fact sheet

Electricity in the body

Without electrical impulses in our bodies, we couldn't read this page, stand up straight, react to pain or even have a heartbeat.

Excitable cells

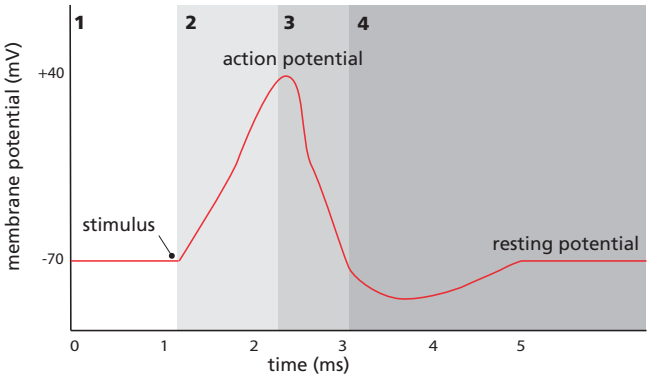
To understand these electrical impulses, we need to look at our cells.

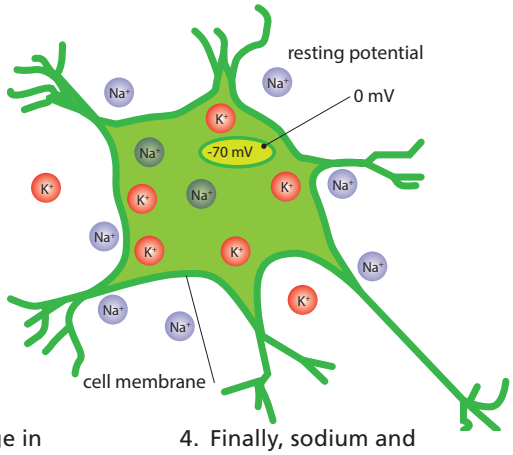
Excitable cells, such as neurons (nerve cells) and muscle cells are polarised, that is, the inside of each cell is negative with respect to the outside.

This negative potential difference is caused by an unequal distribution of ions on either side of the cell membrane.

Movement of these ions across the cell membrane generates an electrical pulse known as an action potential.

Our nervous system uses these action potentials to send signals around our body.





1. At rest, the potential inside a neuron is 70 mV less than outside the neuron. The concentration of sodium ions (Na^+) is larger outside the cell than inside, and the concentration of potassium ions (K^+) is greater inside the cell than outside.
2. A stimulus causes sodium ion channels in the cell membrane to open, which allows sodium ions to rush into the cell. The potential inside the neuron is now 40 mV more than outside.
3. This change in membrane potential prompts potassium ion channels to open, and potassium ions start to rush out of the cell. This restores the neuron to a resting potential of -70 mV.
4. Finally, sodium and potassium ions are redistributed on either side of the cell membrane by ion pumps. This is a process that requires chemical energy.

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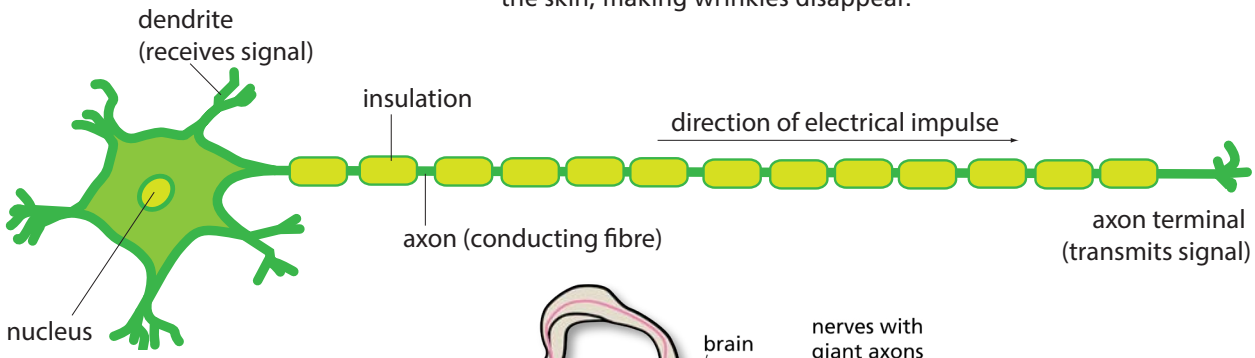
How do nerves transmit responses?

Most neurons have an axon, a long thin fibre along which the electrical impulse travels. At its terminal, an axon either connects to other neurons along which the signal continues to travel, or to muscle cells or glands where it generates a response.

An action potential sweeps along a neuron in a domino effect, as the membrane's changing electrical potential causes yet more ion channels to open in the next portion of the axon. This self-propagating nerve impulse can reach speeds of over 100 m s^{-1} (360 km h^{-1}). Conduction has to be fast as we rely on rapid processing of information to stay alive.



Message interrupted

Anything that interferes with these internal electrical signals, such as physical injury, illness or toxins can cause problems.

Epilepsy is due to a sudden burst of excess electrical activity in the brain; Alzheimer's disease gradually destroys the brain's nerve cells; while Parkinson's disease is associated with a loss of nerve cells in a certain part of the brain.

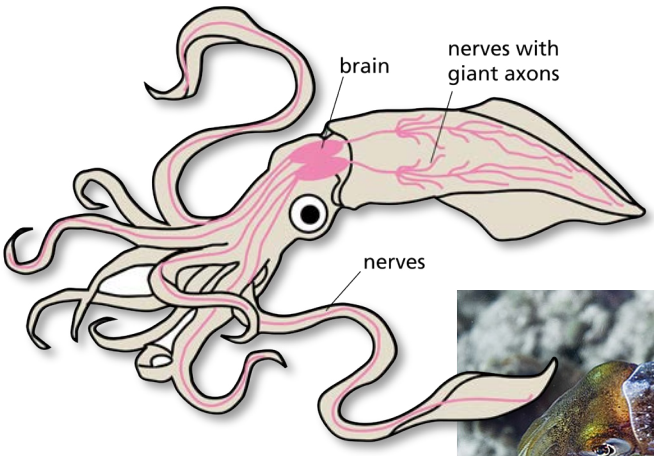
Neurotoxins are another cause of neuron malfunction by interfering with the movement of ions in cell membranes. Some snake and spider venoms are neurotoxins, for example the venom of redback spiders. In spite of this, not all neurotoxins are consistently seen as 'bad'.

Botulinum, a neuroxtoxin produced by a bacterium, is capable of paralysing a human's respiratory system. However, it is now used in the cosmetic industry under the brand name Botox® (from Botulinum Toxin Type A). It temporarily prevents muscle contraction when injected into the skin, making wrinkles disappear.

The helpful squid

It wasn't until 80 years ago that scientists were able to measure electrical activity in nerve cells, thanks to the humble squid.

Squid have a giant axon (compared to us). At 1 mm in diameter, it is just visible to the naked eye. By placing one electrode inside the axon, and a second outside, scientists could measure the voltage difference over the cell membrane as a nerve impulse swept past.



Caribbean reef squid: © Vince Matulewich, Reef Reflections, LLC, used by permission.

Redback spider by Fir0002. GFDL, commons.wikimedia.org/wiki/File:Redback_back_view.jpg

FACT FILE

- There are approximately 100 000 000 000 (100 billion) neurons in the human brain.
- Drugs such as nicotine, cocaine and marijuana interfere with normal nervous system function.
- Axons range from short (less than 1 mm) to long (over 1 m). The longest axon in your body runs from the base of your spine to your big toe.
- An action potential is an all-or-nothing process: the cell either 'fires' or, if the stimulus is too small, it doesn't.
- Most of your nervous system operates without you even being aware of it as it automatically controls your heartbeat, blood pressure, breathing and other body systems.