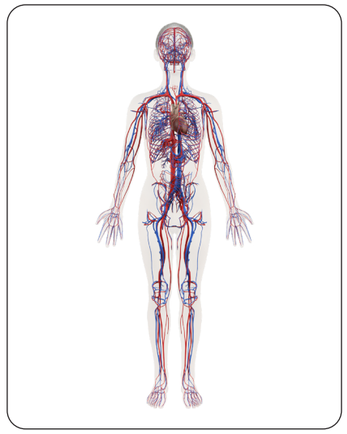
Circulatory System

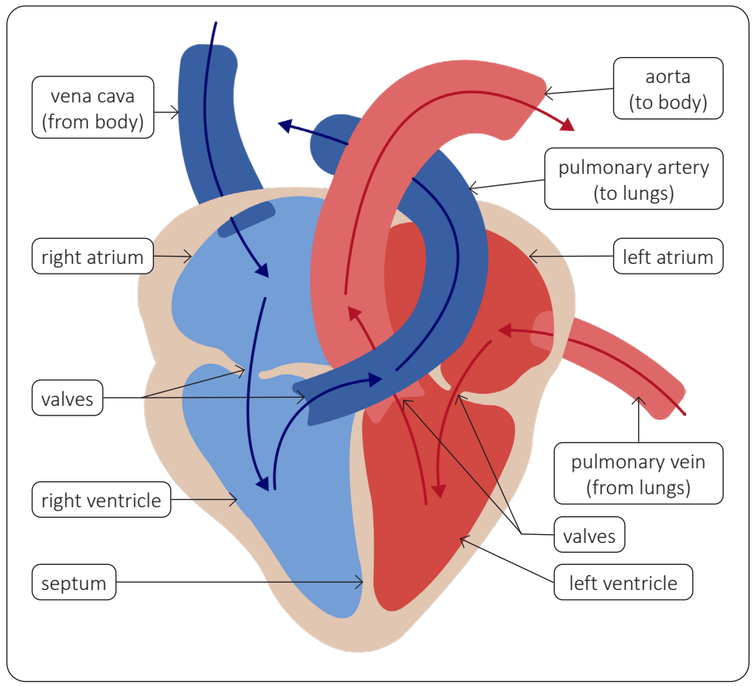
Circulatory system

The circulatory system is the system that moves blood around the body. It has three parts:

- the heart
- blood vessels
- blood



Heart



The heart is a muscular organ that acts as a pump. It pumps blood around the body through the blood vessels. Deoxygenated blood enters the right atrium through the vena cava. It passes through a valve and into the right ventricle. From there, it is pumped through a valve into the pulmonary artery. The pulmonary artery carries the blood to the lungs, where it absorbs oxygen. The pulmonary veins carry the oxygenated blood back from the lungs to the left atrium. It passes through a valve to the left ventricle and is pumped out through a valve into the aorta. Then the blood travels to the rest of the body.

Blood vessels

There are three types of blood vessels.

Arteries carry oxygenated blood from the heart to the body.

Capillaries connect arteries to the veins. They deliver oxygen and other nutrients to the body's tissues and carry deoxygenated blood and waste products to the veins.

Veins move blood back to the heart, where it is pumped to the lungs and oxygenated.

Structure of arteries

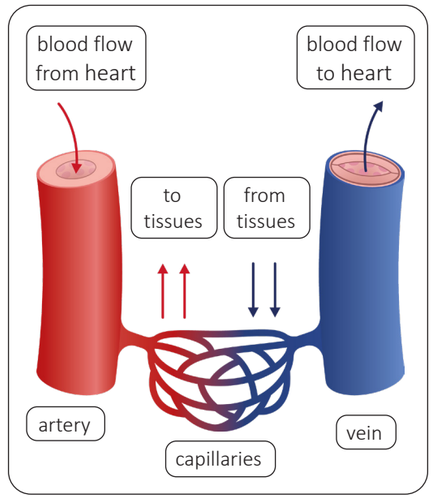
Arteries have thick walls and narrow tubes, called lumen, because the blood is under high pressure as it is pumped from the heart. The arteries are also tough and flexible to withstand this pressure.

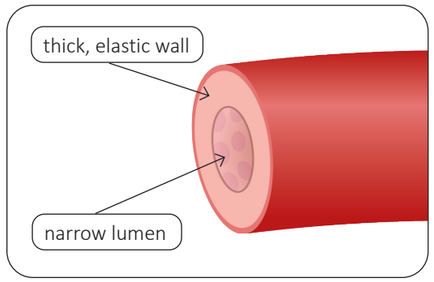
Structure of capillaries

Capillaries are tiny and have very thin walls and narrow lumen so oxygen, other nutrients and waste products can move easily between the blood and the body's tissues.

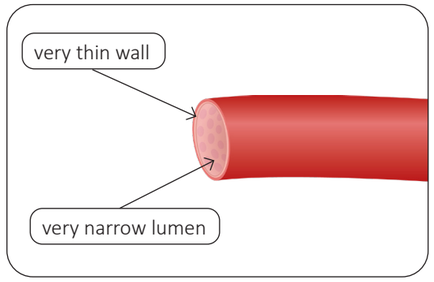
Structure of veins

Veins have thin, elastic walls and wide lumen. The walls do not need to be thick because the blood is not under high pressure. Veins contain valves that prevent the blood from flowing backwards.

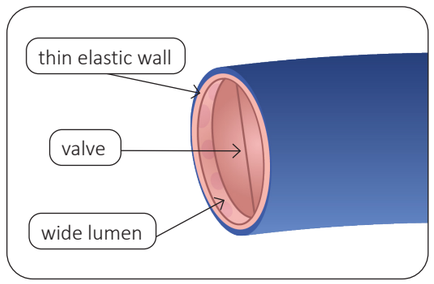




artery cross section



capillary cross section



vein cross section

Blood

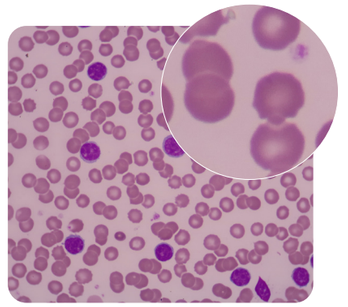
The main function of blood is to transport the things the body needs, such as oxygen, other nutrients, hormones, antibodies and heat, around the body. It also transports carbon dioxide and other waste products for excretion. Blood has four components: plasma, red blood cells, white blood cells and platelets.

Plasma

Plasma is the yellowish liquid part of blood. It makes up about 55% of blood. It carries red blood cells, white blood cells and platelets around the body. It also helps to distribute heat.

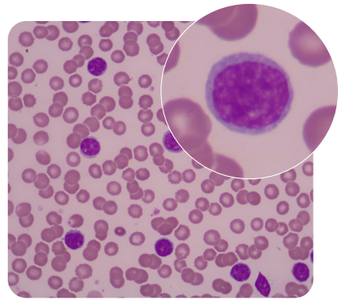
Red blood cells

Red blood cells make up about 45% of blood. Their main function is to carry oxygen from the lungs to other parts of the body and carry waste carbon dioxide from the body's tissues to the lungs so it can be excreted.



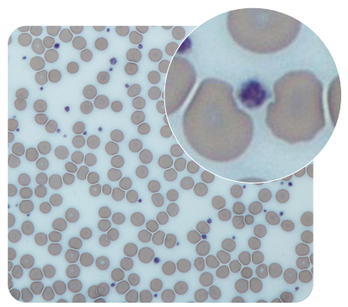
White blood cells

White blood cells only make up about 1% of blood. The main function of white blood cells is to fight infection and other diseases. They are part of the body's immune system.



Platelets

Platelets are small cell fragments that make up less than 1% of blood. Their main function is to clump together, or clot, to stop bleeding.



Pulse and heart rate

The pulse can be felt each time the arteries expand as blood is pumped through them from the heart. It is especially noticeable where the arteries are close to the skin's surface, such as at the wrist and neck.

Heart rate is measured in beats per minute (bpm). The resting heart rate is the number of times your heart beats per minute when you are at rest. Heart rate increases during exercise.

Exercise and a healthy heart

When the body exercises, it needs more oxygen and other nutrients, so the heart beats more quickly to pump more blood around the body.

Regular exercise makes the heart stronger so it can pump more blood each time it contracts. As more blood is pumped out with each beat, there is a lower resting heart rate.

Smoking, alcohol and drugs

Smoking, alcohol and drugs have many negative effects on the human body. For example, they can cause high blood pressure, heart disease, cancer, stroke, bladder problems, fertility problems and respiratory problems. They can also affect mental health, such as causing anxiety and depression.

Sugar, salt and fat

Some foods, especially processed foods, such as crisps, ready meals and sweets, are high in sugar, salt or saturated fat. Too much of any of these types of foods can have harmful effects on the body.

Sugar

Sugar is added to many foods and drinks we consume, including sweets, cakes, biscuits, chocolate and some fizzy drinks. Eating too much sugar can cause weight gain and tooth decay. It can also cause the body to retain water and raise blood pressure, which can lead to a heart attack or stroke.

Salt

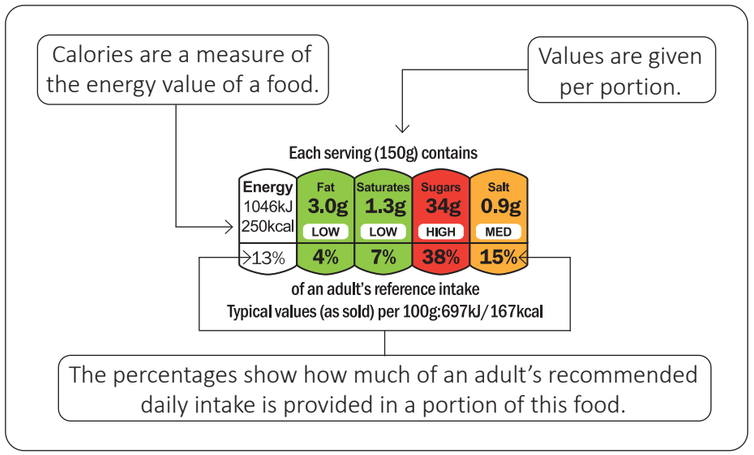
Salt occurs naturally in some foods, including meat and dairy products. It is added to others, including bread, breakfast cereals and ready meals. Too much salt can cause the body to retain water and raise blood pressure. This can lead to an increased risk of heart disease and stroke.

Fat

There are different types of fat in food, saturated fat and unsaturated fat. Saturated fat is found in butter, cheese, fatty meats and some processed foods. Too much saturated fat can cause weight gain and increase the risk of heart disease.

Nutrition labels

Nutrition labels on pre-packaged foods tell us what each food contains. Nutrition labels are often displayed using a traffic light system, so consumers can easily see whether the food has high (red), medium (orange) or low (green) amounts of sugar, salt and saturated fat. It also gives other useful information.



Glossary

antibody	A protein in the blood produced by white blood cells to fight infection and other types of disease.
excretion	The process of expelling waste.
hormone	One of many chemical messengers produced inside the body of an animal or plant that controls growth or other bodily processes.
immune system	The bodily system that offers protection from infections and other diseases.
oxygenated	Contains oxygen.
processed food	Food that has been changed during its preparation.
respiration	A process where oxygen is absorbed by the body and carbon dioxide is excreted.
valve	A structure in the body that prevents blood from flowing backwards.

Electrical Circuits and Components

Electricity

Electricity is a form of energy that makes things work. Electrical appliances with cords and plugs are powered from the mains power supply. Cordless and portable devices are powered by electrical energy stored in cells or batteries.

Components

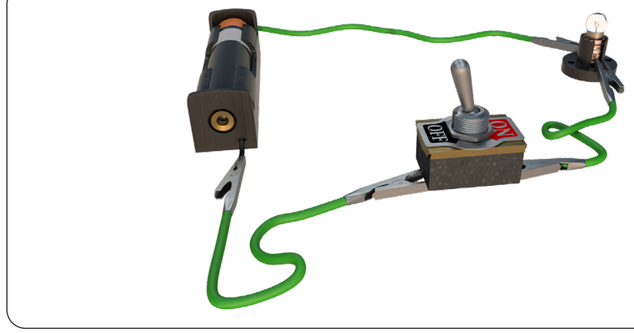
All electrical items are made up of components, which make them work.

Components have different jobs. For example, a cell provides electrical power, a buzzer creates a sound, a switch makes or breaks a circuit and a motor creates movement.

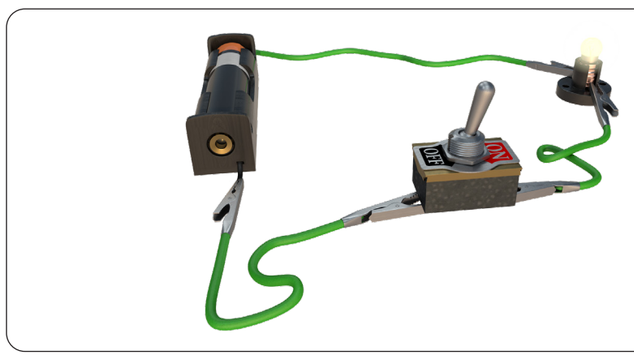
 switch	 lamp	cell	battery
 wire	 buzzer	 motor	 LED

Circuits

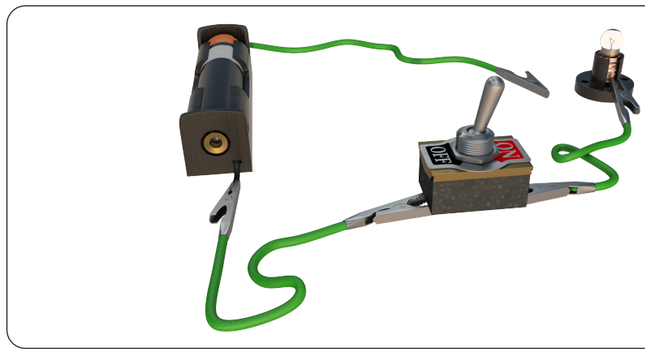
A circuit is a collection of components connected by wires through which electricity can flow. If a circuit forms a loop with a single path for the current to take, it is called a series circuit.



When electricity flows through all the components of a circuit, it is called a complete circuit.

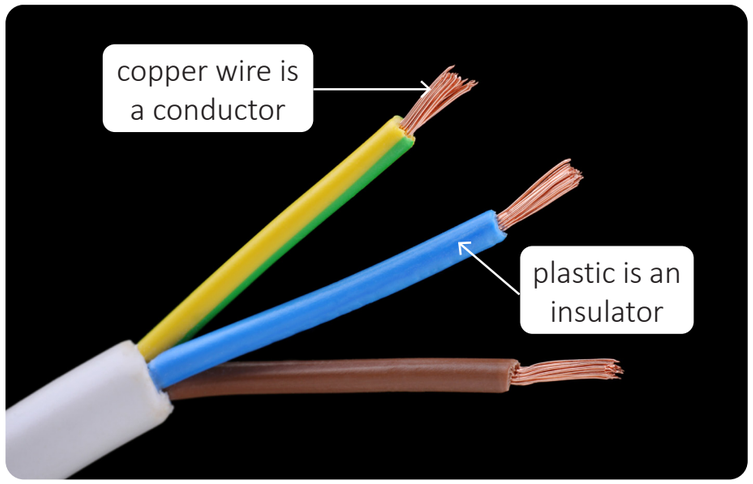


When electricity cannot flow through all the components of a circuit, it is called an incomplete circuit. Loose wires, damaged components and flat cells or batteries can all stop the flow of electricity around a circuit.



Conductors and insulators

Materials that allow electricity to flow through them are called conductors. Most metals are conductors. Materials that do not allow electricity to flow through them are called insulators.



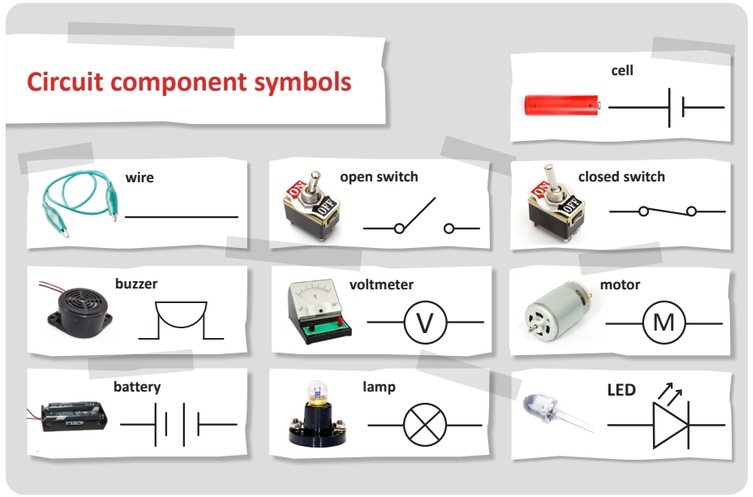
Electrical hazards

Electricity can be dangerous. If a mains electric current goes through your body, it can cause serious injuries or death.

There are many situations where electrical appliances can be dangerous. For example, overloading plug sockets can lead to fires and touching electrical appliances with wet hands can cause electric shocks. Touching damaged wires can also cause electric shocks.

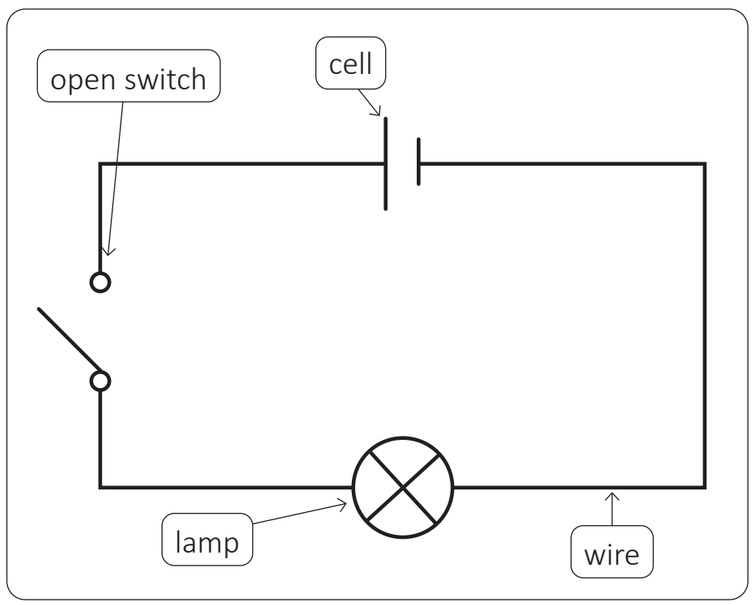
Circuit symbols

Circuit components are represented by different symbols.



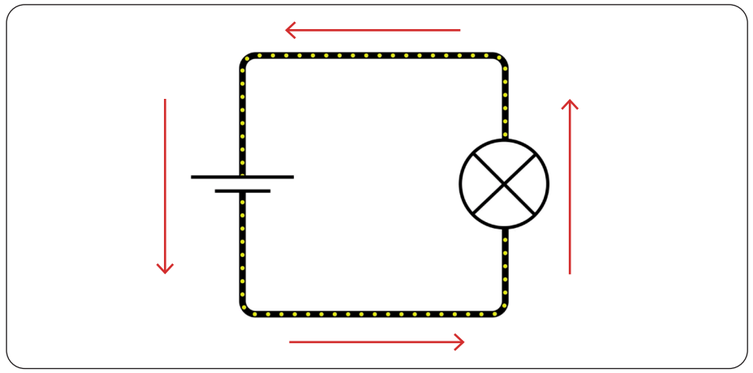
Circuit diagrams

A circuit diagram is a simplified drawing that represents a real electrical circuit. Circuit symbols are used to draw circuit diagrams.



Electric current

An electric current is the flow of electric charge through a circuit. For an electric current to flow, a circuit must be complete. The electric current flows from the cell through the components and back to the cell.



Voltage

In a circuit, the cell acts like a pump, pushing electric charge around the circuit. This pushing force can be measured using a voltmeter or multimeter. The pushing force is known as voltage, which is measured in volts (V).

Cells

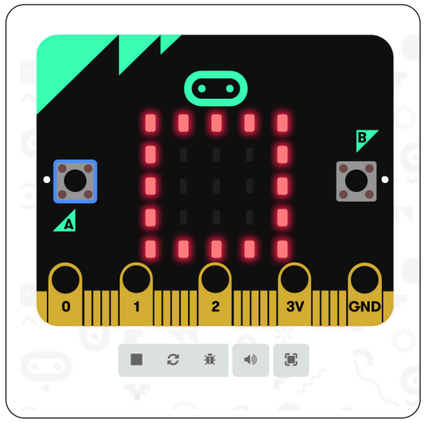
Cells have different names, such as AA, AAA and D. They are labelled with the voltage they supply to a circuit. For example, an AA cell is labelled with 1.5V. As cells are used, their voltage, or pushing force, decreases.

Sensors

Many devices, such as nightlights, burglar alarms and thermostats, use sensors to monitor environmental variables, such as light, movement or temperature. These devices are programmed to give a response by switching on or off if the environment changes. For example, some nightlights have sensors that cause them to switch off when light levels rise.

Programming micro:bits

Micro:bits are small, programmable computers with an LED display and sensors. Micro:bits can be programmed to respond to environmental variables and are used to make a wide variety of different devices.



Glossary

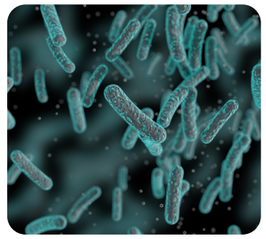
appliance	A piece of electrical equipment used in the home.
environmental variable	A feature of the environment that changes, such as temperature or light.
LED	Stands for light-emitting diode. A device that produces light when an electric current flows through it. An LED only conducts electricity in one direction.
sensor	A device that detects changes in the environment.

Image from: Shutterstock editorial/Nadya Buyanowa

Evolution and Inheritance

Classification

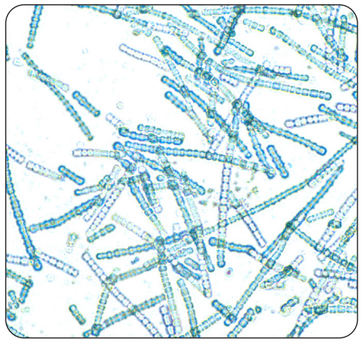
Grouping living things based on their characteristics is called classification. The first classification system developed by the Swedish scientist Carl Linnaeus (1707–1778) divided all living things into two kingdoms, animals and plants. Today, scientists classify all living things into five kingdoms. The members of each kingdom have specific features in common.

Kingdom	animal kingdom	plant kingdom	fungus kingdom	protista kingdom	monera kingdom
					
Features	• multicellular • cannot make food • can move • live on land or in water • reproduce sexually	• multicellular • make food using sunlight • cannot move • live on land or in water • reproduce sexually or asexually	• unicellular or multicellular • cannot make food • cannot move • live on land or in water • reproduce sexually or asexually	• unicellular or multicellular • some make food, others can not • most can move • live in water • reproduce sexually and asexually	• unicellular • make food • most can move • live on land or in water • reproduce asexually

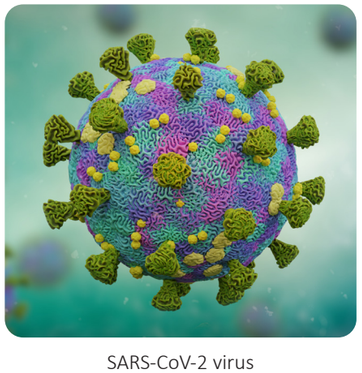
Microorganisms and viruses

A microorganism is a living thing. It is too small to be seen without a microscope. Microorganisms can be found in the fungus, protista and monera kingdoms. Most microorganisms are beneficial. For example, cyanobacteria make oxygen, and a unicellular fungus called yeast is added to bread to make it rise. Some microorganisms are pathogens, which means they cause disease in other living things.

Viruses are not microorganisms as they are not living and need a host to survive. They are not part of any of the kingdoms. Some viruses can be beneficial and others harmful. For example, the virus SARS-CoV-2 causes the illness COVID-19.



cyanobacteria



SARS-CoV-2 virus

Fossils and the fossil record

Fossils are the remains of once-living things or traces of life, such as footprints, tracks, dung or burrows, that have been preserved as rock. Preserved remains and traces of life are called fossils if they are over 10,000 years old.

The fossil record was created by scientists to group and make sense of the vast amount of fossils that have been discovered. It is ordered from the oldest fossils found deepest in the ground to the newest fossils found closest to the surface. It provides a history of the Earth.

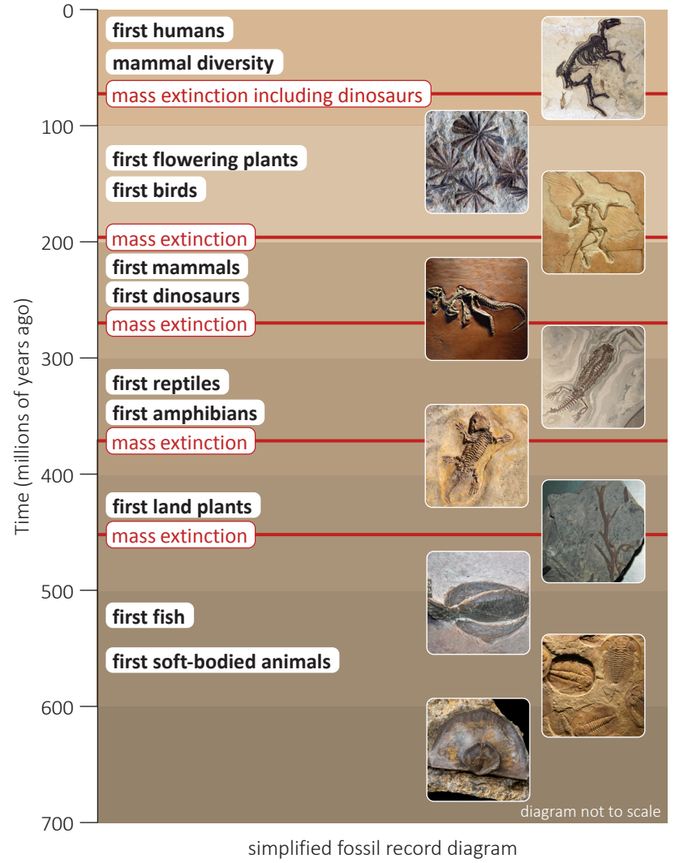
The fossil record tells us about:

- the living things that have inhabited Earth
- the Earth's environment over time
- how species have evolved
- extinction events

However, the fossil record is incomplete because soft-bodied animals decayed too quickly to be fossilised and fossils are still buried in the Earth's rocky layers.

fossilised turtle

fossilised footprint



simplified fossil record diagram

Images from: Wikimedia Commons/Public domain

The theory of evolution

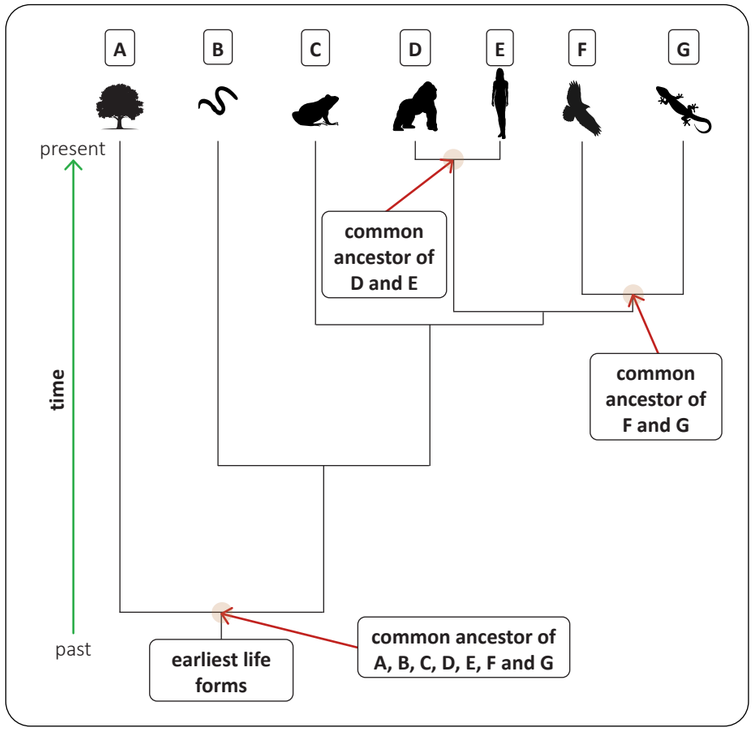
The theory of evolution was first developed by the naturalists Charles Darwin and Alfred Russel Wallace in 1858. The theory states three assumptions:

- All life on Earth has evolved from simple life forms to more complex ones over time.
- All life on Earth has common ancestors and is therefore related.
- Living things with characteristics most suited to their environment are more likely to survive and reproduce.

At first, the theory was controversial. Some saw it as an explanation for the variety of species on Earth, but others saw it as blasphemous as it challenged the Christian belief that God created the Earth and all living things. Today, the fossil record and DNA evidence support the theory of evolution.

Evolutionary tree diagrams

Charles Darwin sketched a branching tree diagram to help explain the theory of evolution. Evolutionary tree diagrams today represent what scientists think they know about the evolutionary relationships between different living things; however, they are not fact. Those living things with a more recent common ancestor, such as D and E, are said to be more closely related than those with a less recent common ancestor, such as F and G.



Simplified evolutionary tree diagram

Inheritance

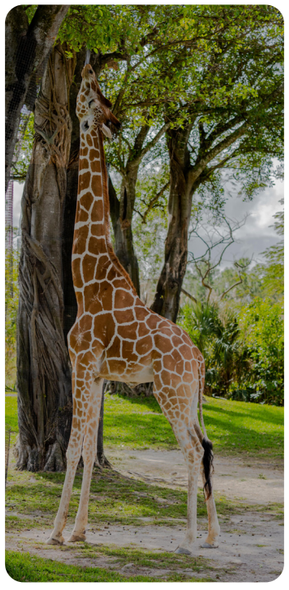
Living things that sexually reproduce pass on inherited characteristics to their offspring, such as skin colour and eye colour. Offspring inherit one copy of each gene from the female parent and one from the male parent. This mixing of genes means that offspring are unique, differing from their parents and each other.

Variation

Variation is the natural differences in characteristics between individuals of the same species. There are two types of variation: continuous and discontinuous. Continuous variation has a range of values, such as the height or mass of individuals of the same species. Line graphs display continuous variation. Discontinuous variation has a specific number of outcomes, such as eye colour or blood groups. Bar charts show discontinuous variation.

Natural selection, adaptation and survival of the fittest

Natural selection is the process behind the theory of evolution. Variation within a species is caused by small, natural changes in DNA between individuals and the random mixing of parent DNA following sexual reproduction. If a variation positively affects a living thing's ability to survive, they are more likely to live long enough to reproduce and pass on the attribute to their offspring. This process naturally selects those individuals who are better able to survive in their habitat, and is known as 'survival of the fittest.' Over time, positive attributes become common among a species and are seen as adaptations. For example, ancestors of the giraffe had shorter necks, but due to variation and natural selection, individuals with longer necks became common in the species.



There are three different types of plant adaptation:

Structural: Cacti have modified leaves called spines to deter animals from eating them.

Behavioural: Mature sunflowers face the rising Sun in the east because pollinators prefer warm flowers.

Chemical: Stinging nettles have hairs containing chemicals that sting when touched to deter animals.

Artificial selection

Artificial selection, also called selective breeding, is the process where humans breed animals and plants to produce offspring with what they consider to be desirable characteristics.

Examples include breeding cows that produce large quantities of milk or crops that are disease-resistant and produce lots of grain.

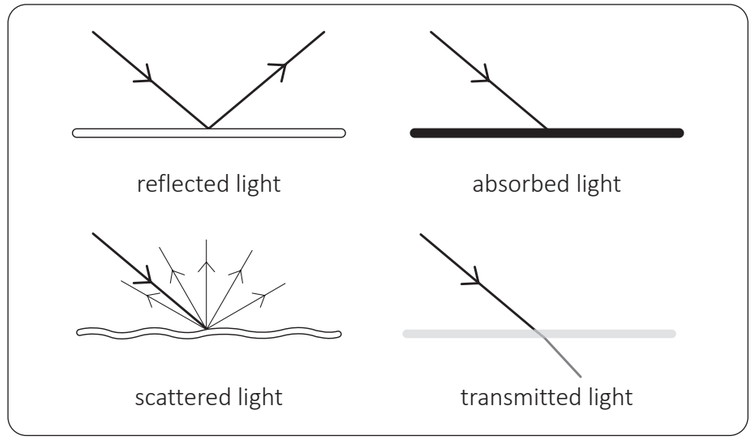
Glossary

adaptation	A physical or behavioural characteristic that allows a living thing to better survive in its habitat.
ancestor	A living thing from which others have evolved.
deoxyribonucleic acid or DNA	The inherited material inside all cells that carries the instructions needed for that living thing to develop and survive.
evolve	To change gradually over a long period of time.
gene	A small section of DNA that acts as instructions for a specific inherited characteristic, such as eye colour.
multicellular	Consisting of many cells.
species	A group of similar living things that can reproduce naturally.
unicellular	Consisting of a single cell.

Light Theory

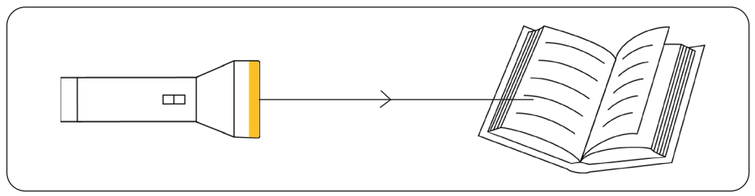
Light sources

A light source is something that produces light. This can be a natural source, such as the Sun or a glow-worm, or an artificial source, such as a light bulb or candle. Most objects do not produce light. Instead, they either reflect, absorb or scatter the light given out by a light source. Light can also travel through transparent objects.

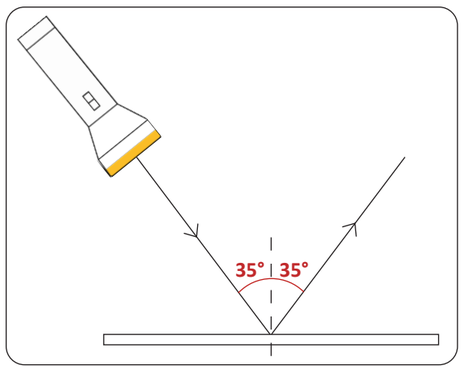


How does light travel?

Light is a form of energy that travels as waves in straight lines. In diagrams, light waves are drawn as straight lines with arrowheads that show the direction of travel.

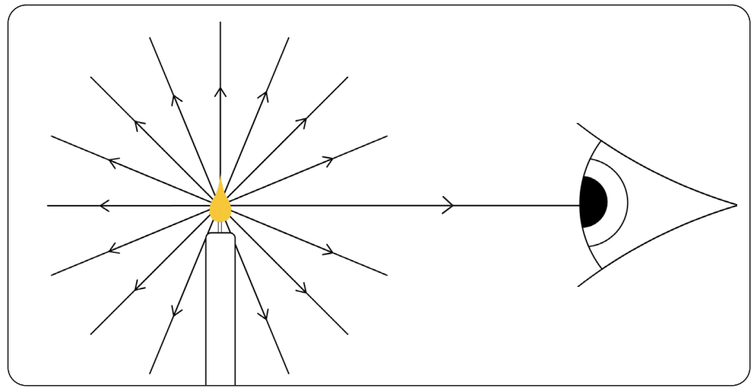


Light continues to travel when it is reflected off the surface of an object. When light hits a mirror, it reflects off the surface in a straight line. All mirrors reflect light at an angle equal to the angle of impact.

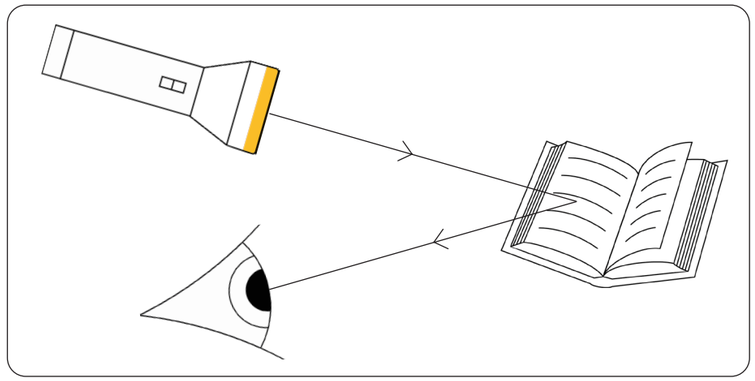


Light and sight

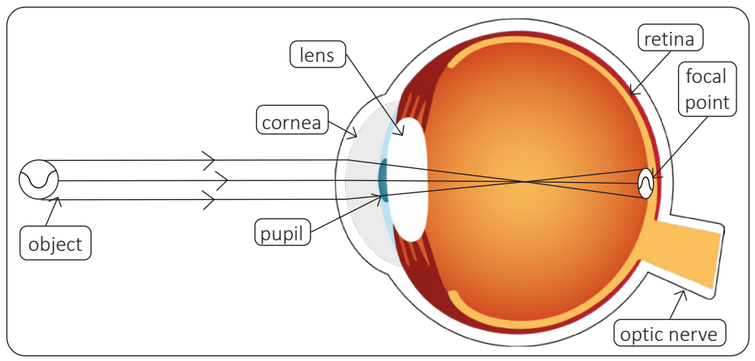
For us to see any object, light must enter our eyes. Light rays can travel to our eyes directly from a light source, so we can see the light source.



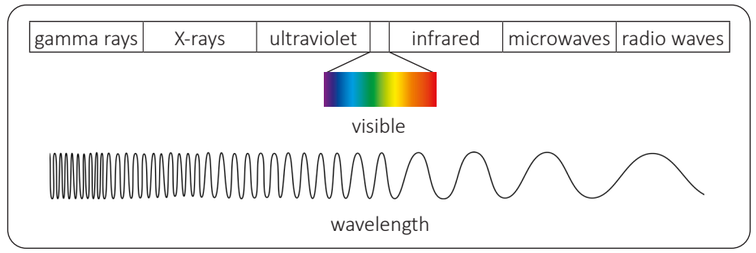
Light can also travel to our eyes after it has been scattered or reflected. In this diagram, light from the torch travels to the book and is then reflected from the book into the person's eye.



Light rays reach the eye and travel through the cornea before entering the eye through the pupil. The lens focuses the light onto the back of the eye, called the retina. The retina turns this light information into electrical signals, which travel through the optic nerve to the brain, where the signals are 'seen' as an image. Without light, we cannot see.



Electromagnetic spectrum



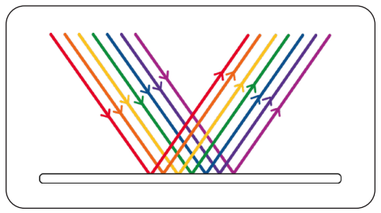
The electromagnetic spectrum shows all the different types of light, from gamma rays with waves that are close together, to radio waves with waves that are far apart. Visible, or white light is the only light the human eye can see and is only a small part of the electromagnetic spectrum.

Visible light

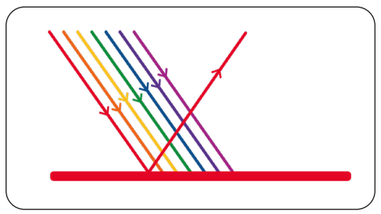
Visible light is made up of a continuous spectrum of different colours of light, from violet to red. All the colours of light mix together to create white light.

The way objects reflect or absorb light determines their colour.

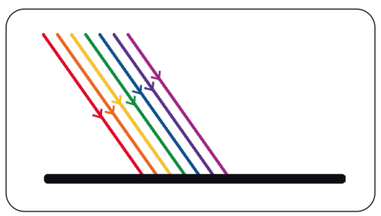
Some objects reflect all the colours of light, so we see those as white.



Other objects absorb some of the colours in white light, but some colours are reflected. We see these objects as the coloured light that is reflected.

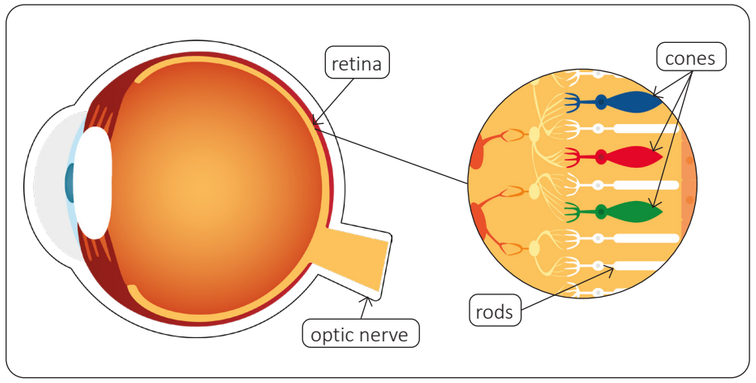


Black objects absorb all the colours of white light.

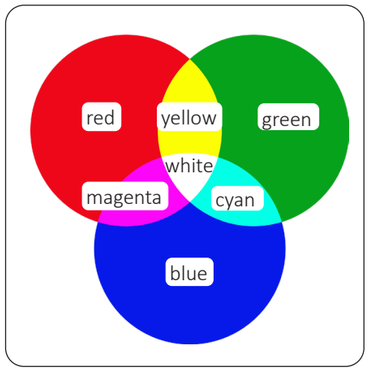


Perceiving colour

Light enters our eyes through the pupil and is focused onto light-sensitive cells called rods and cones that cover the retina at the back of the eye. Rods help us to see light and dark and cones help us to see different colours. Once the cone cells have been stimulated, a signal is sent to the brain through the optic nerve. The brain interprets the signal as a particular colour, giving us colour vision.



Red, green and blue are the primary colours of light. When the red and green cones in our eyes are stimulated, we perceive a yellow colour. When the blue and green cones are stimulated, we perceive a cyan colour. When the red and blue cones are stimulated, we perceive a magenta colour. If the red, green and blue cones are all stimulated, we see white.



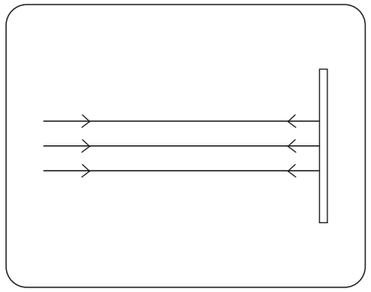
Shadows

Shadows form when an object blocks the passage of light, leaving an area of darkness. The size and length of an object's shadow can vary depending on the position of the light source.

Reflection in different mirrors

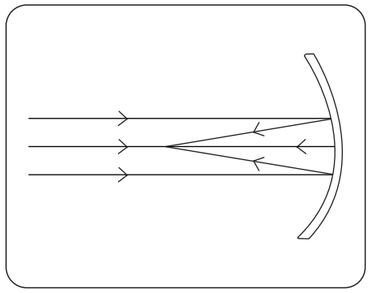
There are three main types of mirror: plane, concave and convex.

A plane mirror has a flat reflective surface, so perpendicular light rays are reflected back along the same path. This means the reflected image is the same size and the same way up as the object, but the image is reversed.



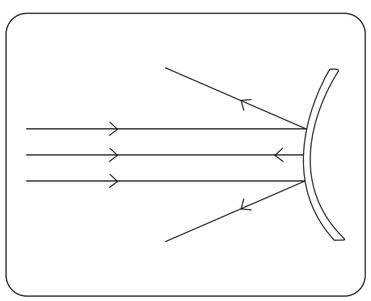
plane mirror

The surface of a concave mirror curves inwards, so light rays are reflected inwards to a focal point. Images appear larger and brighter in a concave mirror, but they reflect a narrower view. Dental mirrors and torches use concave mirrors.



concave mirror

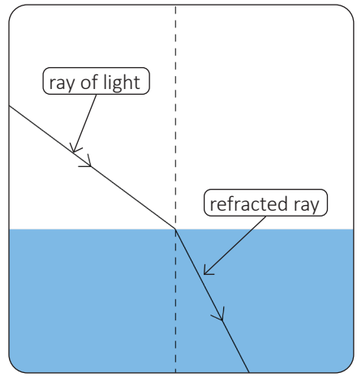
The surface of a convex mirror curves outwards, so light rays are reflected outwards and dispersed. Convex mirrors make images smaller, but they reflect a wider view. Shop security mirrors and car wing mirrors are convex.



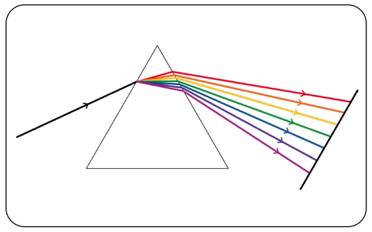
convex mirror

Refraction

Refraction is the change in direction of light as it passes from one transparent material to another. This diagram shows a light ray travelling in a straight line through the air, then hitting the surface of the water. Water is denser than air because water is a liquid and air is a gas, so the light slows down and changes direction.



When white light travels through a triangular prism, light is refracted twice. This, along with the prism's angled edges, splits white light into a spectrum of colours from red to violet.



Refraction creates different phenomena on Earth. For example, light refracted by raindrops creates a rainbow. Light refracted by a glass of water can make a straw look bent or disjointed.

Glossary

absorb	The ability to soak something up, such as a liquid or light.
reflect	To bounce off a surface.
scatter	To move apart in different directions.
spectrum	A band of colours produced when white light is separated.
visible light	The part of the electromagnetic spectrum that the human eye can see, also known as white light.