the action potential gets to the end of the axon (called the synaptic terminal) it has to cross to the next neurone. Synapses usually occur between the synaptic terminal of one neurone, sending the message, and the dendrites of the next neurone, receiving the message.

types of synapses

Synapses can be either electrical or chemical.

- In electrical synapses the membranes of the two neurones touch and the ions can pass directly from one cell to another. This means that the electrical message is sent quickly. This is like taking the channel tunnel, where you get on the train and it goes straight to France without stopping.

- In chemical synapses, the two cells are separated by a ‘synaptic gap’. Messages are slower than at electrical synapses, because the electrical message is turned into a chemical message – a neurotransmitter. The neurotransmitter travels across the synaptic gap to the next neurone, where it is turned back into an electrical message. This is like taking a ferry to get to France – you stop at the port to load the ferry, the ferry leaves the dock and slowly crosses the channel (like the synaptic gap) to get to the dock in France, where you have to get off the ferry again before the rest of your journey.

how neurotransmitters help send messages

Neurotransmitters are chemicals that are stored in small sacs called ‘synaptic vesicles’ inside neurones. Neurotransmitters are released by the neurone sending the message, to help transfer this message across the synaptic gaps to the next neurone. There are many different neurotransmitters including adrenalin, histamine, acetylcholine, and serotonin.

How neurotransmitters help to send messages across a synapse can be broken down into stages.

Firstly, the message travels down to the synaptic terminal of the neurone. As the cell membrane at the synaptic terminal becomes depolarized, calcium ion channels open. This allows calcium to flow into the cell from outside it. This flow of calcium causes synaptic vesicles inside the cell to fuse with the cell membrane, and release neurotransmitters into the synaptic gap.

Secondly, the neurotransmitters flow across the synaptic gap to the dendrites of the next neurone. When the neurotransmitters reach the next neurone, they bind to receptors on the cell surface.

Each neurotransmitter has its own kind of receptor. As the neurotransmitter binds, it causes ion channels to open. As ion channels open, they affect the neurone so that the chemical message is turned into an electrical message again.

The neurotransmitter causes either an excitatory effect or an inhibitory effect, depending on the receiving cell.

excitatory and inhibitory effects

If the effect is excitatory, this means that the message received causes the receiving cell to become excited and depolarise. This causes an action potential to be set up in the receiving cell, and the message continues along the neurone.

If the effect is inhibitory, this means that the message causes the receiving cell to become hyperpolarized, which stops it becoming depolarised. If the neurone is inhibited, an action potential cannot be set up and this stops the message from continuing.

There are other things that happen in neurones when messages are sent, but this is a simplified version. Understanding how messages are sent, and how the brain functions, helps us to understand what happens when messages go wrong, and why seizures happen.

further information

Epilepsy Society information
a closer look – the brain