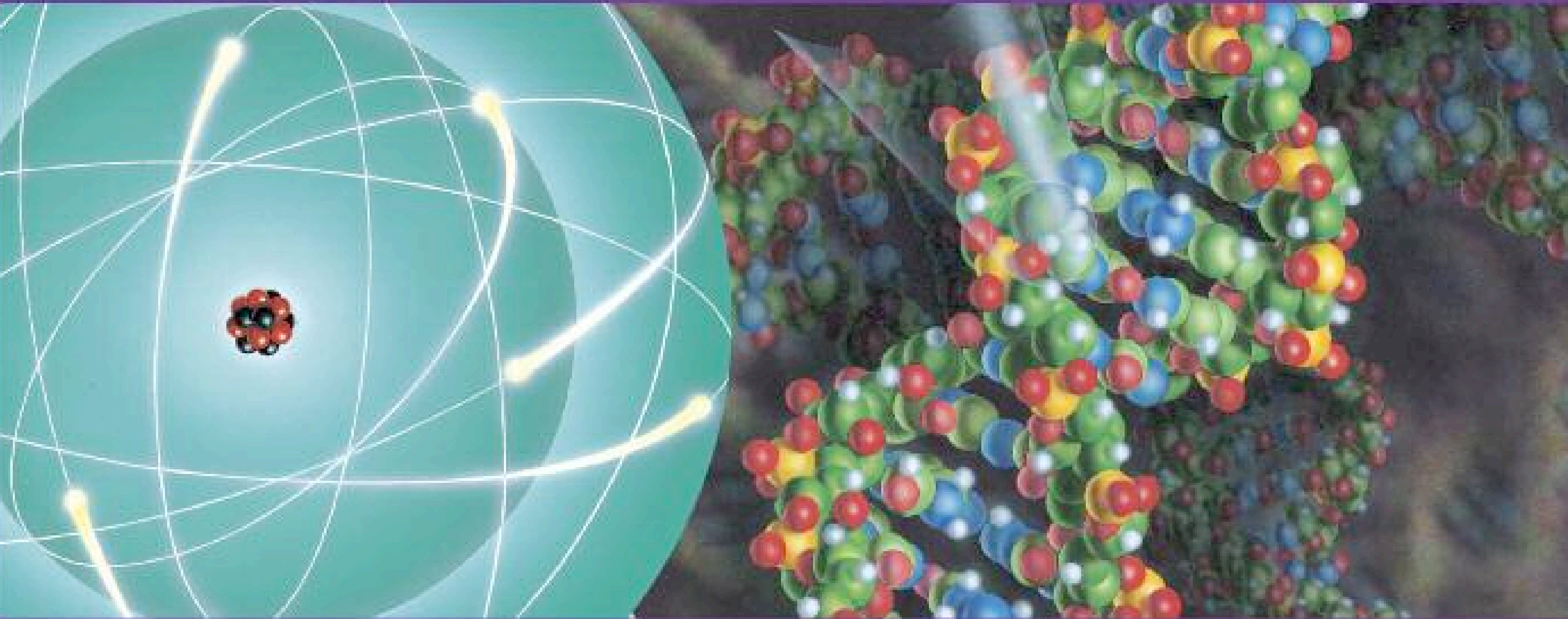
ILLUSTRATED ENCYCLOPEDIA

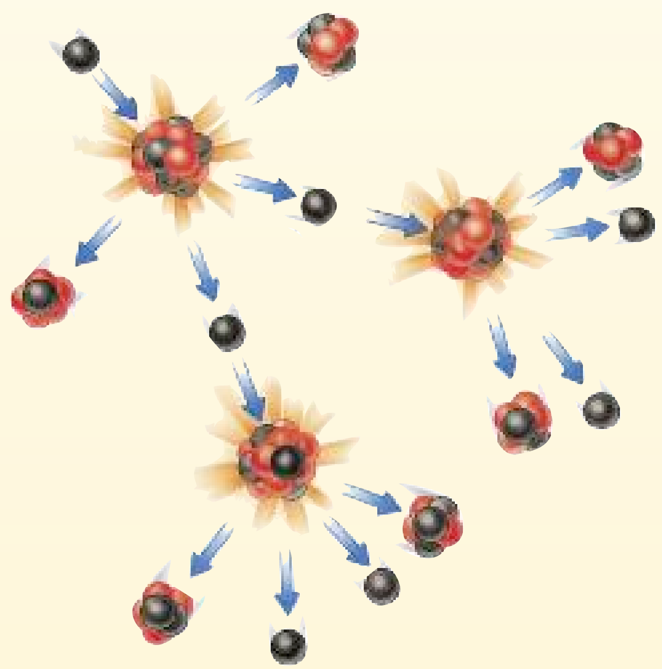


SCIENCE

More than 200 keywords

ILLUSTRATED ENCYCLOPEDIA

SCIENCE



First published in 2012 by Orpheus Books Ltd.,
6 Church Green, Witney, Oxfordshire, OX28 4AW, England
www.orpheusbooks.com

Created and produced by Nicholas Harris, Sarah Hartley,
Katie Sexton, Ruth Symons and Erica Williams, Orpheus Books Ltd.

Text Ruth Symons

Illustrated by Susanna Addario, Chris Chapman, Elisabetta Ferrero,
Guiliano Fornari, Mike Fuller, Andrea Ricciardi di Gaudesi, Gary Hincks,
Stewart Lees,Shane Marsh, Lee Montgomery, Steve Noon, Sebastian Quigley,
Alessandro Rabatti, Eric Robson, Claudia Saraceni, Roger Stewart,
Thomas Trojer, Mark Wilkinson, Martin Woodward and David Wright

Consultant David Hawksett, astronomer, writer and broadcaster

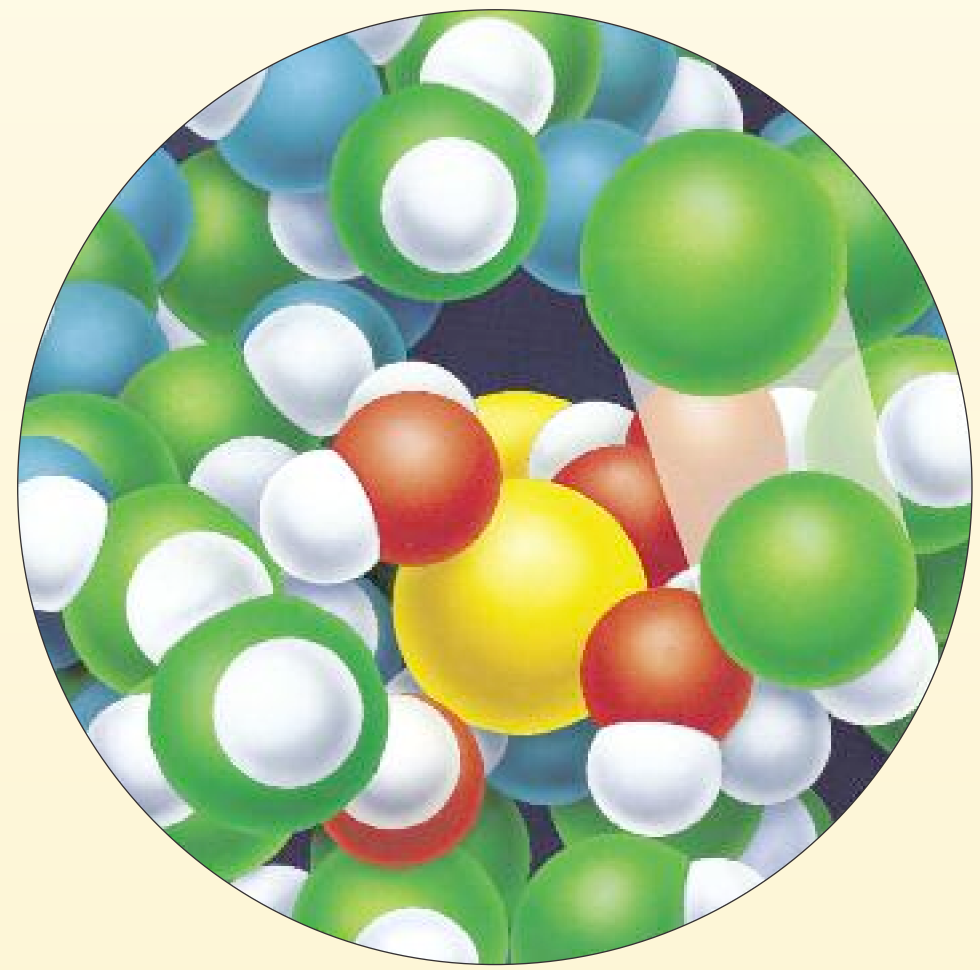
ISBN 978 1 7418 3760 1

Printed and bound in Singapore

Photographs on pages 9, 25, 27 and 29: Science Photo Library
Photograph on page 11: Wikimedia Commons/Public Domain
Photograph of scientist on page 14: Copyright ©2010 Alexander Raths
Used under licence from Shutterstock.com
Photograph of windmill on page 19: Copyright ©2010 T.W. van Urk
Used under licence from Shutterstock.com

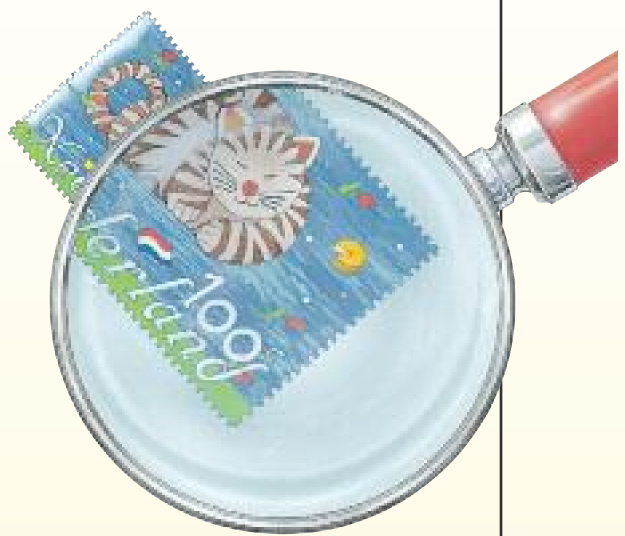
ILLUSTRATED ENCYCLOPEDIA

SCIENCE

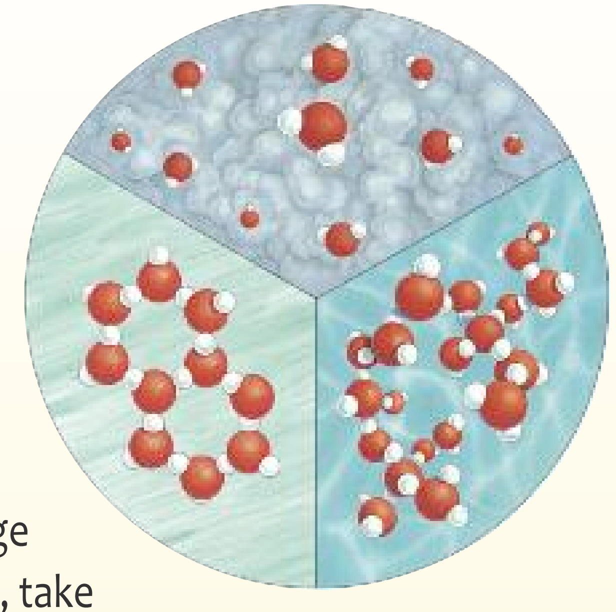


Orpheus

Contents



About this book



Each double page contains a brief introduction, explaining the general subject, followed by key words arranged in alphabetical order. To look up a specific word, turn to the index at the back of this book: this will tell you which page to go to. If you want to learn more about a subject, take a look at the factfile, or follow the arrows to read related entries.

INTRODUCTION
This explains the general subject and provides some basic knowledge.

KEY WORDS AND ENTRIES
Key words are arranged alphabetically across each double page. Each entry provides a short explanation of what the key word means.

FACTFILE
The factfile provides extra information on the subject. Facts are presented in easy-to-read bullet points.

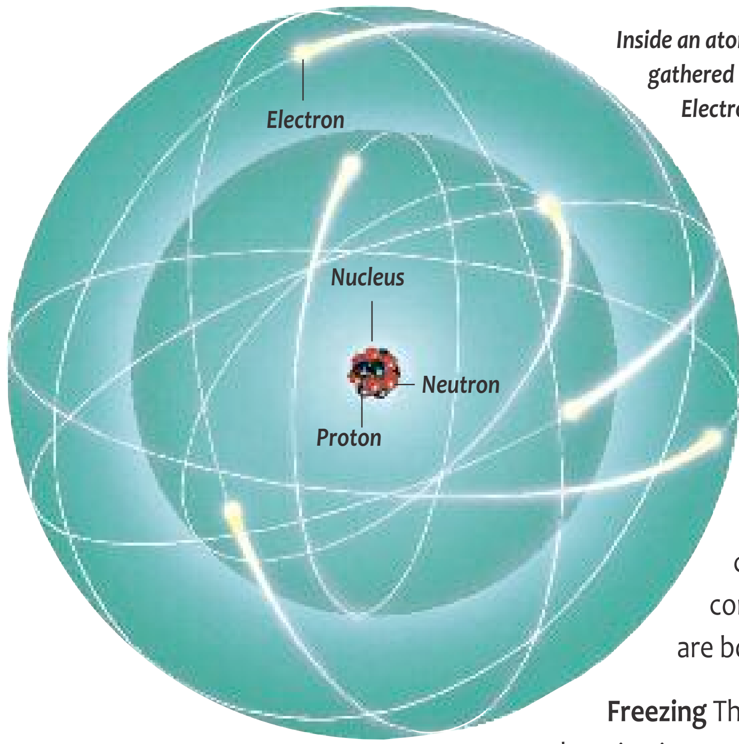
ARROWS
These arrows show you where to look up other words mentioned in the entry. For example, (➡26) tells you to go forward to page 26 and (⬅6) tells you to turn back to page 6.

BOLD WORDS
These highlight useful words that do not have their own entry.

PAGE NUMBER
Page numbers are easy to find at the side of the page.

MATTER

Every thing around us, living creatures, lumps of rock, or even invisible gases, is made up of matter. Matter exists in three main forms, or states. These are: solid, liquid and gas. All matter is made up of tiny building blocks called atoms. They are far too small for us to see and are themselves made up of even tinier parts called subatomic particles.



Inside an atom. Protons and neutrons are gathered in the atom's nucleus. Electrons circle the nucleus.

Atom A basic building block of matter. Atoms are not solid but are mostly made up of empty space. At the centre of the atom, the subatomic particles protons and neutrons are clumped together to form the nucleus. Surrounding this are smaller electrons, which move at speed around the nucleus.

Atomic number The number of protons found in the nucleus of an atom.

Condensing The process of a gas changing into a liquid. Condensation occurs when a gas cools down or is subject to an increase in pressure (➡17).

Density A measure of how compact something is. An object is denser than another if its atoms are more tightly packed together.

Electron A subatomic particle that circles the nucleus of an atom. Electrons do not move at random, but stay in layers known as shells. Electrons have a negative electrical charge (➡26), while protons carry a positive charge. Positive and negative charges attract each other, so the atom is held together.

Evaporation The process of a liquid changing into a gas. Evaporation occurs when a liquid heats up or experiences a drop in pressure (➡17).

Fluid A substance that has no fixed shape but changes shape to fill its container. Liquids and gases are both fluids.

Freezing The process of a liquid changing into a solid. Freezing occurs when a liquid cools down or is subject to an increase in pressure (➡17).

Gas A state of matter in which molecules are separate from each other and can move about freely. This is why gases have no fixed shape and can expand or contract depending on the size of their container.

Liquid A state of matter in which molecules are close to each other but not fixed rigidly together. The molecules can move about to fill the bottom of their container. Liquids can be easily poured.

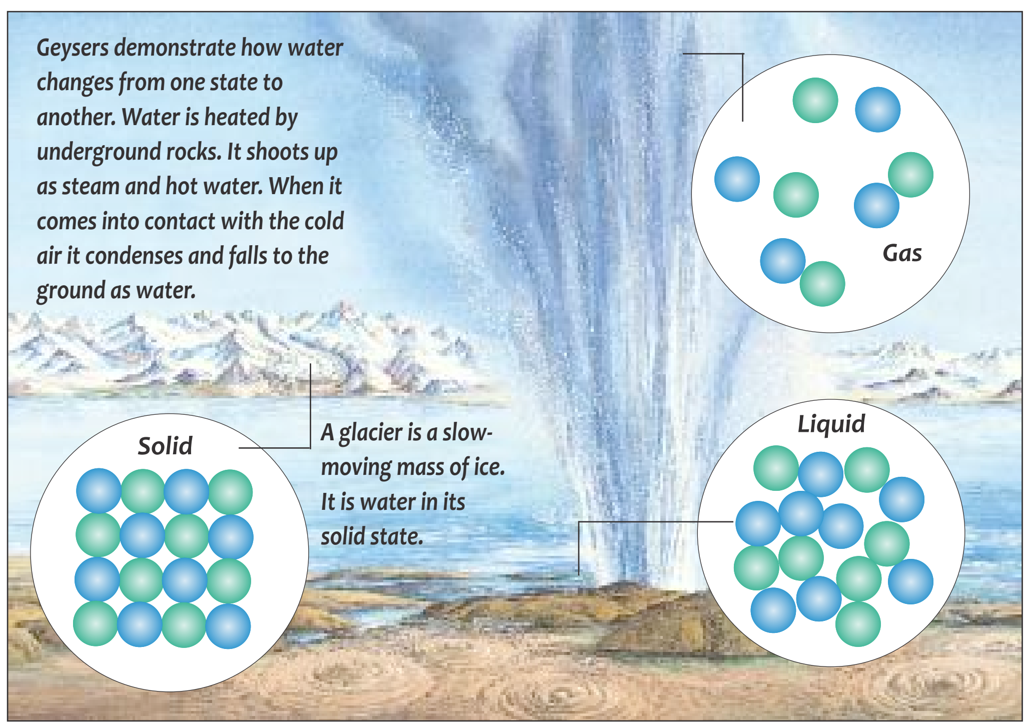
Mass The amount of matter in an object.

Melting The process of a solid changing into a liquid. Melting occurs when a solid heats up and reaches its "melting point".

Molecule The smallest part of a substance that can exist by itself and still possess its chemical properties. A molecule consists of atoms, either of the same type, or a combination of different types of atom bonded together with molecular bonds.

Neutron A subatomic particle found in the nucleus of an atom. Neutrons have no electrical charge (➡26).

Nucleus The centre of an atom, made up of protons and neutrons.



Geysers demonstrate how water changes from one state to another. Water is heated by underground rocks. It shoots up as steam and hot water. When it comes into contact with the cold air it condenses and falls to the ground as water.

A glacier is a slow-moving mass of ice. It is water in its solid state.

The air inside a hot air balloon is less dense than the cooler air outside, making it buoyant.

Plasma A state of matter rare on Earth, found at very high temperatures. For example, plasma is found inside most stars, including our local star, the Sun. A gas becomes a plasma when it is so hot that its atoms collide with each other. The force of the collisions knocks electrons loose from some atoms, so that the gas becomes electrically charged (➡26).

Properties of matter The characteristics of a substance. **Chemical properties** relate to the structure of atoms in a substance. **Physical properties** are characteristics that can be easily observed, such as weight, shape, density and colour.

Proton A subatomic particle found in the nucleus of an atom. Protons have a positive electrical charge (➡26).

Radioactivity Particles or rays of energy given off by unstable atoms, for example, uranium. An unstable atom is one that is likely to give off one of its subatomic particles.

Solid A state of matter in which molecules are tightly packed together in a rigid pattern. This gives solids a fixed shape.

States of matter The three main forms in which matter exists. These are: solid, liquid and gas. A change of state is caused by a change in temperature or pressure (➡17).

Subatomic particles The tiny parts that make up an atom. They include electrons, neutrons and protons.

Sublimation The process of a solid turning straight into a gas without first becoming a liquid.

Vacuum A place where there is a complete absence of matter.

Viscosity A measure of how thick a liquid is. For example, honey is thicker and more viscous than water.

Volume The amount of space taken up by an object.

FACTFILE

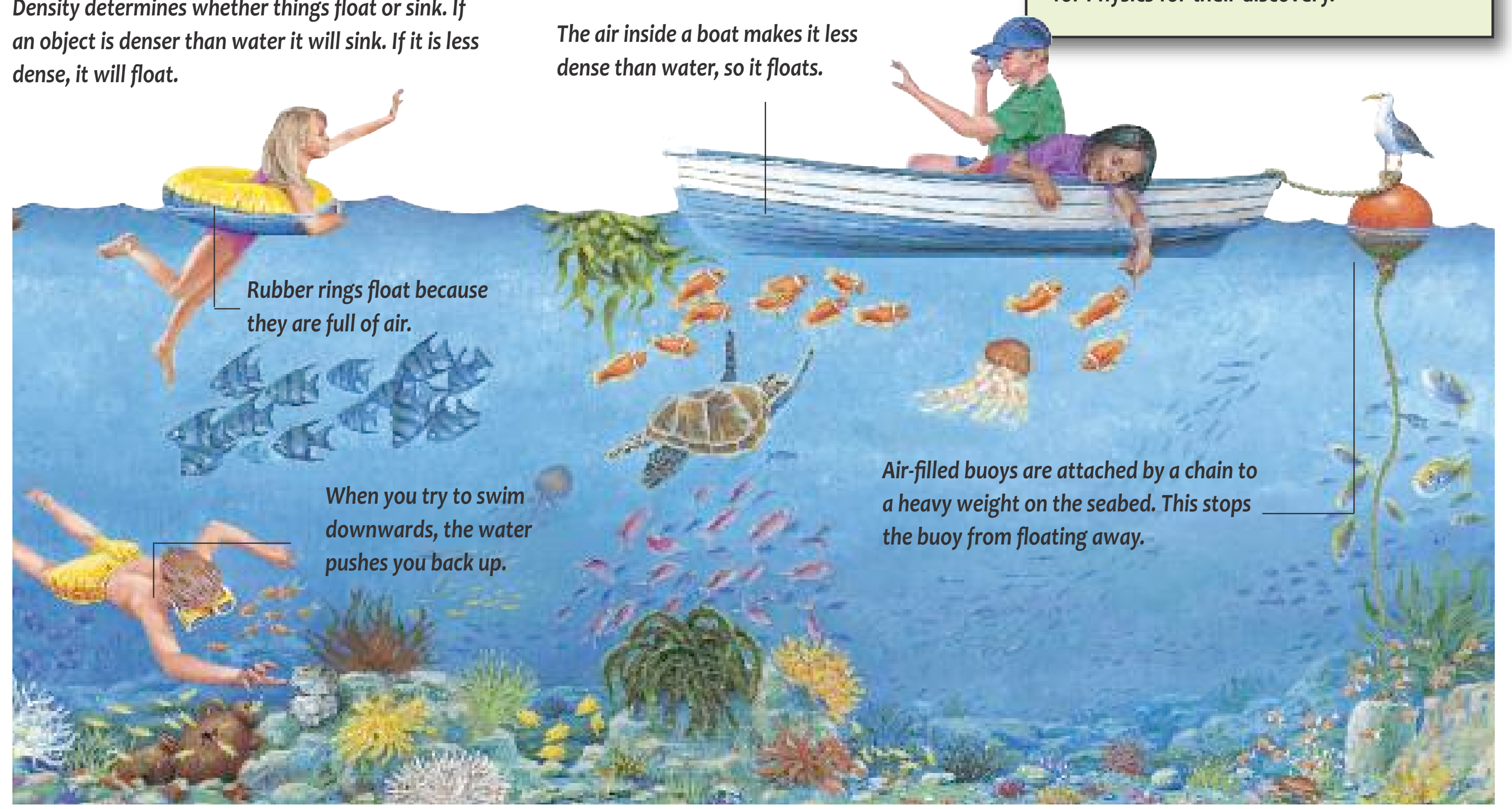
★ A pinhead contains about one billion billion atoms.

★ The Greek philosopher Democritus (460-400 BC) was the first person to suggest that matter was made up of tiny particles.

★ The nucleus of a hydrogen atom is 100,000 times smaller than the whole atom. If the nucleus was a golf ball in the centre of a stadium, the edge of the atom would be the stadium's outer wall.

★ Radioactivity was discovered by French physicist Henri Becquerel in 1896 and named by Polish-born scientist Marie Curie. In 1903, Becquerel, Curie and Curie's husband Pierre all won the Nobel Prize for Physics for their discovery.

Marie Curie



Density determines whether things float or sink. If an object is denser than water it will sink. If it is less dense, it will float.

The air inside a boat makes it less dense than water, so it floats.

Rubber rings float because they are full of air.

When you try to swim downwards, the water pushes you back up.

Air-filled buoys are attached by a chain to a heavy weight on the seabed. This stops the buoy from floating away.

ELEMENTS & COMPOUNDS

An element is a substance made up of atoms (➧ 6) of the same type. It cannot be broken down into simpler substances. Different elements have different characteristics, which are determined by the number of subatomic particles (➧ 7) they have. There are 94 natural elements known to us. These are divided into metals (➧12) and non-metals. If atoms of one element join with atoms of another element, they form a new substance. This process is called a chemical reaction (➧14). The substance created is called a compound.

Adhesion The force of attraction between the atoms of two different elements or compounds.

Allotrope Different forms of the same element. For example, diamond and graphite are both allotropes of the element carbon.

Bond A link between atoms.

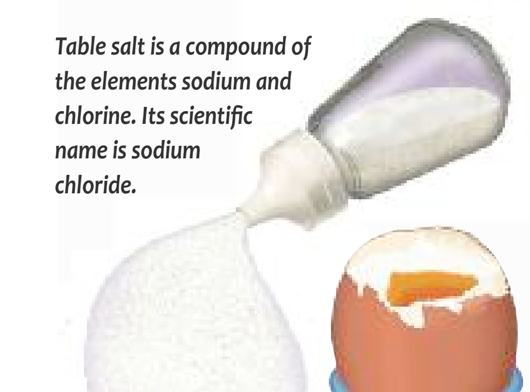
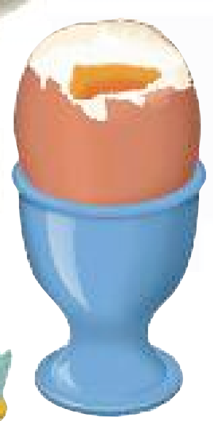
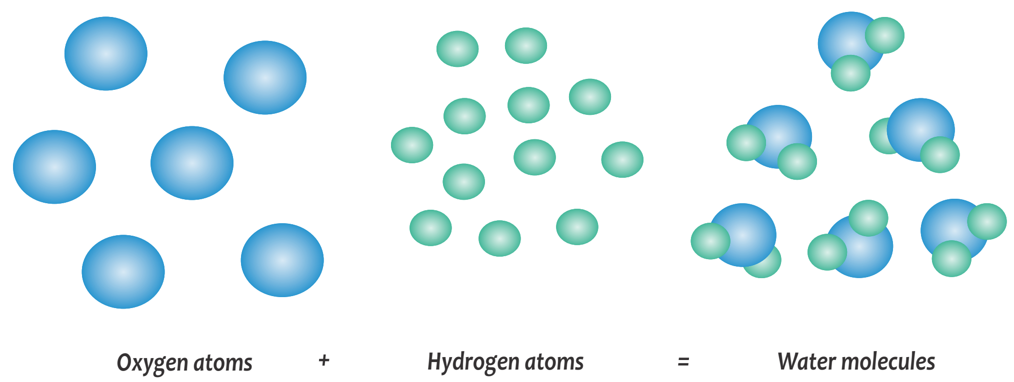


Table salt is a compound of the elements sodium and chlorine. Its scientific name is sodium chloride.

This plastic toothbrush is mostly made up of a compound of hydrogen and carbon.



Egg yolk is rich in the element sulphur.



Water is both a molecule and a compound. It is made up of oxygen atoms and hydrogen atoms.

Carbon One of the most common elements in the Universe and the main element in all living things.

Chemical symbols A letter that is used to represent a chemical element. For example, C represents carbon and Cu stands for copper.

Cohesion The force of attraction between atoms of the same element or compound.

Compound A substance formed by more than one element. For example, water is a compound made up of hydrogen and oxygen atoms.

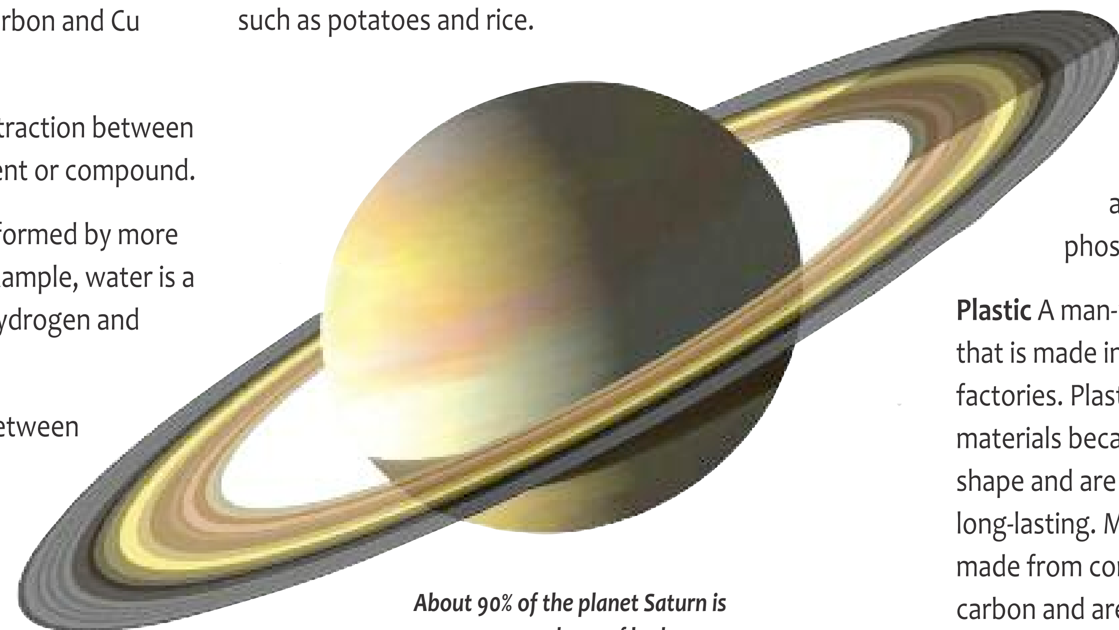
Covalent bond A bond between atoms, where one atom shares an electron (➧ 6) with another atom.

Crystal A solid substance with a geometric shape. A crystal's atoms are arranged into a pattern. Crystals have sharp edges and flat sides at regular angles to each other.

Halogens A group of non-metallic elements with similar characteristics. They easily form bonds with other elements. The halogens are: **chlorine**, **fluorine**, **bromine**, **iodine** and **astatine**.

Helium One of the noble gases. Helium is the lightest of all gases. It is used to fill party balloons.

Hydrogen The commonest element in the Universe. It is the simplest and lightest chemical element because each atom contains one proton and one electron but no neutrons (➧ 6). Hydrogen joins with oxygen to make water. It also joins with carbon and oxygen to make carbohydrates, found in starchy foods such as potatoes and rice.



About 90% of the planet Saturn is made up of hydrogen.

Ionic bond A bond between atoms, where an electron leaves one atom and joins another. An atom that loses an electron becomes positively charged, while an atom that gains an electron becomes negatively charged. Atoms that have become positively or negatively charged are known as **ions**. Positive ions attract negative ions. This keeps the atoms bound together.

Metallic bond A bond between atoms in a metal. The metal's electrons flow freely from one atom to another.

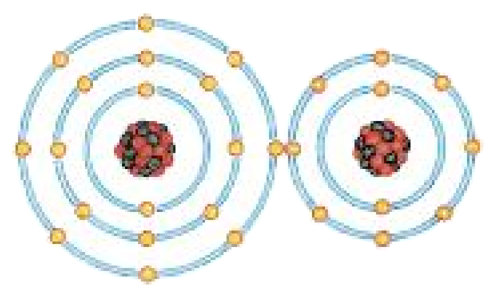
Nitrogen A colourless, odourless gas that makes up 78% of the air around us. Nitrogen is essential for life because it makes up a part of all living cells.

Noble gases A group of gases that have similar characteristics. They are sometimes known as the **inert gases** because they do not easily form compounds with other elements. One common noble gas is **neon**, which is used to make lights and street signs. Because it does not react with other elements, it will not ignite or explode.

Oxygen A colourless, odourless gas that makes up one-fifth of the air around us. Oxygen is crucial to much life on Earth as humans and other animals must breathe oxygen to stay alive.

Phosphorus A chemical element that is found in many rocks and minerals. It is also found inside our bones and DNA. In its basic form, phosphorus is highly flammable.

Plastic A man-made, or synthetic material, that is made in laboratories or factories. Plastics are useful materials because they are easy to shape and are often light and long-lasting. Most plastics are made from compounds of hydrogen and carbon and are a type of polymer.

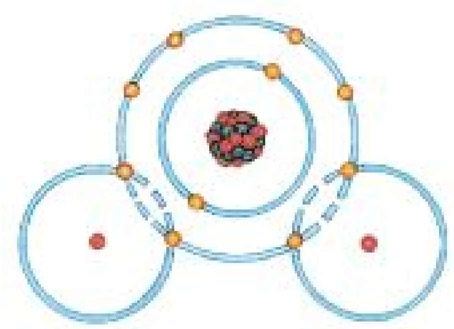


In an ionic bond an atom loses or gains electrons. Here a sodium atom (right) has donated one electron from its outer shell to an atom of chlorine (left). Sodium becomes positively charged, and chlorine becomes negatively charged. Positive and negative attract and keep the atoms bonded together, producing a molecule of sodium chloride.

Diamond is a very hard allotrope of carbon.

Polymer A large molecule made from chains of smaller molecules called **monomers**. Many types of plastics and other artificial materials such as **acrylic** and **nylon** are polymers. Natural polymers are found in our hair and in DNA.

Scuba divers carry oxygen in a tank on their back so that they can breathe underwater.



In a covalent bond (above) one atom shares an electron with another atom. Here, two hydrogen atoms are bonded covalently to one oxygen atom.

Sulphur An element that is found in some rocks. It readily forms bonds with other elements. It is used in gunpowder and matches because it easily catches alight.

Valency The number of bonds an atom can possibly make with other atoms.

FACTFILE

★ Hundreds of years ago, scientists believed that all things were made up of four elements—earth, air, fire and water.

★ The bodies of all living things are made up of carbon-based molecules. This includes our own skin, hair, muslces, bones and brain, as well as parts of animals and plants.

★ Carbon-based molecules outnumber tenfold the molecules of all the other elements put together.

★ The word "plastic" comes from the Greek word *plastikos* meaning "to form". It is called this because it is easy to form into different shapes.

Bones contain calcium, carbon, phosphorus and sodium.

The Periodic Table

The Periodic Table of elements is a list of all known elements arranged in order of their atomic numbers (the number of protons in each atom). The horizontal rows are called periods, and the vertical columns are called groups. Elements with similar chemical properties (← 7) are placed in the same group. Each element has a higher atomic number than the element to its left. The Periodic Table was designed by Russian scientist Dmitri Mendeleev (1834-1907). Mendeleev left gaps where he thought elements would be discovered in the future. He correctly predicted the existence of germanium, gallium and scandium, which were all discovered in his lifetime. Of the 118 elements known to us, 94 occur naturally on Earth. The rest are produced artificially.

Dmitri Mendeleev, creator of the Periodic Table. Element number 101, mendelevium, is named after him.

- Alkali metals (→ 12)
- Alkaline earth metals (→ 12)
- Transition elements (→ 12)
- Poor metals (→ 12)
- Semi-metals (→ 12)
- Halogens (← 8)
- Other non-metals
- Noble gases (← 8)
- Lanthanides (→ 12)
- Actinides (→ 12)

H 1 Hydrogen 1.008								
Li 3 Lithium 6.941	Be 4 Beryllium 9.012							
Na 11 Sodium 22.990	Mg 12 Magnesium 24.305							
K 19 Potassium 39.098	Ca 20 Calcium 40.08	Sc 21 Scandium 44.956	Ti 22 Titanium 47.90	V 23 Vanadium 50.941	Cr 24 Chromium 51.996	Mn 25 Manganese 54.938	Fe 26 Iron 55.847	Co 27 Cobalt 58.933
Rb 37 Rubidium 85.468	Sr 38 Strontium 87.62	Y 39 Yttrium 88.906	Zr 40 Zirconium 91.22	Nb 41 Niobium 92.906	Mo 42 Molybdenum 95.94	Tc 43 Technetium 97	Ru 44 Ruthenium 101.07	Rh 45 Rhodium 102.906
Cs 55 Caesium 132.910	Ba 56 Barium 137.34	57-71	Hf 72 Hafnium 178.49	Ta 73 Tantalum 180.948	W 74 Tungsten 183.85	Re 75 Rhenium 186.207	Os 76 Osmium 190.2	Ir 77 Iridium 192.22
Fr 87 Francium 223	Ra 88 Radium 226.025	89-103	* Rf 104 Rutherfordium 261	* Db 105 Dubnium 262	* Sg 106 Seaborgium 226	* Bh 107 Bohrium 264	* Hs 108 Hassium 277	* Mt 109 Meitnerium 268

								He 2 Helium 4.003
			B 5 Boron 10.81	C 6 Carbon 12.011	N 7 Nitrogen 14.007	O 8 Oxygen 15.998	F 9 Fluorine 18.998	Ne 10 Neon 20.179
			Al 13 Aluminium 26.982	Si 14 Silicon 28.086	P 15 Phosphorus 30.974	S 16 Sulphur 32.06	Cl 17 Chlorine 35.453	Ar 18 Argon 39.948
Ni 28 Nickel 58.70	Cu 29 Copper 63.546	Zn 30 Zinc 65.38	Ga 31 Gallium 69.72	Ge 32 Germanium 72.59	As 33 Arsenic 74.922	Se 34 Selenium 78.96	Br 35 Bromine 79.904	Kr 36 Krypton 83.80
Pd 46 Palladium 106.4	Ag 47 Silver 107.868	Cd 48 Cadmium 112.40	In 49 Indium 114.82	Sn 50 Tin 118.69	Sb 51 Antimony 121.75	Te 52 Tellurium 127.60	I 53 Iodine 126.905	Xe 54 Xenon 131.30
Pt 78 Platinum 195.09	Au 79 Gold 196.967	Hg 80 Mercury 200.59	Tl 81 Thallium 204.37	Pb 82 Lead 207.2	Bi 83 Bismuth 208.98	Po 84 Polonium 209	At 85 Astatine 210	Rn 86 Radon 222
* Ds 110 Darmstadtium 281	* Rg 111 Roentgenium 272	* Cn 112 Copernicium 285	* Uut 113 Ununtrium 284	* Uuq 114 Ununquadium 289	* Uup 115 Ununpentium 288	* Uuh 116 Ununhexium 292	* Uus 117 Ununseptium	* Uuo 118 Ununoctium 294

La 57 Lanthanum 138.906	Ce 58 Cerium 140.12	Pr 59 Praseodymium 140.908	Nd 60 Neodymium 144.24	Pm 61 Promethium 145	Sm 62 Samarium 150.4	Eu 63 Europium 151.96	Gd 64 Gadolinium 157.25
Ac 89 Actinium 227	Th 90 Thorium 232.038	Pa 91 Protactinium 231.036	U 92 Uranium 238.029	Np 93 Neptunium 237.048	Pu 94 Plutonium 244	* Am 95 Americium 243	* Cm 96 Curium 247

Tb 65 Terbium 158.925	Dy 66 Dysprosium 162.50	Ho 67 Holmium 164.930	Er 68 Erbium 167.26	Tm 69 Thulium 168.934	Yb 70 Ytterbium 173.04	Lu 71 Lutetium 174.97
* Bk 97 Berkelium 247	* Cf 98 Californium 251	* Es 99 Einsteinium 254	* Fm 100 Fermium 257	Md 101 Mendelevium 258	* No 102 Nobelium 255	* Lr 103 Lawrencium 260

Key (example: * Cu 29 Copper 64):

- Chemical symbol (← 8)
- Atomic number—the number of protons (← 6) in one atom
- Elements with a star in their top-left corner are produced artificially
- Name of element
- Atomic mass—the average mass of one atom compared with the mass of one carbon atom.

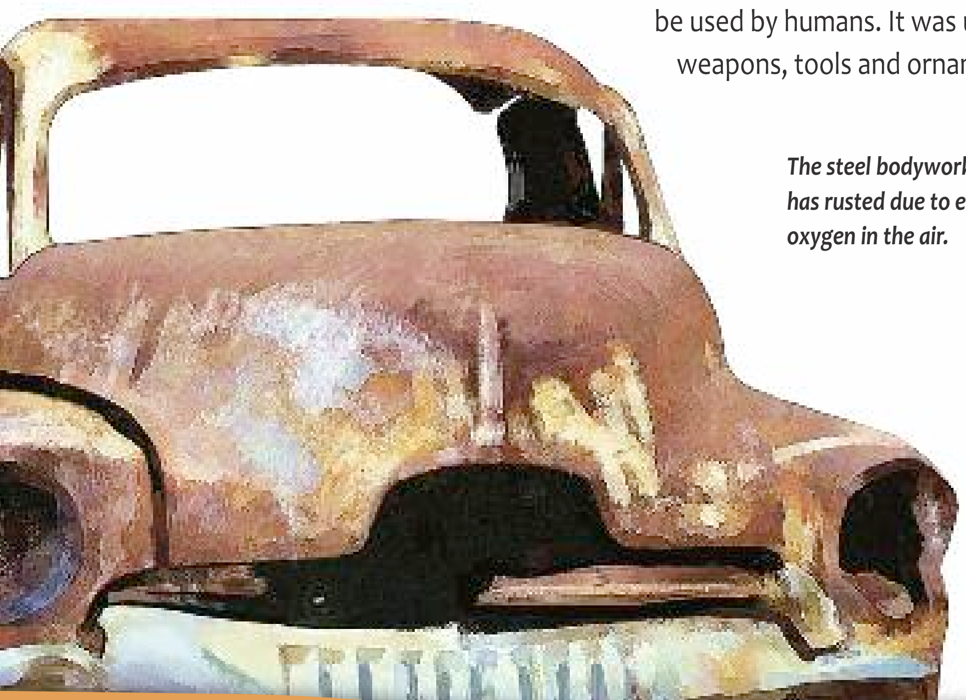
The lanthanide and actinide series (*above, purple*) are normally displayed below the rest of the Periodic Table. This is because they were discovered after the table had been arranged, and by this time there was little room left in it. The arrows show where these elements should fit into the table.

Metals

Metals are the largest group of chemical elements (⬅8), making up about three-quarters of the Periodic Table (⬅10). Metals conduct heat and electricity well compared to non-metals. Most are solid at room temperature. They are strong, hard and tough, and can be polished to give a smooth, shiny surface. When they are squeezed under great pressure, they change shape and become squashed, rather than splinter apart or shatter. These features are true of most metals, but not all. For example, the metal sodium is very soft, while mercury is a silvery liquid at room temperature.

Actinides A group of radioactive (⬅7) metals. They are transition metals.

Alkali metals A group of metals that react with water to form alkaline solutions (➡14). All alkali metals have just one electron (⬅6) in their outer shell. They are generally soft, shiny and a pale silvery colour. **Lithium**, **sodium** and **potassium** are all members of this group.



The steel bodywork of this car has rusted due to exposure to oxygen in the air.

Battery casings are made of zinc.

Alkaline earth metals A group of alkali metals that have two electrons (⬅6) in their outer shell. **Magnesium**, **calcium** and **radium** are all members of this group.

Alloy A mixture of two or more elements, of which at least one is a metal. Alloys can be useful because they have different chemical properties to the elements that make them up. For example, steel, made of iron and carbon, is much stronger than iron.

Aluminium A light, soft metal that does not rust. It easily bonds with other elements to make alloys that are light weight and durable. It is the commonest metal found in the Earth's rocky crust.

Bronze A strong, shiny, brown alloy of tin and copper. Bronze was the first alloy to be used by humans. It was used to make weapons, tools and ornaments.

Copper A shiny, pinkish-brown metal. Copper is a good conductor (➡26) and is often used to make wires and pipes.

Gold A soft, shiny, yellow element. Gold is often found in small lumps, called **nuggets**. It is valuable because it is rare and does not easily spoil or rust. It is a good electrical conductor (➡26).

Iron A heavy, silvery metal. Iron is a popular construction metal because it is abundant and strong. It is used to make steel and can be used as a magnet (➡26). Iron is a vital element needed by the human body: iron inside our red blood cells helps to carry oxygen around our bodies.

The Statue of Liberty in New York is made of a shell of copper built around an internal framework. Exposed to the air, copper develops a greenish covering. This is because it reacts with oxygen to form copper oxide.

Lanthanides A group of silvery metals with very high melting points. They are sometimes called the "rare earth metals". They belong to the transition metals.

Lead A heavy, bluish metal that turns grey when exposed to the air and has a very low melting point. Lead is often made into weights because it is so heavy.

Magnesium A light, silvery-white metal. Magnesium easily reacts with other elements and burns with a bright white flame. It is used to make fireworks or mixed with other metals to make alloys that are strong but light.

The precious metals gold and silver

Mercury A silvery liquid metal. Mercury is the only metal that is a liquid at room temperature. It is used inside thermometers.

Nickel A silvery-white metal. It is used to make stainless steel and other alloys. It is also used to make some coins.

Ore Rock that contains metal compounds.

Poor metals The name sometimes given to a group of soft, weak metals that melt at low temperatures. **Tin**, **lead** and **aluminium** are all poor metals.

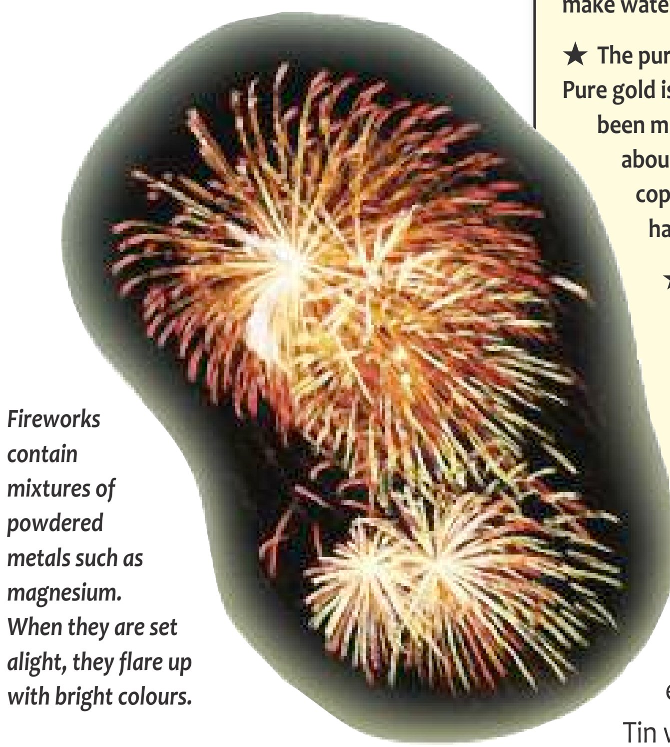
Plutonium A highly radioactive (⬅7) metal. Plutonium is used to produce nuclear energy (➡18).

A bicycle frame made from a titanium-steel alloy

Precious metals Valuable metals such as **gold**, **silver** and **platinum**. They are prized for their rarity and for their beautiful appearance. They are often used to make jewellery and other ornaments.

Semi-metals Otherwise known as the **metalloids**, the semi-metals are a group of elements that are neither metals nor non-metals. Typically they have the hard, shiny appearance of a metal, but make poor electrical conductors (➡26). **Arsenic** and **bismuth** are both semi-metals.

Silver A soft, bright, shiny metal. Silver is a precious metal, used to make ornaments and jewellery. It is also a good conductor of electricity (➡26).



Fireworks contain mixtures of powdered metals such as magnesium. When they are set alight, they flare up with bright colours.

Steel An alloy of iron and carbon (⬅8). There are many different types of steel alloys, each containing slightly different amounts of various elements, and each designed to do a different task. **Stainless steel** is a mixture of steel, chromium, and small amounts of other metals. It is used to make sinks and cutlery. **Titanium** and **vanadium** steels resist high temperatures without melting.

FACTFILE

★ At present, there are 86 different metals known to us.

★ Humans first started working metals about 8000 years ago. At first they used copper and gold nuggets that came out of the ground in their pure form. Bronze may have been discovered by accidentally mixing tin and copper. Because it could be made harder, sharper and longer-lasting than other metals, it could make far better tools and weapons. It gave its name to the Bronze Age, which started in around 3000 BC.

★ For many centuries lead was used to make water pipes. It was then discovered that lead-contaminated water could cause serious illnesses. Copper or plastic is used to make water pipes today.

★ The purity of gold is measured in carats. Pure gold is 24 carats (24k). Gold that has been mixed with other substances is about 10k. Gold is often mixed with copper or other metals to make it harder and more durable.

★ Most cars have bodywork made of steel plate. This is strong and easy to shape, but steel is mostly iron, and iron rusts when exposed to oxygen. Because of this, the steel panels receive an anti-rust coating before they are painted.

Tin A silvery metal that can easily be bent and shaped. Tin was once used to make cans and foil, but aluminium has since taken its place, because it is cheaper.

Transition metals A group of metals that are mostly hard, dense and shiny and make good electrical conductors (➡26). **Gold**, **silver**, **iron** and **copper** are all transition metals.

Zinc A bluish-white metal. It is used to make battery casings. Zinc is also an important part of our diet and is found in foods such as nuts and red meat.

CHEMICAL REACTIONS

A chemical reaction takes place when one substance joins with another to form a completely new substance. Chemical reactions are taking place all around us. Some happen naturally. For example, the food we eat is chemically changed inside our bodies to produce energy. Other reactions are made to take place artificially, for example in the manufacture of medicinal drugs.

Chemists wear goggles, labcoats and gloves to protect themselves from corrosive chemicals. Strong acids and alkalis can dissolve substances, including human skin and even bones.

Acid A substance that contains a positively-charged (➜26) hydrogen atom (ion). An acid will always give up its hydrogen ion in order to rid itself of its positive charge and become neutral. Alternatively, it can accept an electron, which is negative, to achieve the same result. This means that acids readily react with other substances.

Liquid oxygen and hydrogen are ignited inside a rocket engine. This is called combustion (right).

Alkali A base that dissolves in water. An alkali is a substance that has an overall negative charge (➜26). It is always willing to give up an electron or receive a proton in order to become neutral. This means that it readily reacts with other substances. All alkalis are bases.

Base A substance that reacts with an acid to form a salt and water.

Catalyst A substance that triggers or speeds up chemical reactions.

Combustion A chemical reaction in which oxygen combines with a fuel, releasing energy. This is otherwise known as burning. Combustion is a type of oxidation.

Concentration A measure of how strong a solution is.

Corrosion The breaking down of a substance into the individual atoms that make it up. This is caused by a chemical reaction between the substance and its surroundings. For example, steel (➜13) corrodes when it is exposed to oxygen in the air.

Diffusion The process by which molecules move around to fill a space. For example, molecules of ink will diffuse, or spread out, in a glass of water so that the liquid changes colour.

Electrolysis The process of separating the elements in a compound (➜8) by using an electrical current (➜26). The compound must be in a liquid state for this to happen.

Filtration A way of removing solids from liquids by pouring a mixture through a material known as a **filter**. This is a material with very fine holes in it. It allows liquids, but not solids, to pass through it.

Indicator A substance that shows how acidic or alkaline a solution is. **Universal indicator** and **litmus paper** are both examples of indicators. They change colour depending on the acidity of a solution. Acidity is measured using the **pH scale**. A very acidic solution has a pH of 0. A very alkaline solution has a pH of 14. A neutral solution (such as water) has a pH of 7.

The fumes from vehicle exhausts and factories contain nitrogen dioxide and sulphur dioxide. These dissolve in drops of water in clouds to form nitric or sulphuric acids which fall as acid rain. This can seriously damage buildings and statues.

Irreversible change A change, or reaction, that cannot be undone. When you bake a cake, the molecules in its ingredients are rearranged. You cannot change the cake back into its ingredients. Burning is another type of irreversible change. Irreversible changes always produce a new substance.

The sea is a solution of salt. The Dead Sea has so much salt in it that no more can dissolve—it is a saturated solution. Because it cannot dissolve, solid lumps of salt float on the surface.

Miscibility The ability for liquids to mix together. Miscible liquids mix easily. **Immiscible** liquids, for example oil and water, will not mix. If an **emulsifier** is added, immiscible liquids will float together in a mixture called an **emulsion**.

Mixture A blend of two different substances that are not chemically changed by being put together. Sand and salt combined produce a mixture—neither the salt nor the sand are chemically changed.

Neutralize To turn an acid or alkali into a neutral solution—one that is neither acid nor alkaline. This can be acheived by mixing an acid and an alkali together. The acid donates its positive hydrogen atom to the negative alkali, so that they both have a neutral charge (➜26).

Oxidation A reaction in which oxygen combines with another chemical.

Physical reaction A change in a substance that affects its appearance but not its chemical properties (➜7). Crushing a can and melting an ice cube are both examples of physical reactions. The can changes shape and the ice changes state, but they are otherwise unaltered.

Reactive How likely a substance is to join with another substance in a chemical reaction.

Reversible change A change, or reaction, that can be undone. If you freeze water, you can reverse the change by melting the ice. If you dissolve salt in water, you can boil off the water to leave the salt. Reversible changes never create new substances.

FACTFILE

★ The speed at which a reaction takes place is called its rate of reaction. Many reactions take place more quickly at higher temperatures or in bright light, because their molecules are given more energy.

★ In the Middle Ages the plague killed millions of people. The dead bodies of its victims were sprinkled with lime, a strong and corrosive base. It helped to make them rot faster and to kill harmful germs.

★ A bee's sting is painful because it is acidic. The pain can be treated by using an alkaline solution of ammonia, which neutralizes the acid in the sting.

★ Citrus fruits, such as oranges, lemons and grapefruits, all contain a natural citric acid. This gives them a sharp or sour taste. A weak alkali has a bitter or soapy taste.

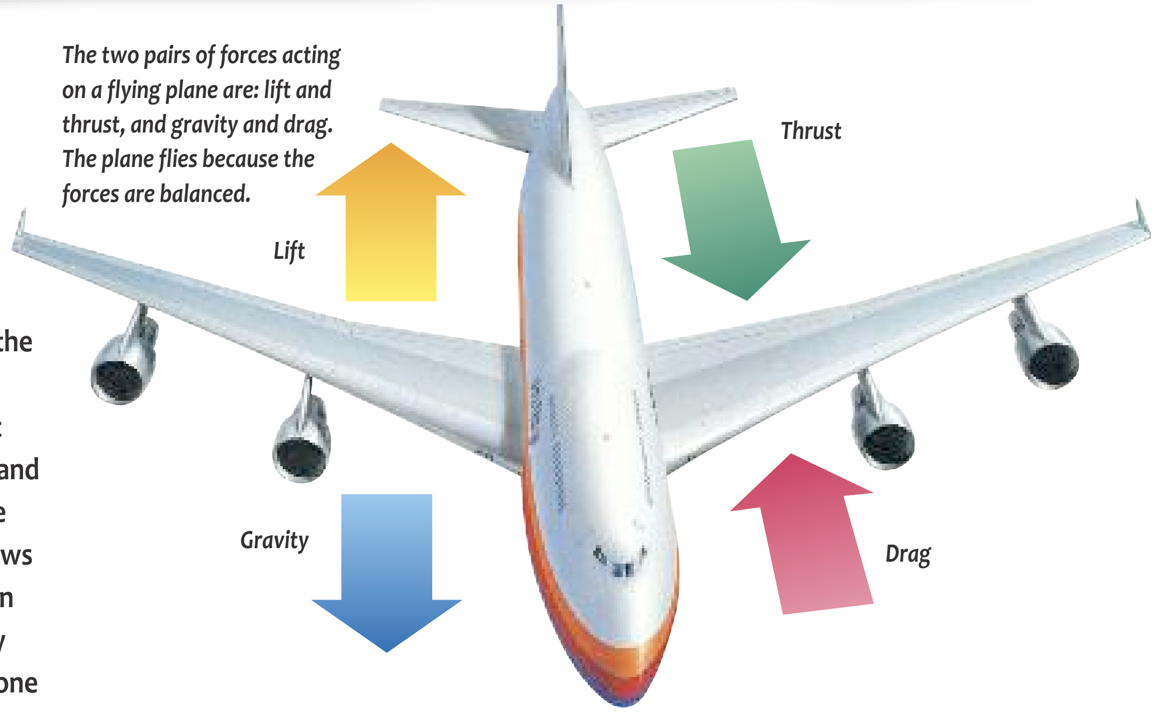
Salt A solid compound made when a base joins with an acid. A salt is a type of crystal (➜8). Many types of salt dissolve in water. Table salt is called **sodium chloride**, but chalk (calcium carbonate) and saltpetre (potassium nitrate) are also types of salt.

Soluble The ability of one substance to dissolve in another one.

Solution A liquid mixture of two different substances. One substance, known as the **solute**, usually a solid, is dissolved in another substance, known as the **solvent**, which is usually a liquid. For example, table salt stirred into water is a solution.

Ingredients are mixed together to make a cake. When the cake is cooked, its ingredients are chemically changed.

FORCES & MOTION



The two pairs of forces acting on a flying plane are: lift and thrust, and gravity and drag. The plane flies because the forces are balanced.

A force is something that changes the movement or shape of an object. Once an object is set in motion, it will carry on moving at the same speed and in the same direction until another force speeds it up, changes its direction or slows it down. Forces always act in pairs. When both forces are equal, an object will stay still or will move at a constant speed in one direction. When one force is greater than the other, the forces are unbalanced and the object will change direction or speed. When several forces act on an object, the overall effect is called the resultant force. For example, lift, thrust, gravity and drag all act on an aeroplane, while its resultant force is a forward motion.

Acceleration The measure of how quickly velocity increases. A decrease in velocity is called **deceleration**.

Centrifugal force The force that seems to push outwards on an object moving in a circle. When we sit on a spinning fairground ride such as a "Chair-o-Plane" (*below*) we feel centrifugal force pushing us outwards. At the same time there is another force at work, keeping us moving in a circle. This is called the centripetal force.

A "Chair-o-Plane"

Centripetal force The force that pulls inwards on an object moving in a circle. It balances centrifugal force. Gravity is a type of centripetal force that keeps the planets moving around the Sun.

Drag A force that slows an object down as it travels through a gas or liquid. Drag occurs because of friction between the object and the molecules around it. Unlike friction, drag is affected by an object's speed. Drag that takes place in the air is called **air resistance**. Drag that takes place in a liquid is called **water resistance**.

Friction A force that tries to stop things moving. Friction is produced when two surfaces rub together. Rough surfaces produce more friction than smooth ones. Friction can make machines wear out, but it can also be helpful. For example, a vehicle stops because of friction provided by its brakes.

Gravity The force that attracts all objects to each other. The larger an object's mass, or the greater its density (◀ 6), the greater its gravitational pull. The greater the distance between objects, the smaller the force of gravity between them. When we jump in the air, gravity is the force that pulls us back to the Earth.

If a bus suddenly stops moving, people on it fall forward because of their momentum.

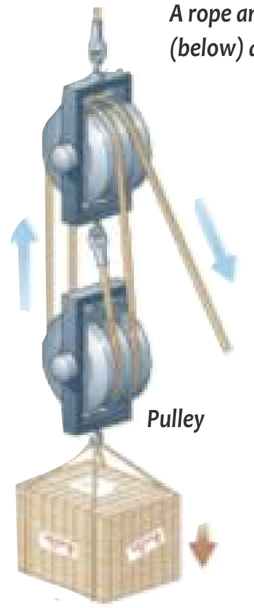
Inertia The tendency for objects to resist changes to their motion; that is, the tendency for objects that are moving to carry on moving, and for objects that are still to stay still. All objects always have inertia, whether they are moving or still.

Lift An upward force that holds aircraft in the air. As an aeroplane moves, the shape of its wings forces air to flow faster over the top of the wing than the air flowing beneath it. This means that there is less pressure on the upper side of the wing than on the lower side. The result is lift.

Machine A device that changes the direction or size of a force, making it easier to perform certain tasks. The most simple machines are: a wheel, a lever, a wedge, a screw, a pulley and an inclined plane.

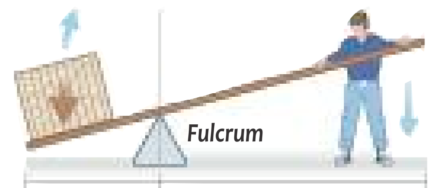
Momentum The tendency for objects that are moving to carry on moving. An object's momentum is a result of its mass and its velocity.

A rope and pulley (left) and a lever (below) are both types of machine.



A rope and pulley changes the direction of a pulling force so that you pull down on a rope in order to move a weight upwards. This is because it is easier to pull down than to pull up.

A lever is a stiff bar that pivots at a fulcrum. If the fulcrum is near one end, a small force at the other end will move a heavy weight.



Motion The word given to any kind of movement. All movement is caused by forces. An object going in a straight line has **linear motion**. An object that circles a central point has **circular motion**. An object that twists around on the spot has **rotary motion**. An object moving to and fro has **reciprocating motion**.

Newton, Isaac (1643-1727) The British scientist who discovered the laws of gravity and motion. Newton proposed that the Earth's gravity attracted the Moon and kept it circling the Earth.

Newton The unit in which force is measured. One newton is the force of the Earth's gravity on an object with a mass of 102g (about the size of a small apple).

Nuclear force The force that binds neutrons and protons together inside the nucleus of an atom (◀ 6).

Pressure The amount of force acting on a certain area.

Reaction A force that opposes another force of equal strength. Forces always act in pairs, where one force is called the action and the other is called the reaction.

Thrust The force from a vehicle's engine that results in forward motion.

Velocity How quickly an object changes its position. Velocity measures both how quickly an object moves and the direction in which it travels. Speed measures how quickly an object moves, but does not specify its direction.

Weight A measure of the gravitational force pulling on an object. A big book is weighty because it is pulled downwards by the Earth's gravity. In space, away from the Earth's gravity, objects and people are not pulled down, so they become weightless and float about freely. Objects in space still have mass, however.

FACTFILE

★ The Earth's gravitational force is what gives all objects on Earth their weight.

★ The Moon has less mass than the Earth, so its gravitational force is less. On the Moon this book would weigh about one-sixth of what it weighs on Earth.

★ Even still objects exert forces. When you sit on a chair, the chair pushes up against you with the same force as your weight pushes down on the chair. If this did not happen, the chair would collapse beneath you.

★ Birds and fish have naturally streamlined bodies. Their shape minimizes the flow of air or water around them, which reduces friction and allows them to move faster.

★ It is said that Isaac Newton first had the idea for gravitational force when he saw an apple fall from a tree, and questioned why it fell straight to the Earth.

Isaac Newton

Wheels have rotary motion.

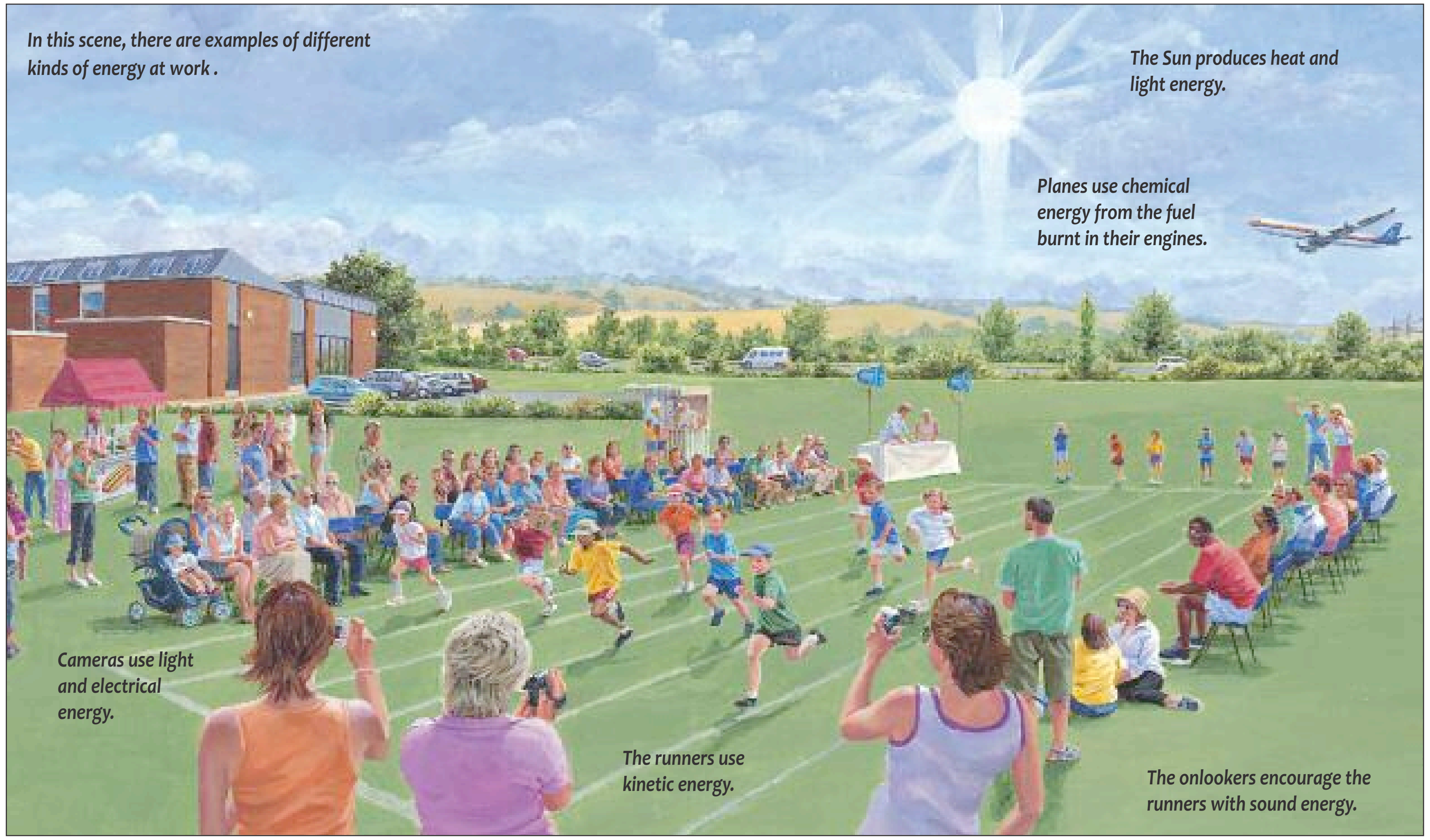
Gravitational force pulls you down a slide.

Neither the dog nor his owner can move because they are both pulling with the same force.

When you sit on a roundabout, you are affected by both centripetal and centrifugal forces.

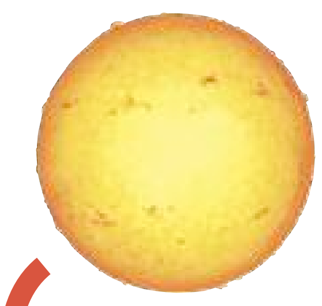
ENERGY

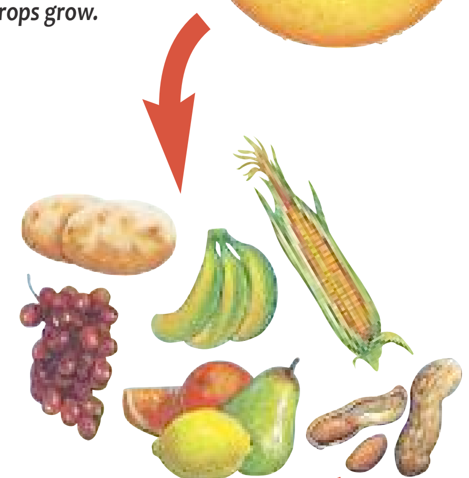
Energy is the ability to make things happen, cause change and carry out work. Energy is all around us, in many different forms, including heat (➡24), light (➡22), sound (➡20), chemical, kinetic and electrical energy (➡26). Energy can change from one form to another, or stored waiting to be used—it is never lost or gained. For example, different energies are converted into electrical energy, which is useful in our modern world. This process is called generating electricity. Without energy, our world would be completely dark and silent.



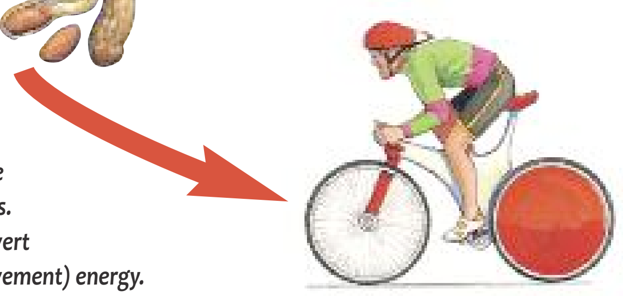
Chemical energy The energy that keeps atoms bonded together (⬅6). We make use of chemical energy in fuels. As the fuel burns, the bonds between atoms are broken, which releases energy.

This energy chain shows how energy can change form. Heat and light energy from the Sun make food crops grow.





Food crops store energy from the Sun in the form of chemical energy. When we eat we absorb this energy into our bodies. When we move, our muscles convert chemical energy into kinetic (movement) energy.



Fossil fuel A fuel formed from the remains of living things that died millions of years ago. **Coal, oil** and **natural gas** are all types of fossil fuel.

Fuel Any source of energy.

Geothermal energy Energy that comes from heat stored deep inside the Earth. This energy will last for millions of years.

Hydroelectric energy Energy that comes from the kinetic and potential energy of moving water. **Hydroelectric power stations** control the rush of water through a dam. The movement of the water is used to generate electricity.

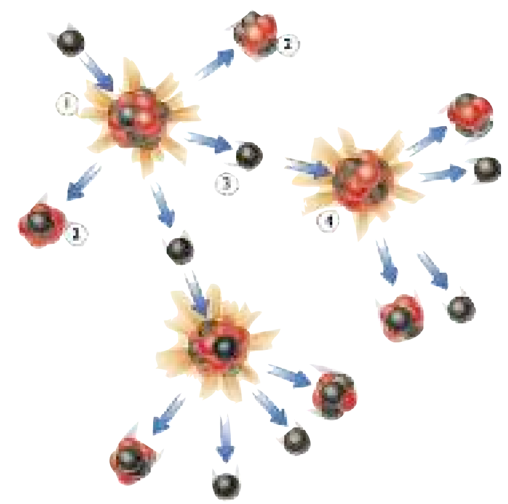
Joule The unit used to measure energy. One joule (J) is the energy exerted when a force of one newton (⬅17) moves an object a distance of one metre.

Kinetic energy The energy that an object has because of its movement. For example, a ball rolling down a hill has kinetic energy. The faster it rolls, the more kinetic energy it has.

Non-renewable energy Energy sources that will eventually run out and cannot be replaced for hundreds of millions of years. Oil and coal are both examples of non-renewable energy sources.

Nuclear energy The energy contained by an atom, due to the strong force that holds together the protons and neutrons in its nucleus (⬅6). There are two ways of releasing nuclear energy. These are: nuclear fission and nuclear fusion. They are both forms of **nuclear reaction**.

Nuclear fission The process of splitting open the nucleus of an atom by blasting it with a high-speed neutron (⬅6). This releases a huge amount of nuclear energy.



NUCLEAR FISSION: A nuclear particle called a neutron smashes into the nucleus of a uranium atom (1). The nucleus breaks into two parts (2). This releases heat and other energy alongside two more fast-moving neutrons (3). These smash into more uranium nuclei in a chain reaction (4).

Nuclear fusion The process of fusing together the nuclei of two atoms. This releases an enormous amount of nuclear energy.

Potential energy Energy that is stored. For example, a boulder on a hillside has potential energy. As the boulder starts to roll under the force of gravity (⬅16), its potential energy changes into kinetic energy.

Power The rate, or speed, at which energy is converted or work is done. Power is measured in watts.

Renewable energy Energy sources that will not run out because they are constantly replenishing themselves. They come from natural sources, such as sunlight, waves, tides, wind and geothermal heat.

The Hoover Dam in the United States is a hydroelectric power station. A lake is formed by damming a river in a steep-sided valley. Some of the water is allowed to rush out through pipes and the movement is used to generate electricity.

Solar energy The heat and light energy that is given off by the Sun. A **solar cell** is a device that converts solar energy into electrical energy when the cell is exposed to sunlight.

Watt The unit used to measure power—the speed at which energy is converted. One watt (W) of power is the same as one joule (J) of energy per second.

A wind farm out at sea is used to harness wind energy and generate electricity.

Work The energy transferred when a force (⬅16) moves an object over a distance. For example, you have to work to lift a box. You must exert a force on the box to overcome the Earth's gravitational pull (⬅16). In order to do this you must first have energy, which you obtain in the form of chemical energy from your food.

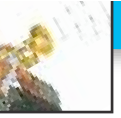
FACTFILE

★ The word energy comes from the Greek word *energia*, which means "activity".

★ One wind turbine can generate enough energy to power heat and electricity in up to 300 homes. People have been using wind energy since ancient times, when windmills were used to grind grain.

★ In just one hour, enough sunlight falls on the Earth to power every home on the planet for a whole year.

★ When you run, your muscles only convert about 25% of the chemical energy from your food into kinetic energy to keep you moving. The rest is lost as heat energy.



SOUND

Sound is a form of energy (◄ 18) made when objects vibrate (move to and fro rapidly). As an object vibrates it sets the air around it vibrating too: molecules of the gases in the air press close together and then pull apart. These regions of higher and lower air pressure are called sound waves. They move away from the sound source in all directions, like ripples in a pond. Sounds also travel as vibrations through liquids and solids. The molecules are closer together in liquids and solids than in gases, so sounds travel through them much faster.

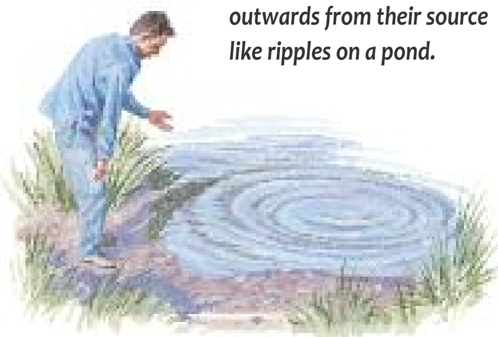
Acoustics The study of how sound is affected by location, for example, how sound bounces around a concert hall.

Amplitude The height of a wave. Sound waves with high amplitudes make loud sounds and sound waves with low amplitudes make quiet sounds.

Decibel The unit used to measure the volume, or intensity, of sounds. A very quiet sound, such as the rustling of leaves is about 20 decibels (dB). A very loud sound, such as a rocket taking off, is about 120 dB. Sounds over 80 dB can damage your ears.

Echo The sound we hear when sound waves bounce off a surface.

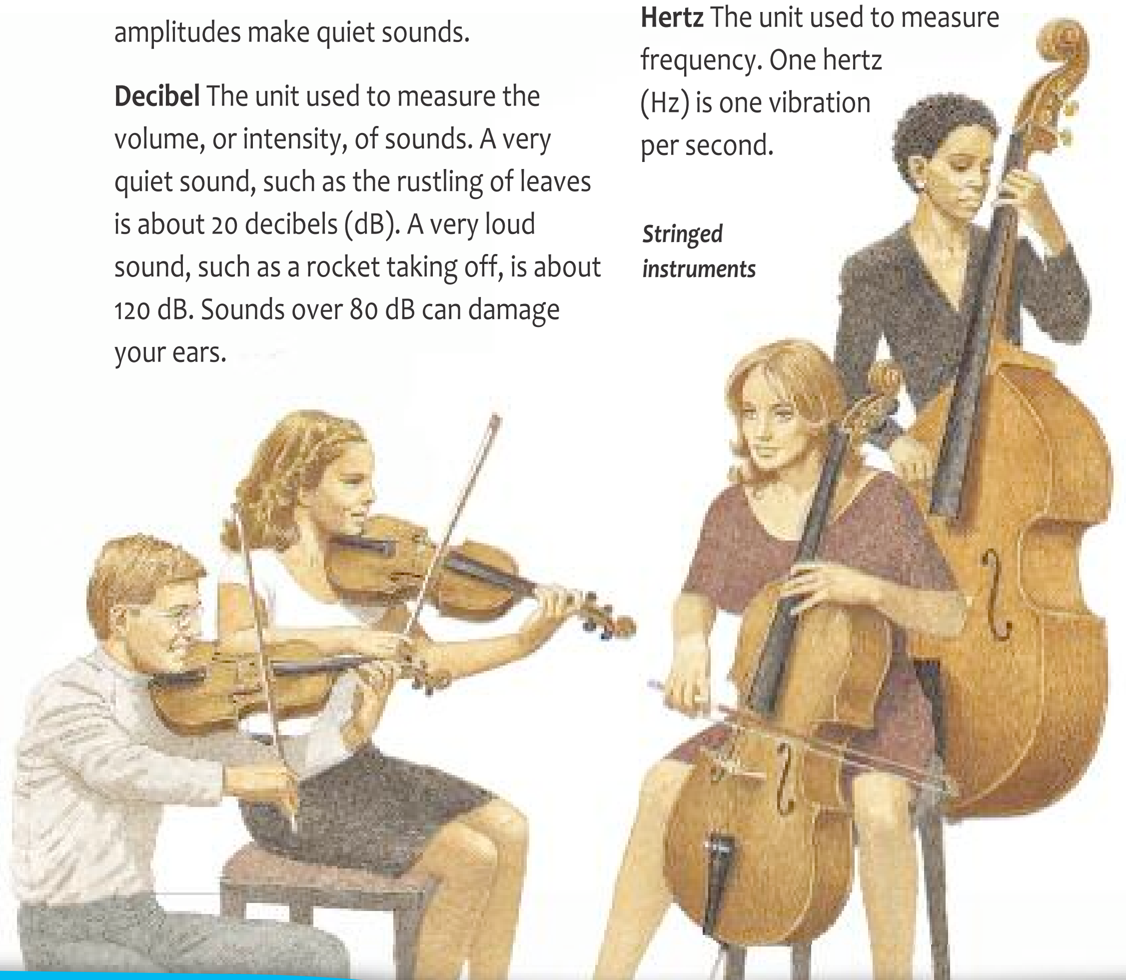
Echolocation A type of sonar used by animals such as bats and whales. The animals emit sounds and listen to their echoes in order to locate solid objects. Echolocation allows animals to hunt in dark or murky conditions where it is difficult to see.



Sound waves travel outwards from their source like ripples on a pond.

Frequency The number of vibrations, or sound waves, per second. Sound waves with high frequencies make high-pitched sounds. Sound waves with low frequencies make low-pitched sounds.

Hertz The unit used to measure frequency. One hertz (Hz) is one vibration per second.



Stringed instruments

A trumpet produces sound waves.

Infrasonic Sounds that are too low-pitched for humans to hear. It is thought that some animals are able to hear them.

Intensity The amount of energy that sound waves carry. The intensity of sound waves determines their volume.

Music A form of art using pleasant sounds.

Water (1530 m per second) *Air (343 m per second)* *Steel (5050 m per second)*

Sound travels quickest through solids, slower through liquids and slowest of all through air.

Musical instrument An object that is used to make musical sounds. In a cello, a bow rubs over the cello's strings to make them vibrate. The vibrations pass into the air and also to the cello's hollow body, making the sound louder and richer.

Noise Any kind of sound. Noise is often used as a word for unwanted sounds.

Pitch How high or low a note is. High-pitched sounds have high frequencies and low-pitched sounds have low frequencies.

Resonance The frequency at which an object will vibrate if you hit it. This is sometimes called the **natural frequency** of an object.

Reverberation The sound heard when sound waves continue to travel after the original source of a sound has gone.

Sonar (SOund Navigation And Ranging) A technique that uses sound waves to detect solid objects. The sound waves bounce off them and reveal their position. Ships use sonar to find shoals of fish or other ships.

Speed of sound The speed at which sound travels. Sound travels through air at about 343 metres per second. The speed of sound varies depending on the substance it travels through. Loud and soft sounds all travel at the same speed.

Volume The loudness of a sound. Volume is measured in decibels (dB). Some sounds are so quiet that we can only just hear them. Others are so loud that they may damage our ears. *(See intensity.)*

Wavelength The distance between one sound wave and the next. Sound waves with short wavelengths have high frequencies and make high-pitched sounds. Sound waves with long wavelengths have low frequencies and make low-pitched sounds.

The sound made by a jet engine measures about 140 dB, but it can only be heard faintly from the street because it is so far away.

The sound made by busy traffic can register between 70 and 80 dB.

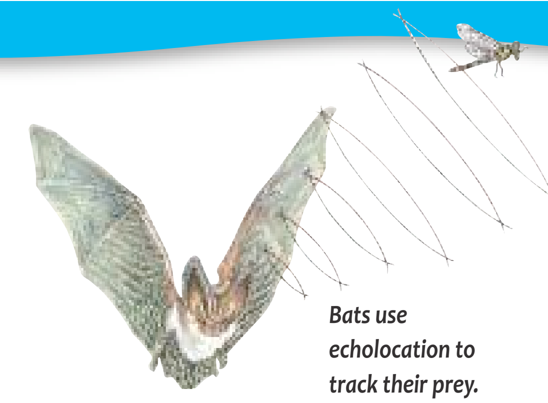
An electric drill makes a sound of about 100 dB. The people that use it must wear ear-protectors.

The sound of a car horn can be up to 110 dB.

Supersonic Faster than the speed of sound. When objects travel faster than the speed of sound the they make a loud noise called a **sonic boom.**

Ultrasound Sounds that are too high-pitched for humans to hear. Some animals, such as dogs and bats, can hear them. An **ultrasound scanner** is used to make images of inside the human body. It beams high-pitched sound waves into the body. A computer transforms the echoes into an image.

The Bell X-1 rocket plane was the first aircraft to fly faster than the speed of sound.



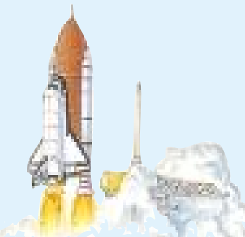
Bats use echolocation to track their prey.

An ultrasound scan of a baby in the womb

FACTFILE

★ Whales and dolphins use sound to communicate. Whalesong can travel up to 800 km under water. Whales are believed to be the loudest animal in the world. They can make sounds as loud as 188 dB. The loudest land animal is the howler monkey. Its calls can be as loud as 88 dB and can be heard up to 16 km away.

★ Sound waves can only travel through matter. Space is completely silent because there are no gas molecules for sounds to pass along.



A rocket makes a loud, low-pitched sound.

★ Most sounds only carry a relatively small amount of energy. The sound of 200 pianos playing together produces about the same amount of energy as it would take to light one light bulb.

A singer makes a medium-loud, medium-pitched sound.

A watch makes a soft, medium-pitched sound.

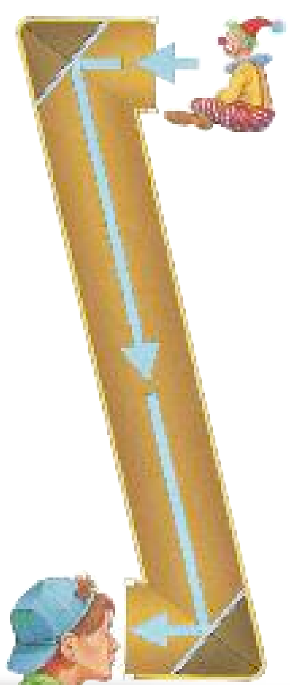
LIGHT & COLOUR

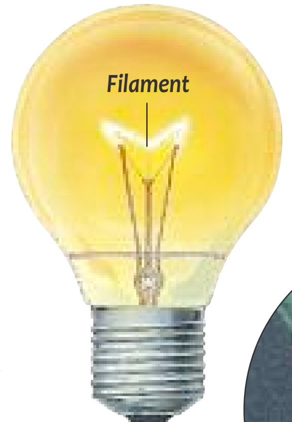
Light is a kind of energy (◂ 18) that our eyes can detect, enabling us to see. It is mostly produced by very hot things. It travels in straight lines, but it can reflect (bounce) off objects. In fact, we can only see an object when light reflects from it and into our eyes, or if it produces light itself. Sunlight is not colourless, but is made up of all the colours of the rainbow: the spectrum of light.

Bioluminescence The ability of some animals to produce light. The light is generated by chemical reactions (◂ 14) in the animal's body.

Concave lens A shaped piece of glass or plastic that is thicker at its edges than at its centre. It makes light rays diverge (spread out). When you look through a concave lens, objects appear smaller than they really are.

By placing two mirrors in a tube you can make a periscope, a device used to see around corners. Light coming in at one end is reflected through to the viewer at the other end.





Light is produced in a bulb when the filament is heated by an electrical current.

Female glow-worms (a type of beetle) emit light when they are ready to mate.

Convex lens A shaped piece of glass or plastic that is thicker at its centre than at its edges. It brings light rays together at a single point called a focus. When you look through a convex lens, objects appear larger than they really are.

Diffraction The spreading out of light rays as they pass through a narrow gap.

Focus The point where rays of light meet when directed by a lens or mirror.

Lens A shaped piece of glass or plastic that bends light rays.

Light filter A piece of coloured, transparent plastic or glass that allows light of its own colour to pass through it, but stops all other colours. Light filters are often used in stage lighting, to change the colour of a light. If a blue filter is placed over a white light, the light that shines on to the stage will be blue.

Luminescence Light that is created at low temperatures, usually caused by certain chemical reactions or electricity.

Mirage A trick of the eye, that makes far away objects look much closer than they really are. Mirages happen when light from the sky is reflected off a layer of hot air just above the ground or the sea. They are commonly seen in deserts.

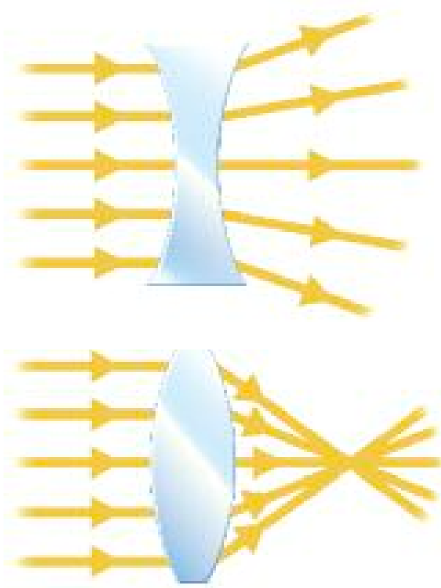
Mirror A sheet of glass with a thin layer of metal on the back. Mirrors form images by reflecting light from the surface of the metal.

Opaque A material that does not allow light to shine through it.

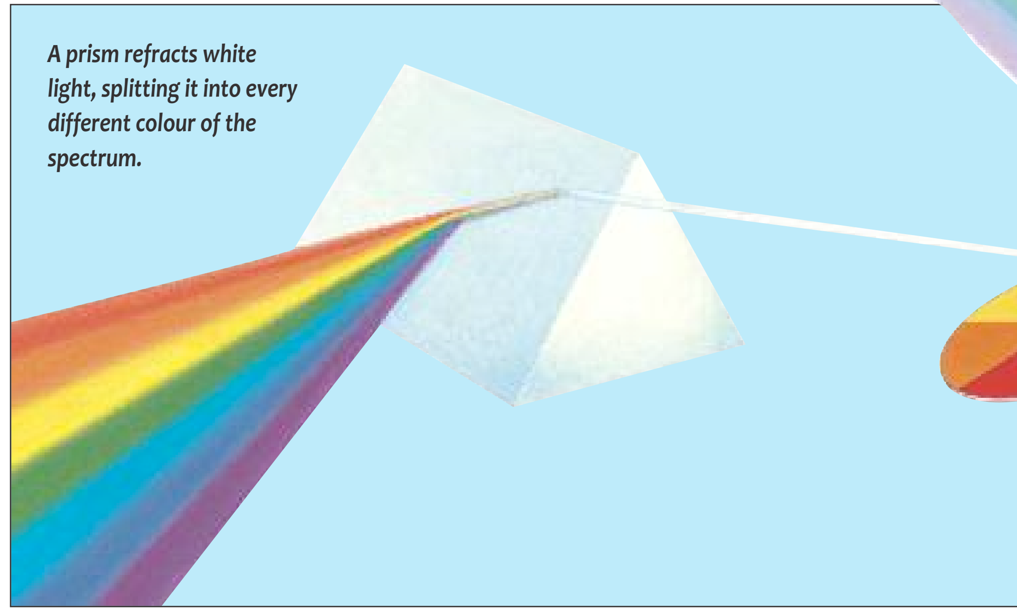
Pigment A substance that is added to another substance to give it colour.

Primary colours Any of the three colours that can be mixed together to form all other colours. The primary colours of light are red, green and blue. They can be mixed to make any colour. When all three are mixed together they make white light. In paints, which contain pigments, the primary colours are red, yellow and blue.

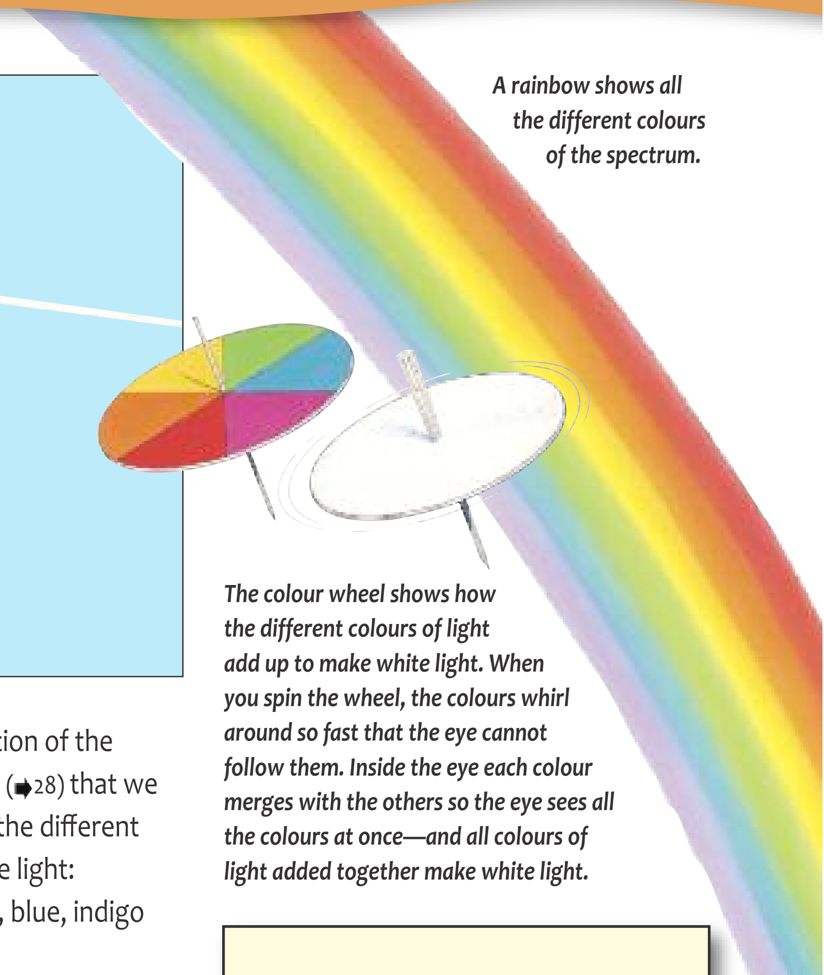
A concave lens (top) and convex lens (bottom).



A magnifying glass is a convex lens.



A prism refracts white light, splitting it into every different colour of the spectrum.



A rainbow shows all the different colours of the spectrum.

The colour wheel shows how the different colours of light add up to make white light. When you spin the wheel, the colours whirl around so fast that the eye cannot follow them. Inside the eye each colour merges with the others so the eye sees all the colours at once—and all colours of light added together make white light.

Prism An angled block of transparent material such as clear glass or plastic. As light waves pass through a prism, they change speed and are bent, or refracted. Longer waves of red light refract least. Shorter waves of violet light refract most. The other colours of the spectrum spread out in between.

Rainbow An arch of colours that forms across the sky when the Sun shines from behind you at rain falling in front of you. The raindrops act as millions of tiny prisms, each splitting the white light in sunlight into every colour of the spectrum.

Reflection The bouncing of light rays off an object. Smooth, shiny, light surfaces reflect more light than rough, dark ones.

Refraction The bending of light rays as they travel through different transparent materials. This occurs because light travels at different speeds through different materials. At the boundary between two materials, the light changes speed and is bent from its straight path.

Shadow A dark shape or area produced when an opaque object stands between a surface and a source of light. Shadows are formed because light can only travel in straight lines and cannot bend around the opaque object.

Spectrum of light The section of the electromagnetic spectrum (▸ 28) that we can see. It is formed of all the different colours that make up white light: red, orange, yellow, green, blue, indigo and violet.

When the three primary colours of light, red, blue and green are added together they make white light.

Speed of light The speed at which light travels through empty space. This is about 300,000 km/s—about seven and a half times around the Earth in one second. The speed of light is the speed limit for the Universe: nothing can travel faster.

Translucent A material that allows light to pass through it, but which spreads the light rays out in all directions. We can make out shapes behind translucent materials but we cannot see them clearly. Tracing paper and ice are both translucent materials.

FACTFILE

- ★ It takes sunlight more than eight minutes to travel nearly 150 million km from the Sun to the Earth.
- ★ In one year, light travels 9.46 trillion km. This distance is called a light year.
- ★ The colour of an object depends on which colours it absorbs and which it reflects. For example, a leaf looks green because its surface absorbs all the colours in white light, except green, which it reflects.
- ★ The eye contains a natural convex lens which focuses an image on to the retina at the back of the eye.
- ★ Concave lenses are used in glasses for people who are short-sighted (they have difficulty seeing objects far away from them). Convex lenses are used for people who are long-sighted (they have difficulty seeing objects close to them).

Transparent A material that transmits light, or allows light to pass through it. We can easily see through transparent materials, such as glass. We can see the glass because a tiny amount of light is reflected off the material.

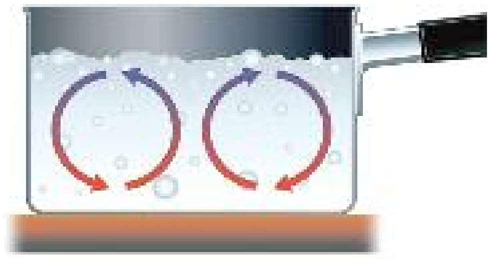
Heat & Temperature

Heat is a type of energy that objects possess when their atoms are moving or vibrating. It is sometimes called thermal energy. The more an atom moves, the more heat it has. Heat moves around and between objects in three main ways: conduction, convection and radiation. Heat will always move from a hot area to a cold one. Temperature is not the same as heat. It is a measure of how much heat energy something possesses.


1

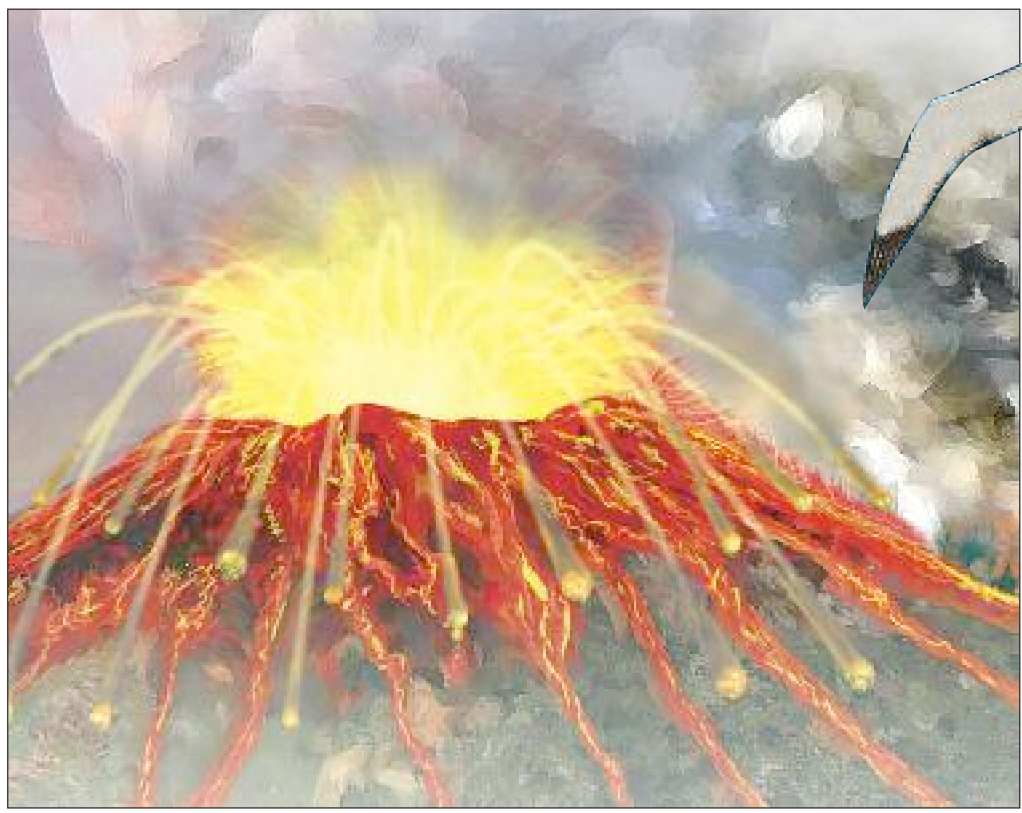
Heat travels in three ways:
1 Radiation: heat travels in the form of waves.
2 Conduction: heat energy passes between two objects that are touching.
3 Convection: heat energy moves through a gas or a liquid, rising up as the hot atoms become less dense.


2


3

Absolute zero The lowest temperature possible. At absolute zero, an object's atoms would be absolutely still and not vibrate at all. Absolute zero is zero on the Kelvin scale. It is -273.15°C in the Celsius scale.

Even rocks melt at above 800°C or higher. The liquid rock that spurts from volcanoes is called lava.



Celsius scale One of the scales used to measure temperature. Zero degrees Celsius (0°C) is the temperature of freezing water and 100°C is the temperature of boiling water.

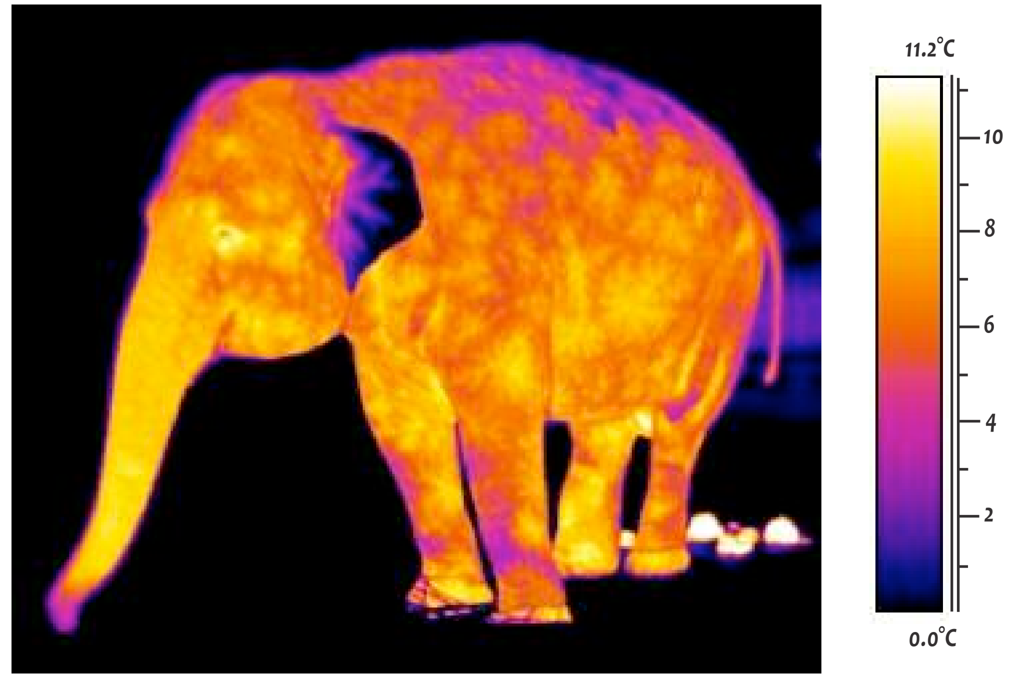
Cold The absence of heat. Objects that are cold have very low temperatures.

Conduction One of the ways in which heat energy moves. In conduction, heat passes between two objects that are in physical contact. When you touch an object to see how warm it is, you receive some of its heat by conduction.

Birds glide in the convection currents that rise off warm areas of land and sea.

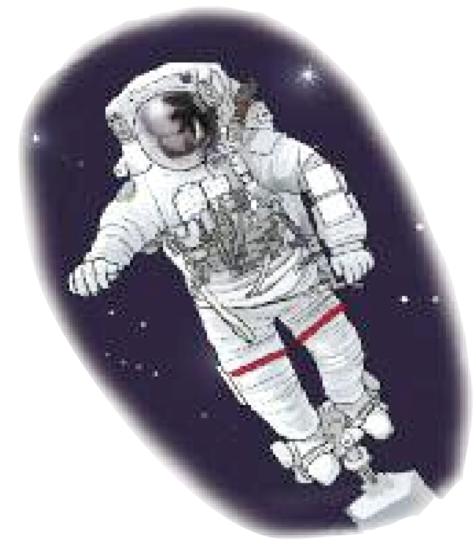
Convection One of the ways in which heat moves. Convection only occurs in fluids (liquids and gases). As some of the atoms in a fluid receive heat, they gain energy and spread out. The hot part of the fluid becomes less dense than its cooler surroundings and rises upwards. But as it rises, it moves away from the source of the heat, so cools down and sinks.

Convection current The circulation of heat produced when a liquid or gas rises and sinks as it repeatedly heats up and cools down.



Above: a thermogram of an elephant

Below: the temperature in space varies hugely between areas of sunlight and shadow. Astronauts wear suits that regulate their temperature. Shiny foil reflects the intense heat of the Sun. Insulation inside the suit stops the astronauts from freezing.



Fahrenheit scale One of the scales used to measure temperature. In the Fahrenheit scale, 32 degrees Fahrenheit (32°F) is the temperature of freezing water and 212°F is the temperature of boiling water.

Kelvin scale Sometimes known as the **absolute scale**, the Kelvin scale is one of the scales used to measure temperature. It starts at absolute zero, or 0 K. The temperature of freezing water is 273 K and the temperature of boiling water is 373 K.

Radiation One of the ways in which heat moves. Radiant heat travels in the form of waves. Unlike conduction and convection, radiation can travel through empty space (a vacuum). This is how the Sun's heat reaches the Earth.

Temperature A measure of how much heat energy a substance or an object possesses.

Thermals Pockets of warm, rising air in the Earth's atmosphere. They rise from areas of sea and land that have been recently warmed by the Sun.

Thermal conductor A substance that heat can travel through easily. Most metals are good thermal conductors.

Thermal insulator A substance that slows down the movement of heat. Air, wood and plastic are all good thermal insulators.

Thermodynamics The study of heat and how it can be changed into different forms of energy.

Thermogram A type of photograph that shows areas of different temperatures in different colours. Typically the hottest areas appear white and the coolest areas appear black.

FACTFILE

★ Like light, radiant heat can reflect from surfaces.

★ On a hot day, light-coloured clothes reflect the Sun's warmth and keep you cooler than dark clothing, which absorbs warmth. In very hot countries, people paint their houses white so that they reflect heat.

★ Air acts as a thermal insulator. Layers of clothing trap air between them, helping to keep you warm.

★ The faster an aircraft goes, the hotter its outer surface will become due to friction (➜ 16) with molecules in the air. Very fast planes have special heat-radiating paint that gives out heat as fast as possible. This prevents the metal skin of the plane from melting.

★ Normal human body temperature is about 37°C. If body temperature falls below this temperature, fatal hypothermia may set in.

Thermometer An instrument used to measure temperature. Glass thermometers are made of a long glass tube containing alcohol or mercury, which expands as it heats, and rises up the tube. Digital thermometers have small electric sensors that record changes in temperature.

Penguins are kept warm by their natural insulation: feathers and a thick layer of fat, called blubber.

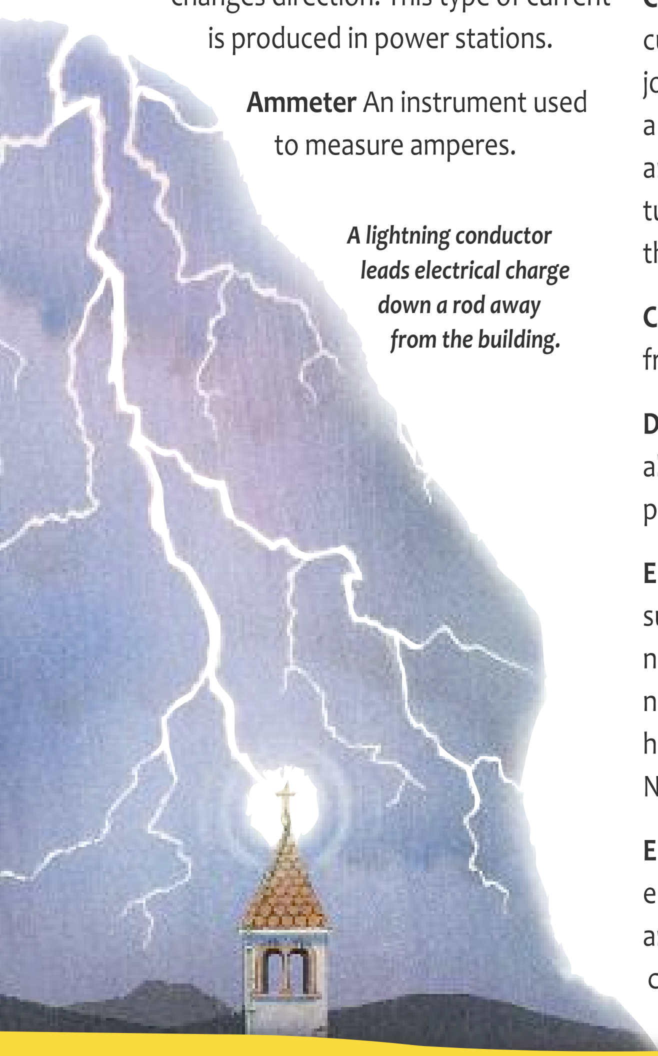
ELECTRICITY & MAGNETISM

Electricity is a form of energy made by the movement of electrons (← 6), the negatively charged particles found inside atoms. Electricity flows when electrons are free to move from one atom to another. It is easily changed into other forms of energy and is easy to use because it can be directed along wires. Magnetism is a force that attracts some objects to other objects. An object with a magnetic field is called a magnet, and is usually made of the metal iron. Electricity can produce magnetism and magnetism can produce electricity.

An electrical circuit of battery, wires and bulb.

Alternating current An electric current where the flow of electrons regularly changes direction. This type of current is produced in power stations.

Ammeter An instrument used to measure amperes.



A lightning conductor leads electrical charge down a rod away from the building.

Ampere The unit used to measure the strength of an electric current. Amperes (A), or amps, measure how many electrons pass a certain point in one second.

Battery An object that converts chemical energy into electrical energy. When a battery is connected to a circuit, chemical reactions inside it push electrons out of one end, around the circuit, and back to the other end of the battery.

Circuit A pathway along which an electric current can flow, for example, a wire joining a battery and a light bulb. If there is a gap in the wire, the circuit will be broken and the current will stop flowing. Switches turn electrical appliances off by breaking the connections in a circuit.

Current electricity Electricity that flows from one point to another.

Direct current An electric current that always flows in one direction. Batteries produce direct current.

Electrical charge Atoms are made up of subatomic particles called protons, neutrons and electrons. Electrons have a negative (-) electric charge and protons have a positive (+) electric charge. Neutrons have no charge at all.

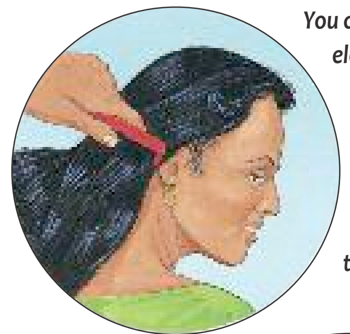
Electric conductor A substance that electricity can easily flow through. Metals are good conductors because metal atoms contain electrons that are free to move.

Electric current The flow of electricity through a conductor.

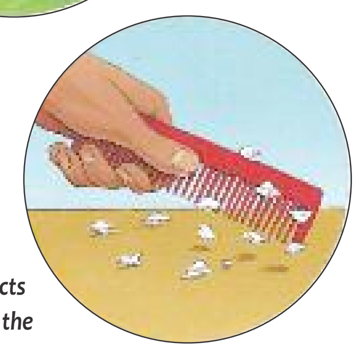
Electric insulator A material that reduces or stops the flow of electricity. Substances such as wood, plastics, rubber and glass make good insulators because the electrons inside their atoms do not easily move.

Electromagnet A temporary magnet produced by sending an electric current along a wire. If the wire is twisted into a coil it will produce a stronger magnetic field because the field around each loop of wire combines. The magnet can be turned on and off by switching the electricity on and off.

Electromagnetism Magnetism produced using an electric current.



You can make static electricity by running a comb through your hair. The comb leaves some of its electrons in the hair.



Having lost some electrons, the comb now has a positive charge. It can pick up small pieces of paper because it attracts the electrons in the paper's atoms.

Generator A machine, sometimes known as a **dynamo**, that uses movement to generate electricity.

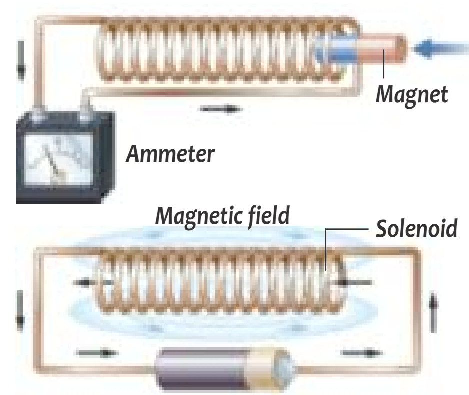
Lightning A visible spark of static electricity produced during a thunderstorm. Static electricity builds up inside clouds when ice and water molecules bump against each other and become electrically charged. The light we see is a strip of air being suddenly heated by the electricity. The heat of the flash makes the air around it expand so fast it makes a loud boom of thunder.

A large electromagnet is used to lift metal objects on a scrap heap.

Magnet An object that has two ends, called poles, and a force of attraction between them. Most magnets are made of the metals iron or steel and attract other objects made of these materials. The Earth itself has a magnetic field, as if it had a magnet inside it. Magnets have no effect on wood, plastic, or most other kinds of metal.

Magnetic compass An instrument that has a small needle-shaped magnet balanced inside it. The ends of the needle are attracted to the Earth's magnetic poles, so that one end always points due North.

Magnetic field The region surrounding a magnet where the effects of the magnet can be felt.



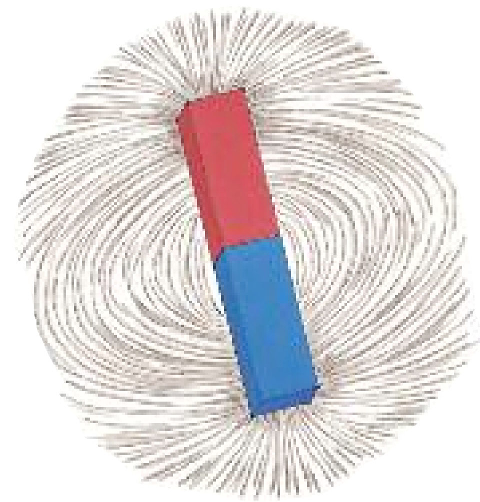
A magnetic field moving near a wire causes electricity to flow in the wire (top). An electric current flowing in a wire creates a magnetic field around the wire (bottom).

Magnetic poles The two points at either end of a magnet, called the north and south poles. Lines of magnetic force run between opposite poles.

Magnetism The invisible force of attraction or repulsion between magnetic materials.

Resistance A measure of how easily electrons can flow through a material. Good conductors have low resistance, meaning that electrons can pass along them quickly and easily. Resistance is measure in units called **ohms** (Ω).

Semiconductor A substance whose resistance lies half way between that of a conductor and that of an insulator.



A sprinkling of tiny pieces of iron around a magnet shows the pattern of its magnetic field.

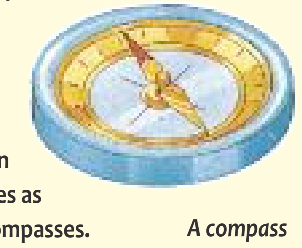
Solenoid A coil of wire that acts as a magnet when electricity is passed through it.

Static electricity Electricity that does not move. Static electricity is produced when electrons are separated from their atoms. It builds up when electrons rub off from one material on to another. The material that has lost electrons becomes positively charged; the material that has gained them becomes negatively charged.

FACTFILE

★ When lightning passes from clouds to the ground, the amount of electric energy produced can be enough to destroy a building or kill a person. A lightning conductor can be used to prevent accidents. This is a metal rod that runs from the top of a tall building to the ground. It leads the electric charge down the rod and away from the building to the ground, spreading the electricity over a wide area.

★ The first magnets were called lodestones. A lodestone is a naturally magnetized piece of the mineral magnetite. Lodestones were used in ancient times as primitive compasses.

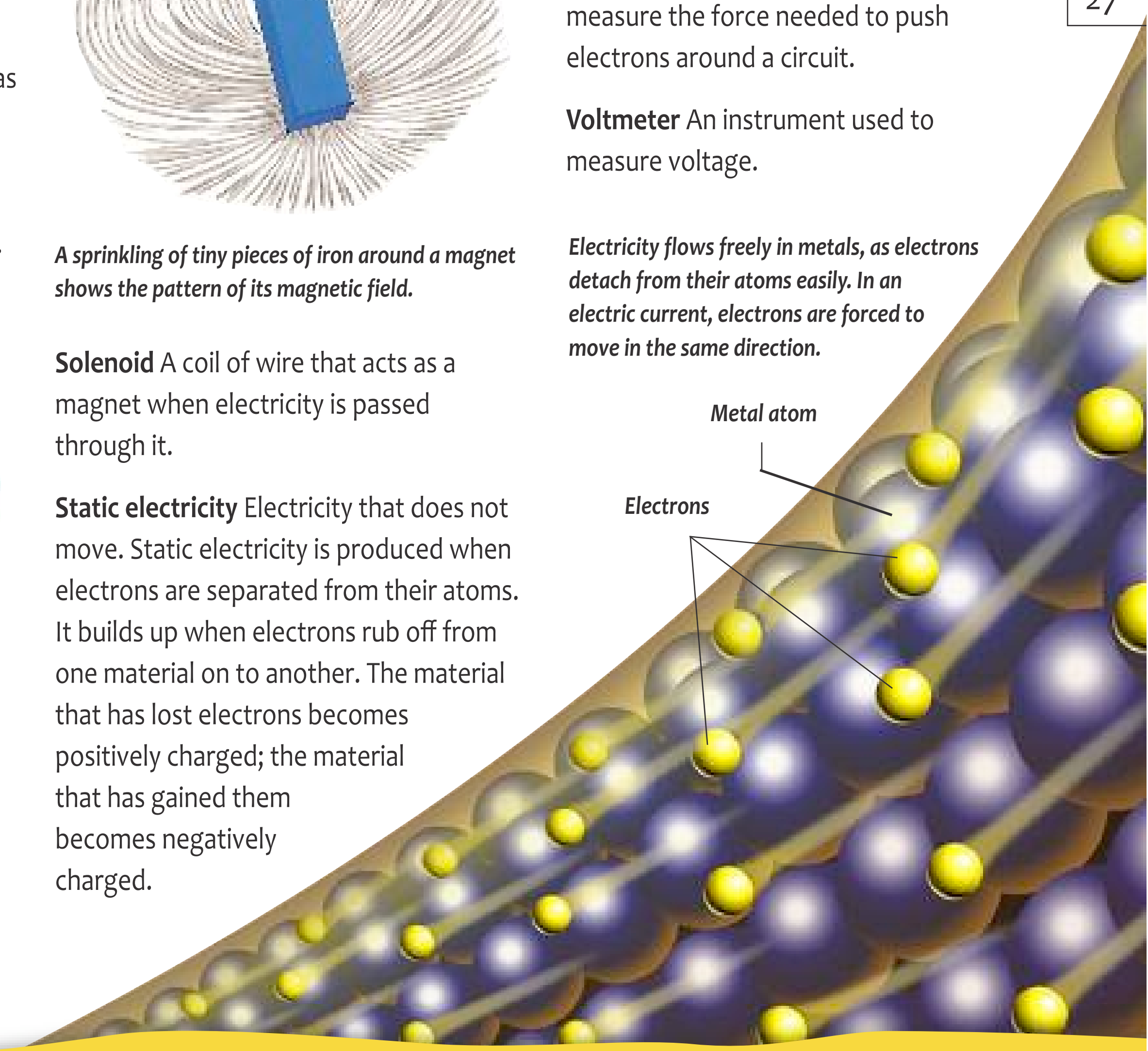


A compass

Voltage The unit used to measure electrical force. Voltage (V), or volts, measure the force needed to push electrons around a circuit.

Voltmeter An instrument used to measure voltage.

Electricity flows freely in metals, as electrons detach from their atoms easily. In an electric current, electrons are forced to move in the same direction.

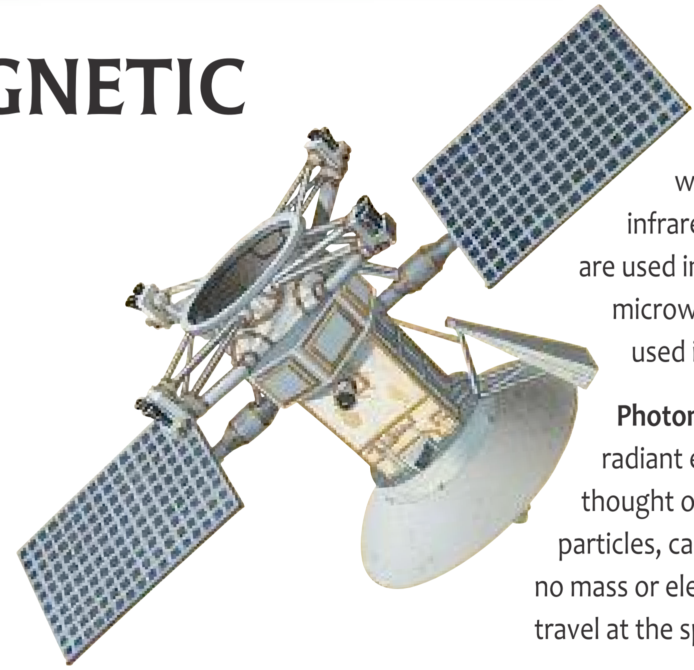


Electromagnetic Spectrum

The electromagnetic spectrum is a classification of different types of radiation—energy that travels in waves. Radio waves, microwaves, light, heat and X-rays are all forms of electromagnetic radiation. They all travel at the speed of light, but have different wavelengths—the distance between one wave crest and the next—and therefore different frequencies—the number of waves per second. Different forms of electromagnetic radiation are grouped according to their wavelengths. Those with shorter wavelengths carry the most energy. Visible light (⬅ 22) is the only part of the spectrum that we can see.

Electromagnetic radiation A form of energy that travels in waves at the speed of light. Unlike other forms of energy, such as sound waves, radiant energy can travel through empty space (a vacuum).

Gamma rays A form of electromagnetic radiation with a very high frequency and short wavelength. They are given out by radioactive atoms (⬅ 6) or produced in nuclear reactions (⬅ 18). They can pass right through some substances.



Some space probes use radar to map the surface of planets. Instead of light, radio waves are used to build up an image of the planet's landscape.

Infrared (IR) radiation A form of electromagnetic radiation, with a wavelength just longer than that of visible red light. It is the radiation that you feel as heat from hot objects. IR radiation is used for short-range communications, such as in television remote controls and remote locking in cars.

Maxwell, James Clerk (1831–1879) Scottish physicist who discovered the existence of electromagnetic waves.

Microwaves A form of electromagnetic radiation with a wavelength longer than infrared radiation. Microwaves are used in communications. Some microwave frequencies can also be used in cooking.

Photons Light and other forms of radiant energy can either be thought of as waves or as tiny particles, called photons. Photons have no mass or electrical charge (⬅ 26). They travel at the speed of light.

Radar (RAdio Detection And Ranging) A system that detects objects by transmitting radio waves and receiving the "echoes" that bounce back from them. Radar is used by ships and aeroplanes to detect other craft or oncoming storms.

Radio waves A form of electromagnetic radiation with a very long wavelength. Radio waves are important in communications through air and space.

Röntgen, Wilhelm (1845–1923) German physicist who discovered X-rays.

Transmitter An electronic device that sends out electromagnetic waves, such as radio waves.

Some banknotes are printed with an ink that only shows up under a special UV light bulb. Bankers can check for fake notes by using one of these lights.

Ultraviolet (UV) radiation A form of electromagnetic radiation with a wavelength just shorter than that of visible violet light. Some of the energy emitted by the Sun takes the form of UV radiation. Most UV rays from the Sun are absorbed by the Earth's atmosphere, but they still cause tanning of the skin and sunburn.

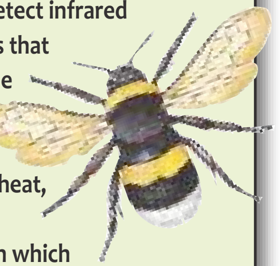
Visible light The part of the electromagnetic spectrum that is visible to the human eye. Light waves with slightly different wavelengths appear as different colours. The colour red has the longest wavelength and violet has the shortest wavelength.

FACTFILE

★ Overexposure to ultraviolet radiation from exposure to the Sun can cause skin cancer.

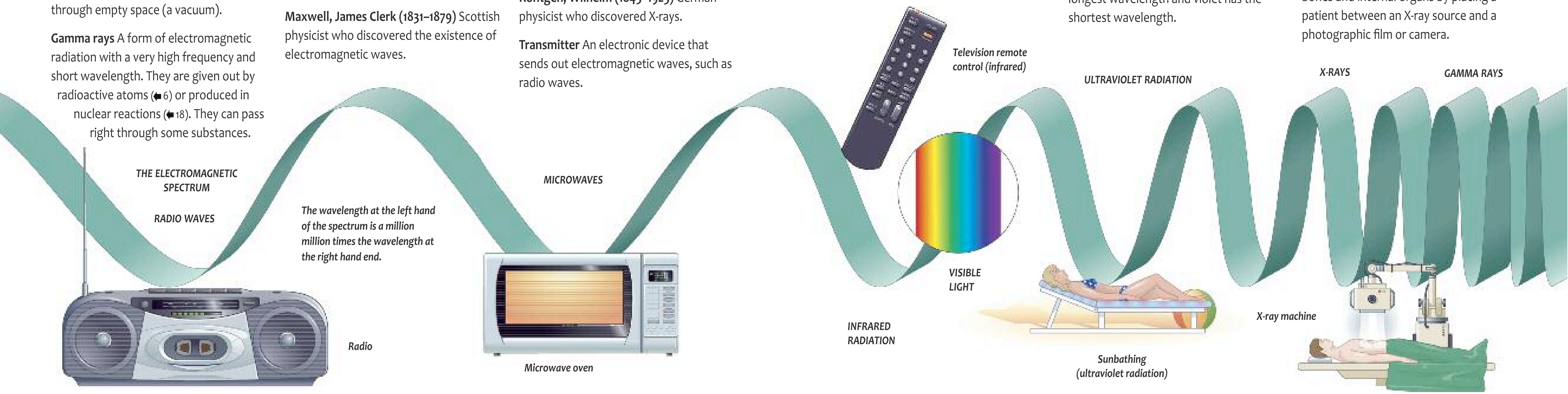
★ The longest waves in the electromagnetic spectrum are over 100 km long. The shortest waves are only a billionth of a millimetre long.

★ Although ultraviolet and infrared rays are invisible to humans, some animals can see them. Bumblebees are able to see ultraviolet light and snakes have pits near their eyes that can detect infrared radiation. This means that snakes can hunt in the dark because they can detect objects that give off heat, such as the warm-blooded mammals on which they prey.



Bumblebee

X-rays A form of electromagnetic radiation with very short wavelengths and extremely high frequencies. They pass right through some solids. In medicine they can be used to see the structure of bones and internal organs by placing a patient between an X-ray source and a photographic film or camera.



The wavelength at the left hand of the spectrum is a million million times the wavelength at the right hand end.

INDEX