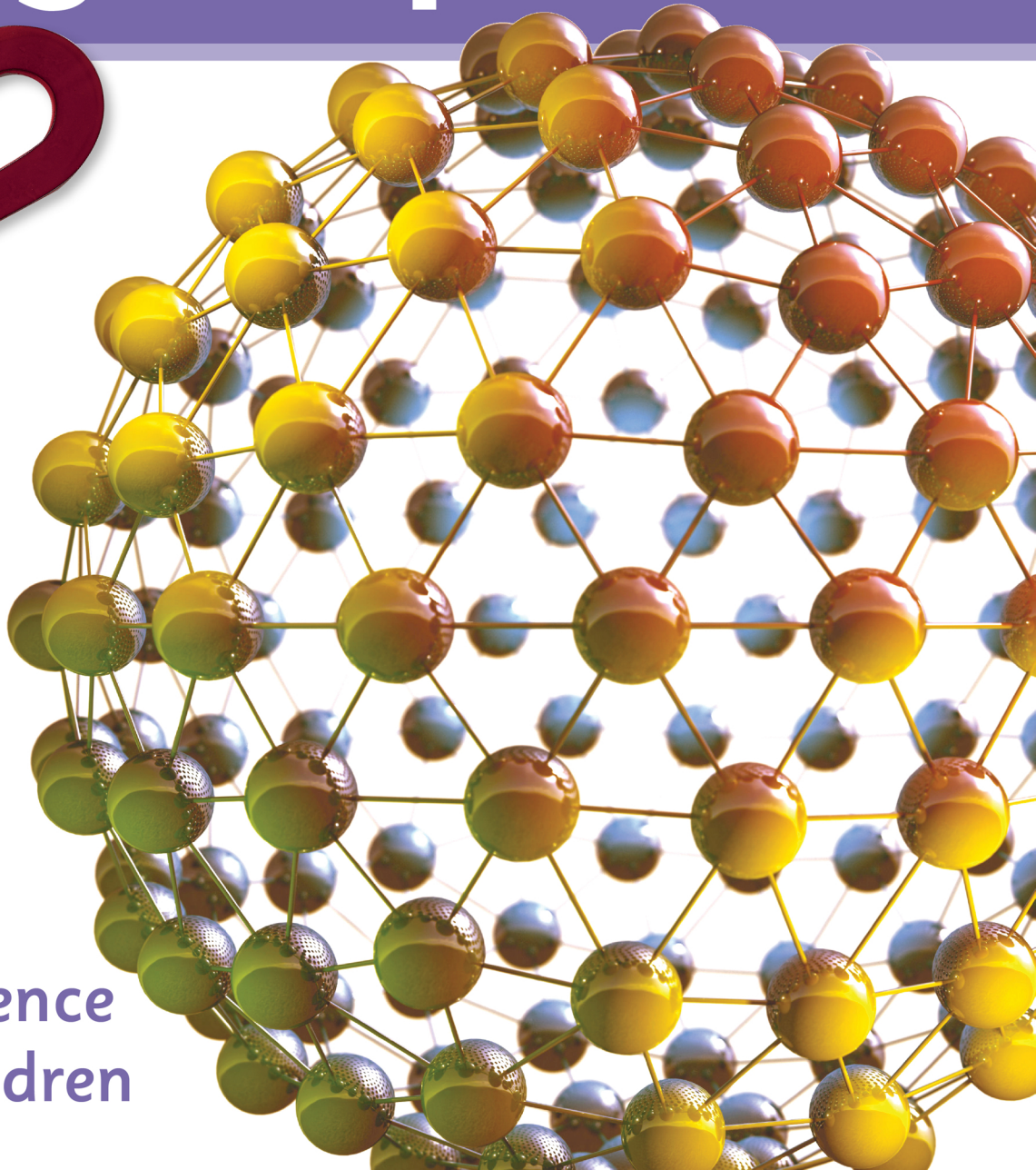


First Science Encyclopedia



A first reference book for children



First Science Encyclopedia





Penguin
Random
House

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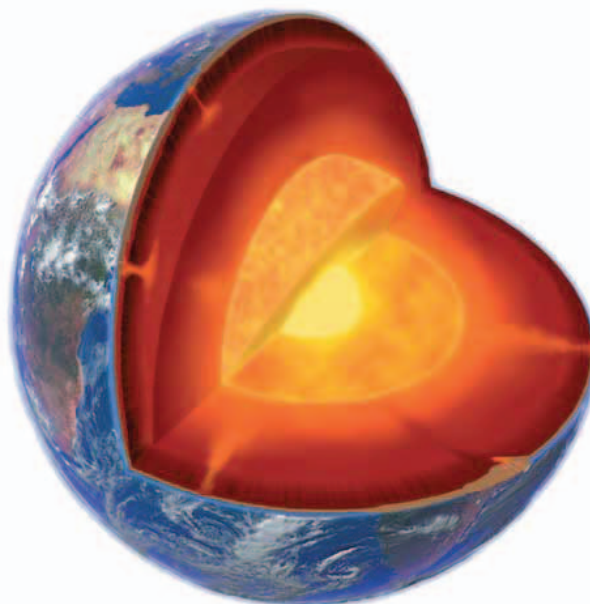
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A WORLD OF IDEAS:
SEE ALL THERE IS TO KNOW

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About this book

The pages of this book have special features that will show you how to get your hands on as much information as possible! Look out for these:



The Picture Detective will get you searching through each section for the answers.

Turn and Learn tells you where to look for more information on a subject.

Every page is colour-coded to show you which section it is in.

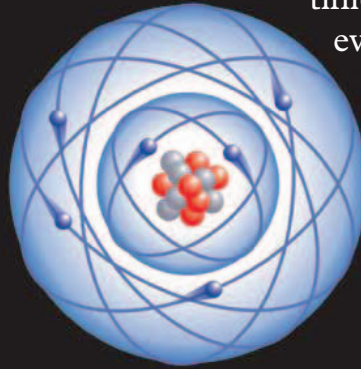


What is science?

Science is the search for truth and knowledge. Scientists suggest explanations of why things are as they are, and then they test those explanations, using experiments. Some of what science discovers can be applied to our everyday lives.

From atoms to space

Scientists study a huge variety of things – from the tiniest atoms that make up everything around us to the mysteries of space.



Everything you see is made up of minuscule atoms.

Life science

How do living things survive and grow, where do they live, what do they eat, and how do their bodies work? Life science seeks to answer such questions about the living world, from microscopic bacteria to plants and animals – including you!



The scientific study of plants is called botany.

Physical science

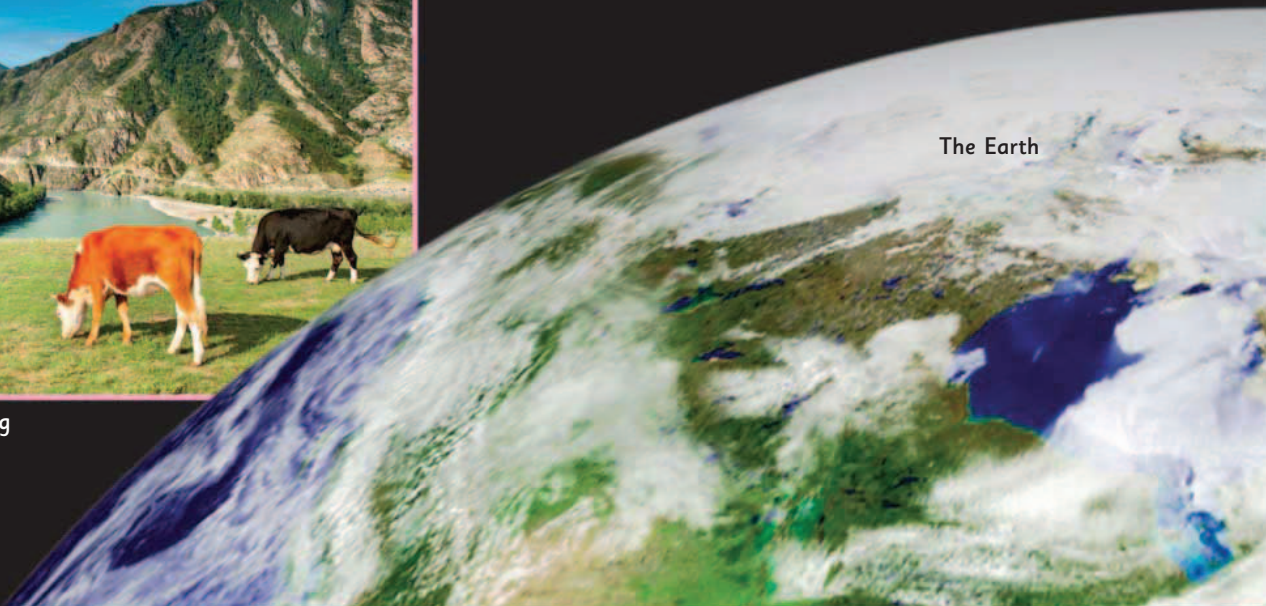
This science looks at energy and forces. There are different types of energy, including light, heat, and sound. Forces are the things that hold everything in place in our world. Without the force of gravity, for example, you would fly off into space!



The study of electricity is part of physical science.



Life science studies the living world around us.



The Earth



This is NASA's Atlantis orbiter – part of its Space Shuttle programme, which ended in 2011.

Earth and space science

The Earth is a dot in a vast Universe filled with planets and moons, stars and galaxies. As far as we know, the Earth is special because it is the only place that supports life. Earth and space science is the study of the structure of our planet – and everything that exists beyond it.



Volcanology is the scientific study of volcanoes.



One branch of science studies how materials can change.

Materials science

Our Universe is filled with atoms and molecules, which make up elements, compounds, and mixtures. Materials science is the study of these things, how they behave, how we use them, and how they react with one another.

All about change

People always want to make life better, and that's what puts us on the road to scientific discovery. Whether it's finding cures or sending rockets into space, science drives us onwards, changing the world we live in.

Pictures of the Earth from space help scientists understand the Earth better.

Advances in science

Great scientists are thinkers who understand the world around us, provide solutions to problems, and create new things. This has led to many great inventions and discoveries.

A falling apple probably inspired Newton to think about gravity.



In a rainbow, white light breaks up into seven colours.

Johannes Gutenberg (c.1398–1468)

Gutenberg played a key role in printing. Experts believe he invented metal-type printing in Europe. Gutenberg's press was quick, accurate, and hard-wearing, compared to earlier woodblock printing.



Gutenberg's first printed book was the Bible in 1455.

Isaac Newton (1642–1727)

Newton investigated forces and light. He realized there must be a force that keeps the planets in orbit around the Sun. This force is known as gravity. Newton also discovered that white light is a mixture of lots of different colours.

1400

1500

1600



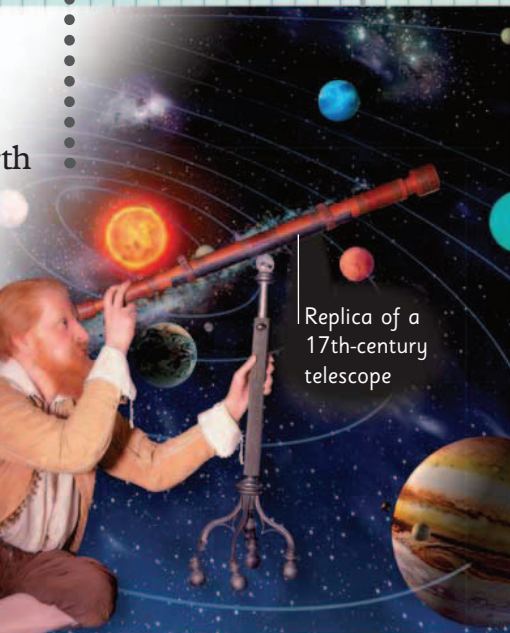
Wooden replica of da Vinci's Ornithopter

Leonardo da Vinci (1452–1519)

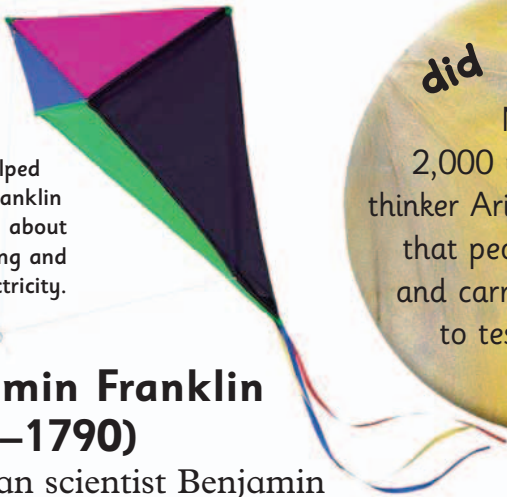
Da Vinci was a painter and inventor. He drew plans for helicopters, aeroplanes, and parachutes. Unfortunately, the technology of the time was not good enough to build a working model for any of these.

Galileo Galilei (1564–1642)

Galileo proved that the Earth moves around the Sun by looking at the solar system through a telescope. A few wise thinkers had always suspected the truth, but most people at the time believed that our Earth was the centre of everything.



Replica of a 17th-century telescope



A kite helped Benjamin Franklin learn about lightning and electricity.

Benjamin Franklin (1706–1790)

American scientist Benjamin Franklin experimented with lightning and electricity. His work in the 1700s laid the foundations for today's electrical world.



Franklin risked his life flying a kite – he could have been struck by lightning.



did you know?
More than 2,000 years ago, Greek thinker Aristotle recommended that people study nature, and carry out experiments to test the accuracy of ideas.

Louis Pasteur (1822–1895)

Pasteur is known for discovering pasteurization – a process that uses heat to destroy bacteria in food, particularly milk. He also discovered that some diseases were caused by germs and encouraged hospitals to be very clean to stop germs spreading.



Super inventions!

Inventions and discoveries have changed the course of our history.



The first known **wheel** was used in Mesopotamia around 3500 BCE.



Paper was invented in China around 105 CE, but kept secret for many years.



The magnetic **compass** was first used by the Chinese. It was invented around 247 BCE.



The **parachute** was first tested in 1617 by Faust Vrancic, centuries after da Vinci made his drawings.



The **steam engine** was invented in 1804. The earliest successful model reached 48 kph (30 mph).



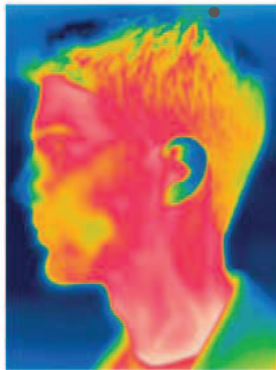
The **colour photo** was first produced by physicist James Maxwell in 1861.

1700

1800

William Herschel (1738–1822)

Herschel is well known for his work in astronomy (he was the first to identify the planet Uranus). He also discovered infrared radiation – this technology is used today for wireless communications, night vision, weather forecasting, and astronomy.



Wilhelm Conrad Röntgen (1845–1923)

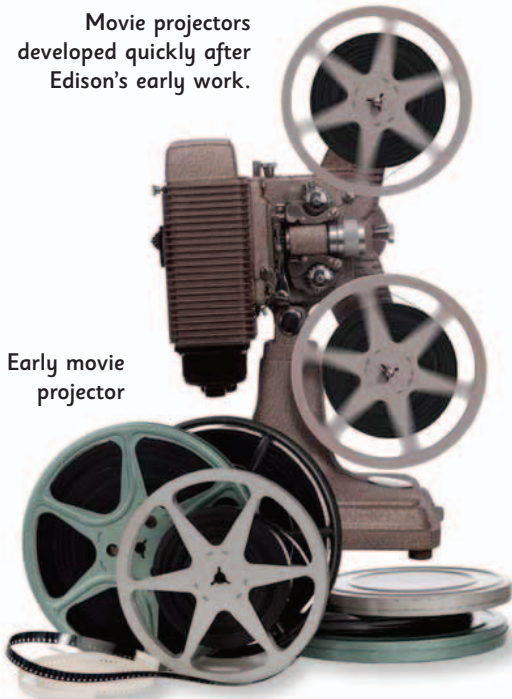
Röntgen discovered electromagnetic rays – today known as X-rays – on 8 November 1895. This important discovery earned him the first Nobel Prize for Physics in 1901.

X-rays allow doctors to look inside the human body.



Movie projectors developed quickly after Edison's early work.

Early movie projector



Thomas Edison (1847–1931)

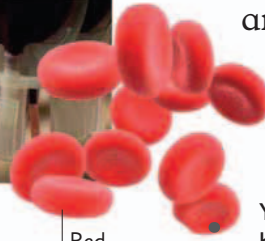
Thomas Alva Edison produced more than 1,000 inventions, including long-lasting light bulbs, batteries, and movie projectors.

Karl Landsteiner (1868–1943)

Austrian-born physiologist Landsteiner discovered that human blood can be divided into four main groups – A, B, AB, and O. This laid the foundation of modern blood groupings.

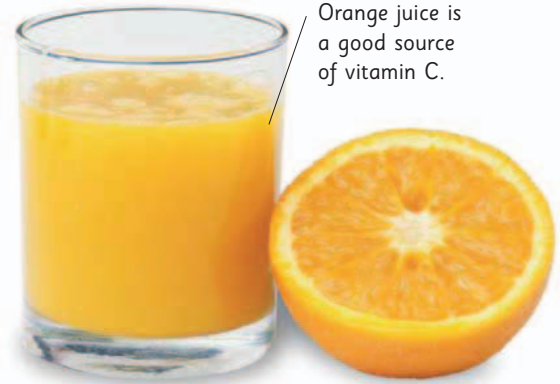


Blood transfusions play an important part in modern medicine.



Red blood cells

You inherit your blood type from your parents.



Orange juice is a good source of vitamin C.

Albert Szent-Györgyi (1893–1986)

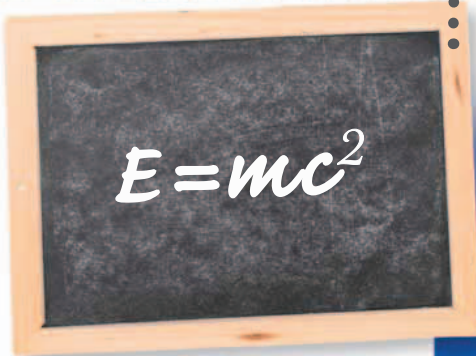
The Hungarian scientist Albert Szent-Györgyi is best known for discovering vitamin C. He also pioneered research into how muscles move and work. In 1937, he won the Nobel Prize for physiology and medicine.

1800

1850

Albert Einstein (1879–1955)

German-born physicist Albert Einstein's famous equation $E=mc^2$ explained how energy and mass are related. It helped scientists understand how the Universe works.



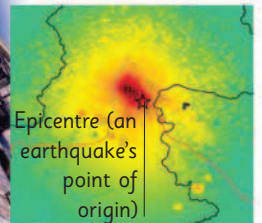
Einstein's equation

A "great" earthquake (8–9.9 on the Richter scale) strikes on average once a year.

Earthquakes destroy homes and office buildings.

Charles Richter (1900–1985)

Richter developed a way to measure the power of earthquakes. He worked on his scale with fellow physicist Beno Gutenberg.



Epicentre (an earthquake's point of origin)

Alan Turing (1912–1954)

During World War II, Alan Turing, a brilliant mathematician, helped develop code-breaking machines that eventually led to the invention of modern computers.

The English used Turing's machine to break German codes that were sent through the Enigma machine during World War II.



Tablet



An Apple smartphone

Modern inventions

Imagine the world without these fantastic inventions!



The first **antibiotic**, penicillin, was discovered accidentally.



Modern **cars** are driven by internal combustion engines that run on petrol or diesel.



Nuclear power is efficient, but some people think it could harm us.



Plastics technology is used to make many of the things in your home.



Compact discs are small and light, and they store lots of information.

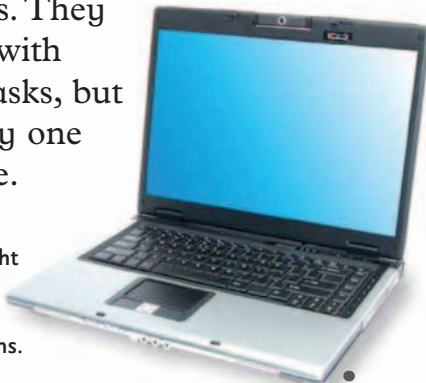


Energy-efficient light bulbs help save energy in your home.

Computers (1941)

The first computers were huge machines. They couldn't cope with complicated tasks, but worked on only one thing at a time.

Today's laptops can be lightweight and portable. Early computers filled whole rooms.



Mobile phones and tablets (1980s)

The first mobiles were large and heavy, weighing about 35 kg (77 lb). Tablet technology has also improved drastically since its invention in the late 1980s.

1900

1950

DNA profiling (1986)

The discovery of DNA (which holds information in human cells) led to DNA profiling, a huge help to the police – criminals can now be identified by a single hair or spot of blood.



Nuclear bombs (1945)

The USA dropped two nuclear bombs on Japan in World War II, killing nearly 300,000 people. It is the only time nuclear weapons have been used in war.



The Internet (1990s)

With its roots in the 1960s, the Internet (short for internetwork) became public during the mid-1990s, and is now used for fun and education by about 2.5 billion users – 70 per cent of whom are online every day.

Before DNA profiling, police identified criminals by their fingerprints. This system was developed in the 1890s.

Being a scientist

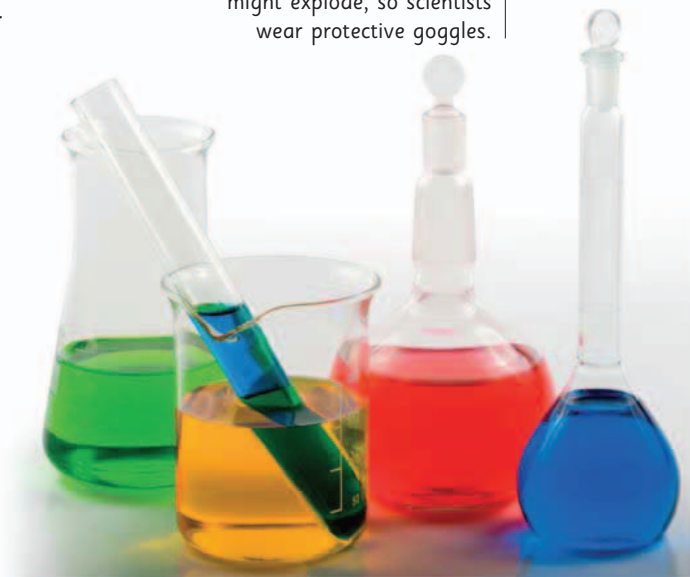
Scientists study the world around us. They look for gaps in existing knowledge and try to find the answers. Not all scientists study the same things – they specialize in different areas.

Testing, testing

Scientists explore their ideas and theories using tests called experiments. In this book, there are lots of experiments you can try out for yourself.



Experiments can involve toxic fumes or chemicals that might explode, so scientists wear protective goggles.



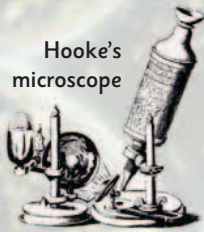
Mixing it up

Experimenting with chemicals and their reactions can produce some mixed results. Some mixtures can be dangerous, while others can be the answer the scientists are after.



A closer look

The microscope was developed by two Dutch spectacle makers in around 1610, and then refined by Robert Hooke in England. Early models revealed tiny organisms in water, while modern versions can look inside a single cell.



Hooke's microscope



Modern microscope



Inside view

When you go to a hospital, the doctor may send you for a body scan. Using a powerful machine, the medical team can see what's going on inside you.

hands on

Fill a cup or vase with water, and add a few drops of food colouring. Cut the end off the stem of a flower and put the flower in the water. The petals turn the colour you mixed in the water.



Experiments allow scientists to observe and theorize how things work and why. It has been found, for instance, how plants take up food and water from the soil and transport it up the stem.

Types of scientist

Almost everything in the world is the subject of study by a scientific specialist.



Zoologists study animals of all kinds except human beings.



Biologists are interested in everything about life and living organisms.



Paleontologists are experts on fossils, and try to learn about organisms from them.



Botanists learn about the world of plants, plant types, and plant groups.



Chemists study elements and chemicals, and they help make new substances.



Astronomers are experts on space, planets, stars, and the Universe.



Entomologists are a special kind of zoologists who learn about insects.



Geologists find out about our Earth, particularly by studying rocks.



Archaeologists are interested in the remains of past peoples and lives.



Ecologists study the relationship between living things and their environment.



Oceanographers know all about oceans and ocean life.

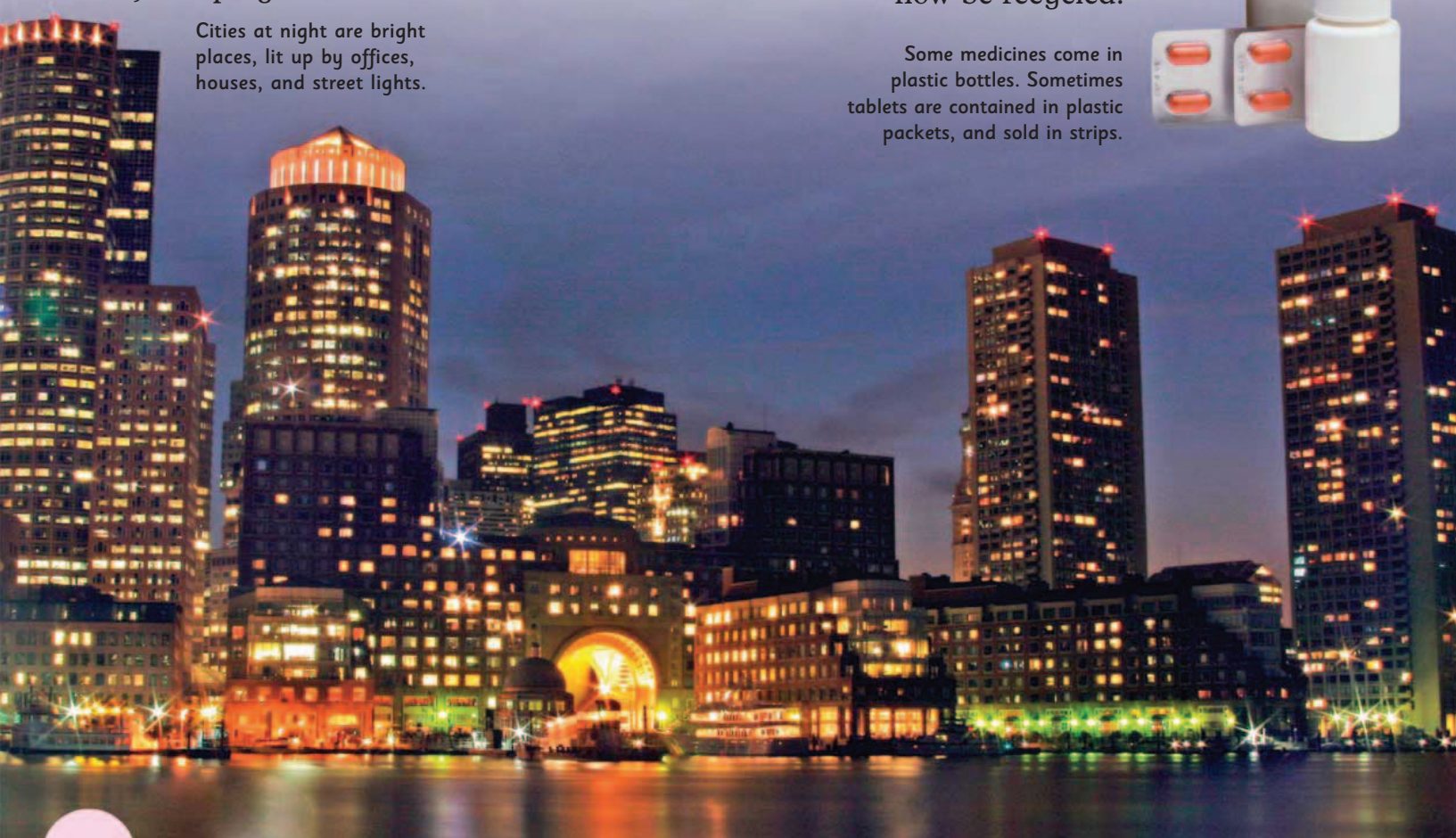
Science and everyday life

Science is not just used by experts working in laboratories. It is part of all our lives. From brushing your teeth to setting your alarm, science is with you all day, every day, in the form of technology.

Electricity

Electricity lights up the world and gives us the energy to run machines and gadgets with which we can cook, travel, work, and play.

Cities at night are bright places, lit up by offices, houses, and street lights.



Plastic building blocks

Teflon

Invented in 1938, Teflon was used in space suits. In everyday life, it stops stuff from sticking to hot surfaces.



Iron

Teflon pan

Plastic fantastic

Look around you and you will see dozens of things made of plastic. From containers to toys, plastic is a versatile and hard-wearing material. Many plastics can now be recycled.

Some medicines come in plastic bottles. Sometimes tablets are contained in plastic packets, and sold in strips.



Surgeons get a helping hand from computers.



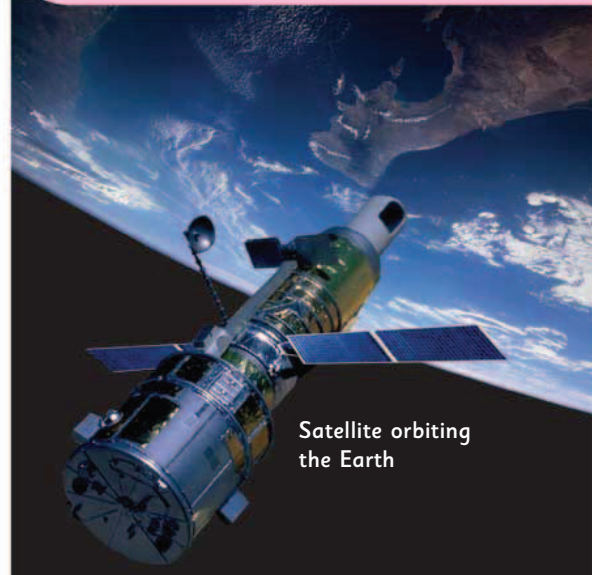
In the best of health

Long ago, people relied only on herbs to cure diseases. Thanks to modern science, many illnesses, including those that were once untreatable, can now be cured or prevented.

Masks, aprons, and gloves help doctors keep operation rooms free from infection.

Communications

Satellites orbit the Earth, beaming back all sorts of information. They send TV signals, supply weather information, and help us look into space.



Satellite orbiting the Earth

Clothing technology

Advances in sports-clothing technology have impacted everyday clothes. Breathable fabric, stretchy spandex, and thermal underwear were developed from specialized sportswear.



From here to there

Science and technology make it much easier to get around. Trains, planes, and cars make the world a smaller place and allow us to visit exotic destinations. They are also useful for getting to school on time.

Bullet trains in Japan travel up to 300 kph (186 mph).



Turn and learn
Health:
pp. 40-41
Electricity:
pp. 76-77

The living world

Our amazing world is filled with millions of species, or types, of living thing.

They can be as big as elephants or so small that you have to look through a microscope to see them.



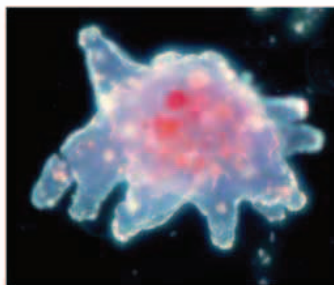
Spider



Dragonfly

Animals

The animal kingdom is made up of vertebrates (animals with a backbone) and invertebrates (animals without a backbone).



Micro-organisms

Micro-organisms are very tiny – each of them is made up of a single cell. This amoeba has been magnified more than 100 times.



Coral reef, home to a variety of living organisms

Mammals, birds, reptiles, amphibians, and fish are vertebrates.



Deer



Sunflower



Snake

Insects, such as butterflies, are invertebrates.

Tree frog

Plants

Plants cannot move around like animals. To survive and grow, they have to make their own food. Plants provide food for many animals and fungi, too.

Signs of life

Living things share some characteristics. They all need food and water. They also grow, reproduce, and adapt to their environment.

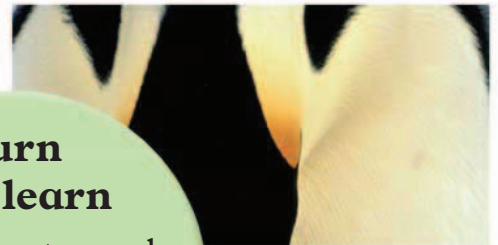
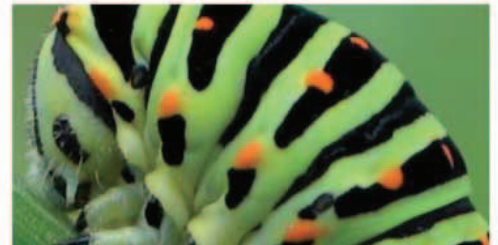
Fungi

Fungi (like toadstools, mushrooms, and moulds) are neither plants nor animals, but they're more like plants than animals.

Fungi

Picture detective

Look through the Life Science pages and see if you can identify the pictures below.



Turn and learn

How plants work:

pp. 22-23

Types of animal:

pp. 28-29

Micro life

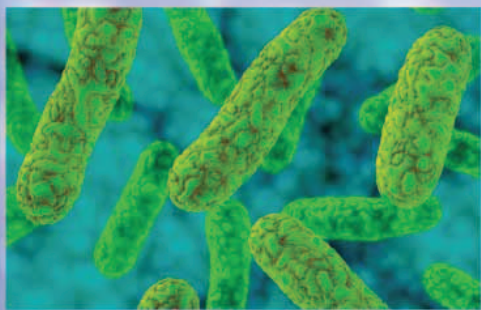
Most living things are made up of just one cell, and are too small to see. To study them, we must use powerful microscopes.

Bacteria

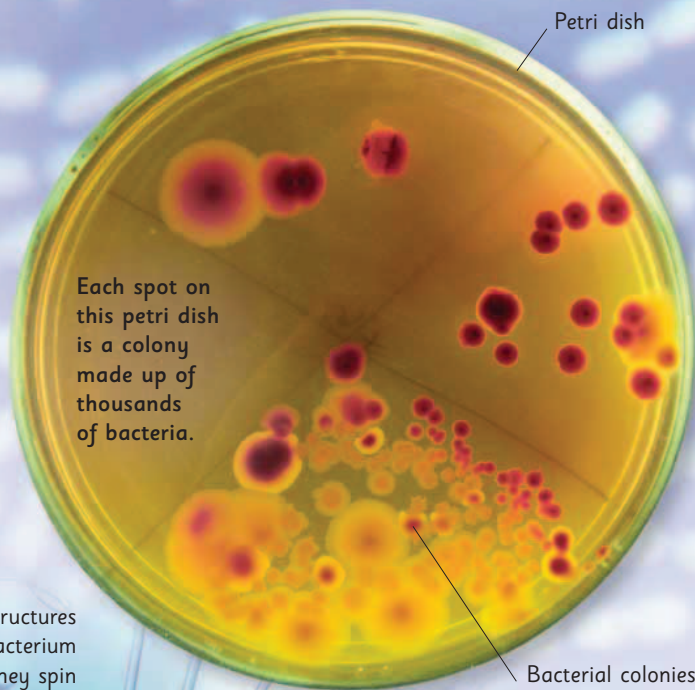
Bacteria are single-celled life forms. They are found in the ocean, in the air, and even in our bodies. They can reproduce very quickly by splitting into two. Some bacteria can make energy from sunlight. However, most feed on dead plants and animals.

Harmful bacteria

Some bacteria can cause serious illnesses such as cholera and tetanus. Good sanitation and antibiotic drugs help fight diseases caused by harmful bacteria.



Bacteria may be shaped like rods, spirals, or spheres.



Each spot on this petri dish is a colony made up of thousands of bacteria.

Petri dish

Bacterial colonies

Whip-like structures push the bacterium along. They spin round like screws.

Thin hairs attach the bacterium to a surface.

Model of a bacterium

The cell is full of a jelly-like substance that helps it to work and grow.

DNA inside the bacterium acts like a control centre.

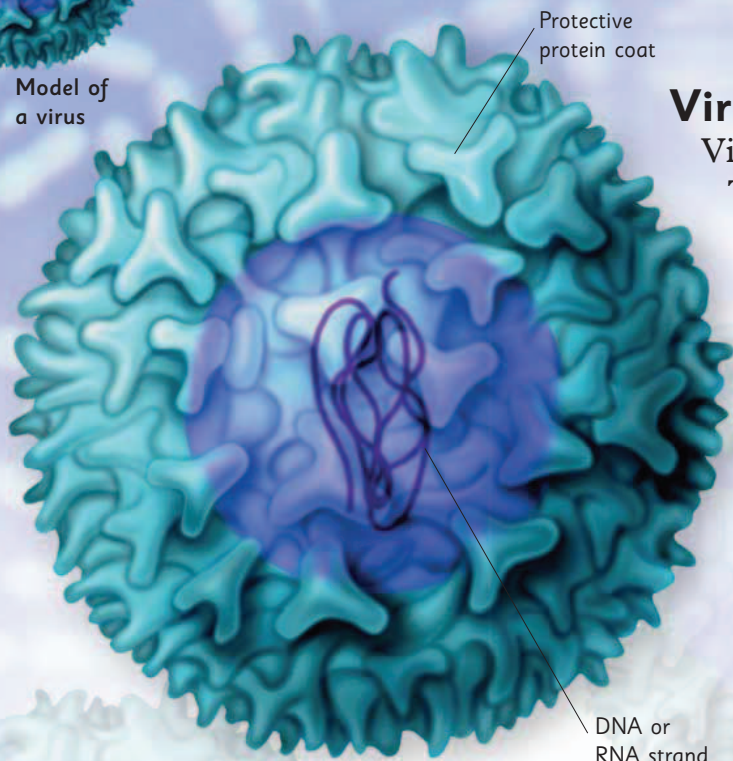
The cell wall holds the bacterium together and protects it.

Good bacteria

Some bacteria are helpful to humans. Bacteria in our guts protect us from illnesses. Other bacteria are used to make foods such as yoghurt and cheese.



Model of a virus



Viruses

Viruses are much, much smaller than bacteria. They are shaped like spheres or rods. Viruses are not really alive, because they are not made of cells. They only become active when they invade a cell. They copy themselves by taking over the cell and turning it into a virus factory.

Plant viruses

Plant viruses can change the way that plants develop. For example, one virus affects the pigment in tulips' petals. It stops the pigment from working in some places. This makes the petals look stripey.



from working in some places. This makes the petals look stripey.

A virus has made light patches appear on these leaves.



The streaked patterns on this tulip are caused by a virus.

Vaccinations

Vaccinations can help to protect people from harmful diseases. A person is injected with a weakened form of a virus or bacterium. This prepares the immune system for the real thing.



Harmful viruses

Viruses can cause different illnesses.



Chickenpox is easy to catch. The main symptom is itchy spots.



Rabies is a fatal virus that is common in animals such as dogs.



Colds are viruses and can bring on a sore throat, runny nose, and cough.



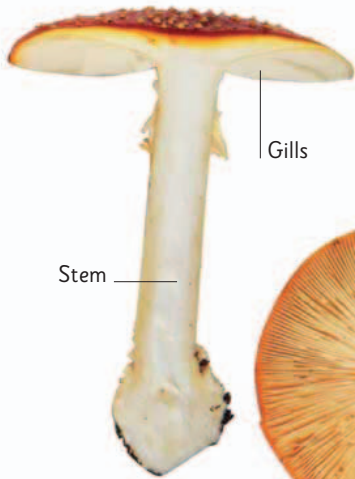
Microscope photograph of algae

Other tiny cells

Like bacteria, another group of organisms called archaea are all single-celled. There are also some single-celled organisms, such as amoebas, algae, and yeasts, that are closely related to animals, fungi, and plants.

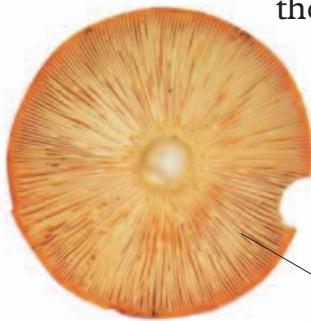
Fungi

Mushrooms, toadstools, yeasts, and moulds are kinds of fungi. Fungi are neither animals nor plants. They feed on living or dead animals or plants, and absorb their nutrients.



Mushrooms

Many fungi are hidden in the soil, or inside food sources like trees. They only become visible when they grow mushrooms. Mushrooms scatter spores, which will grow into new fungi.



The gills release spores into the air.

Picking wild mushrooms

Many wild mushrooms are not only edible, but also delicious. However, some are highly poisonous! Harmful mushrooms are often called toadstools. They sometimes have bright colours that warn animals not to eat them.

Wood blewit mushroom

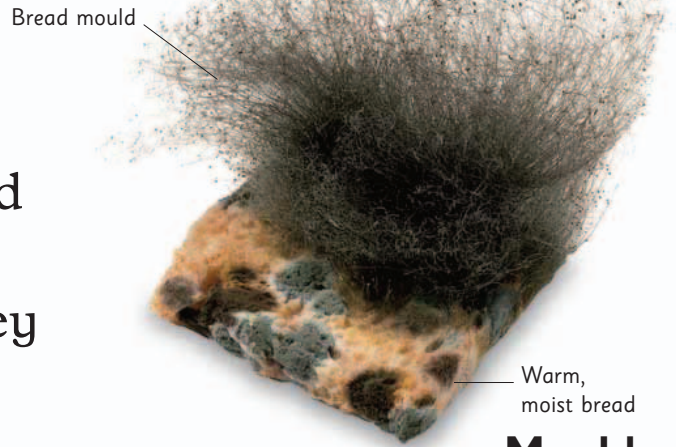


Penny bun mushroom



Fly agaric mushrooms

Jelly antler fungus



Moulds

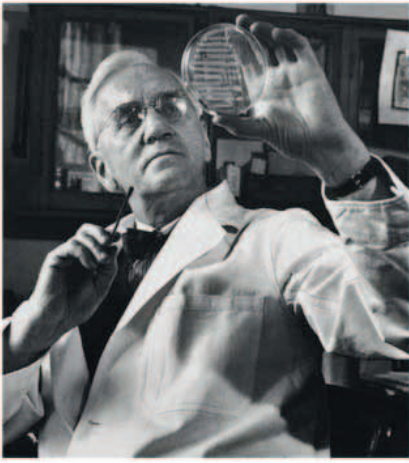
Moulds are microscopic fungi which grow in long strands called "hyphae". They feed on dead organic matter – like our food – by making it rot.



Athlete's foot

Athlete's foot is a disease caused by ringworm fungi growing on human feet.

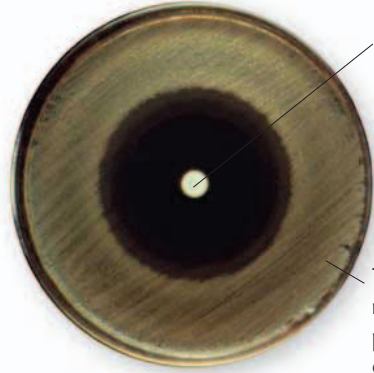
It makes the skin between your toes turn red and flaky.



Sir Alexander Fleming (1881–1955)

Penicillin

In 1928, the Scottish scientist Sir Alexander Fleming made an important discovery. He realized that the mould *Penicillium notatum* makes a chemical that kills bacteria. That chemical, called penicillin, is used today as a medicine to treat many illnesses.



Penicillin on a petri dish

The bacteria have retreated from the penicillin, leaving a clear ring.

Truffles

Truffles are strong-smelling fungi that grow underground. They are a delicacy used in cookery. Truffle hunters use pigs and dogs to sniff them out.



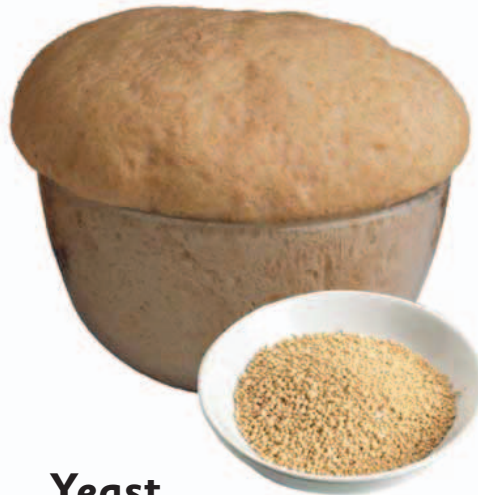
Pig sniffing out mushroom



White truffle



Black perigord truffle

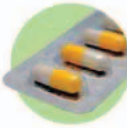


Yeast

Yeast are microscopic, single-celled fungi. When they feed, they turn sugar into the gas carbon dioxide and alcohol. Yeast plays an important part in bread-making. As it releases gas, it makes bread rise.

Uses of fungi

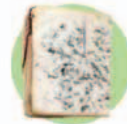
Fungi have many uses in the home and in industry.



Medicinal fungi can be used to cure many diseases that were once fatal.



Wine is made from grape juice when yeast turns the sugar in the juice into alcohol.



Blue cheese is made with a mould called *Penicillium roquefortii*.



Soy sauce is made by adding fungi and yeast to soy beans and roasted wheat.



Pesticidal fungi can be an environmentally friendly way of killing insects or weeds.

Shaggy parasol mushroom

Shaggy cap mushroom

Common chanterelle mushroom

Chicken of the woods mushroom



What is a plant?

Plants make their own food from the Sun's rays. Most have leaves that reach outwards to capture sunlight, and roots that dig deep for nutrients and stability.

Plant parts

There are lots of different plants. But most are made of the same vital parts – roots, stems, leaves, and flowers.

Stems

Stems support the leaves and flowers, and allow water and food to flow from the roots to the leaves.

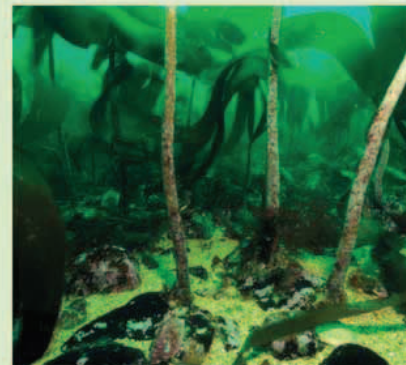
Roots

These are the foundations of the plant. They dig deep into the soil, providing stability, as well as sucking up nutrients.



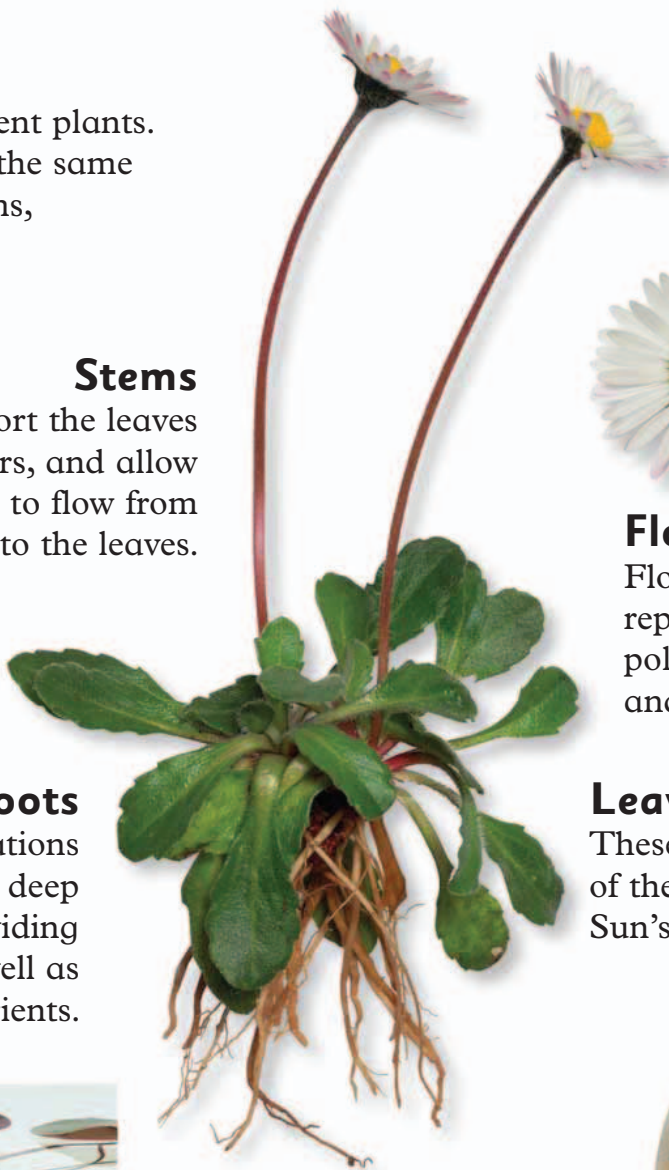
Water lily

The water lily's flat leaves float on the pond surface, as its roots sink into the pond bed.



Seaweed

Seaweed looks like a plant, but is an alga. It doesn't have roots, so it has to stick to rocks or float with the tide.



The petals attract insects and birds that collect pollen.

The stamen and carpels form the reproductive organs of a plant.

Flowers

Flowers are key to plant reproduction. They make pollen, and develop seeds and fruit.

Leaves

These are the work factories of the plant and capture the Sun's energy.

weird or what?

The Venus flytrap doesn't get its energy just from the Sun. It also lures and feeds on unsuspecting insects. Yum!

Types of plant

Have a look around you. Not all plants are the same. But some plants are more similar than others.

Fern leaves unfurl as they grow.



Ferns

Ferns love damp and shady areas. They have prong-like leaves and spread using spores.

There are about 12,000 species of moss.



Moss

Mosses love moisture and grow in clumps. They don't have roots or grow flowers.



Flowering plants

This is the biggest group of plants. They produce flowers, fruits and seeds, which mainly grow in seasonal cycles.



Rainforest

These warm and wet forests are home to nearly half the world's plant species.



Deciduous

Deciduous plants shed their leaves to survive drier seasons.

Most conifer trees keep their leaves all year round.



Conifers

Conifer trees grow cones that store their seeds. Most conifers have needle-shaped leaves.

The sequoia is the largest tree in the world.

Leaves

You can identify a tree by the shape of its leaves. In most plants, leaves are broad and flat.



Ash leaf

Maple leaf

Scarlet oak leaf

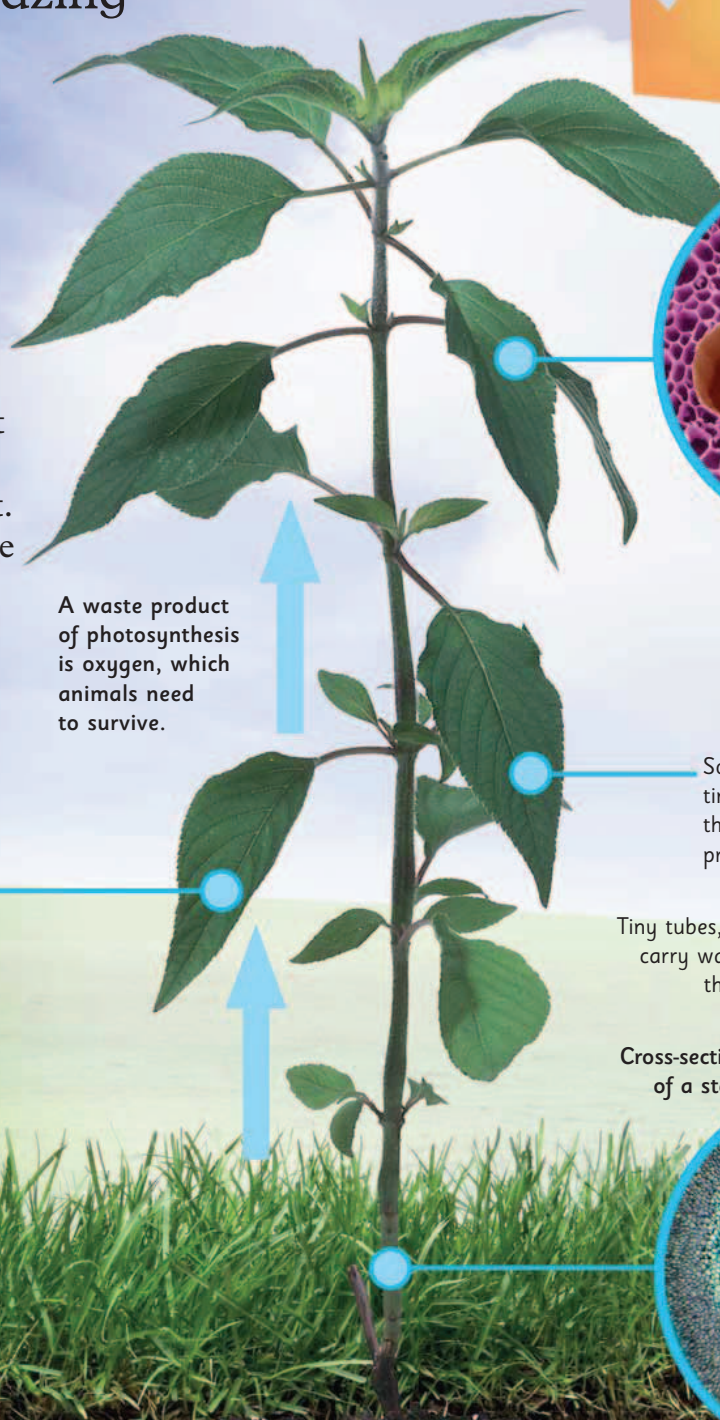
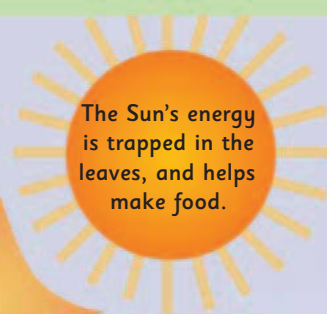
The raffia palm has leaves that grow up to 24 m (79 ft) long.

How plants work

Plants have an amazing system for making and transporting food to all their different parts.

Photosynthesis

Leaves have a green pigment called chlorophyll, which absorbs energy from sunlight. This energy is used to change water and carbon dioxide into sugar.



Cross-section of a leaf vein



Food is moved from leaves to roots and growing tips along a set of tubes called phloem vessels.

A waste product of photosynthesis is oxygen, which animals need to survive.



Some water evaporates through tiny holes, called stomata, on the surface of the leaf. This process is called transpiration.

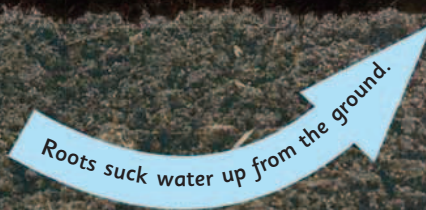
Tiny tubes, called xylem vessels, carry water up the stem from the roots to the leaves.



Cross-section of a stem



Veins carry water around the leaf.





New growth

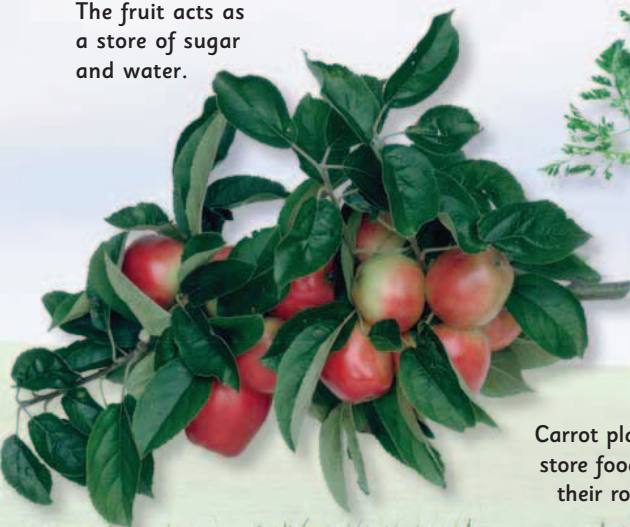
Plants use sugar and starch as fuel. The fuel is transported to cells where it is burnt to release energy, which is used to grow new cells and repair old ones.



Wilting leaves

On warm, sunny days, plants lose a lot of water from their leaves. If they lose too much, their leaves collapse. This is called wilting. If plants don't get enough water, their leaves will shrivel and die.

The fruit acts as a store of sugar and water.

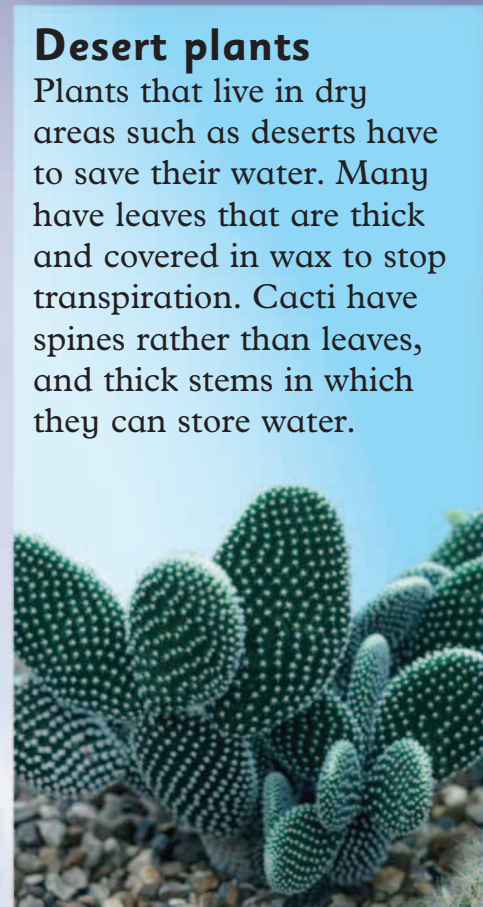


Carrot plants store food in their roots.



Storing food

Spare food is stored for future use. Plants such as hyacinths store food in the base of their leaves. This makes the leaves swell and form a bulb. The bulb survives the winter and in spring it sprouts new leaves.



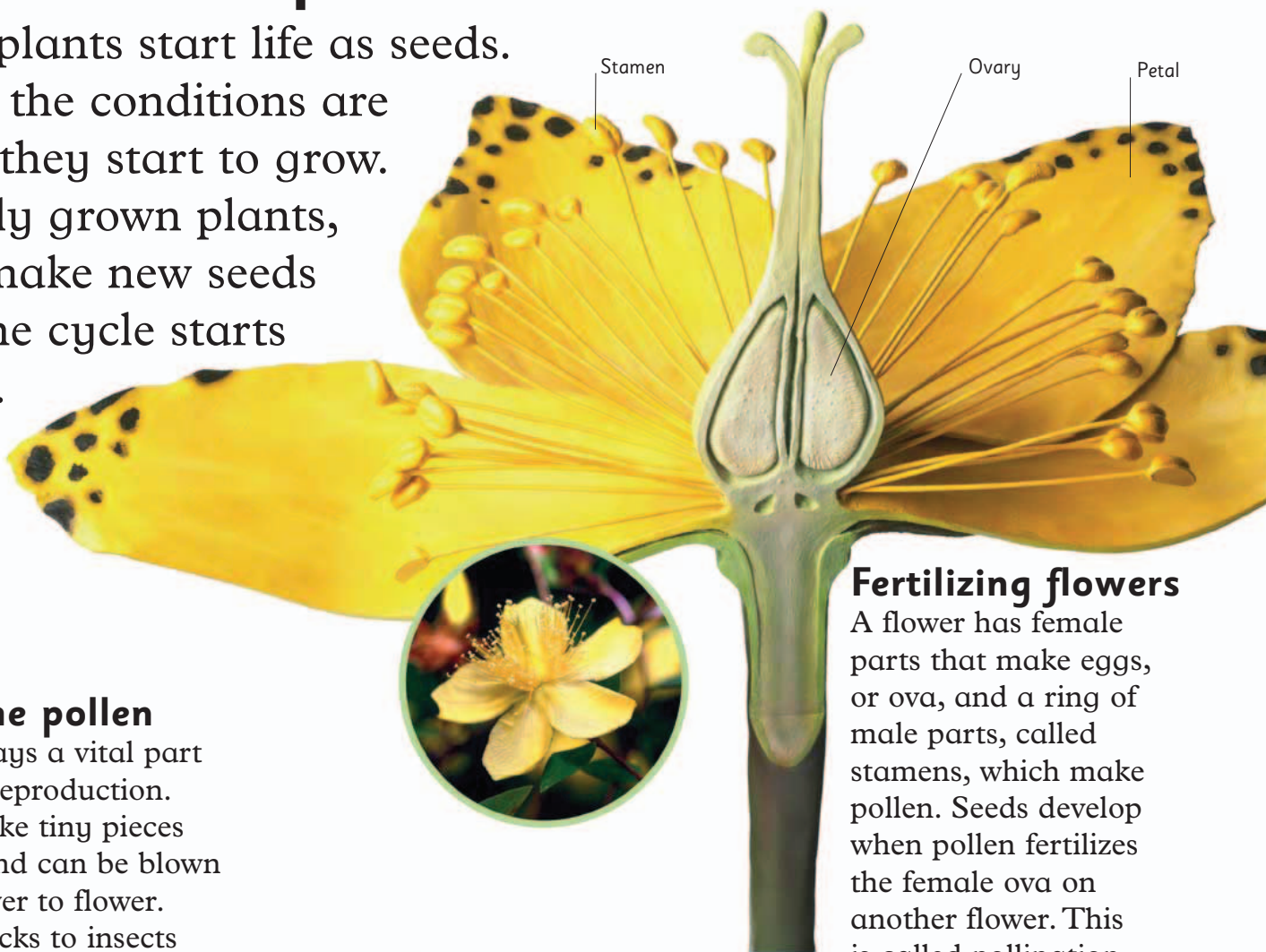
weird or what?
 The sea slug *Elysia chlorotica* uses photosynthesis. The slug eats algae that it doesn't fully digest. The remains in its system continue to photosynthesize the food and provide energy.

Plant reproduction

Most plants start life as seeds.

When the conditions are right, they start to grow.

As fully grown plants, they make new seeds and the cycle starts again.



Fertilizing flowers

A flower has female parts that make eggs, or ova, and a ring of male parts, called stamens, which make pollen. Seeds develop when pollen fertilizes the female ova on another flower. This is called pollination.

Pass the pollen

Pollen plays a vital part in plant reproduction. It looks like tiny pieces of dust and can be blown from flower to flower. It also sticks to insects and birds and gets flown to new flowers.



Waving in the wind

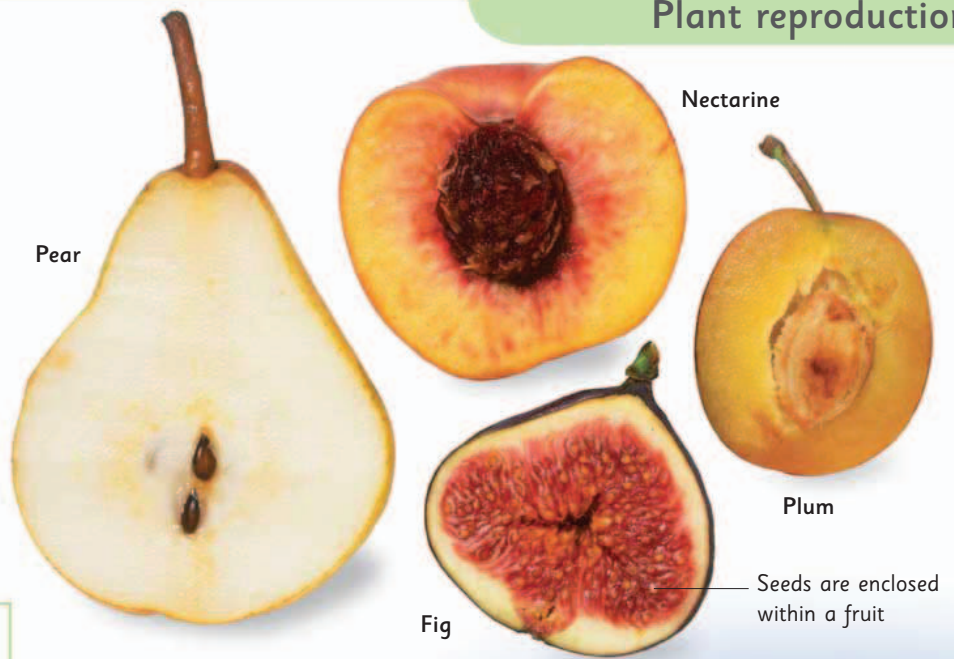
A catkin is the flower of the willow tree. In catkins, the male and female parts are on separate flowers. Catkins move in the wind and release a lot of pollen, which then pollinates the female flowers.



Bees carry pollen in sacs on their legs.

Fruits and seeds

When a plant has been fertilized, the ovary swells up and becomes a fruit. There are many different types of fruit. Some are fleshy and sweet tasting, and others are dry and hard.



Scattering seeds

Plants scatter their seeds in different ways.



Dandelions have seeds with tiny **parachutes** that are carried by the wind.



Sycamore seeds have a **wing** that allows them to glide to the ground.



Burrs become attached to animal fur and get carried far away.



Animals eat fruits and drop the seeds on the ground.

New life

Seeds contain everything needed to grow a new plant. With enough food, water, and light the seed sprouts a root and baby stem, known as a shoot.



Running away

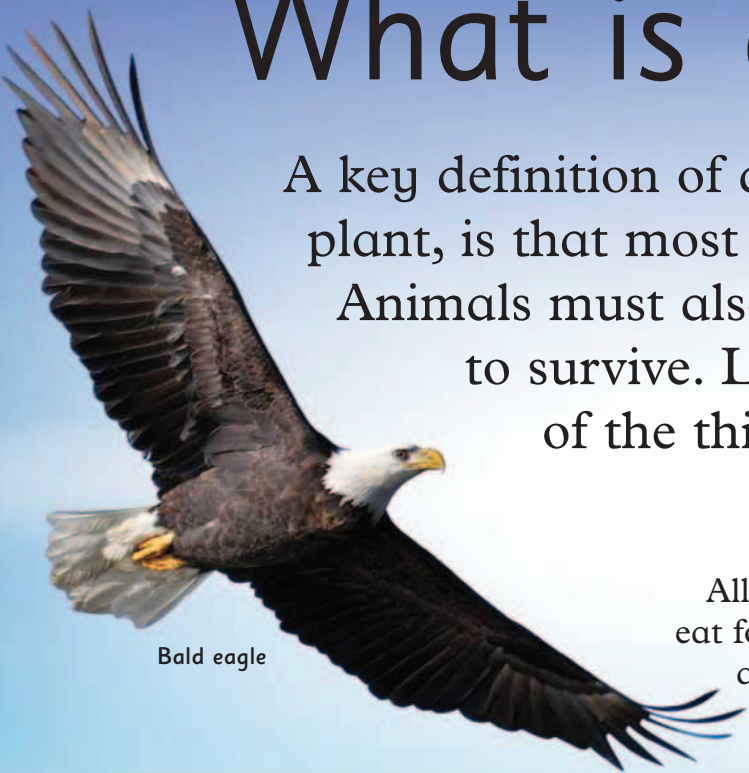
Not all new plants grow from seeds. The strawberry plant produces long stems, called runners, that grow along the ground. When the runner touches the ground, a new plantlet takes root and becomes a new plant.

get mucky

Make your own small garden inside a jar or tin. Fill it with some soil, then plant some seeds. Water them and watch them grow!

What is an animal?

A key definition of an animal, as opposed to a plant, is that most animals can move voluntarily. Animals must also eat other living things to survive. Let's take a look at some of the things animals do.



Bald eagle

Food is fuel

All animals have to find and eat food to survive. Carnivores are animals that eat meat. Herbivores eat mainly plants. Omnivores are creatures that eat both plants and meat.



Squirrels eat seeds, nuts, fruits, and fungi.

Getting around

Many animals have muscles, which allow them to move in a variety of ways.



Birds **fly** by flapping wings or gliding on currents of hot air.



Animals like fish **swim** by moving their bodies and fins.



Some snakes **wriggle**, others raise and flatten their bodies.



Many animals **walk** and **run** using their legs.



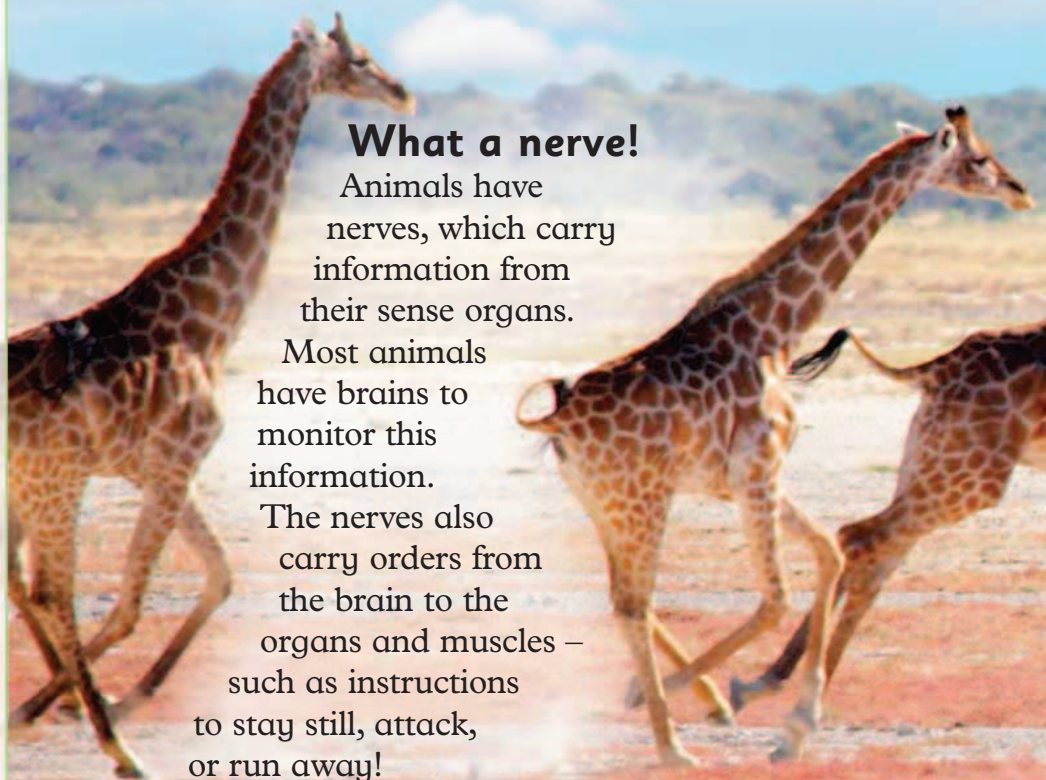
Sea anemones **reach out** their tentacles to sting prey.

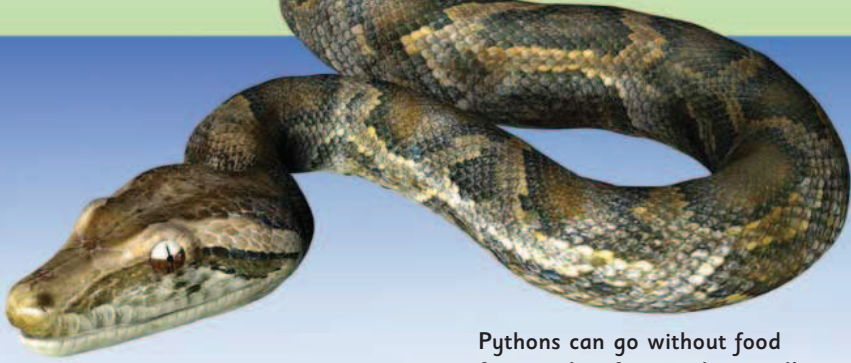
What a nerve!

Animals have nerves, which carry information from their sense organs.

Most animals have brains to monitor this information.

The nerves also carry orders from the brain to the organs and muscles – such as instructions to stay still, attack, or run away!





Pythons can go without food for months after one big meal!

Making babies

Most animals reproduce when a female egg is fertilized by a male sperm. Some animals give birth to babies, while others lay eggs.



Most beetles will send "messages" to other beetles using special chemicals.



Honey bees constantly communicate. They give directions with a special dance.



Birds lay hard-shelled eggs, which hatch into chicks or ducklings.



Baby birds have to break out of the egg on their own.



Monkeys scream at each other to sound an alarm.



Giraffes have seven vertebrae in their necks – the same as most other mammals. They are just much longer.





Types of animal

There are many different types, or species, of animals. Scientists put them in groups based on their similar characteristics. Mammals, birds, reptiles, amphibians, and fish are vertebrates. Creepy-crawlies are invertebrates.



Lizard

Tortoise

Reptiles

Most reptiles have dry, scaly skin. They mainly live on land. Nearly all reptiles lay eggs, but some give birth to babies.



Zebra

Mammals

Mammals usually have babies, which feed on their mother's milk when they're born. Mammals often have fur on their bodies. Humans are mammals.



Wolf

Mouse

Lion cub

Deer fawn



Parrot

Birds

All birds have wings, and most (but not all) can fly. They have feathers and a beak. Baby birds hatch from eggs.



Ostriches can run fast but can't fly.

Amphibians

Amphibians live both in water and on land. They usually have slimy skin. Baby amphibians hatch from jelly-like eggs.



Frog

Salamander

Fish

Fish need to live in water. They breathe through gills, and most are covered in scales. Fish use their fins to move through water.



Spineless creatures

Animals without backbones are called invertebrates. There are several types of invertebrate.



Insects, spiders, and crustaceans are part of the largest animal group.



Snails and slugs are part of an invertebrate group called gastropods.



Worms have long, soft bodies and no legs. They like damp areas.



Jellyfish, starfish, and sponges are invertebrates that live in water.



Octopus and squid live in the sea. They have eight arms.



Butterfly

Ladybird

Insects

There are more types of insect on the Earth than any other animal. There are species of insects living almost everywhere. They have six legs and bodies with three sections.

Animal reproduction

Every kind of animal has young – this is called reproduction.

Usually, it happens after males and females mate.

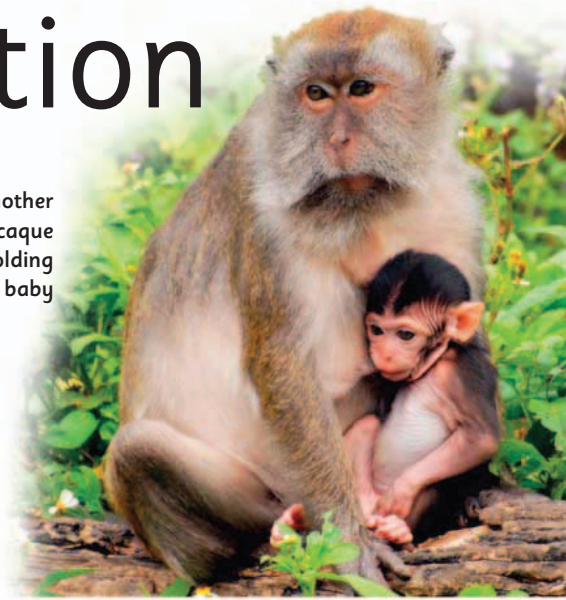


Zebra mother and baby

Mammal reproduction

After animals mate, egg cells develop inside the mother. With mammals, the eggs develop fully into babies before the mother gives birth.

A mother macaque holding her baby



Helpless creatures

Monkeys and apes need years of nurturing before they can look after themselves.

An elephant develops inside its mother for two years!

Family ties

Elephants look after their young longer than any other animal apart from humans.

Like all mammal babies, elephants drink milk from their mother.

Turn and learn

Plant reproduction:
pp. 24-25
Inheritance:
pp. 32-33

Babies from eggs

Most birds, fish, insects, and reptiles lay eggs. The number of eggs they lay can range from one to millions!

A baby crocodile hatching out of its egg



Young and free

Once hatched in the sand, baby turtles have to find their own way into the sea.

Pouch babies

A female kangaroo has a pouch on its tummy. After it's born, the tiny baby crawls into the pouch, where it stays for around three more months, feeding and growing.



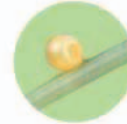
Family ties

Female elephants stay with their family their whole lives. Males leave when they are around 13 years old.



Change and grow

Some animals, like butterflies, change enormously during their life cycle.



A butterfly begins its life as an **egg**, which hatches into a tiny caterpillar.



The **caterpillar** attaches itself to a twig and forms a hard outer shell.



Inside the shell, the caterpillar **changes** and grows.



The **shell**, which is often camouflaged, eventually splits open.



A **butterfly** emerges. This process is known as metamorphosis.



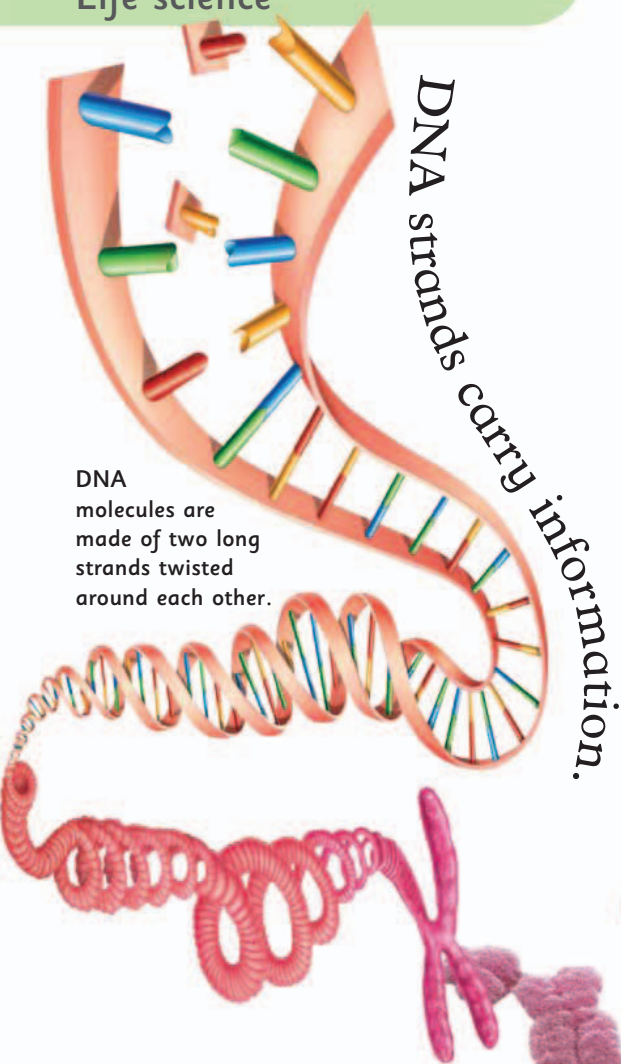
Male emperor penguins look after the young while the females search for food.

Inheritance

Your genes are a set of chemical instructions for building someone just like you. You inherit them from your parents, which is why you are like them in many ways. But unless you are a twin, your genes are unique.

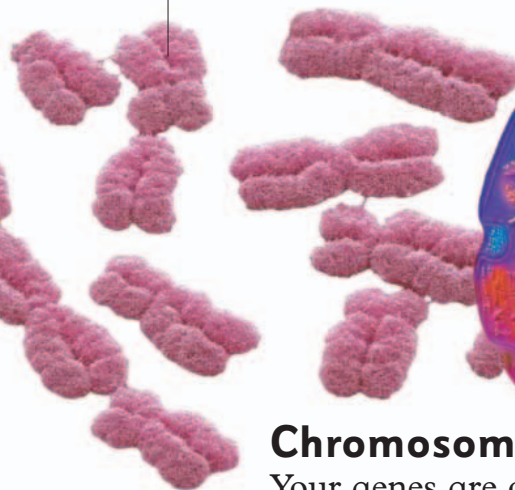
Tiny cells

Cells are the building blocks that make up all living things. Each cell in your body contains a complete set of genes – the information to make you as you are.

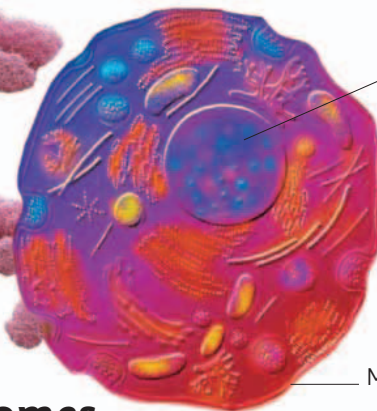


DNA molecules are made of two long strands twisted around each other.

Chromosome



Nucleus



Membrane

Amazing DNA

DNA is made of long molecules. Each molecule is made up of two parts joined together like a twisted rope ladder. DNA carries instructions on how to make cells work, and how different types of cells develop and join together to build a living thing, such as a plant or animal.

Chromosomes

Your genes are organised into 46 chromosomes, arranged in 23 pairs. Genes and chromosomes are made from the chemical called DNA.

What is a gene?

Every cell in your body contains a set of about 20,000 genes. All living things pass on their genes to their offspring. Sexual reproduction combines two sets

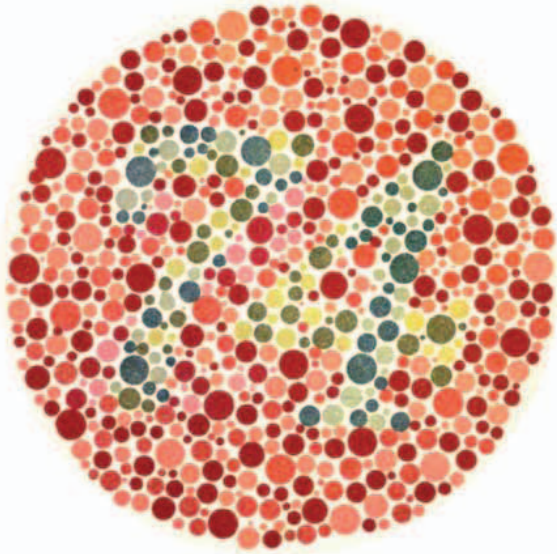


You can only roll your tongue if the right genes are active.

of genes. You've got two of each gene, one from your mother and one from your father. Sometimes the gene from your mother comes into action, and other times your father's gene wins out.

Colour blindness

Some people have a gene which causes them to be colour blind. Look at the circle below. If you can see the number inside then you aren't colour blind.



Test your family and friends to see if anyone you know is colour blind.



Seeing double

Identical twins share most of their genes. A quarter of these are mirror twins, which means that they are a mirror image of each other. For example, they might have an identical mole, but on the opposite arm to each other.

Who do you look like?

Children have a mixture of genes from their parents. This is why you might have your mum's eyes but your dad's smile!

The chromosomes of your father determine whether you will be a boy or a girl.

Turn and learn

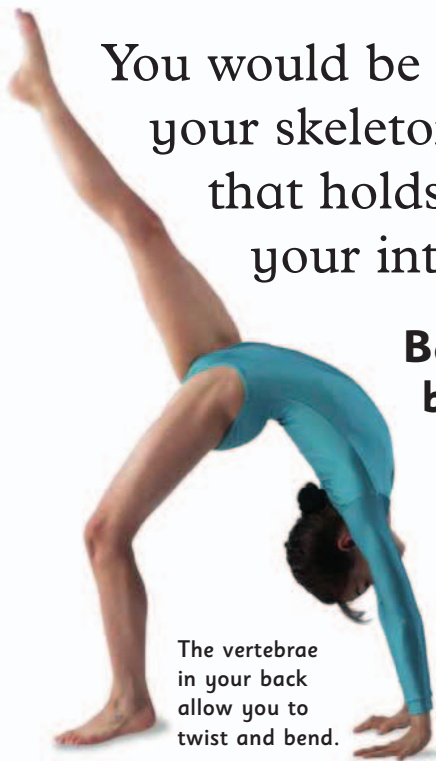
Animal reproduction:
pp. 30-31
Health:
pp. 40-41

This child has inherited her hair and skin colour from her mother.



Bones and muscles

You would be like a lump of jelly without your skeleton – a frame of bones that holds you up and protects your internal organs.



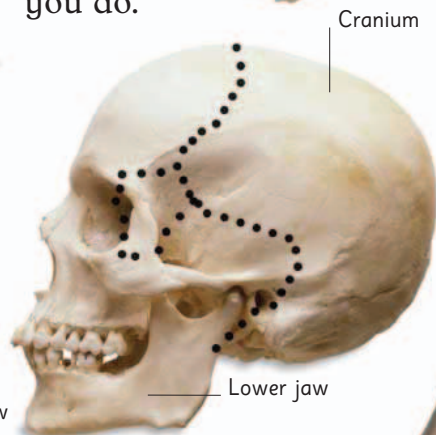
The vertebrae in your back allow you to twist and bend.

Bending backbone

Your backbone contains 24 small bones called vertebrae. They move almost every time you do.

Head case

The bones that make up your skull join after you are born. The skull has two parts – the lower jaw and cranium. Only your jaw can move.



Cranium

Lower jaw

Bone marrow supplies your body with red blood cells.

The honeycomb structure of some bones makes them weigh less than if they were solid.

Brilliant bone

Bones have a clever structure that makes them light but strong. They can heal themselves if broken.

Snake ribcages can run almost the entire length of their bodies.



Ribcage

A ribcage has long, curved bones that protect vital organs such as the heart and lungs.

Both the knee and elbow are hinged joints that only move in one direction.

The hip is a ball and socket joint, allowing the legs to move around.

The wrist is made up of eight small bones.

Backbone

Ribcage

Skull

Bending bits

Different kinds of joints all over your body keep you moving.



Fingers and thumbs have joints that allow them to move in many ways.



Ankles contain different joints for up-and-down and side-to-side movement.



Wrists have a joint that allows them to turn but not go all the way round.



Neck bones feature a pivot joint that allows your head to turn.

Making faces

Muscles in your face are attached to skin as well as bone. They allow you to make all kinds of expressions to show how you are feeling.



Muscle magic

Muscles are rubbery, stretchy straps. You can control some of your muscles, like the muscles in your arms and legs. Others, such as your heart and bladder, operate without you having to think about it.

The pectoralis muscle moves your arm at the shoulder.

Biceps and triceps bend and straighten your arm.

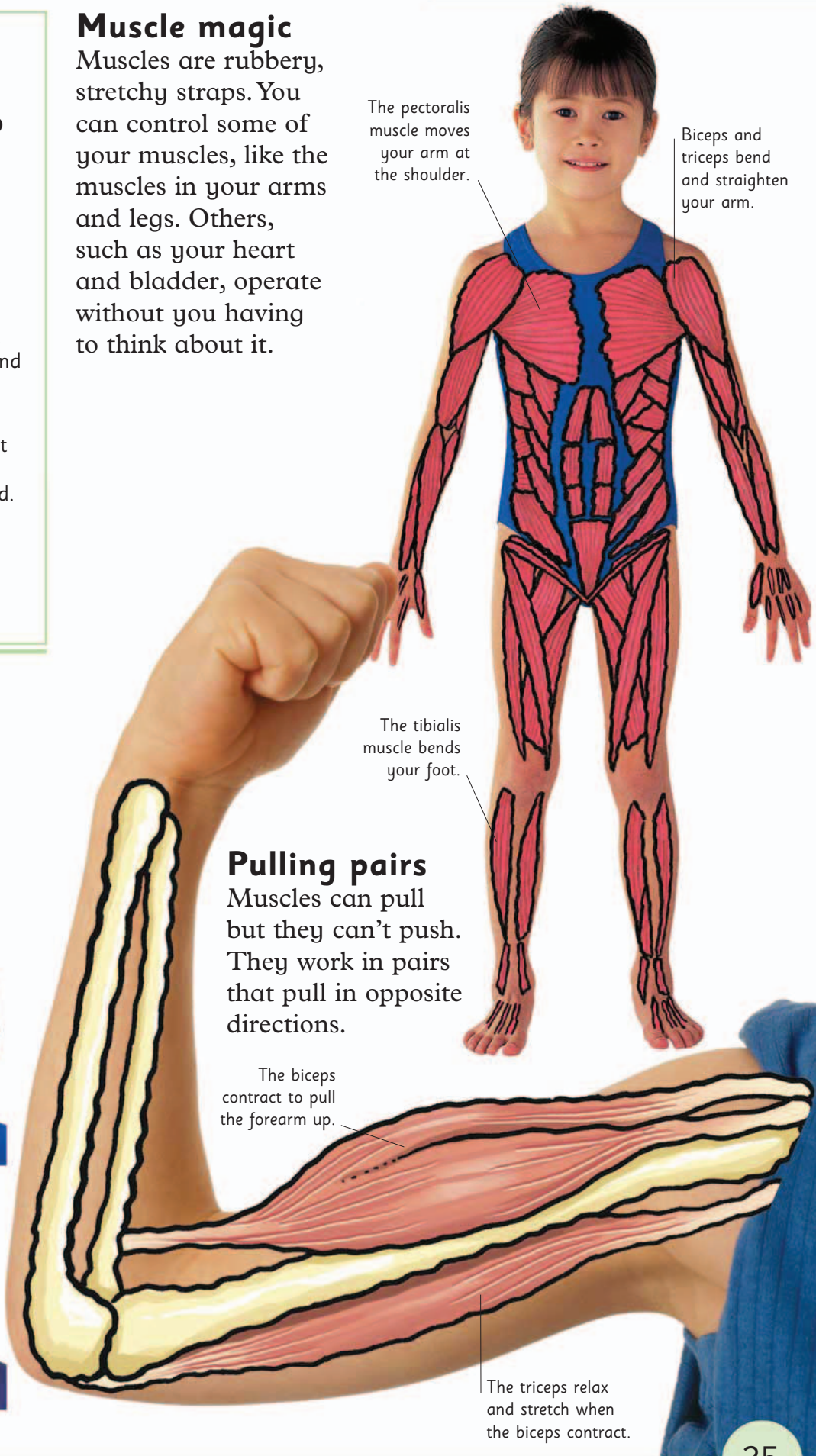
The tibialis muscle bends your foot.

Pulling pairs

Muscles can pull but they can't push. They work in pairs that pull in opposite directions.

The biceps contract to pull the forearm up.

The triceps relax and stretch when the biceps contract.



Blood and breathing

Every few seconds you breathe in air. Inside your lungs, oxygen from the air passes into your blood, which then carries the oxygen all round your body.

Liquid of life

Blood is made up of three types of cells floating in plasma.



Red blood cells, the most common type of blood cell, carry oxygen.



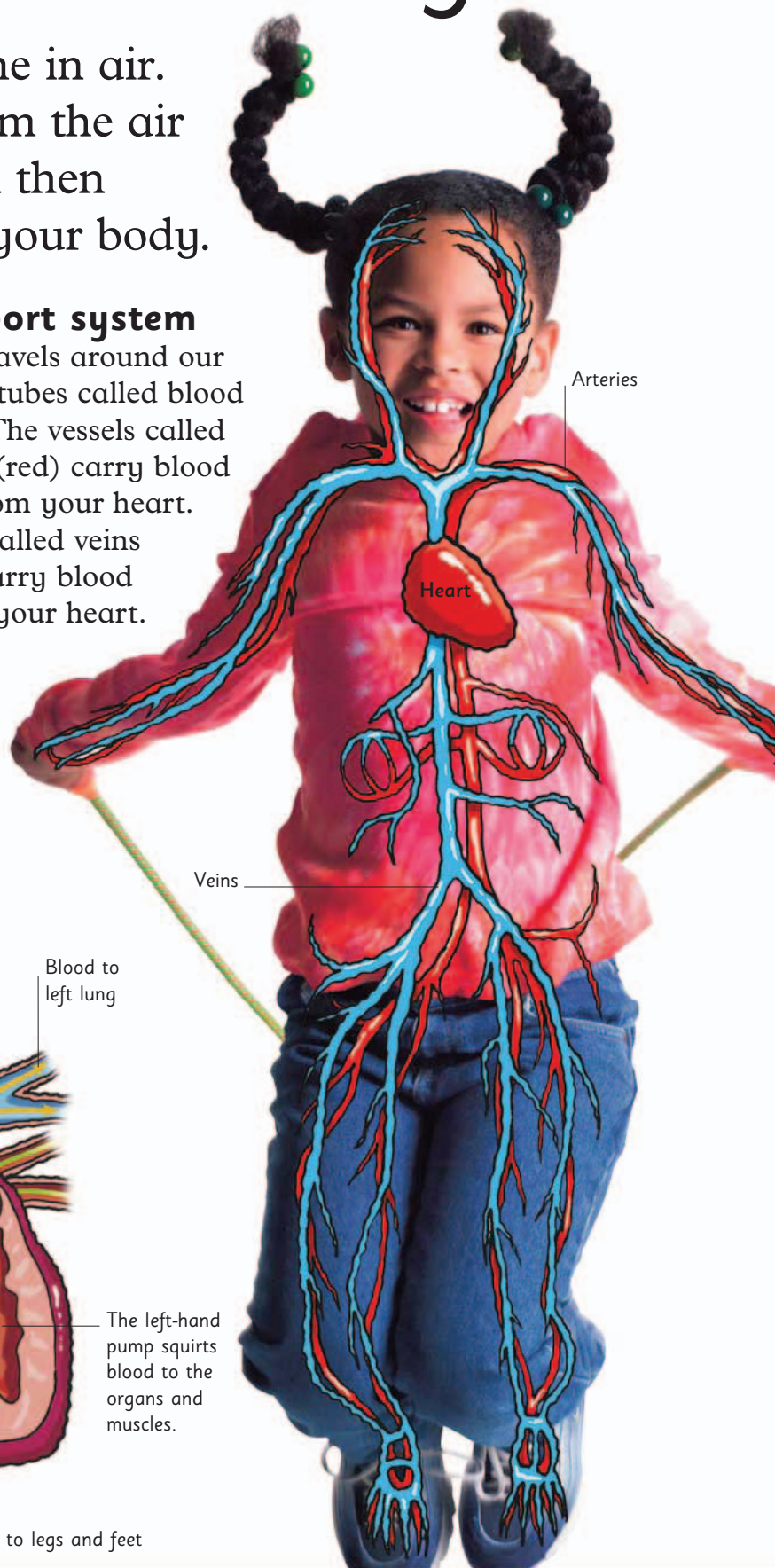
White blood cells, which are part of the immune system, fight disease.



Platelets help to repair broken skin and blood vessels.

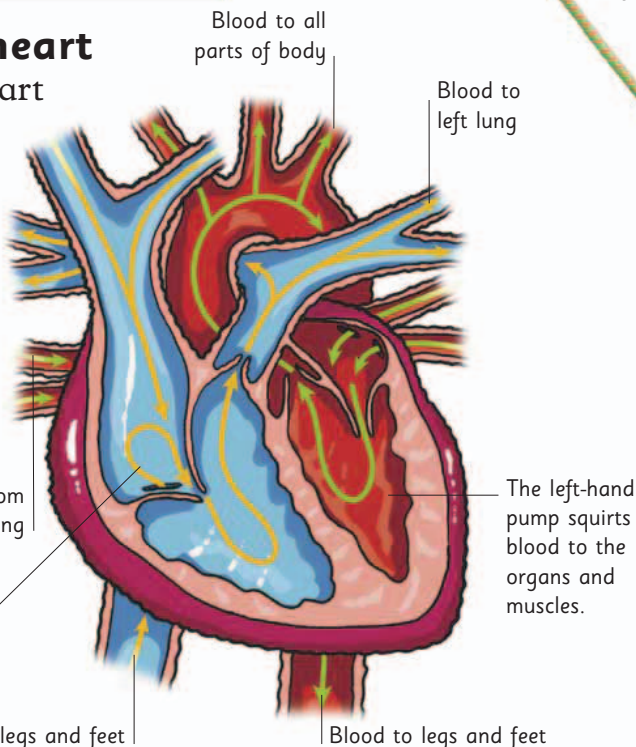
Transport system

Blood travels around our body in tubes called blood vessels. The vessels called arteries (red) carry blood away from your heart. Vessels called veins (blue) carry blood back to your heart.



Your beating heart

Every time your heart beats, it pumps blood around your body. Half of the heart sends blood through your lungs. The other half sends blood around the rest of your body.



Lungs

Your lungs fill most of the space inside your ribcage. They take in oxygen from the air and send out waste carbon dioxide.

No lungs

Not every animal has lungs. There are other ways animals breathe.



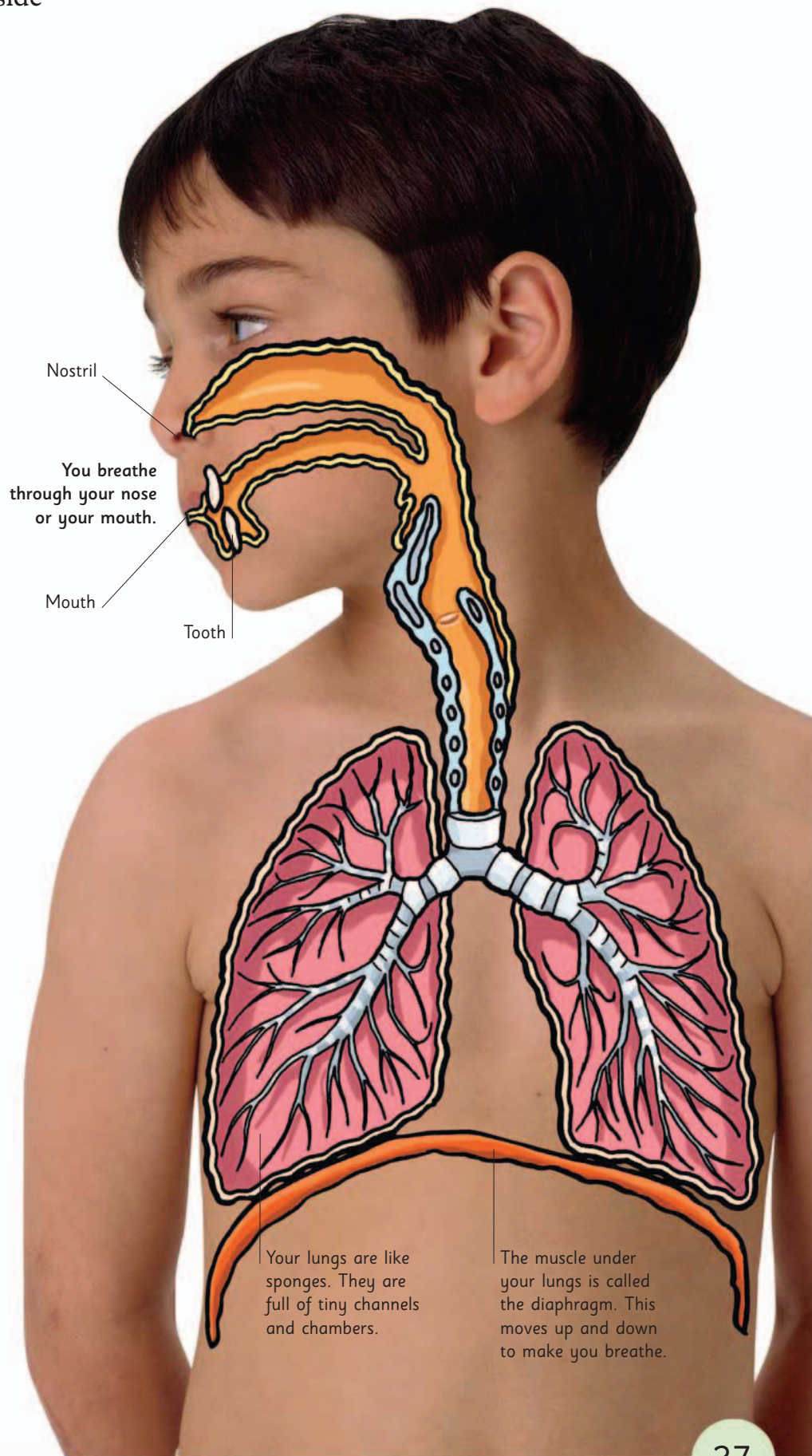
Frogs can absorb oxygen through their skin – even underwater.



Insects such as caterpillars breathe through body openings called spiracles.



Many sea creatures such as sharks breathe through gills.



Your lungs are like sponges. They are full of tiny channels and chambers.

The muscle under your lungs is called the diaphragm. This moves up and down to make you breathe.

The digestion ride

Take a ride down your digestive system as it breaks down your food to take out the nutrients and get rid of waste.

Mouth

First stop is the mouth. Saliva moistens the food to make it easier to chew and swallow. Food then heads down the oesophagus to your stomach.

Stomach

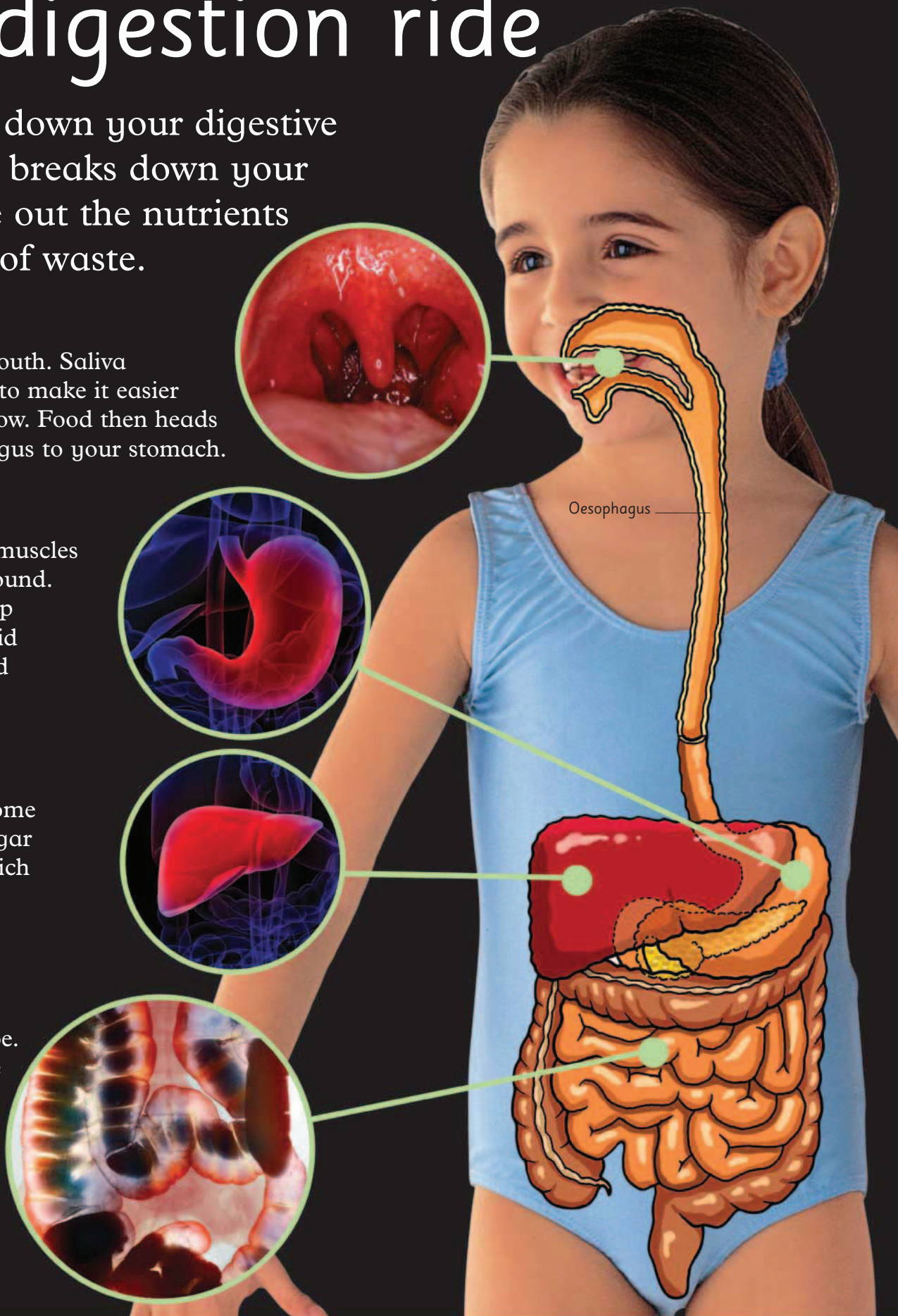
In your stomach, muscles churn the food around. Stomach acids help turn it a semi-liquid before it is squirted into the intestines.

Liver

Your liver stores some vitamins and a sugar called glucose, which gives you energy.

Intestines

Your intestines are a long, tangled tube. The small intestine absorbs food into your bloodstream. The large intestine deals with undigested leftovers.





Super system

Cows have an amazing digestive system. There are four parts to a cow's stomach. Each one performs a different function to make sure food is digested and used in the most efficient way. Cows need this system to help them digest tough grass.

Stone eaters

Some birds eat grit. The tiny stones help digestion by breaking down food in the bird's stomach.



Kidneys

Your kidneys filter and clean your blood, taking out the chemicals that your body doesn't need. Kidneys also control the amount of water in your blood.

Waste disposal

Solid waste from the large intestine is stored in the rectum, and urine is stored in the bladder, until you are ready to go to the toilet.

Food for health

You need to eat a variety of foods to keep your body working efficiently. A good diet includes a balance of food from each of the five food groups.



Carbohydrates, found in food such as bread, cereal, and potatoes.



Fats, which can be found in food such as oils. Fats give you energy.



Proteins, which can be found in eggs, fish, meat, dairy products, and nuts.



Minerals such as iron and calcium. Iron is found in some green vegetables.



Vitamins such as vitamin C are found in fresh fruit and vegetables.

weird or what?

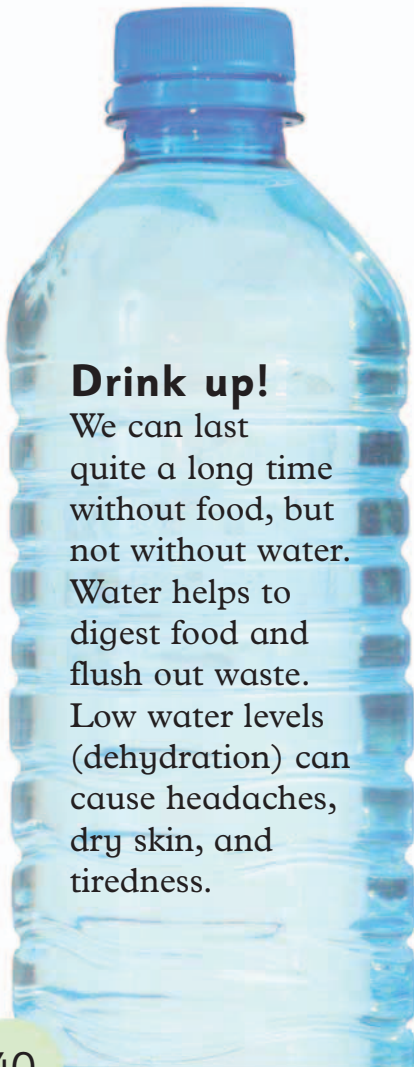
Humans taste with their tongues – but other animals have different methods. Butterflies use their feet!

Health

Our way of life affects our health. Eating properly, exercising regularly, and getting enough sleep are all important for staying happy and fit.

A balanced diet

It is vital to eat a balance of the right foods. There are five major food groups and they all help your body in different ways.



Drink up!

We can last quite a long time without food, but not without water. Water helps to digest food and flush out waste. Low water levels (dehydration) can cause headaches, dry skin, and tiredness.

You need to drink water frequently each day or you will dehydrate.



5-a-day

You need to eat at least five portions of fruits and vegetables each day.



Ideally, children should be getting about 60 minutes of exercise a day.



Swimming is a good way of exercising all your muscles.

Exercise

Exercise strengthens the muscles and heart, and encourages the production of special chemicals called endorphins. These make us feel good and act to reduce pain.

Many children relax more easily into sleep with a special, cuddly toy.



Sleep

When you sleep, your body rests and your mind refreshes itself. When you are young, you need a lot of sleep, but you need less as you get older.



A child needs between 10 and 12 hours sleep a night.

Keeping clean

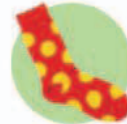
Dirt contains harmful bacteria. Keeping clean helps you stay healthy.



Brush your teeth in the morning and again before you go to bed.



Wash off the dirt with regular baths or showers.



Wear clean clothes, especially clean pants and socks, each day.



Read a book!

Health is not just about your body; it helps to have an active mind. Reading is a good activity because it stimulates your brain.

Turn and learn

Muscles:
pp. 34–35
Digestion:
pp. 38–39



Carbohydrates
Foods in this group include bread, pasta, and potatoes. Carbohydrates provide your body energy. They should make up just over a third of your diet.

Food chains

Everything in the living world needs food to survive. And everything must feed on something else.

This is called a food chain. Each species is part of several different food chains.

5 Decomposers

At the start and end of every food chain there are decomposers, such as earthworms, fungi, and dung beetles. They help break down dead animals and plants, releasing the nutrients back into the soil.

1 Producers

Plants, such as acacia trees and grasses, get their energy from the Sun. They are known as producers.

2 Herbivores

Herbivores, such as impala or zebra, eat the plants. They do not eat meat.

4 Scavengers

Dead meat is known as carrion and is eaten by scavengers such as hyenas, vultures, and bald eagles. These creatures rarely kill for food – they find animals that have died of natural causes and eat other animals' leftovers.



3 Carnivores

Carnivores only eat meat. On the African plains, carnivores include lions, leopards, and cheetahs.



Sea food

The further you go up the chain, the fewer animals there are. So, in the sea, there are countless plankton, fewer fish, just a few seals, and fewer polar bears.



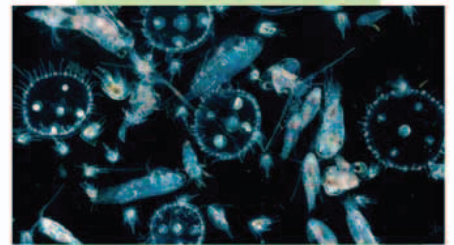
Polar bear



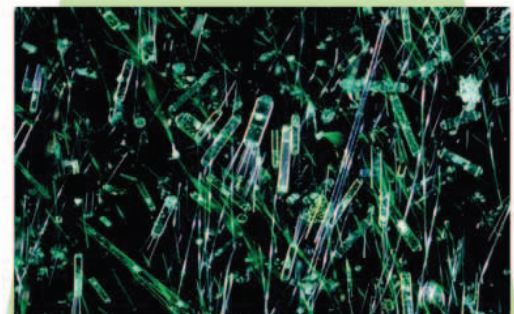
Seals



Fish



Zooplankton



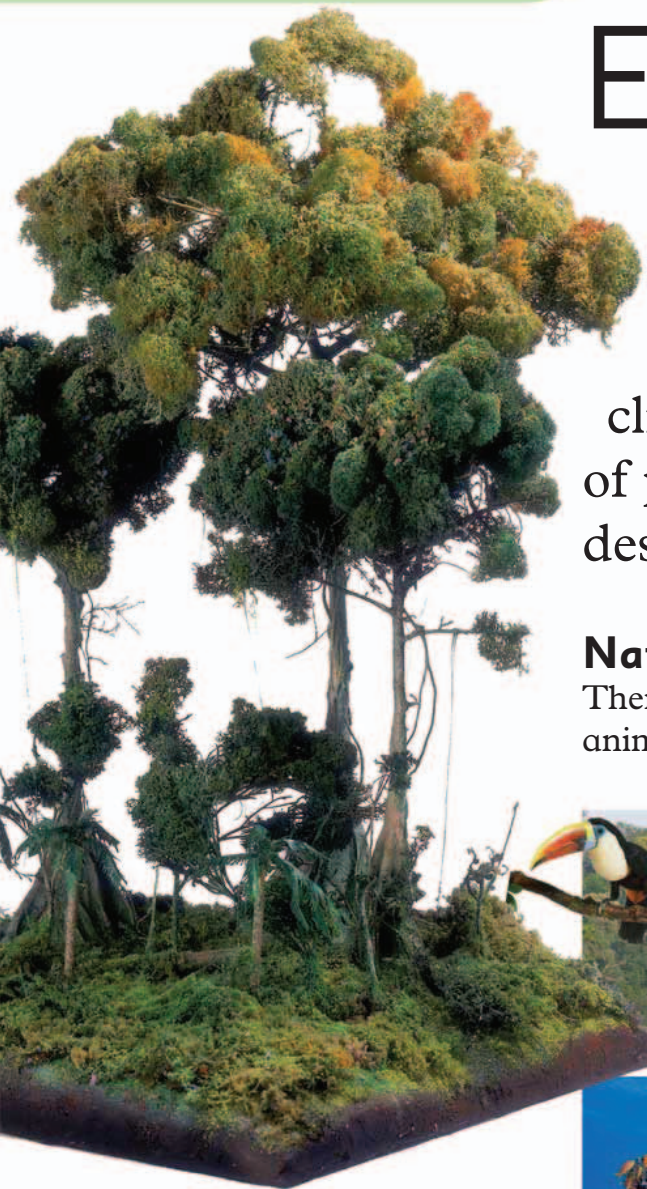
Phytoplankton

Ecosystems

All over the world, living things exist in distinct kinds of places called ecosystems. Each has its own climate, soil, and complex community of plants and animals. Oceans and deserts have their own ecosystems.

Natural variety

There are different ecosystems all over the world, and the animals and plants in each one are adapted to its conditions.



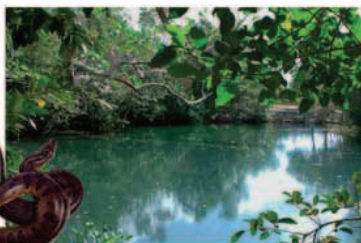
Forests

Wherever there is enough rain, forests grow, and they provide homes for a huge range of plants and animals.



Oceans

More than 70 per cent of the Earth's surface is covered by oceans, which contain many different habitats.



Rivers and lakes

Freshwater ecosystems exist in pools, lakes, rivers, and streams. They are found over most of the world's land surface.



Polar and tundra

The freezing polar lands are at the far north and south of the Earth, in the Arctic and Antarctic. At the edges farthest away from the poles, they merge into warmer tundra areas.

Homes, sweet homes

One ecosystem contains a number of habitats. A habitat is the natural home of a particular plant or animal. A tree, or even a leaf, can be a habitat.

Turn and learn

Animal survival:
pp. 46-47
The carbon cycle:
pp. 50-51

Mountains

Climate conditions change as you go up a mountain, so different ecosystems can exist here.



Seashores

Seashore ecosystems are half land and half sea. They change as the tide comes in and out.



Grasslands

Humans evolved in grassland habitats. Today, the largest and fastest land animals live here.



Deserts

They can be hot or cold, but deserts are always dry, with little rain. Only a few animals and plants survive here.



Living together

A group of living things in a habitat is called a community. Each one contains plants, animals, and other organisms that all rely on each other.



Frogspawn hatches into tadpoles. Some of these are eaten by other water creatures.

Rotting leaves and wood are home to fungi and small animals, such as beetles and slugs.

Snails feed on the leaves of plants, and provide food for other animals.

Ferns grow and absorb nutrients from the soil.

Frogs, which eat insects, live both on land and in the water.



Trees offer shelter for animals, and food in the form of leaves and berries.

Insects feed on flowers, and pollinate them at the same time.

Staying alive

In order to survive, all animals and plants need food, water, shelter, and space. Each type of animal or plant has its own particular way of finding them.



Let's stick together

Clownfish and sea anemones live together and help each other (symbiosis). The sea anemone's tentacles can sting most fish, but the clownfish don't get hurt.



Camouflage

On the grasslands of Africa, lions try to creep up on their prey. They can hide in the long grass because they are the same colour. This is called camouflage.



Long-eared bat eating a moth

Night hunter

Some animals hunt for food at night. The long-eared bat uses sound to find insects in the dark. It makes a squeaking noise and listens to the echo as the noise bounces back off objects. It can tell exactly where an insect is.

A huge worm is enough food to keep a shrew going for only a few hours.

All-day hunter

Some animals have to hunt for food day and night. Shrews need to eat 80 to 90 per cent of their body weight every day to survive.

These animals are tiny, but aggressive.



The tiny Arctic tern makes a long migration. It flies between the North and South poles each year.



A wasp has laid eggs on this caterpillar. The grubs that hatch out will feed on the caterpillar as parasites.

Parasites

Some organisms, called parasites, live on or inside the bodies of other organisms, which they feed on. Caterpillars live as parasites on plants.

Great travellers

When food and water become scarce in one place or the weather gets too cold, animals may move home (migrate). Some animals migrate once every year.



Pack of wolves

Wolves live and hunt in groups called packs. This is safer than living alone, and makes it easier to hunt larger animals.

House builders

Many animals build homes for themselves to provide shelter from predators and bad weather.



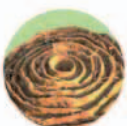
Birds make nests out of mud or twigs, often hidden away in trees or bushes.



Rabbits and badgers use burrows dug into the soil.



Beavers pile up sticks in rivers to make a nest with an underwater entrance.



Wasps chew up wood to make soggy paper, which they then shape into nests.

An elephant eats for about 16 hours each day.

Big hunger

Elephants have big appetites. A hungry elephant will push over a whole tree and eat every leaf and twig to satisfy its hunger.



The Earth's cycles

At night, plants take in oxygen and give out carbon dioxide.

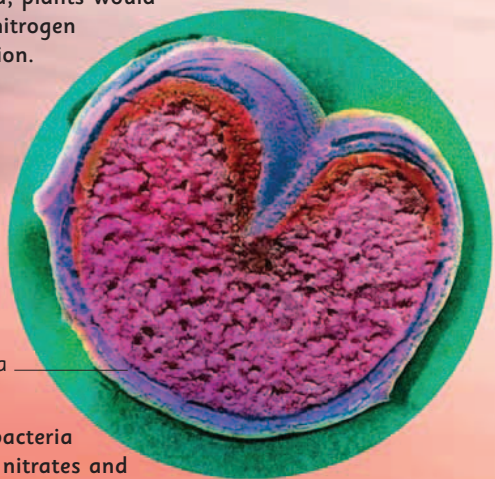
Everything in nature is recycled. Living things take in oxygen, nitrogen, carbon, and water and use them to live. When they die and decompose, the substances they are made of are used again.

Nitrogen cycle

All living things need nitrogen. Plants take in nitrogen from the soil. Animals get nitrogen from eating plants. When animals and plants die, they put nitrogen back into the soil.

Certain bacteria play an important role in the nitrogen cycle. They change nitrogen into the form plants can use. Without bacteria, plants would die of nitrogen starvation.

Nitrogen is abundant in our atmosphere.



Bacteria

Other bacteria take in nitrates and release nitrogen back into the atmosphere.

Animals eat plants, which contain nitrates.



Decaying animals and plants put nitrogen back into the soil.



During the day, plants take in carbon dioxide and give out oxygen.



From atmosphere to the Earth

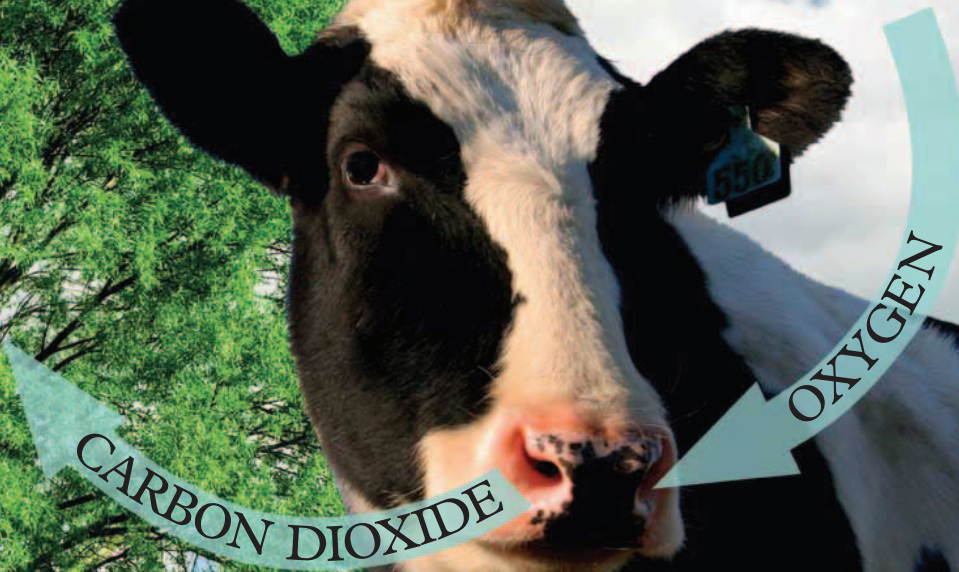
During an electrical storm, some nitrogen is washed out of the atmosphere and falls to the ground. Plants can then draw the nitrogen in through their roots.



Oxygen cycle

Animals take in oxygen and use it to release energy from their food. It is put back into the air by green plants during photosynthesis. Algae and plankton do the same job in water.

Animals breathe in oxygen and breathe out carbon dioxide all the time.



Carbon cycle

Every living thing contains carbon. Human beings take in carbon through carbohydrates, fats, and proteins in food, and release it as carbon dioxide gas when breathing out. It is also released from dead matter, sometimes quite soon, sometimes millions of years later in fuels such as oil and coal.

It's in the air

Green plants take in carbon dioxide from the air and use it to make food, converting it into things such as carbohydrates. Animals take in some of the carbon when they eat plants.

Plants take in carbon dioxide from the atmosphere

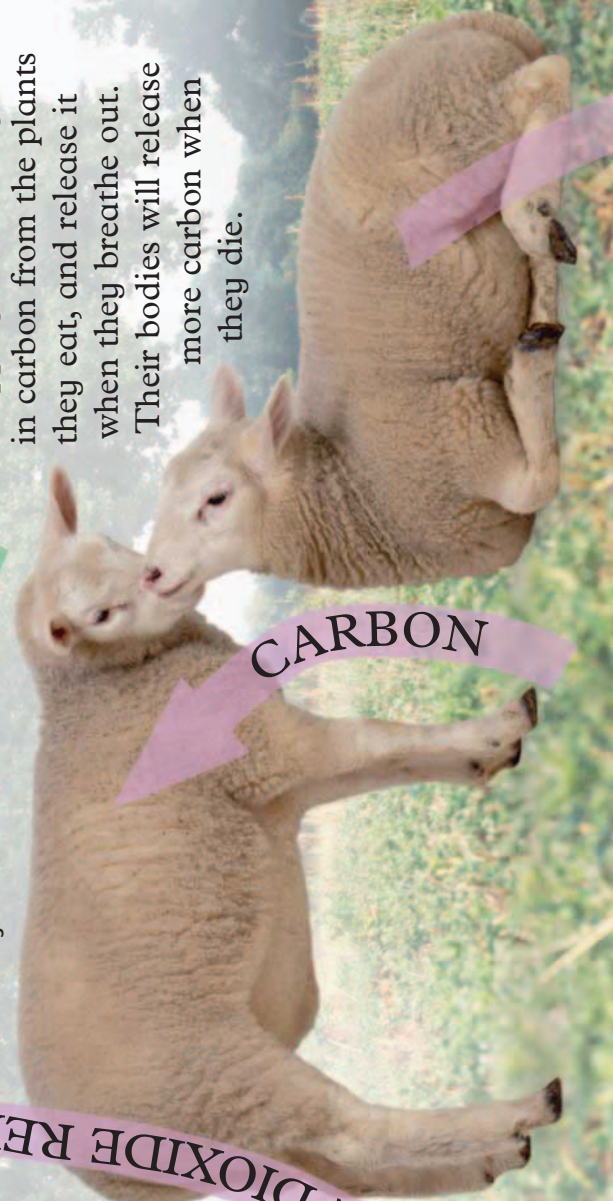


CARBON DIOXIDE

Animals

Animals, such as these sheep, contribute to the carbon cycle by eating grass, breathing in air, and dropping waste. They take in carbon from the plants they eat, and release it when they breathe out. Their bodies will release more carbon when they die.

Animals eat plants and take in some carbon. They breathe out carbon dioxide.



CARBON

CARBON DIOXIDE RELEASED

An animal's droppings also contribute to the carbon cycle.



Waste matters

Part of you might once have been part of a dinosaur. Why? Because like all living things, dinosaurs produced waste and their waste became a part of the never-ending carbon cycle.

DECOMPOSING

Fossil fuels

Sometimes the remains of organisms are exposed to extreme pressure and heat. Over millions of years, they turn into carbon-rich fuels, like coal and oil.

Waste disposal

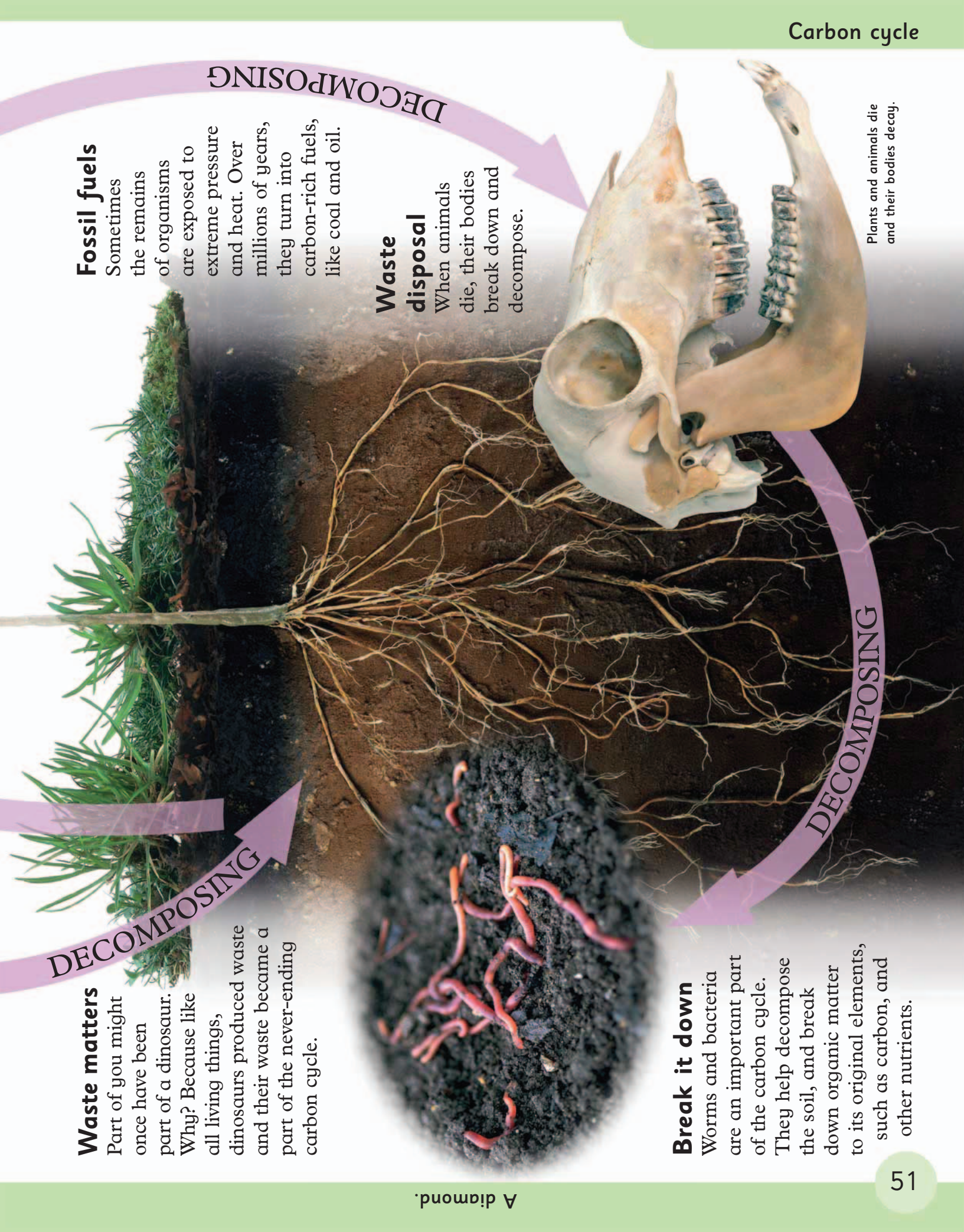
When animals die, their bodies break down and decompose.

Break it down

Worms and bacteria are an important part of the carbon cycle. They help decompose the soil, and break down organic matter to its original elements, such as carbon, and other nutrients.

DECOMPOSING

Plants and animals die and their bodies decay.



What's the matter?

Everything around you is made of matter, even the things you can't see. But everything looks and acts differently – that's because matter has different forms.

Solid, liquid, or gas

The most common states of matter are solid, liquid, and gas. Each state behaves differently because the particles in their make-up move in different ways.

Four states

There are four main states of matter.



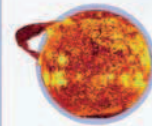
Solids have a definite shape. Most of them are hard, such as rocks.



Liquids take on the shape of their container, and have a fixed volume.



Gases have no fixed shape. They fill any space they are in, such as a balloon.



Plasma exists at very high temperatures, like inside the Sun.

Nearly everything on the Earth is solid, liquid, or gas.

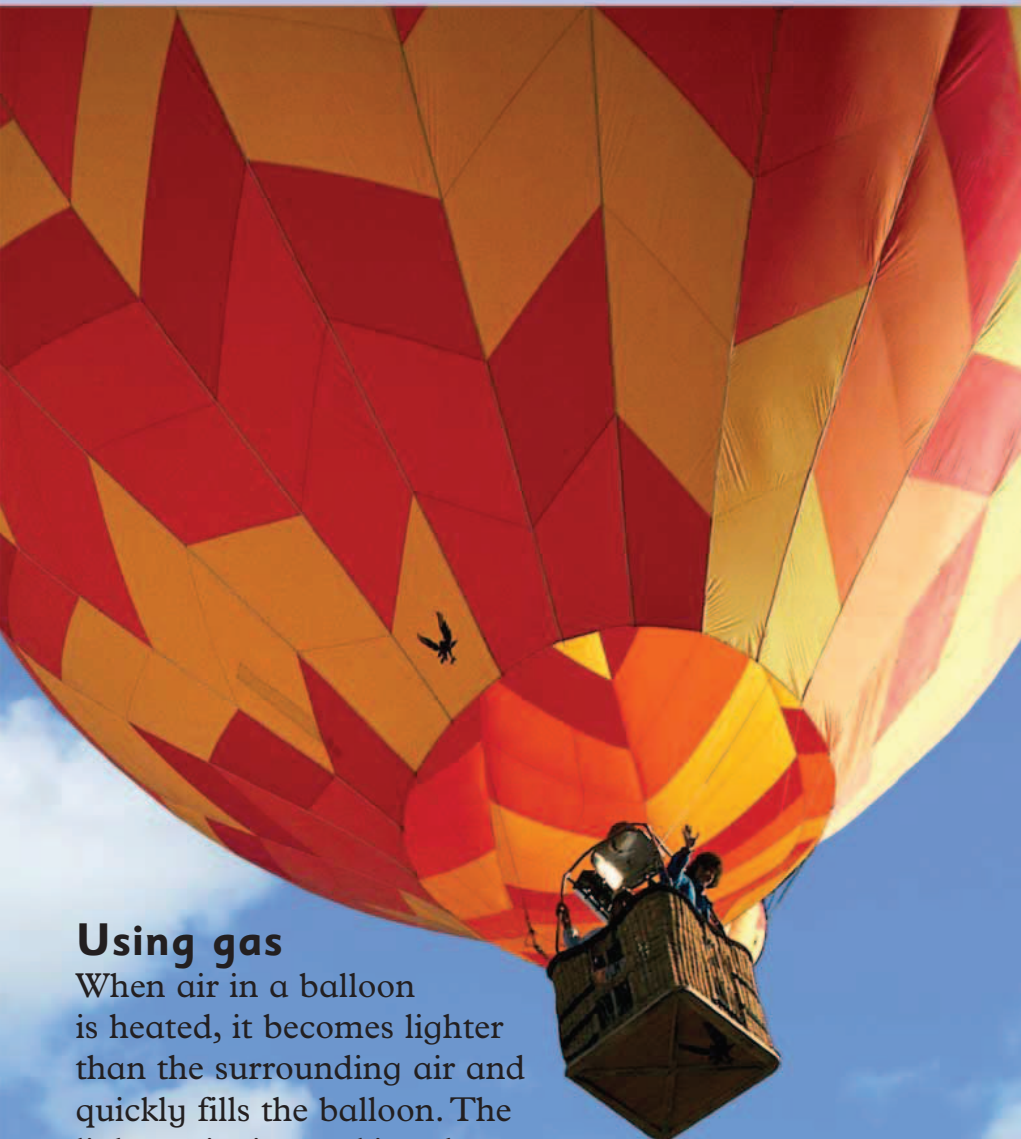
Planet Earth

The Earth has a solid core, surrounded by liquid rock, on which the solid crust floats. Liquid water covers most of the crust, and a layer of gas called the atmosphere surrounds the planet.

Clouds are made of liquid water droplets and solid ice crystals – they form from water vapour, a gas.

The green areas are land, which is made of solid rocks.

The blue areas are the oceans, which are liquid water.



Using gas

When air in a balloon is heated, it becomes lighter than the surrounding air and quickly fills the balloon. The lighter air rises, taking the balloon and passengers with it.

No matter

A place with no matter, not even air, is called a vacuum. The closest thing to a vacuum is the space between stars.



Astronauts wear special suits in space because it is very cold and there is no air to breathe.

Picture detective

Look through the Materials Science pages and see if you can identify the picture clues below.



Turn and learn

Amazing atoms:
pp. 58-59
The Universe:
pp. 94-95

Properties of matter

Main properties

There are many different properties of matter.



Boiling point is the hottest a liquid can get before becoming a gas.



Freezing point is the temperature at which a liquid becomes a solid.



Plasticity is how well a solid can be reshaped.



Conductivity is how well a material lets electricity or heat travel through it.



Malleability is how well a solid can be shaped without breaking.



Tensile strength is how much a material can stretch without breaking.



Flammability is how easily and quickly a substance will catch fire.



Reflectivity is how well a material reflects light. Water reflects well.



Transparency is how well a material will let light pass through it.



Flexibility is how easily a material can be bent.



Solubility is how well a substance will dissolve, such as salt in water.

Some materials are hard and brittle, while others are flexible. Some materials are colourful, while others are transparent. These kinds of features are called “properties”.



A cork floats on oil.
Oil floats on water.

Does it float?

It's easy to learn about some properties, such as the ability to float. The amount of matter in a certain volume of an object is called its density. Objects and liquids float on liquids of a higher density and sink through liquids of a lower density.

A plastic building brick sinks through oil but floats on water.

An onion sinks through oil and water, but floats on syrup.
Syrup sinks below water.

A good insulator

Heat cannot easily pass through some materials.

These are known as insulators. For example, aerogel can completely block the heat of a flame. But don't try this at home!





Broken glass

Brittleness

Some materials, such as window glass, are particularly brittle. They will break when pushed out of shape even a small amount.

Hardness

A scientist called Friedrich Mohs created a scale using ten minerals to compare how hard they are. Many materials are graded on this scale.

Talc is the softest mineral



hands on

Collect some different pebbles and put them in order of hardness. A pebble is harder than another if it scratches it. This is how Mohs worked out his scale.

A smooth flow

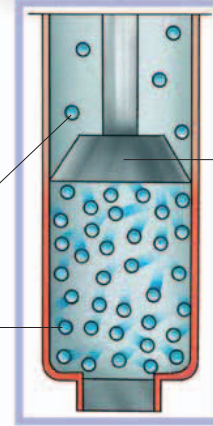
Some liquids flow more easily than others. It depends on their “stickiness”, or viscosity. Hot lava from a volcano flows slowly because it is sticky.

Compressibility

Gases can be squashed, or compressed, by squeezing more into the same space. This is what happens when you pump up a tyre.



Gas can be compressed because its particles are far apart. A bicycle pump pushes the particles closer together.



Diamond is the hardest mineral.

9 Corundum

10 Diamond

Changing states

Many solids melt, to become liquids, when they become hot enough. When liquids get cold enough, they freeze and become solid. This is called changing states and it happens to all kinds of substances.

Liquid metal

Many substances melt and boil at particular temperatures (its melting and boiling points). Most metals are solid at everyday temperatures because they have a high melting point. But mercury has such a low melting point that it is liquid even at room temperature.

Condensation

As water vapour in the air is cooled, it changes into liquid water. This is called condensation. You can see it on the outside of a cold bottle.

When water vapour in the air touches a cold bottle, it condenses into tiny drops of liquid.



Changing states of water

Water exists as a solid, liquid, or gas. You can find all three forms of water in your home. They are ice, water, and water vapour.



Ice is solid water. It forms when liquid is cooled until it freezes. Each piece of ice has a definite shape.

When ice is warmed, it melts and becomes liquid and takes on the shape of the container holding it.

As water is heated, bubbles of water vapour (gas) form. They escape from the surface and condense to form a mist of liquid droplets called steam.

Rivers of iron

Iron must be heated in a furnace to make it melt. Molten iron is so hot it glows yellow. It is poured into a mould and left to harden to make solid iron objects.



Washing dries faster on a hot day, when heat turns water into vapour very quickly.



Evaporating

In the open air, water slowly turns into vapour – this is called evaporation. Wet clothes dry on a line because the water they hold, evaporates.



Freezing

Icicles are spikes of ice that form when dripping water freezes. You often see them on trees in winter. If water keeps dripping down and freezing, the icicle will get longer and longer.



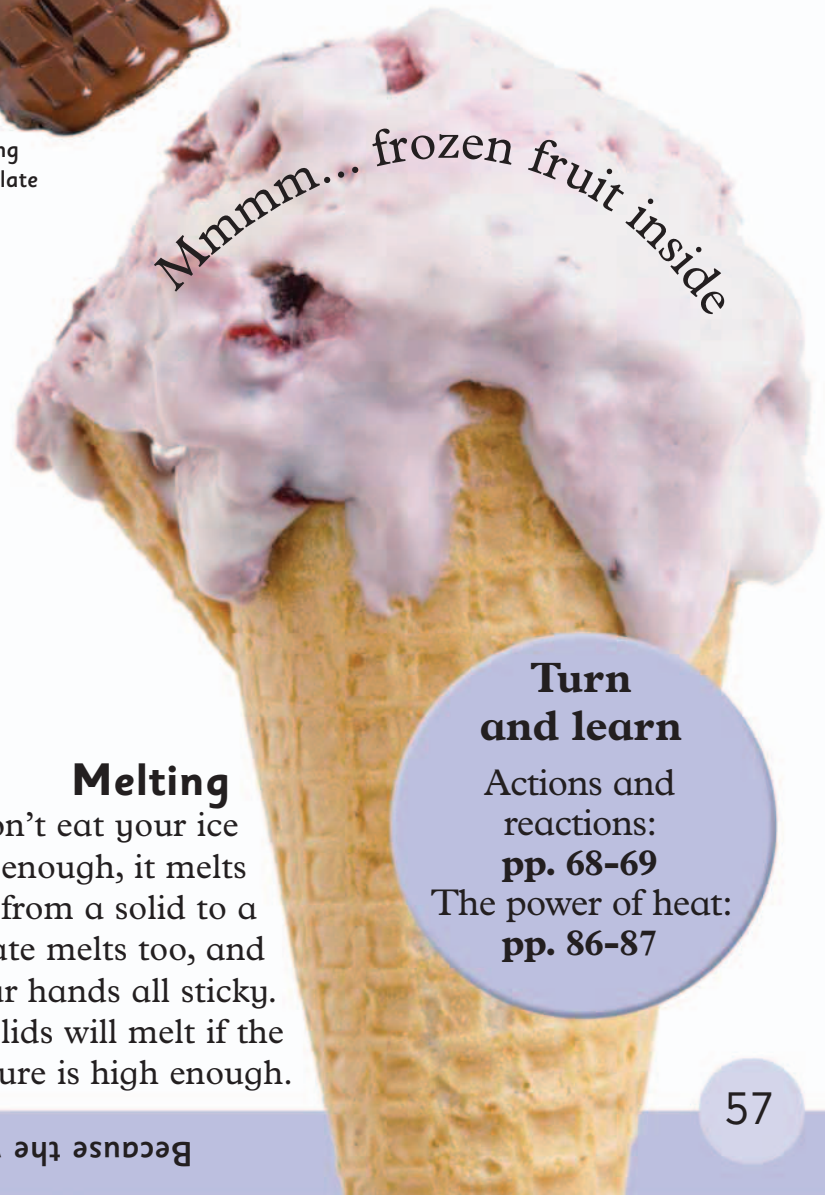
Melting chocolate

Melting

When you don't eat your ice cream quickly enough, it melts and changes from a solid to a liquid! Chocolate melts too, and makes your hands all sticky.

Most solids will melt if the temperature is high enough.

Mmmm... frozen fruit inside



Turn and learn

Actions and reactions:

pp. 68-69

The power of heat:
pp. 86-87

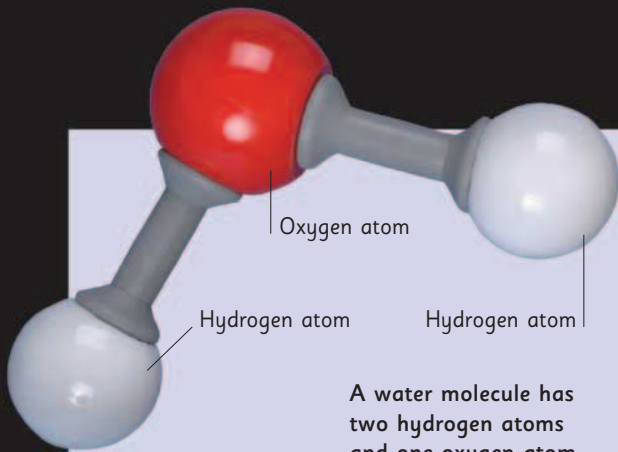
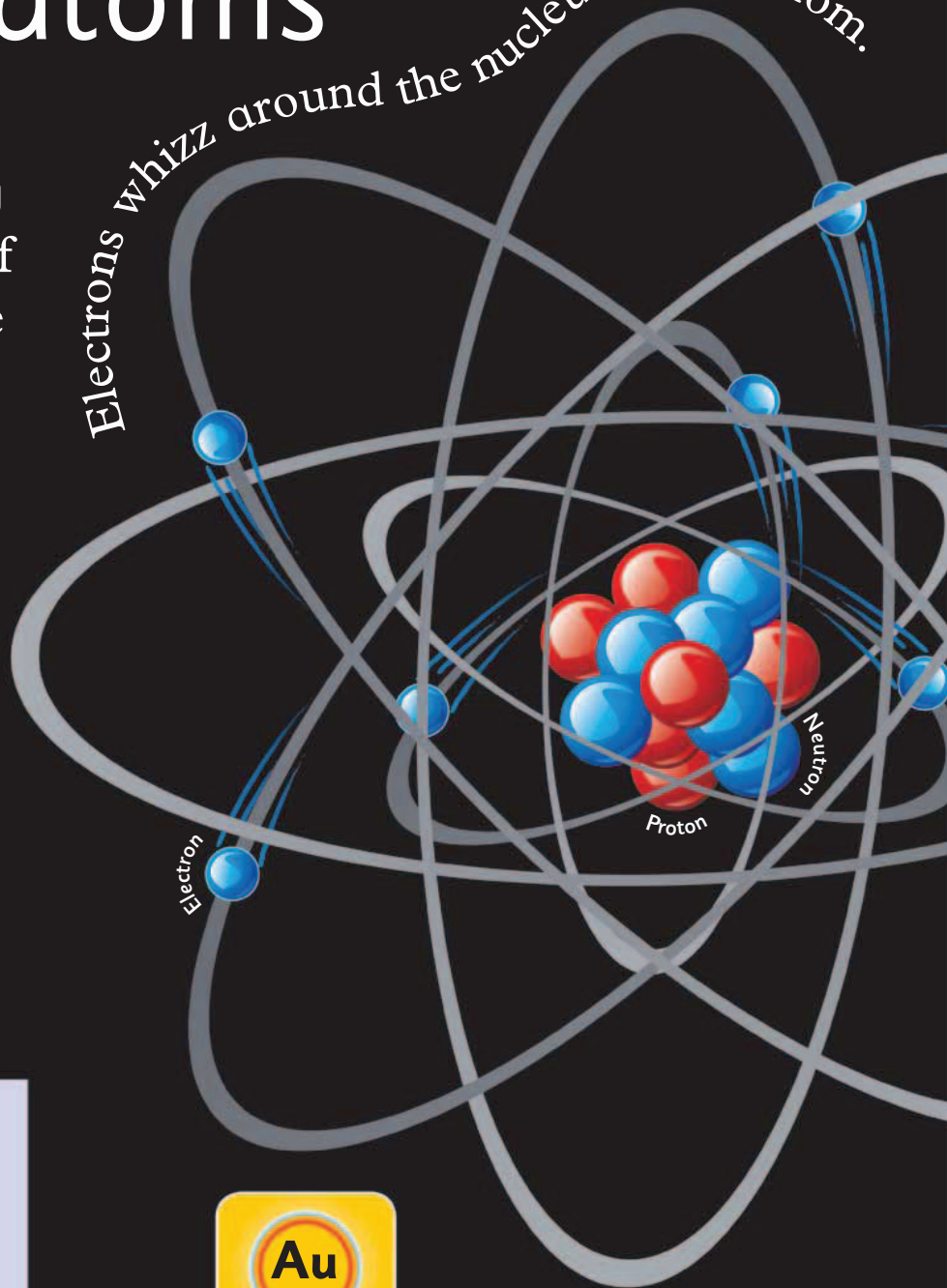
Amazing atoms

Atoms are tiny particles that make up everything around us. Each atom of a substance contains the chemical properties the substance is made up of.

Inside an atom

Inside an atom are three tiny types of particle: protons, neutrons, and electrons. Protons and neutrons make up the atom's nucleus (core). The electrons are outside this.

Electrons whizz around the nucleus of the atom.



Molecules

Substances are made from little groups of atoms called molecules. The molecules of water have three atoms.



Golden number

An atomic number is the number of protons in an atom. The atomic number of gold is 79. This means that each gold atom has 79 protons.

Molecules

In most materials, atoms are joined in tiny groups called molecules. The shapes of molecules and the way they pack together can help explain how different materials behave.

Steaming ahead

Molecules are always jiggling about. When they get hot, they move further and faster. When water heats up, the molecules may start moving so fast that they escape into the air as water vapour.

Frozen solid

Cold molecules move slowly, allowing them to pack together more easily. When water freezes, the molecules line up in neat rows, forming ice crystals.



Steam appears when water vapour cools down and becomes liquid again. The steam from this train is made of millions of tiny liquid droplets.

Snow may look like white powder, but if you look closely you can see thousands of tiny crystals as clear as glass.

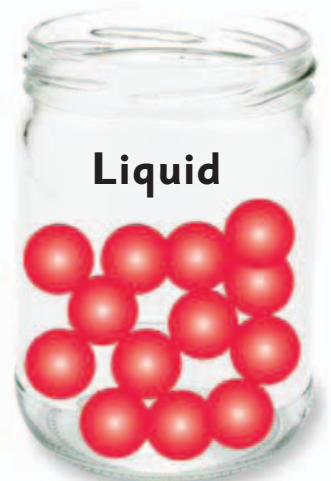


Melt: As a solid heats up, its molecules move faster until they break free from each other and move separately, turning the solid into a liquid.



Solid

Solidify: As a liquid cools, its molecules lose energy and move more slowly. Eventually, they start sticking together, turning the liquid into a solid.



Liquid

If a liquid is poured into a jar or bottle, it takes the shape of its container and stays in place.

Diamond is made into jewels that are almost indestructible.

Diamond molecule

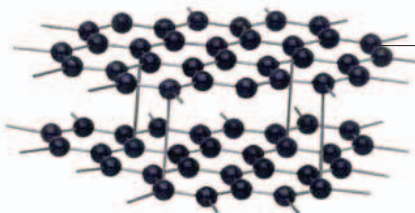
Diamond is the hardest natural substance known. Its hardness comes from the way the carbon atoms in diamond are arranged. Each atom is joined by strong bonds to four neighbouring atoms.

Each group of five atoms in diamond forms a pyramid shape. This shape makes diamond amazingly strong.



Graphite molecule

Graphite, like diamond, is also made of carbon atoms, but the atoms are arranged in a different way, making graphite very soft.



Each carbon atom in graphite is joined to only three neighbours. The atoms form layers that slip over each other, making graphite soft.

Graphite is used to make the soft lead in pencils.

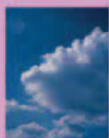
Turn and learn

Changing states:
pp. 56-57
Minerals:
pp. 104-105

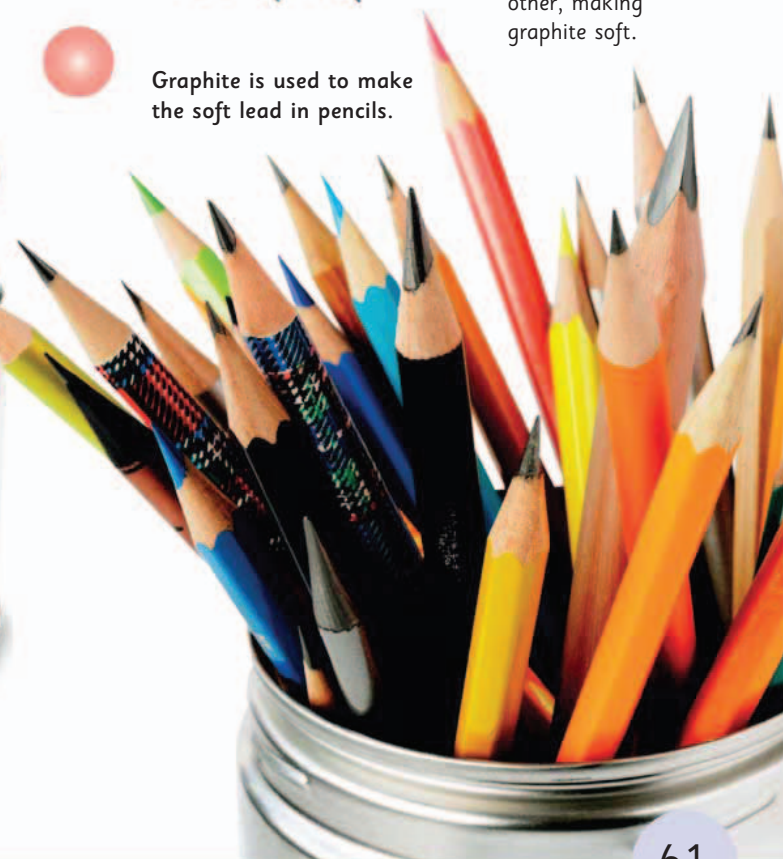


Evaporate: As a liquid heats up, its molecules speed up until they move fast enough to float away as gas.

Condense: When gas molecules lose energy and slow down, they stick together and form liquid.



A gas can fill any container it's put in. If there's no lid to seal the container, the gas will escape into the air.



Elements

An element is a substance made up of just one type of atom. Scientists have discovered 117 different elements. The chart on this page, called the periodic table, shows most of them.

The elements in our bodies mostly come from what we eat.



1																	
2																	
3	4	5	6	7	8	9											
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co									
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh									
Cs	Ba	LANTHANIDES or RARE-EARTH METALS	Hf	Ta	W	Re	Os	Ir									
Fr	Ra	ACTINIDES or RARE-EARTH RADIOACTIVE METALS	Rf	Db	Sg	Bh	Hs	Mt									

The periodic table

In the periodic table, elements are arranged by the number of protons in their atoms, starting with hydrogen. Elements with similar properties fall into groups, which are shown in colour.

Each vertical column is called a GROUP, or family, of elements. Some groups have elements sharing very similar properties. Other groups have elements with less in common.

La	Ce	Pr	Nd	Pm	Sm
LANTHANUM	CERIUM	PRASEODYMIUM	NEODYMIUM	PROMETHIUM	SAMARIUM
Ac	Th	Pa	U	Np	Pu
ACTINIUM	THORIUM	PROTACTINIUM	URANIUM	NEPTUNIUM	PLUTONIUM



Milk contains the element calcium, which helps form your teeth and bones.

This bucket is made of the element iron, coated with the element zinc, which stops iron rusting.

Metal and non-metals

Most elements are metals, and the others are called non-metals. Metals are normally solid, shiny, and hard. They all conduct electricity and heat. Silver, aluminium, and zinc are metals. Carbon, oxygen, and silicon are non-metals.

Every element has a name – a symbol made of usually one or two letters – and an atomic number. The atomic number is the number of protons in one atom of the element.



Oxygen makes up about one-fifth of the air, and it's so important that we have to take it with us when we are underwater.

Kr — Symbol
KRYPTON — Name
36 — Atomic number

			13	14	15	16	17	18
			B BORON 5	C CARBON 6	N NITROGEN 7	O OXYGEN 8	F FLUORINE 9	He HELIUM 2
			Al ALUMINIUM 13	Si SILICON 14	P PHOSPHORUS 15	S SULPHUR 16	Cl CHLORINE 17	Ne NEON 10
10	11	12						
Ni NICKEL 28	Cu COPPER 29	Zn ZINC 30	Ga GALLIUM 31	Ge GERMANIUM 32	As ARSENIC 33	Se SELENIUM 34	Br BROMINE 35	Kr KRYPTON 36
Pd PALLADIUM 46	Ag SILVER 47	Cd CADMIUM 48	In INDIUM 49	Sn TIN 50	Sb ANTIMONY 51	Te TELLURIUM 52	I IODINE 53	Xe XENON 54
Pt PLATINUM 78	Au GOLD 79	Hg MERCURY 80	Tl THALLIUM 81	Pb LEAD 82	Bi BISMUTH 83	Po POLONIUM 84	At ASTATINE 85	Rn RADON 86
Ds DARMSTADIUM 110	Rg ROENTGENIUM 111							
Eu EUROPIUM 63	Gd GADOLINIUM 64	Tb TERBIUM 65	Dy DYSPROSIUM 66	Ho HOLMIUM 67	Er ERBIUM 68	Tm THULIUM 69	Yb YTTERBIUM 70	Lu LUTETIUM 71
Am AMERICIUM 95	Cm CURIUM 96	Bk BERKELIUM 97	Cf CALIFORNIUM 98	Es EINSTEINIUM 99	Fm FERMIUM 100	Md MENDELEVIUM 101	No NOBELIUM 102	Lr LAWRENCIUM 103

Useful elements

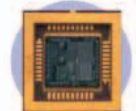
We use elements to make all sorts of useful or decorative objects.



Gold is a precious metal. It is used to make jewellery.



Copper is a metal that conducts electricity well. It is used in electrical wires.



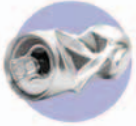
Silicon is a non-metal used to make the chips that power computers.



Carbon fibres are strong but light, so they are used for tennis rackets.



Iron is a strong, silvery metal. It is magnetic and has many uses.



Aluminium is a soft, shiny metal. It is used to make drinks cans.



Sulphur is a yellow non-metal used to harden rubber to make tyres.



Titanium is a very strong, light metal used in aeroplane bodies and space rockets.



Helium is a gas used in balloons because it is less dense than air.



Chlorine is a yellow-green gas, used in bleach and to make some plastics.



Mercury is a liquid metal used in dental fillings and is the gas inside fluorescent light bulbs.

- KEY:**
- Alkali metals:** These silvery metals are very reactive.
 - Alkaline-earth metals:** These shiny, silvery white metals are reactive.
 - Transition metals:** Many are strong and have high boiling and melting points.
 - Lanthanides:** Many are soft, shiny, and silvery white metals.
 - Actinides:** These are radioactive heavy elements.

- Poor metals:** These are softer, weaker metals.
- Non-metals:** Most are gases at room temperature and easily snap as solids.
- Halogens:** These non-metals are highly reactive and harmful.
- Noble gases:** These non-metals are the least reactive of all the elements.

Turn and learn
 Elements: pp. 64-65
 Electricity: pp. 76-77

Properties of elements



Alkali metals

These are soft, lightweight metals that react easily with other chemicals, such as water. When put in water, they fizz and pop violently. Sodium is an alkali metal. It reacts with the gas chlorine to form common salt.

Transition metals

This group includes well-known and useful metals.



Silver is used in medals, ornaments, jewellery, and cutlery (knives and forks).



Zinc protects things from rusting. One of its many uses is in the casing of batteries.



Nickel is used in silver-coloured coins because it does not lose its shine.



Titanium is lightweight yet incredibly strong. It is used to repair bones and joints.

In the periodic table, elements with similar properties are arranged in groups. Some groups are made up of elements that react easily with other chemicals to form new compounds. Other groups include elements that barely react with anything at all.

What are transition metals?

Forty elements make up a group known as the transition metals. These are typical metals, being solid, shiny, and mostly hard. The precious metals gold, silver, and platinum are in this group.

Pure gold is found as grains in rock or, more rarely, as whole rocks (nuggets) that are worth a small fortune.



Precious metals such as gold are long-lasting because they react poorly with other chemicals. Gold is one of the least reactive elements.





Calcium is found in seashells in the compound calcium carbonate.

The dazzling light of fireworks comes from burning magnesium.

Alkaline-earth metals

Five elements, including magnesium and calcium, are called alkaline-earth metals. Like alkali metals, they are soft and light. They don't react as strongly with water, but they join with other chemicals to make many compounds important in nature.

Noble gases

The six noble gases get their name because they hardly react with other chemicals, as though staying aloof. They include neon and argon, which are used to make lasers and coloured lights.



Poor metals

The elements in this group are soft and weak. They are called poor metals but are very useful. Tin, lead, and aluminium are examples of poor metals.



Tin cans are actually made of steel with a thin coating of tin.

Halogens

Five elements make up a group called the halogens. These are all highly reactive chemicals. The gas chlorine is one of the best-known halogens. It is added to the water in swimming pools because it kills germs.

Chlorine smells strongly and can sting your eyes.



Mixtures



Mixture of
milk and
cereal

A mixture is created when two or more things are combined together, without bonding. A mixture can usually be easily separated back into its original bits. When atoms of different elements join, or bond, a compound is formed.



Colorado River, Arizona, USA

Suspension

A muddy river is a type of mixture called a suspension. Small particles of soil are “suspended” in the water, making it brown and cloudy.

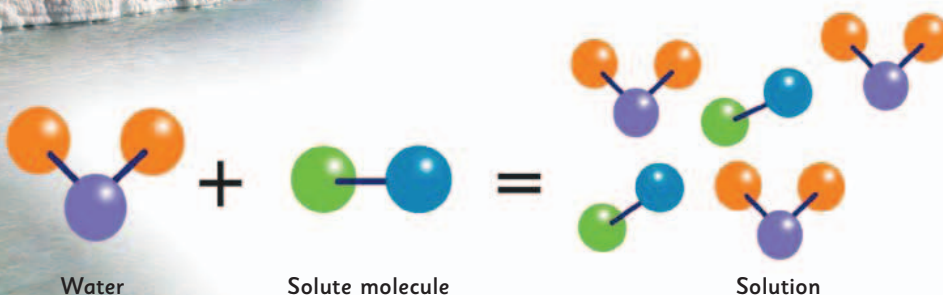
Alloy

Different types of metal can be melted and mixed together to make a kind of mixture called an alloy.

The alloy has different properties from the original metals. This tankard is made of pewter, which is an alloy of tin and lead. Pewter is much harder than tin or lead.

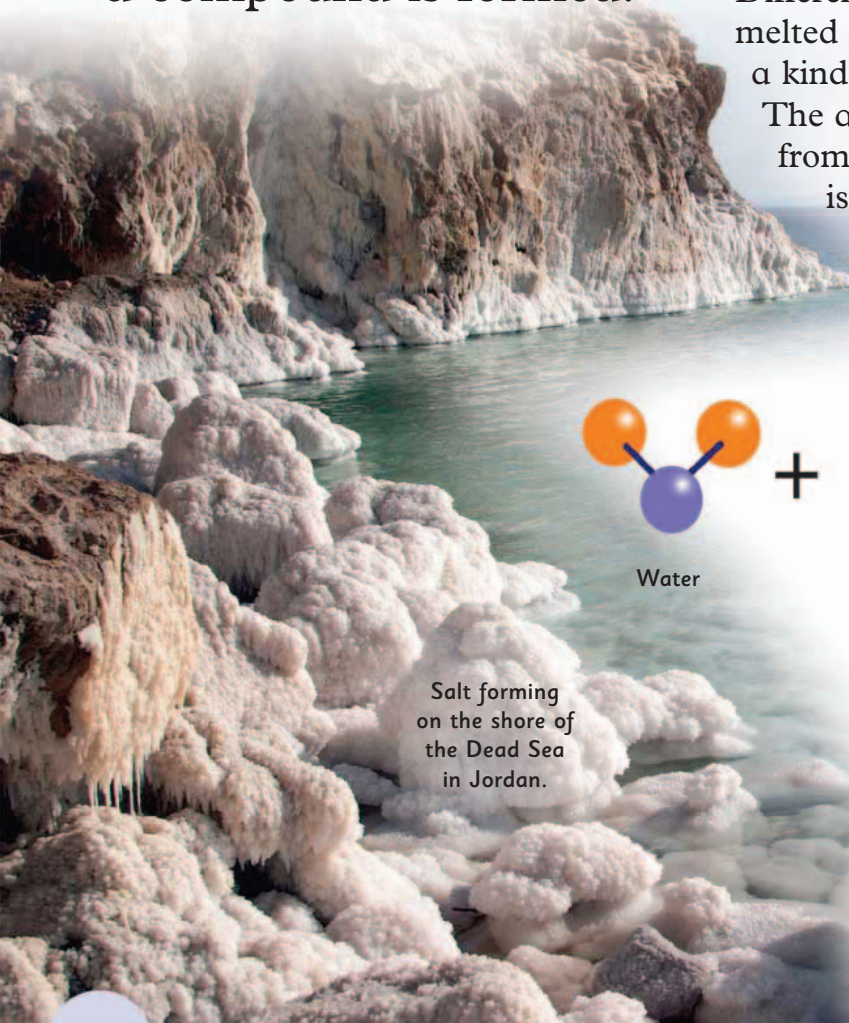


Pewter
tankard



Solution

If you stir sugar into water, the sugar molecules spread out and fit between the water molecules, making the sugar seem to disappear. We say the sugar (a solute) has dissolved in the water (a solvent). This kind of mixture is called a solution. Seawater is a solution of water and salt. If you let seawater dry out, the salt reappears.



Salt forming
on the shore of
the Dead Sea
in Jordan.



Separating compounds

It takes a great deal of effort to separate a compound into pure elements. To make pure iron, you have to separate the compound iron oxide, into iron and oxygen. This is done in a very hot blast furnace.



Iron ore



Pure iron

The mineral iron ore is rich in iron oxide. It is mined to extract iron, which is mostly used to make steel.

Cream and cheese are made by separating milk.



Separating mixtures

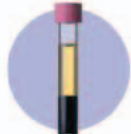
A mixture can be easily separated in several ways.



Evaporation removes water from a mixture by turning it into a gas (water vapour).



Filtration separates large particles, such as coffee grinds, from a suspension.



Spinning at high speed separates blood cells from blood, in a device called a centrifuge.



Distillation separates mixtures of liquids by making them evaporate and condense.



Milk



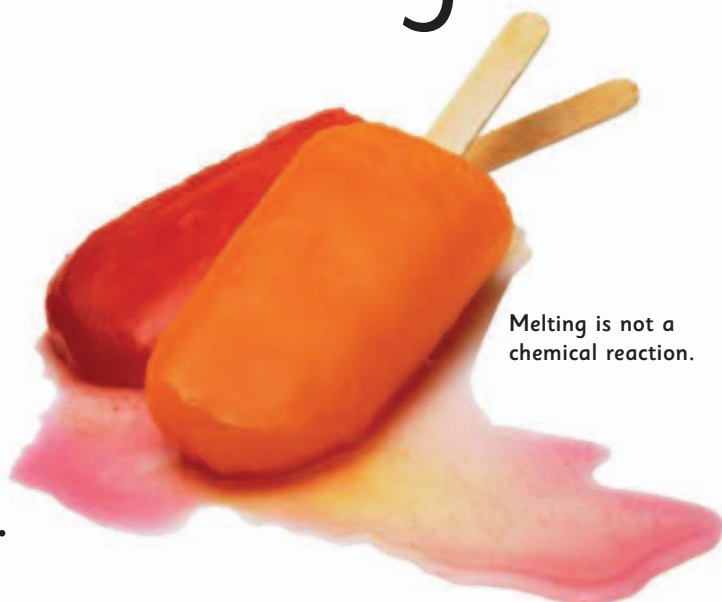
Strawberries and cream

Separating milk

Whole milk can be separated into cream and skimmed milk by spinning it in a bowl. The heavier skimmed milk spins away from the lighter cream, which stays in the centre of the spinning bowl.

Reactions and changes

Materials change as a result of physical processes or chemical reactions. In a chemical reaction, atoms join with or break away from other atoms, forming different compounds. Chemical reactions often lead to a dramatic change.



Melting is not a chemical reaction.

Chemical change

Burning is a chemical reaction involving oxygen (O). Wood is made of compounds containing carbon (C) and hydrogen (H). When it burns, the carbon and hydrogen react with oxygen to produce carbon dioxide (CO_2) and water (H_2O).

Physical change

Not all dramatic changes are caused by chemical reactions. When ice lollies melt, the atoms in the water molecules do not get rearranged into new molecules – they remain water molecules. Melting is simply a physical change.

Burning is a chemical reaction.



Escaping energy

Chemical reactions can release energy as heat and light. A sparkler contains chemicals that release a lot of energy as light to create a dazzling shower of sparks.



Speeding up reactions

Cooking makes carrots softer because the heat causes a chemical reaction. Chopping carrots into small bits speeds up the reaction because it increases the area of contact between the carrots and the hot water.

Sliced carrots cook faster than whole carrots.



Glow in the dark

Light sticks glow in the dark thanks to a chemical reaction that releases energy as light. You can slow down this reaction by putting a light stick in a fridge, which makes it last longer.



hands on

Ask an adult to boil some red cabbage and save the coloured water. Let the water cool. Then add acid (vinegar) or alkali (bicarbonate) and watch for a spectacular change of colour!

Soda volcano

If you drop mints into a bottle of fizzy drink, the drink turns to foam and explodes out in an instant. This is a physical change rather than a chemical reaction. The rough surface of the mints helps gas, dissolved in the drink, to turn into bubbles much more quickly than it normally would.



Irreversible changes



Nylon jacket

Physical changes are reversible – for example, you can freeze water, and heat can turn the ice into liquid water again. However, many chemical reactions are irreversible because they involve atoms joining together in new ways.

Manmade materials

Chemical reactions can be used to create new materials that don't exist in nature. Nylon, for example, is a fabric made using chemicals from oil. Many types of clothes, from socks to coats, are made of nylon.



Cooking

When food is cooked, heat triggers chemical reactions that change it permanently. When a freshly baked cake cools down, it doesn't turn back into gooey cake mixture.



Baking powder

Baking powder makes cakes light and fluffy. It contains chemicals that react when they're wet to produce bubbles of gas.



A fresh pepper looks plump and brightly coloured.



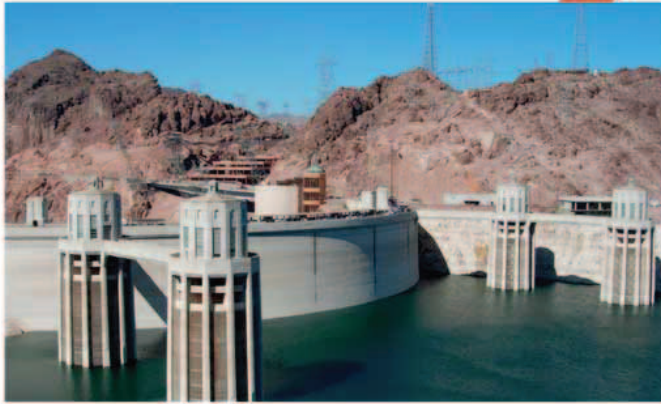
An old pepper darkens and shrivels up as it rots.

Rotting

Rotting food is full of tiny organisms such as a bacteria and fungi. These organisms trigger chemical reactions that break down food molecules, changing them permanently.

Ready to fall

Maple trees shed their leaves in autumn. Before the leaves die, they change from green to golden, orange, or red. The colour changes because a chemical reaction in the leaves breaks down a green compound called chlorophyll inside leaf cells.



Solid as a rock

Concrete is made by mixing gravel, sand, cement powder, and water. A chemical reaction between the water and cement makes the mixture harden permanently to become as solid as rock – ideal for building dams and houses.

Maple leaves turn orange as they die.

Turn and learn

Plants:
pp. 20-21
Ecosystems:
pp. 44-45

Rust

Iron reacts chemically with oxygen in the air to form rust – a flaky, reddish brown compound. Rust can ruin cars, so the metal is painted to protect it.



What is energy?

Energy is what makes everything happen. Your body needs energy so that you can move, grow, and keep warm. We also need energy to power our cars, light our homes, and do thousands of other jobs.

Sunshine

We get nearly all our energy from the Sun. Plants absorb the energy in sunlight and store it as chemical energy. The stored energy enters our body through food and is released inside our body's cells. Sunlight absorbed through our skin is also necessary to produce certain vitamins and minerals in our body. The Sun is the ultimate source of energy for all plants and animals.

Only a tiny fraction of the Sun's energy reaches the Earth.

A bow stores energy by bending. When you let go, the bow springs back into shape and releases the stored energy.

Sources of energy

Energy comes from lots of different sources.



Wind drives wind turbines, which convert movement energy into electricity.



Geothermal energy is heat from deep underground.



Dried plants can be burnt to provide energy for cooking, heating, and lighting.



Waves can be used to generate large amounts of electricity.



Dams harness the energy in rivers flowing downhill to make electricity.



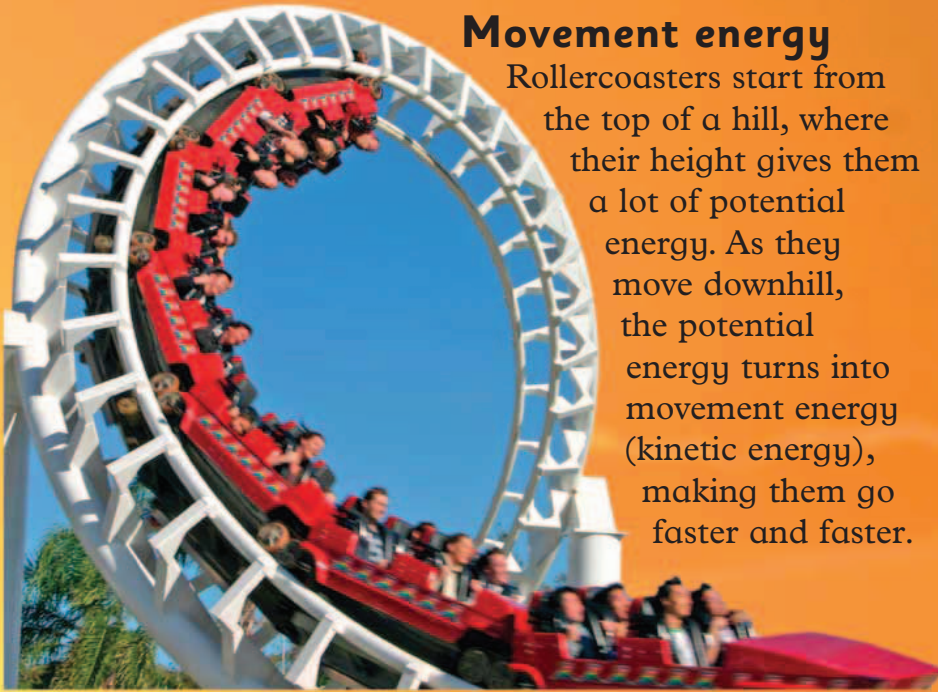
The **Sun's** energy can be captured by solar panels to make electricity.



Fossil fuels, such as oil, are used to power cars and to make electricity.

Stored energy

An object can store energy and release it later. When you wind up a clockwork toy, energy is stored in a spring. A bow and arrow uses stored energy to shoot the arrow. Stored energy is also called potential energy because it has the potential to make things happen.



Movement energy

Rollercoasters start from the top of a hill, where their height gives them a lot of potential energy. As they move downhill, the potential energy turns into movement energy (kinetic energy), making them go faster and faster.

Nuclear energy

Matter is made up of tiny particles called atoms. The centre of an atom, called a nucleus, stores huge amounts of energy. This nuclear energy is used in power stations to make electricity.

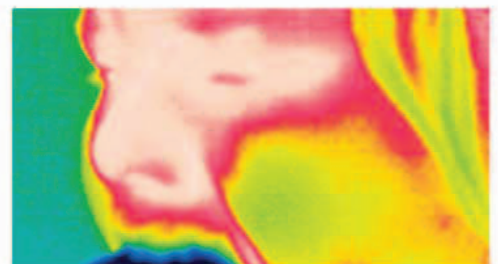


Electrical energy

Lightning is caused by electrical energy in a storm cloud. The electrical energy turns into the heat and light energy of lightning and the sound energy of thunder.

Picture detective

Look through the Physical Science pages to identify each of the picture clues below.



Turn and learn

Light:
pp. 82-83
Heat:
pp. 86-87

Energy chain

Changing energy from one type to another is called “energy conversion”. The steps can be linked to make an energy chain.

Coal contains chemical energy.



Burning coal produces heat energy, which is used to boil water. Boiling water creates steam.



Moving steam is a form of kinetic (motion) energy, which operates turbines.



The kinetic energy produced by the moving turbines creates electricity.



Electrical energy used by television sets changes into light, sound, and heat energy.

Energy changes

All around you, energy is being converted from one form to another. You can see these changes happen – switching on a light turns electrical energy into light energy.

Driving force

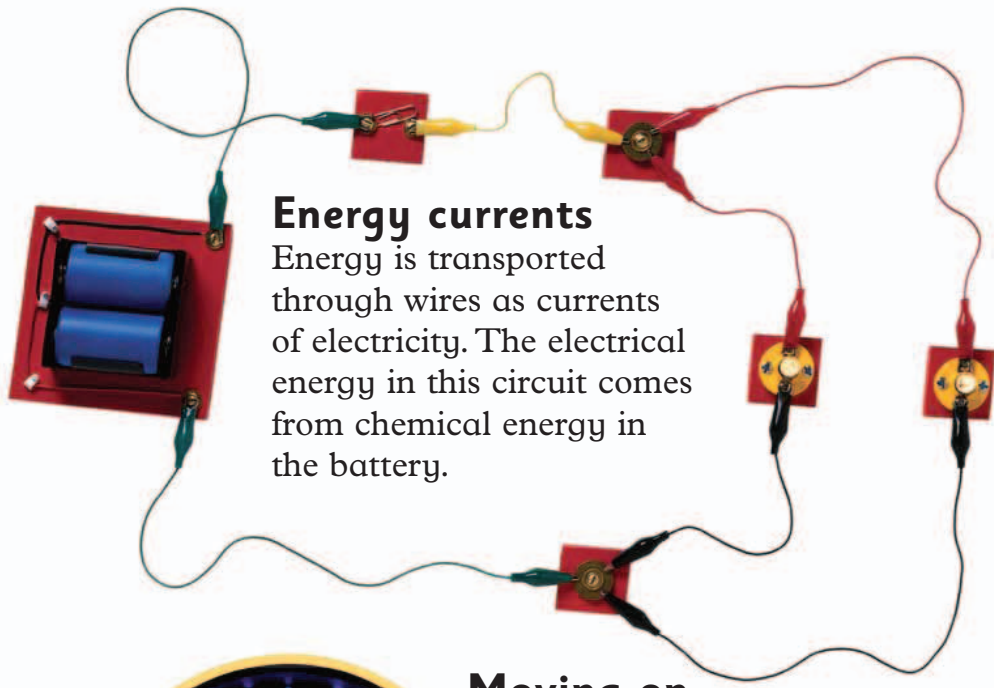
Car fuel is full of chemical energy. When the engine starts, the chemical energy is changed to heat energy. This is the first in a series of energy changes that make cars run.



Heat to sound

Some heat energy becomes sound energy. The roar of a racing car engine can be deafening!





Energy currents

Energy is transported through wires as currents of electricity. The electrical energy in this circuit comes from chemical energy in the battery.

Energy savings

Energy is precious, so people are finding extra ways to limit energy use.



Roof insulation

stops heat energy from escaping and helps keep houses warm.



Energy-saving light bulbs

last longer and use less energy than standard ones.



Washing clothes

at low temperatures saves the energy needed to heat water.

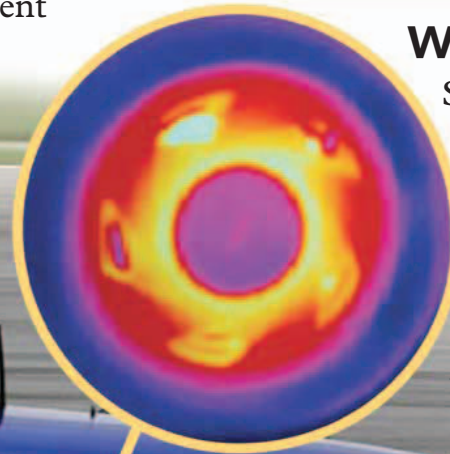
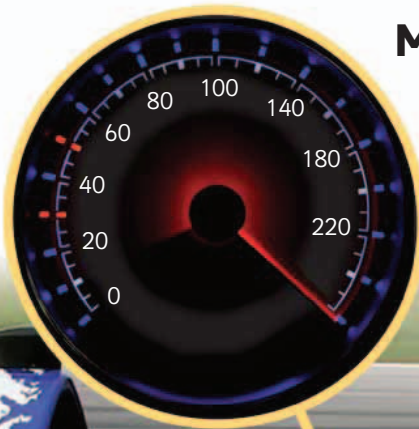


Boiling only as much

water as you need in the kettle saves time and energy.

Moving on

Some heat energy is changed to kinetic energy as the pistons move. The movement of the car is also kinetic energy.



Wheels of fire

Some of the kinetic energy in the wheels becomes heat energy. The hottest parts are shown white and yellow.

Turn and learn

Types of energy:

pp. 72-73

Resources:

pp. 110-111

Electricity

Have you ever thought about what powers your television, your computer, or the lights in your bedroom? A flow of electricity makes all these things work.



Power supply

Electricity travels to your home along wires above and sometimes below the ground. The wires above the ground hang on metal towers called pylons.

Making electricity

Electricity is a form of energy. It can be made using any source of energy, such as coal, gas, oil, wind, or sunlight. On a wind farm, wind turbines use the energy of moving air to create electricity.

Everyday electricity

We use electricity in all sorts of ways in our everyday lives.



Electricity is used to **heat** up household appliances such as irons and cookers.



Electricity is used to **light** up our homes, schools, offices, and streets.



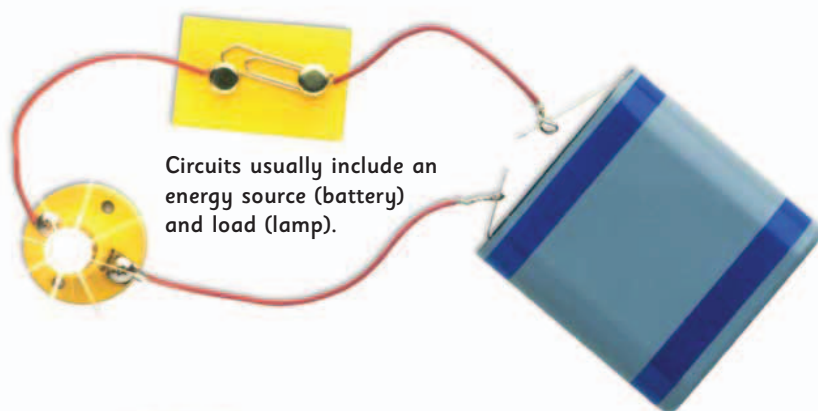
Electricity helps in **communication** by powering telephones and computers.



Electricity helps in **transportation** by powering certain vehicles, such as trains.

Circuits of power

An electric circuit is a loop that electricity can travel around. An electric current moves through the wires in this circuit, and lights up the bulb.



Electrical cables

Electrical cables are made of metal and plastic. Electricity flows through the metal (which is called a conductor). The plastic (which is called an insulator) stops electricity escaping.

hands on

Rub a party balloon up and down on your clothes. The balloon will now stick to the wall. This is because rubbing it gives the balloon an electric charge.

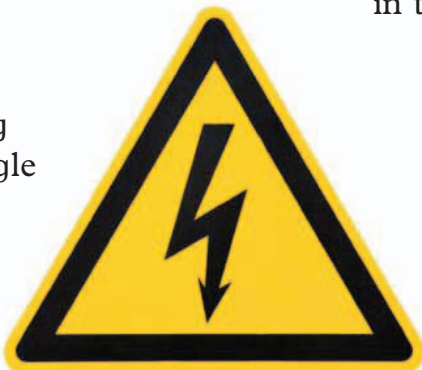
Lightning strikes

Electric charge building up in one place is called “static electricity”. Lightning is an electric current caused by static electricity building up in thunderclouds.



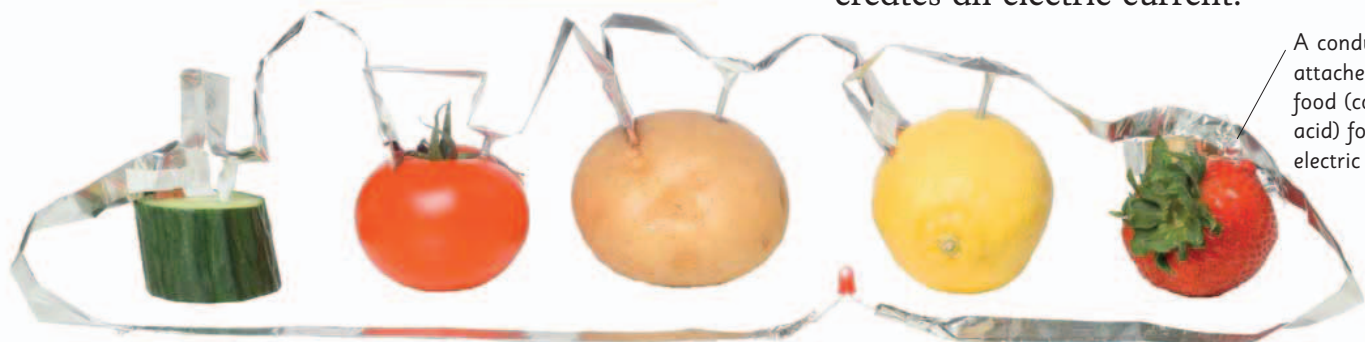
High voltage

Electricity can be very dangerous. This triangle is an international warning symbol. It means “Caution: risk of electric shock”.



Food battery

Food that contains water and weak acid will conduct electricity. In a food battery, a chemical reaction between the metal and the acid in the food creates an electric current.



A conductor attached to food (containing acid) forms an electric circuit.

Magnetism

Magnets exert a force called magnetism, which can attract certain objects – especially those containing iron.



This magnet has attracted a clump of steel paperclips because steel has an iron content.

Attract or repel?

Magnets attract materials containing iron, and they can also attract other magnets. Two magnets can also push apart, or “repel”.

Opposite poles of a magnet attract each other.

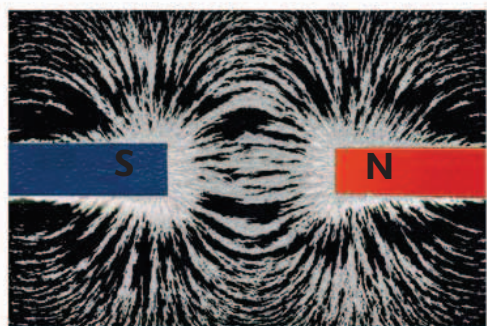


Magnet rules

The ends of a magnet are called the north and south poles. Opposite poles attract each other. Similar poles repel each other.



Similar poles of a magnet repel each other.



Iron filings show the magnetic field between the two magnets.

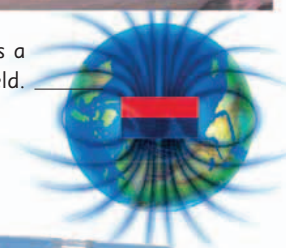


The Northern Lights are partly due to magnetic forces in our atmosphere.

Lights in the sky

Amazing lights are caused when particles in the solar wind (streaming from the Sun) travel into the atmosphere along force lines in the Earth’s magnetic field.

The Earth has a magnetic field.



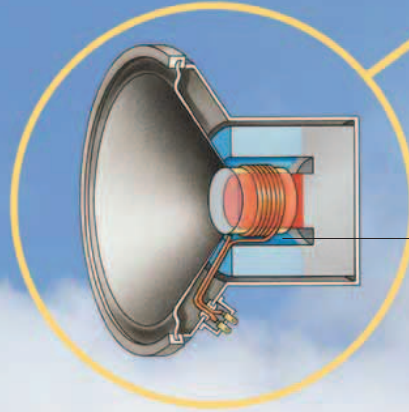
The Earth as a magnet

The Earth behaves as if there is a giant invisible magnet between the North and South poles. That’s why we can use a compass to find our way.



Electromagnets

When an electric current flows through a wire coil, the coil becomes magnetic. This creates an electromagnet. Automatic doors, loudspeakers, and electric motors all use electromagnets.



Electromagnets are used in speakers.

Lifting with magnets

Some cranes use magnetic force, in the form of giant electromagnets, instead of hooks. The electromagnet can be switched on or off.



When switched on, the crane's electromagnet attracts huge pieces of iron and steel.

Magnetic rails

Maglev trains are held above a track by a magnetic force. Maglev is short for "magnetic levitation". The trains literally travel on air.

There are maglev trains in Japan, South Korea, and China – and others are being developed elsewhere.

hands on



Use a magnet to find out which things in your home are made from magnetic materials. Your magnet will be attracted to objects containing iron.

Energy waves

A form of energy called “electromagnetic radiation” travels in waves, like waves on the surface of a pond. Just as waves in a pond can be close together or far apart, different types of electromagnetic radiation have different wavelengths.

The spectrum

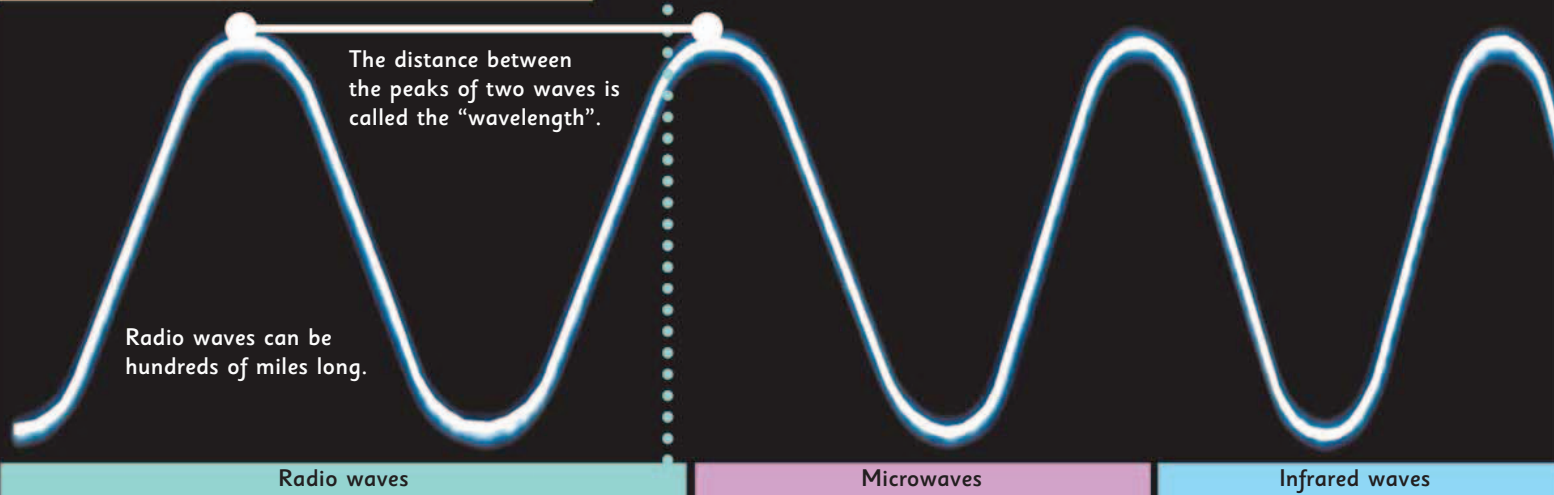
Visible light is a type of energy wave that we can see. There are other waves that are not visible to us, such as radio waves. The spectrum is made up of different types of waves, with varying wavelengths.



Radio waves ●

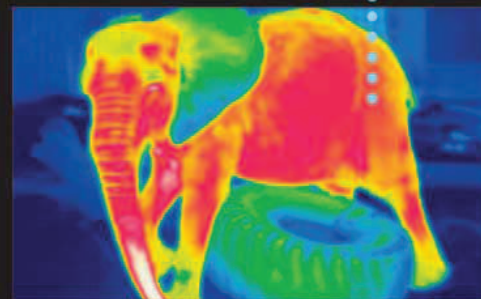
Radio waves have the longest wavelengths and are good at travelling far. Radio and TV programmes are broadcast as radio waves.

Low energy



● Microwaves

Microwaves are used to heat up food in microwave ovens. They are also used by mobile phones and by satellites in space.



● Infrared waves

Hot objects give off invisible rays of heat called infrared waves. An infrared camera can detect these waves to create images.





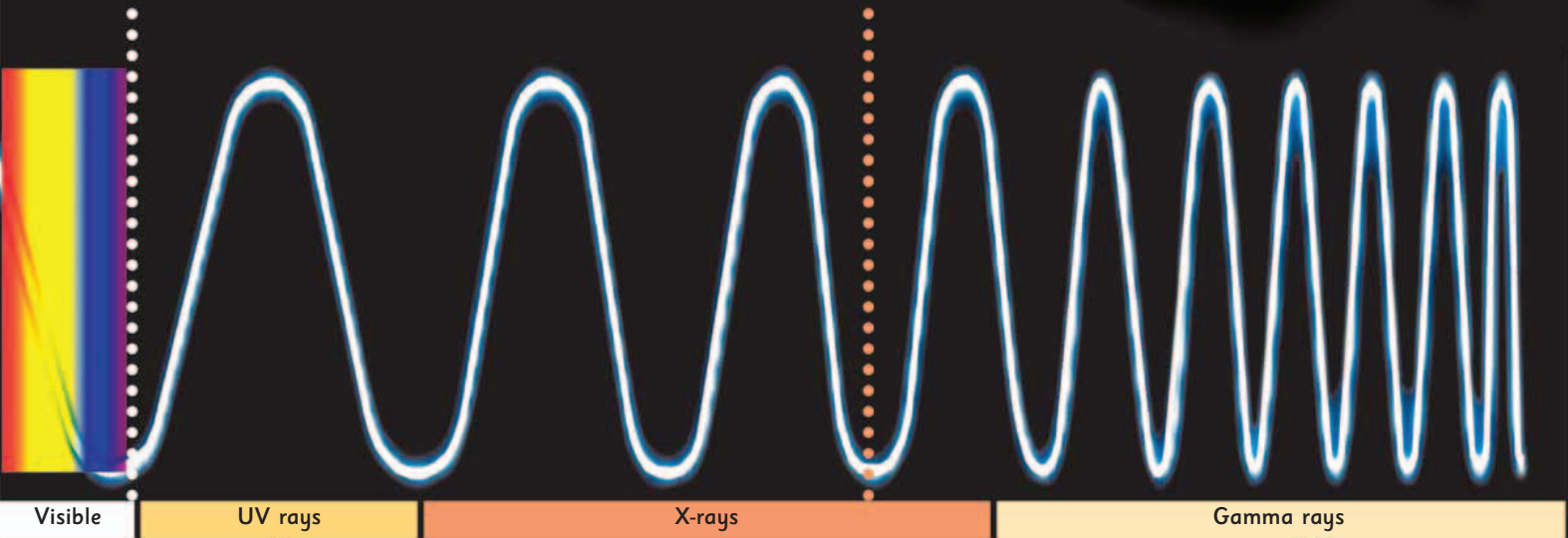
● **Visible light**

Light waves bounce off every object around us, allowing us to see things. Visible light includes all the colours of the rainbow, each of which has a particular wavelength.



● **X-rays**

X-rays are invisible waves that pass through soft parts of the body but not bone. This is why doctors can use X-rays to take images of bones.



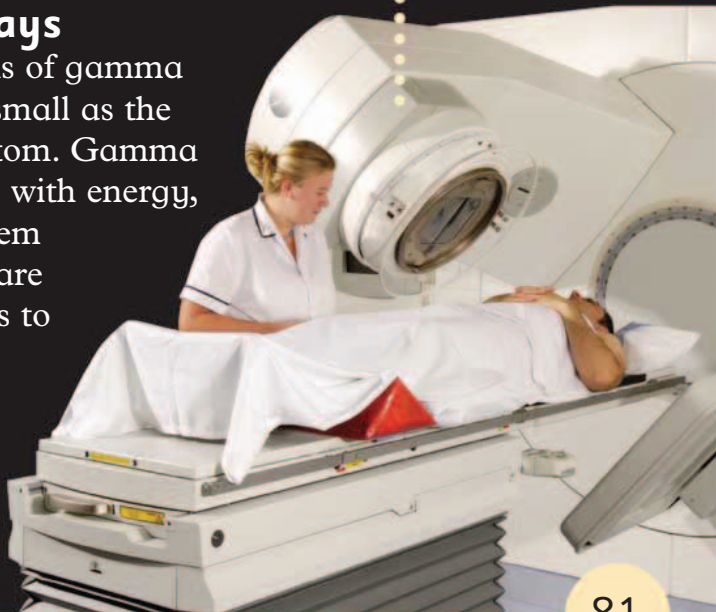
● **Ultraviolet (UV) light**

As well as producing visible light, the Sun produces invisible rays of ultraviolet light. UV light makes you tan but too much of it can cause skin cancer and eye damage.

● **Gamma rays**

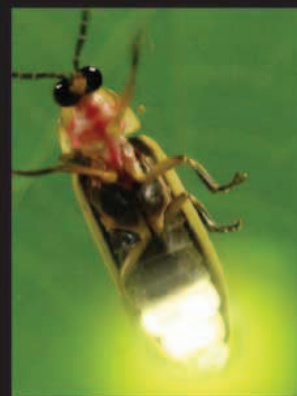
The wavelengths of gamma rays can be as small as the nucleus of an atom. Gamma rays are packed with energy, which makes them powerful. They are used in hospitals to kill cancer cells.

This man is being treated with gamma rays to kill cancer cells inside his body.



Light

Light is a form of energy that our eyes can detect. It comes in all the colours of the rainbow, but when the colours are mixed together, light is white.



Fireflies

Some animals create their own light. Fireflies flash a yellowish-green colour from their abdomen at night to attract mates.

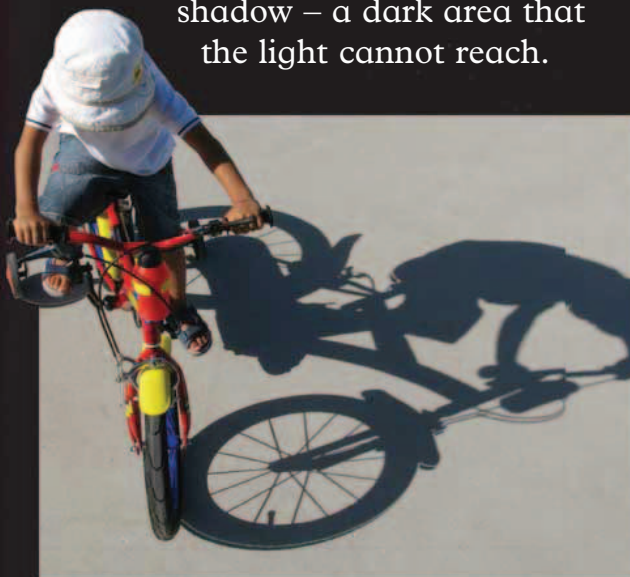
Where does light come from?

Light is produced by electrically charged particles in atoms – especially negatively-charged electrons.

Candlelight is produced by hot atoms in tiny particles of soot inside the flame.

Casting shadows

Light can only travel in straight lines. If something blocks its path, it casts a shadow – a dark area that the light cannot reach.



Using light

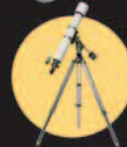
We can use light for many different things.



CDs and DVDs store digital information that can be read by laser beam.



Cameras capture light in a split second to create photographs.



Telescopes collect the light from stars and planets, and produce magnified images of them.



Mirrors reflect light so we can see images of ourselves.



Periscopes bend the path of light so we can see around corners.



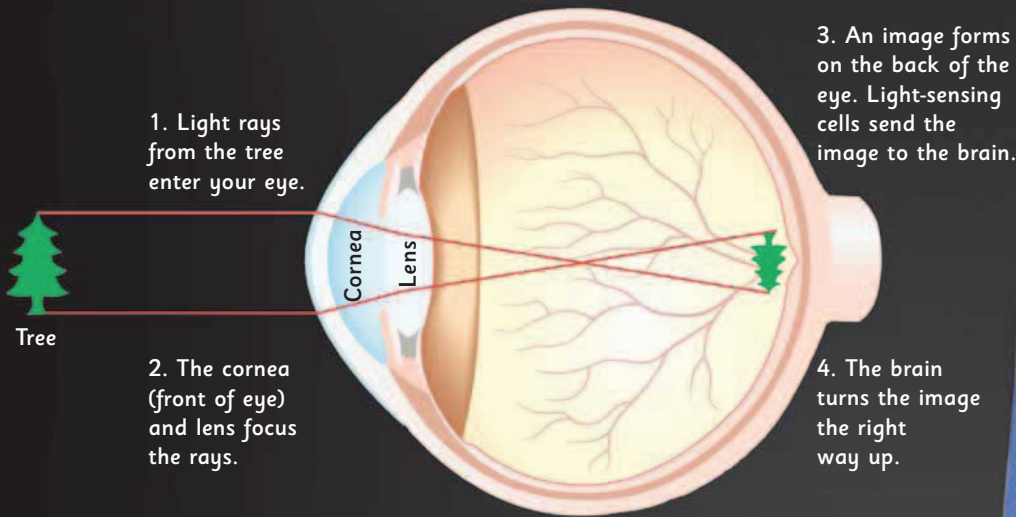
Torches shine a beam of light to help us see in the dark.



Light enters your eyes through your pupils (the black circles in the middle). Pupils can change size. When it's dark they get bigger to let more light in, and when it's bright they shrink so you don't get dazzled.

How your eye works

The human eye works like a camera. The front parts of the eye focus light rays just as a camera lens does. The focused rays form an upside-down image in the back of your eyeball.



Light beams

Unless it enters your eyes, light is invisible. The beam of light from a lighthouse can only be seen from the side if it catches mist or dust in the air, causing some of the light rays to bounce off towards you. Lighthouse beams sweep round in circles and can be seen from far out at sea.

Reflecting light

When light hits a mirror, it bounces straight back off.

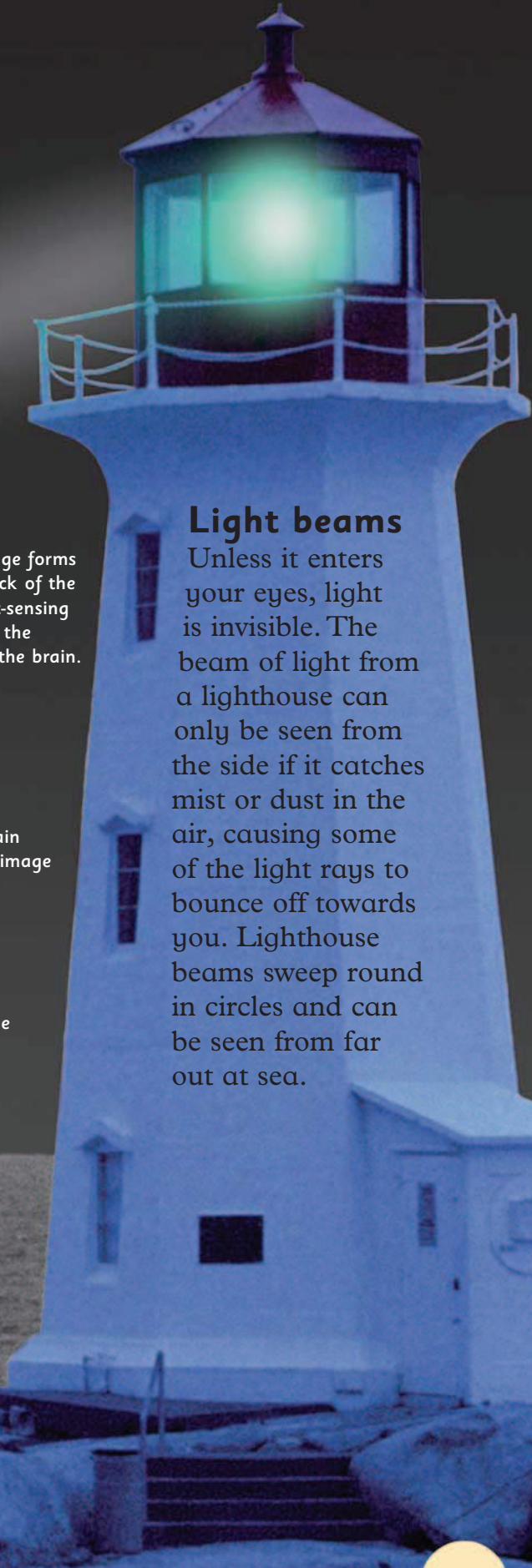
If you look into a mirror, you see this bounced light as a reflection.



Convex mirrors bulge outwards. They make things look smaller but let you see a wider area.



Concave mirrors bulge inwards. They make things look bigger but show a smaller area.



Sound

Every sound starts with a vibration, like the quivering of a guitar string. The vibration squeezes and stretches the air, sending its energy out in waves in all directions. This is a sound wave.

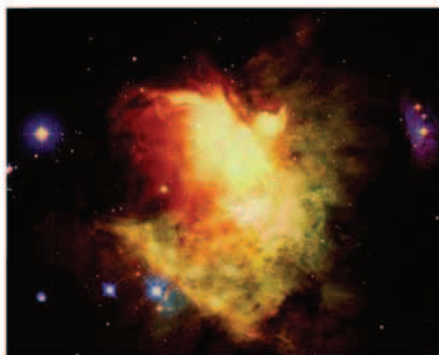


Sound notes

When you blow across a bottle, the air inside vibrates. Small air spaces vibrate more quickly than large spaces, making higher notes. So partly empty bottles produce lower notes than fuller ones.

Silent space

Sound can travel through solids, liquids, and gases, but it can't travel where there is no matter. There is no sound in space because there is no air.



Sound waves travel through air like a wave along a coiled spring.

How hearing works

When a sound reaches your ears, it makes your eardrums vibrate. The vibrations are passed to your inner ear through tiny bones. From here, nerves send messages to your brain that allow you to recognize the sound.

Measuring sound

Loudness is measured in decibels.



Leaves rustling nearby make a sound of only 10 decibels.



Somebody **whispering** close by measures about 20 decibels.



City traffic reaches approximately 85 decibels.



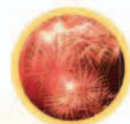
Drums being played nearby makes a sound of around 105 decibels.



Road-drills measure about 110 decibels from a close distance.



A **lion's roar** would measure 114 decibels if you were close enough.



Fireworks can measure 120 decibels or more.



The sound of **jet engines** sometimes hit 140 decibels if heard from nearby.

Speeding sound

Sounds travel through air at about 1,200 kph (750 mph). It travels faster through solids and liquids than through gases. Supersonic jets fly faster than the speed of sound, so they can pass over you before you hear their sound.

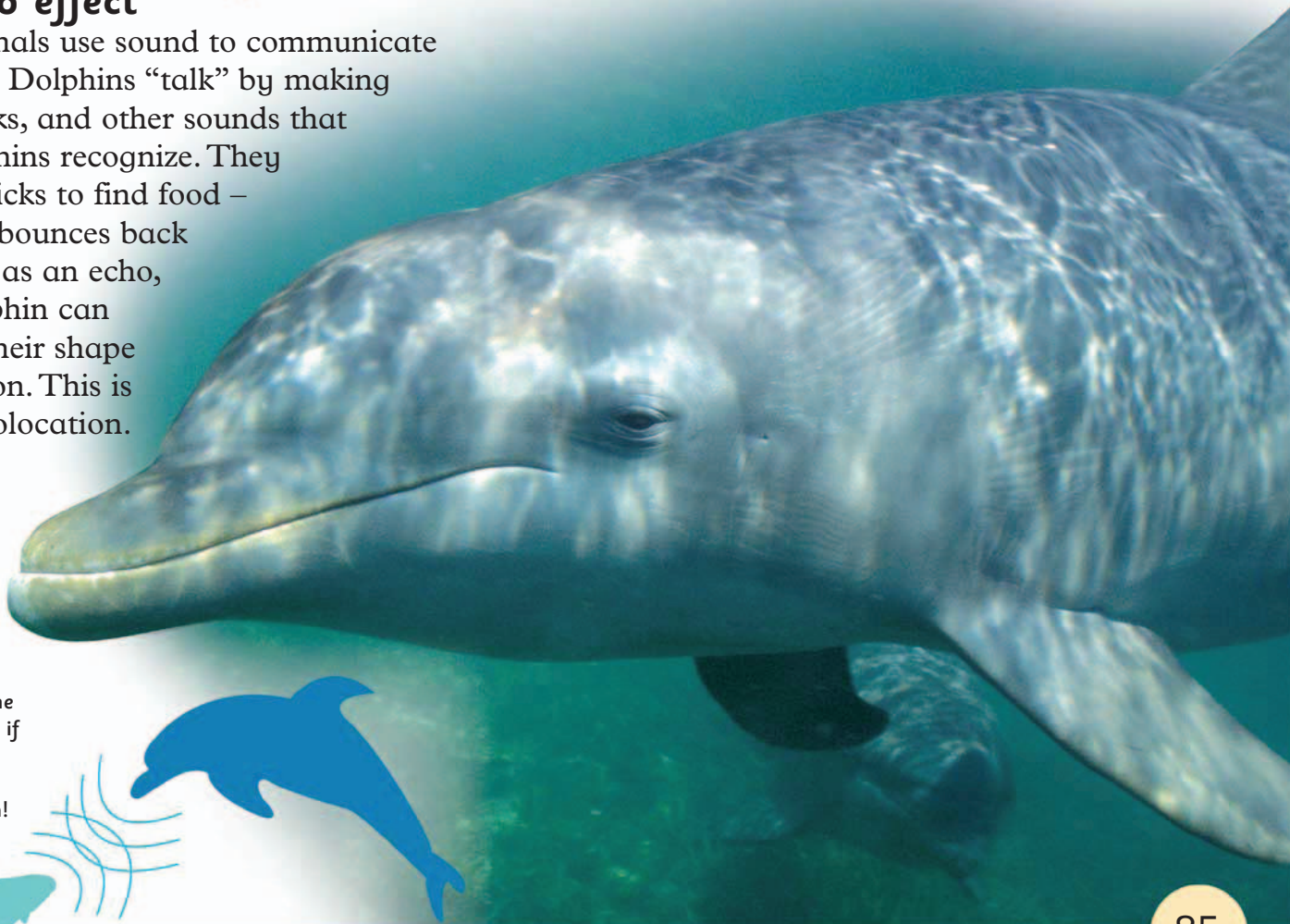
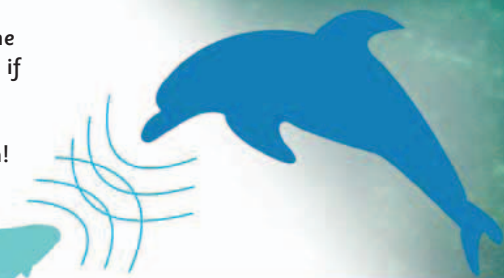
When a supersonic jet breaks the speed of sound, it catches up with the sound waves in front of it and squashes them. As the air is squashed, it produces a sound called a “sonic boom”.



The echo effect

Some animals use sound to communicate or to hunt. Dolphins “talk” by making clicks, barks, and other sounds that other dolphins recognize. They also use clicks to find food – the sound bounces back off objects as an echo, so the dolphin can establish their shape and position. This is called echolocation.

When sounds bounce back, the dolphin can tell if the object is a yummy fish or another dolphin!



Heat

Atoms and molecules are always jiggling about. The faster they move, the more energy an object has. We feel this energy as heat. When something is hot, its atoms are moving quickly. When something is cold, its atoms are moving slower.

Feel the heat

Heat always tries to spread from hot things to cooler things. When you touch a hot object, heat energy flows into your skin, triggering sense cells that make your skin feel hot. When you touch a cold object, heat flows out of your skin, triggering a different feeling.



Temperature

The temperature of an object tells you how hot it is on a numbered scale. A device called a thermometer is used to measure temperature.



Sources of heat

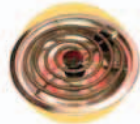
Heat can be produced in several different ways.



Friction (rubbing) makes heat. If you pull on a rope, your hands will feel warm.



Combustion means burning. When something burns, it produces heat.



Electricity is used to create heat in electric ovens and heaters.



Warm glow

Heat escapes from warm objects as invisible rays that travel like light. We call this infrared radiation. Special cameras use infrared rays rather than light to take photos. Hot areas appear white or red and cold areas, such as this ice lolly, appear black.

Keep your cool

Heat travels from the Sun as infrared rays. Just like light, infrared rays are reflected away by white objects but absorbed by black objects. In hot countries, people paint houses white to reflect the heat and keep the indoors cool.

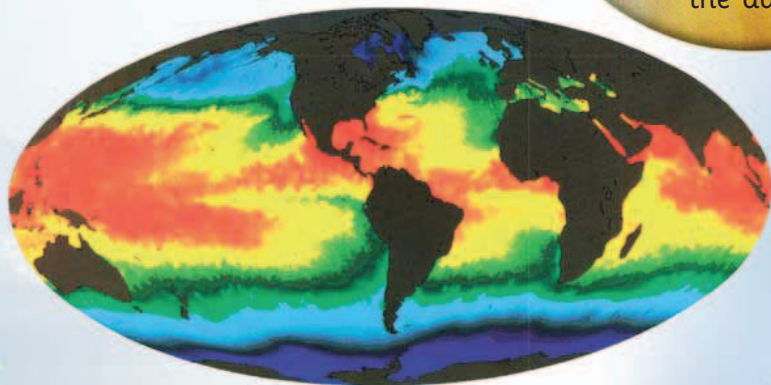
Free ride

When land gets hot, it warms the air above it. The warm air rises. Birds use these areas of rising air (thermals) to lift them high in the sky.

Eagles can fly without flapping when they catch a thermal.

Convection

When air or water warms up, it rises, and cool air or water sinks to take its place. This process is called convection. Convection helps keep the ocean currents moving, spreading heat around the world.



This satellite image shows the temperature of the world's oceans.

weird or what?

Snakes called pit vipers have heat sensors on their heads. The heat sensors work like eyes, allowing the snakes to "see" the warmth of mice when hunting in the dark.

Conduction

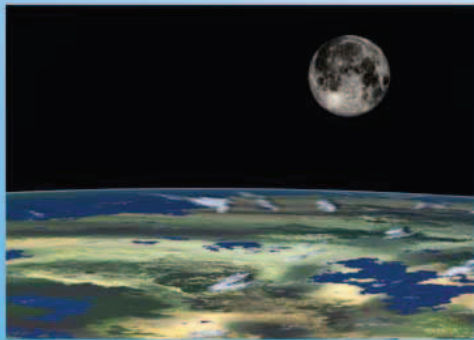
Heat spreads through solids by a process called conduction. Hot atoms, which jiggle about a lot, knock into cooler atoms and make them jiggle faster, passing on the heat energy.

Heat is spreading along this metal bar. Metal is good at conducting heat quickly.

Keeping warm

Emperor penguins live in the icy Antarctic. Their feathers trap air, which stops too much heat escaping from their body by conduction. This trapping layer is called insulation.





Forces

A force is simply a push or a pull. When you push or pull something to make it move, you are using forces. Some forces work only when objects are touching, but others, such as gravity and magnetism, work at a distance.

Gravity

The force that makes things fall to the ground is gravity. Gravity keeps the Earth in orbit around the Sun and keeps the Moon in orbit around the Earth. It is one of the most important forces in the Universe.

This NASA space shuttle, which was in operation until 2011, needed three rockets to help it escape from the Earth's gravitational pull.



In a spin

On a merry-go-round, the riders feel they're being pushed outwards. This pushing, called centrifugal force, isn't a real force. It's caused by the riders' bodies trying to move in a straight line while the chains are holding them back.

Lift-off

A huge force is needed to make a spacecraft take off and escape the Earth's gravity. A force called thrust is provided by rockets. The rockets make hot gases, which expand and stream out at the bottom to push the spacecraft up into the air at great speed.

hands on



Rub your hands together as hard and fast as you can for 10 seconds and see how hot they get. The heat is caused by the force of friction acting on your skin.

To reduce friction, the bottom surface of these skis is very smooth and coated with slippery wax.

Friction

When objects rub or slide against each other, they create a force called friction. Friction slows down moving objects and wastes their energy, turning the energy into heat.

Friction slows down a skier.

Electric forces

When objects become charged with electricity, they pull on each other with an invisible force that is a bit like magnetism. If you rub a balloon on your hair, the balloon becomes charged and will stick to your shirt.

Buoyancy

What makes objects float? The answer is a force called buoyancy. If an object is lighter than water, the force of buoyancy outweighs gravity and the object floats.

Gravity pulls the duck down.

Upthrust from the water keeps the duck afloat.

Forces and motion

It can be difficult to make an object move, but once it is moving, it will go on moving until something stops it. Force is needed to start something moving, make it move faster, and make it stop.

The football would stay still if the footballer didn't kick it.



Newton's laws of motion

In 1687, Isaac Newton presented three important rules that explain how forces make things move. They have become the foundation of physics and work for just about everything, from footballs to frogs.

Newton's first law

An object stays still, or keeps moving in a straight line at a constant speed, if it isn't being pushed or pulled by a force.



Forces make things accelerate. In this case, the force is created by the cyclist's powerful legs.

Newton's second law

The bigger the force and the lighter the object, the greater the acceleration. A professional cyclist with a lightweight bike will accelerate faster than a normal person cycling to work.



Newton's third law

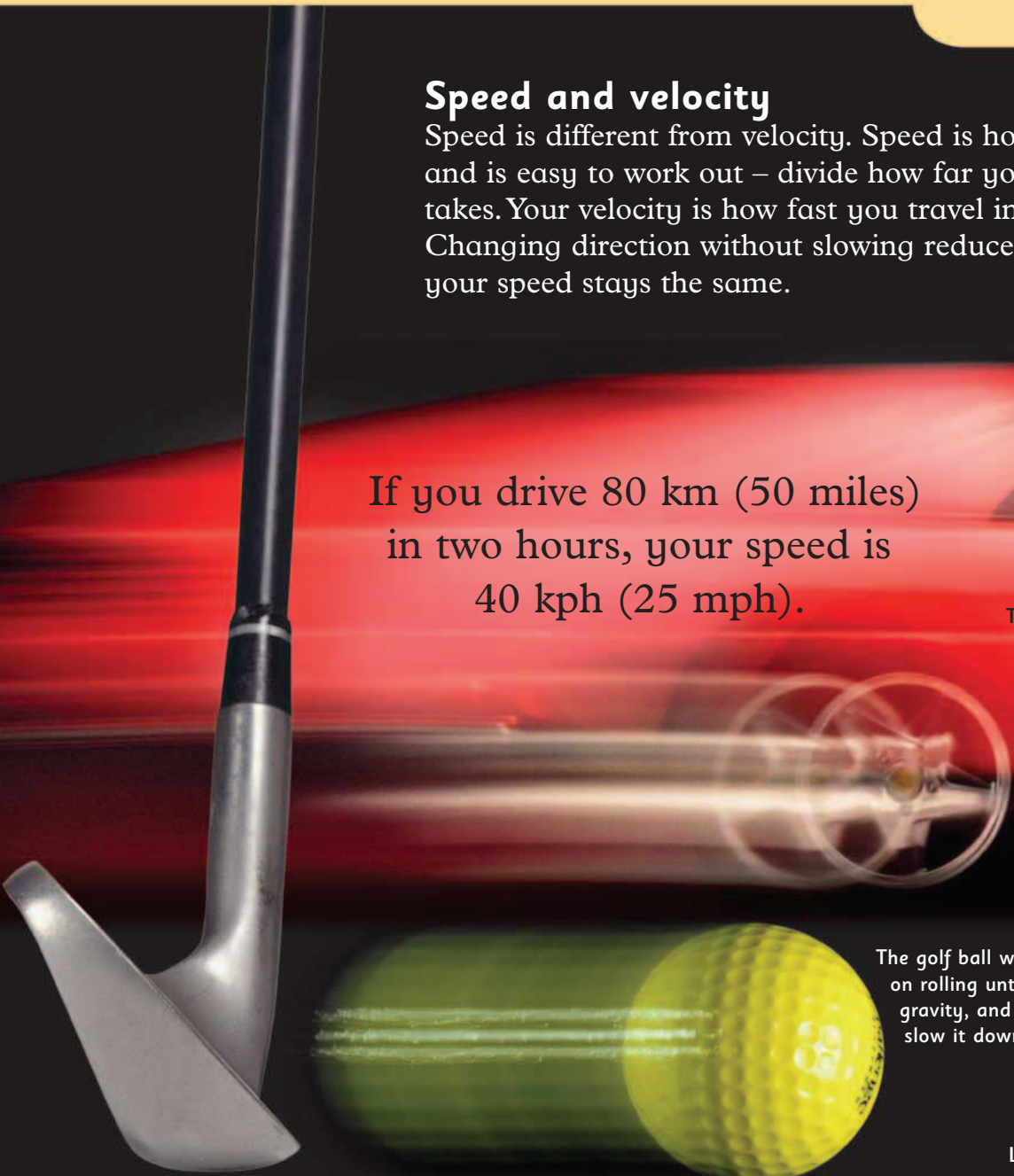
Every action has an equal and opposite reaction. The leaf moves away as the frog leaps in the opposite direction.

Speed and velocity

Speed is different from velocity. Speed is how fast you are going and is easy to work out – divide how far you travel by the time it takes. Your velocity is how fast you travel in a particular direction. Changing direction without slowing reduces your velocity, but your speed stays the same.

If you drive 80 km (50 miles) in two hours, your speed is 40 kph (25 mph).

Accelerating is fun, but defining it in scientific terms can be confusing. This is because acceleration doesn't just mean speeding up. It is any change in velocity. So, it is also used to describe slowing down and changing direction.



The golf ball will carry on rolling until friction, gravity, and air resistance slow it down.

Inertia

When things are standing still or moving, they continue to remain in the state they are in (unless force is applied to them to change it). This tendency to be as they are called inertia.

Turn and learn

Magnetism: pp. 78-79
Gravity: pp. 88-89

Balanced forces

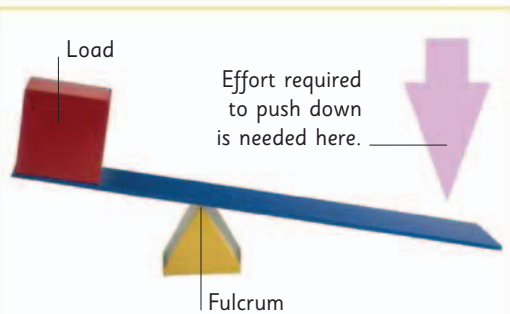
Forces act on objects all the time. Opposing forces can be balanced out. When this happens, the object won't be pushed in any direction.



Rescue helicopters balance forces so they can hover above the waves.

Machines

Machines make tasks easier. They reduce the effort you need to move something, or the time it takes. They work either by spreading the load, or by concentrating your efforts. All the machines you see here are called simple machines.



Levers

A lever is a bar that can turn around a fixed point (fulcrum). If you apply a force (effort) to one part of a lever, another part exerts a force (load).



One type of lever works like a seesaw with the fulcrum between the load and the effort.



Another type places the load between the fulcrum and the effort (as on a wheelbarrow).



A **third type** of lever, shown by tongs, places the effort between the fulcrum and the load.



Wheel and axle

An axle goes through the centre of a wheel. Together they work as a simple rotating machine that makes it easier to move something from one place to another.



Gears

Gears are wheels with teeth that interlock so that one wheel turns another. They increase speed or force. Gears on a bicycle affect how much you must turn the pedal to spin the wheel.

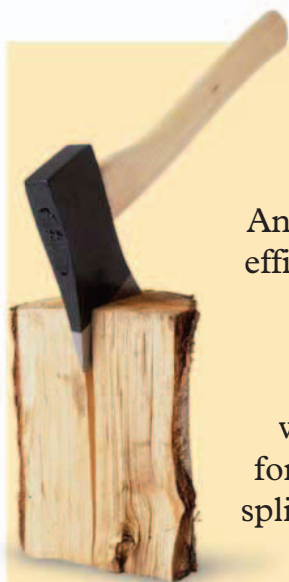


The pedal turns a wheel, which turns a smaller wheel at a greater speed.



hands on

Try walking straight up a hill and then zig-zag your way up. The winding path works like a simple machine. It increases the distance you walk, but decreases the effort you use.

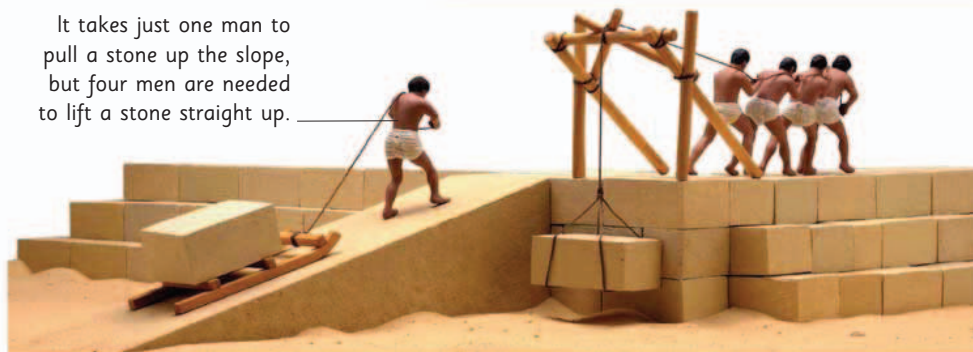


Wedge

An axe blade is an efficient but simple machine that increases force.

When it hits the wood, the wedge forces the wood to split apart between its fibres.

It takes just one man to pull a stone up the slope, but four men are needed to lift a stone straight up.



Inclined plane

It is easier to push or pull something up a slope than lift it straight up. A slope, or inclined plane, therefore increases force. In ancient Egypt, stones were dragged up slopes to build the pyramids.



The crane lifts up heavy loads with a system of pulleys.

The screw turns around a greater distance than it moves into the cork. So it moves into the cork with more force than is used to turn it.

Pulley

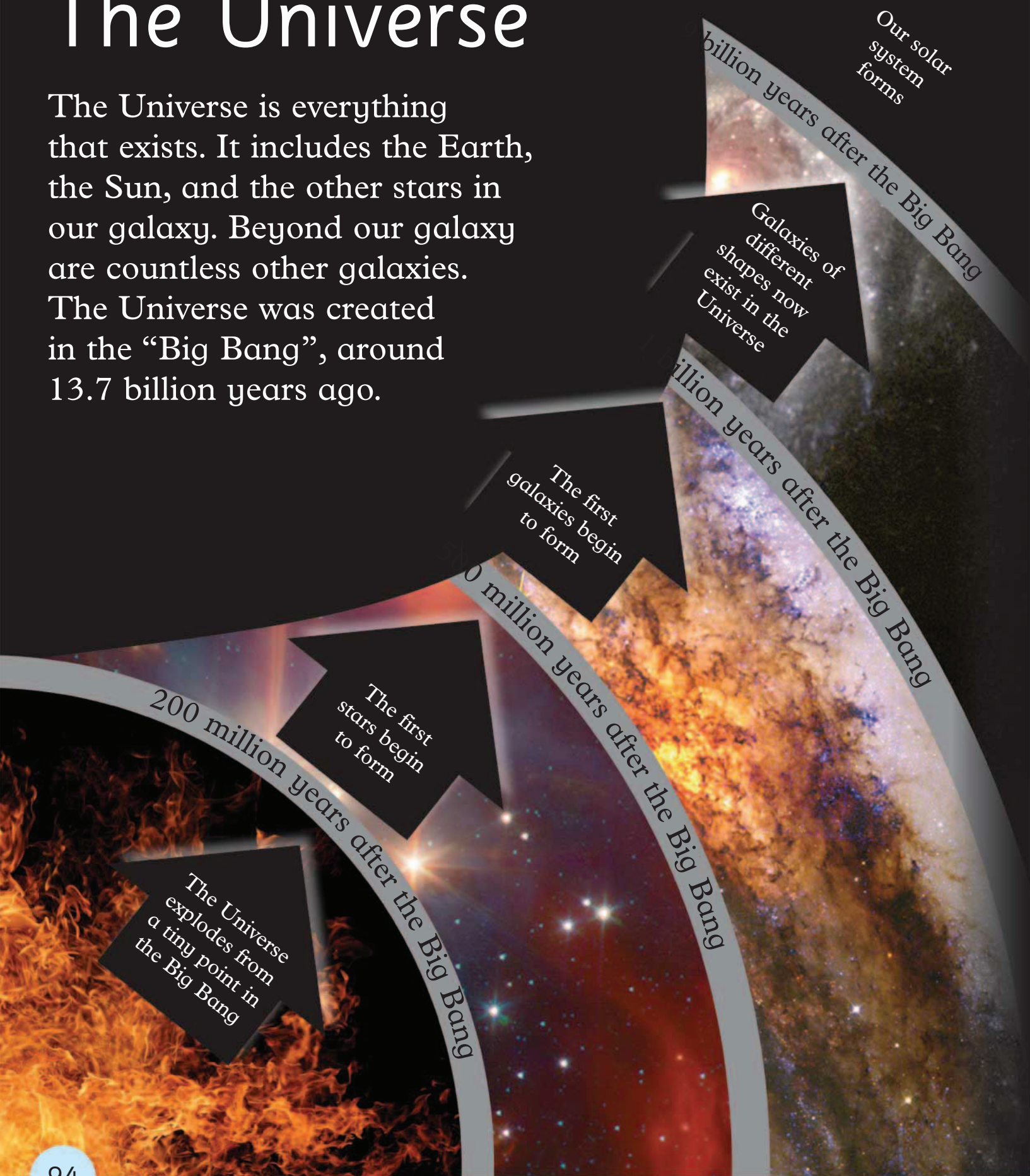
A pulley makes it easier to lift something straight up. It consists of a piece of rope wound around a wheel. One end of the rope is attached to the load and force is applied to the other end to pull up the load. When a pulley has more than one wheel, the pulling force is increased.

Screw

A screw is a machine. It is really an inclined plane, or slope, going round and up. A corkscrew uses a screw. It is easier to twist the point of a screw into a cork than to push a spike straight in.

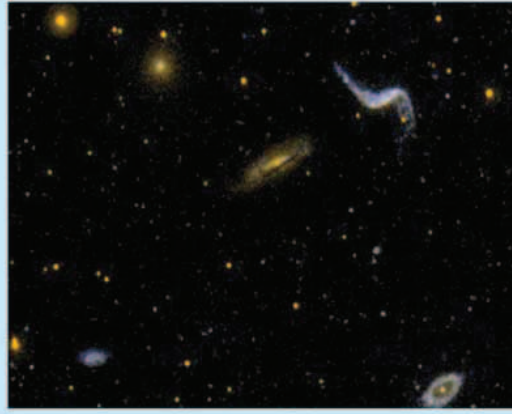
The Universe

The Universe is everything that exists. It includes the Earth, the Sun, and the other stars in our galaxy. Beyond our galaxy are countless other galaxies. The Universe was created in the “Big Bang”, around 13.7 billion years ago.



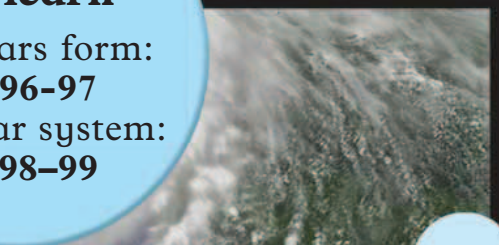
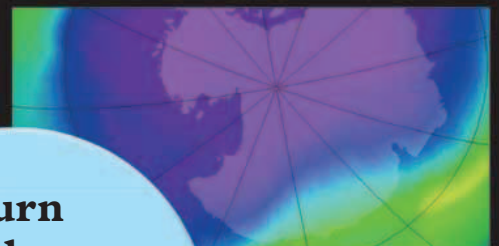
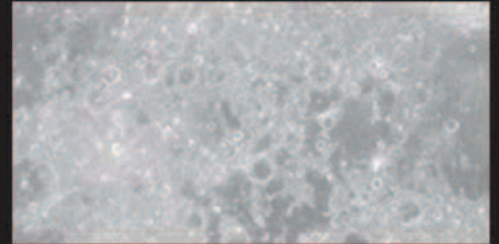
Galaxies

Galaxies are groups of stars held together by gravity. There are more than 100 billion stars in a typical galaxy. Galaxies are different shapes. Some are spirals and some are oval.



Picture detective

Look through the Earth and Space Science pages. Can you identify the picture clues below?



Near neighbour

The nearest galaxy to our own is the spiral-shaped Andromeda galaxy. It would take around 2.2 million years to get there – if you were travelling at the speed of light!



The Milky Way

Our solar system is part of a galaxy called the Milky Way. From the inside (where we are), it looks like a haze of light in the sky.

Turn and learn

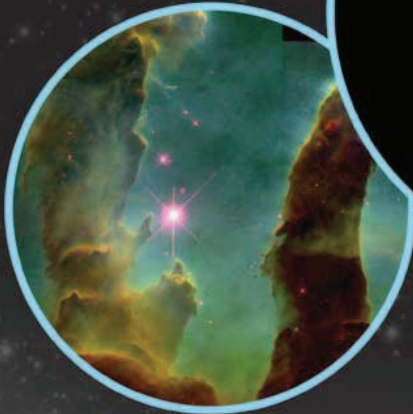
How stars form:
pp. 96-97
The solar system:
pp. 98-99

Starry skies

There are many more stars in the Universe than there are grains of sand on all the beaches on the Earth. Many are far brighter than our Sun.

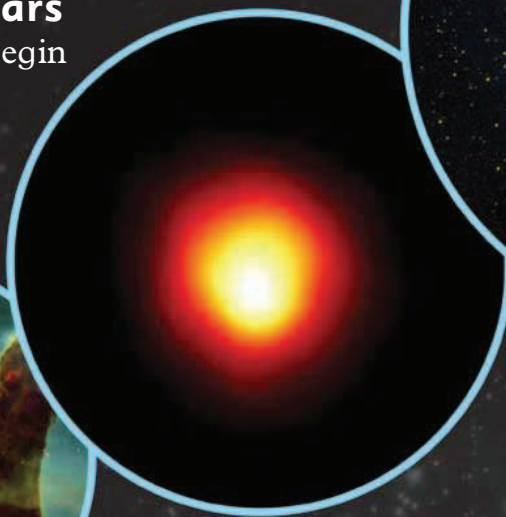
The lives of stars

The lives of stars begin inside thick clouds of gas in space, called nebulae.



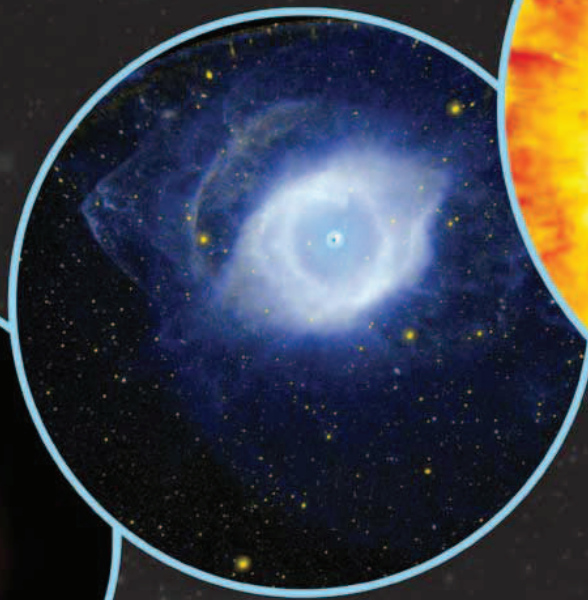
Nebulae

Gravity pulls together little knots of dust and gas inside the nebulae. Each one could become a star, as gravity squeezes it tighter and it becomes hotter.



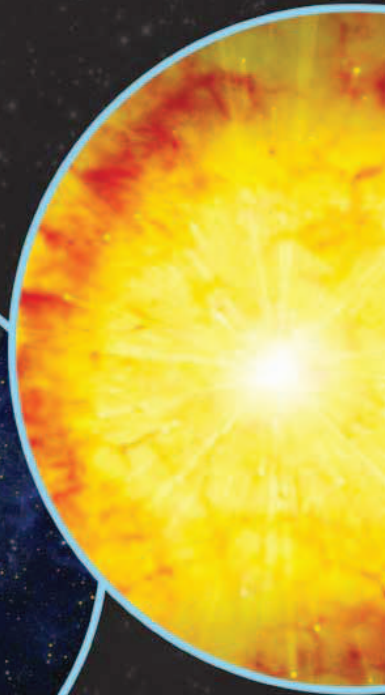
Red giants

Stars are fuelled by the gas hydrogen. They burn until the hydrogen starts to run out. Then they expand, forming a red giant star.



White dwarfs

The outer layers of the star are eventually thrown off into space. The cooling core is left behind. This is called a white dwarf. White dwarfs are no bigger than the Earth.



Supernovae

The most massive stars end their lives in huge supernovae explosions.



Leave a camera shutter open for a few hours on a clear night, and you can see the stars leave trails as the Earth rotates.

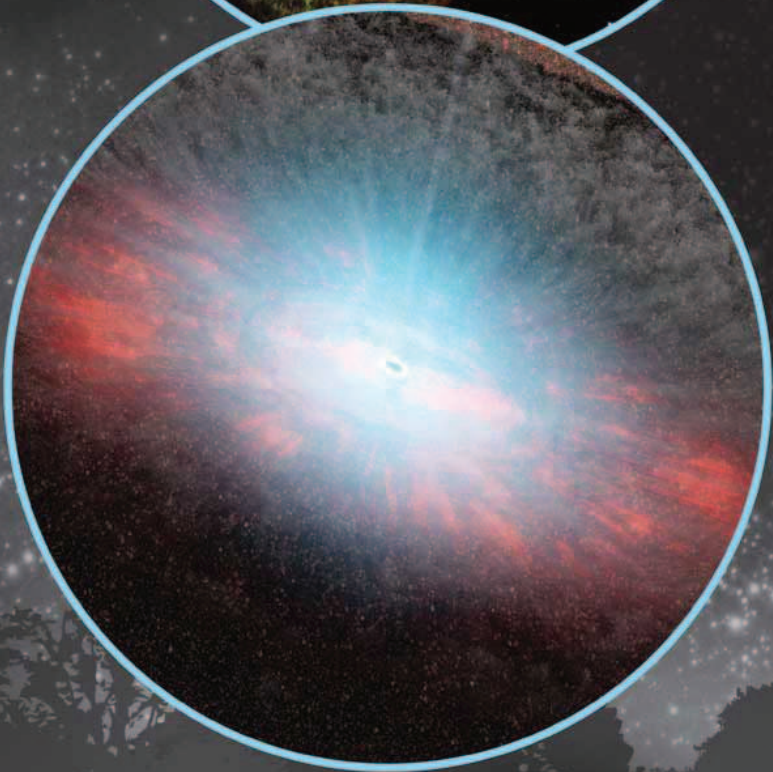
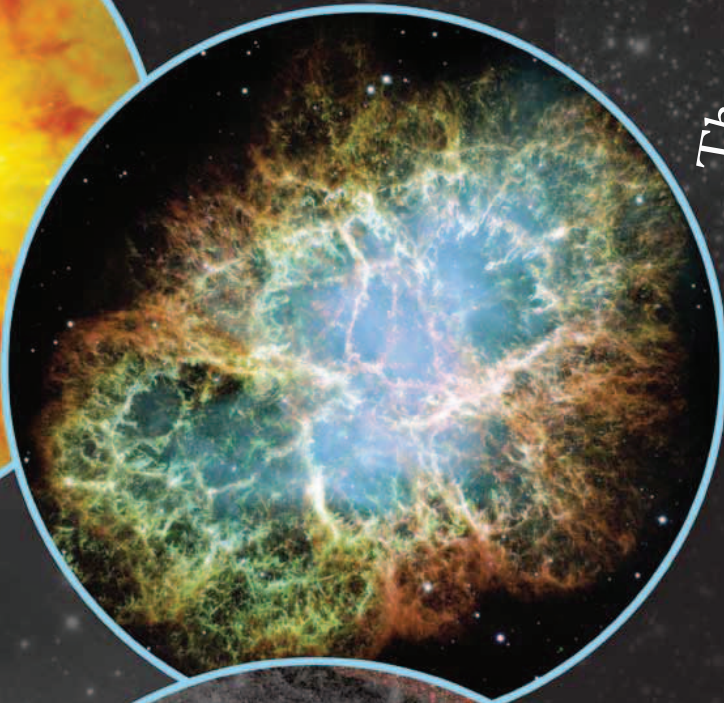
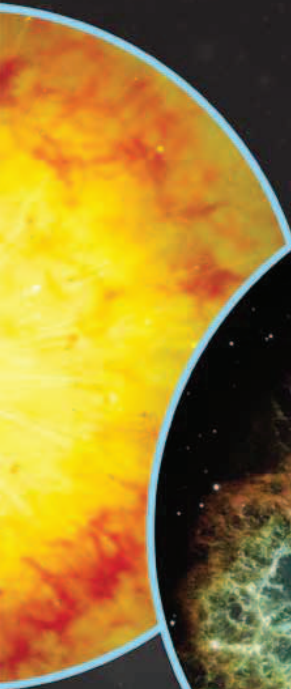
Stars in motion

The position of the stars seems to change throughout the night. The stars are not really moving, though. It is the Earth that is turning beneath them.

The Sun is made mostly of hydrogen.

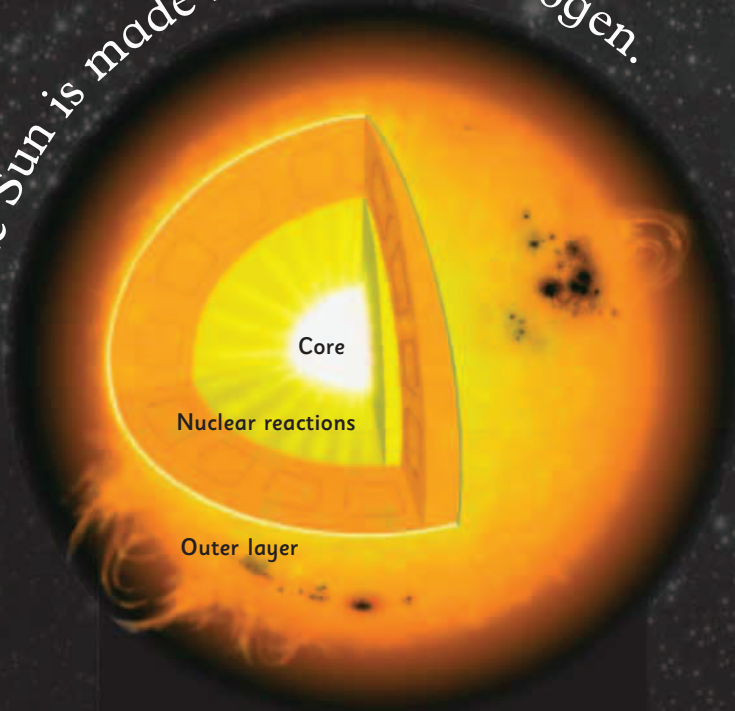
Remnants

The fragments of the star can remain glowing in space for hundreds of years.



Black holes

When the biggest stars explode, most material is blown outwards. But the core is crushed and collapses to form a black hole.



Starshine

Our Sun is a star that is halfway through its life. In the life cycle, it sits between being formed within a nebula and becoming a red giant.



Shapes in the sky

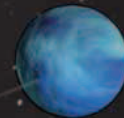
Hundreds of years ago, people grouped stars that appear close together in the sky into shapes called constellations. They all have names – often related to their shapes. This is the Plough, in Ursa Major.

Our solar system

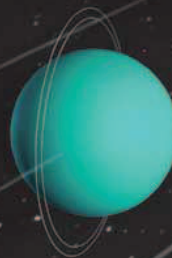
The solar system is our own small part of space. It is made up of the Sun, eight planets, and countless smaller objects, such as comets.

Family of worlds

The planets all move around the Sun in paths called orbits. They are held in these orbits by gravity.



Neptune is the furthest planet from the Sun in the solar system.

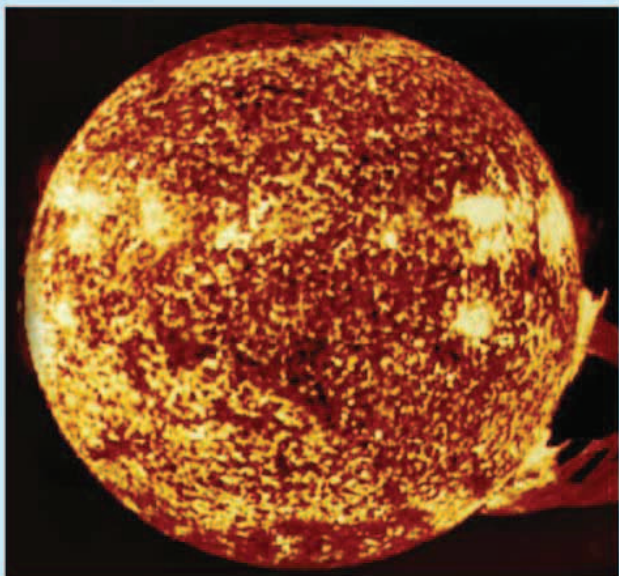


Uranus has 13 rings and 27 moons.



Mars is red because the soil on its surface is full of iron oxide.

Jupiter is the largest planet in the solar system. It has more than 60 moons.



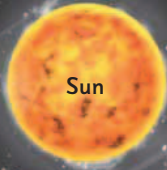
The Sun

The Sun is our closest star. All the heat and light we need to survive on the Earth come from it. Although the Sun is about halfway through its life, it will continue to burn for another five billion years.

Days and years

All planets spin. The time each one takes to spin once is called a day. The time taken for a planet to go all the way round the Sun is a year. Days and years are different lengths on different planets.

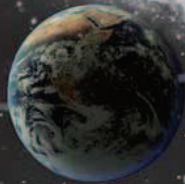
Mercury is the smallest planet, and lies closest to the Sun.



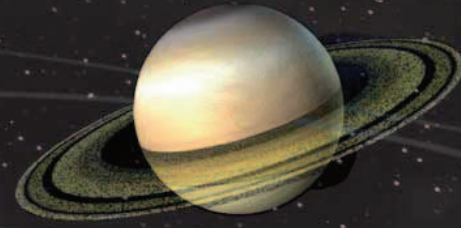
Sun



Venus is the brightest, hottest planet. It has an incredibly thick atmosphere.



Earth is the only planet with an atmosphere that can support life.



Saturn has rings made of ice, dust, and rock.



Fire in the sky

There are many other objects in space. Comets are chunks of ice, rock, and dust. Meteors are lumps of rock that burn up as they enter the Earth's atmosphere. We see them as shooting stars.



Neptune



Uranus



Saturn



Jupiter



Sun

How big?

All the planets are tiny in comparison with the Sun, but the outer planets are much bigger than the four closest to it. The Sun is 100 times wider than the Earth!

The Moon

Our Moon is a cold, dusty world that moves around the Earth in space. There is no air, and almost no water on the Moon, so nothing can live there. Scientists think that the Moon is around 4.5 billion years old.

The Moon spins once during each orbit of the Earth.

As well as craters, there are mountains and valleys on the Moon's surface.

Battered surface

The surface of the Moon is covered in craters. These have been caused by meteors crashing into it over millions of years.

The far side

The Moon takes the same time to turn all the way round as it does to go around the Earth. This means we always see the same side of the Moon. The far side can only be seen by spacecraft.

From the Earth, we only see the near side of the Moon.

Ocean bulges

The pull of gravity between the Moon and the Earth tugs on the Earth's oceans, making them bulge on either side of the planet. As the Earth turns, once every 24 hours, different parts of the oceans bulge – the sea's tides rise and fall.

Orbiting Moon

The Moon moves round the Earth once every 27 days. As the Moon, Sun, and Earth move, we see different amounts of the Moon lit by the Sun each night. These different views are called "phases".



Between the periods the water bulges, the sea falls and it is low tide.



As each bulge arrives, the sea rises and it is high tide.

Moon men

The Moon is the only celestial world that humans have visited. In 1969, astronauts walked on the Moon for the first time.



Astronaut Buzz Aldrin walking on the Moon

Lunar eclipse

When the Earth passes exactly between the Moon and the Sun, the Earth's shadow falls on the Moon and blocks out most of its light. This is called a lunar eclipse.

Solar eclipse

When the Moon passes exactly between the Earth and the Sun, it totally or partially blocks the Sun. This is a solar eclipse.



Total eclipse

A total solar eclipse occurs when the Moon blocks the Sun fully. Not all parts of the world can view a total eclipse.

The Earth's structure

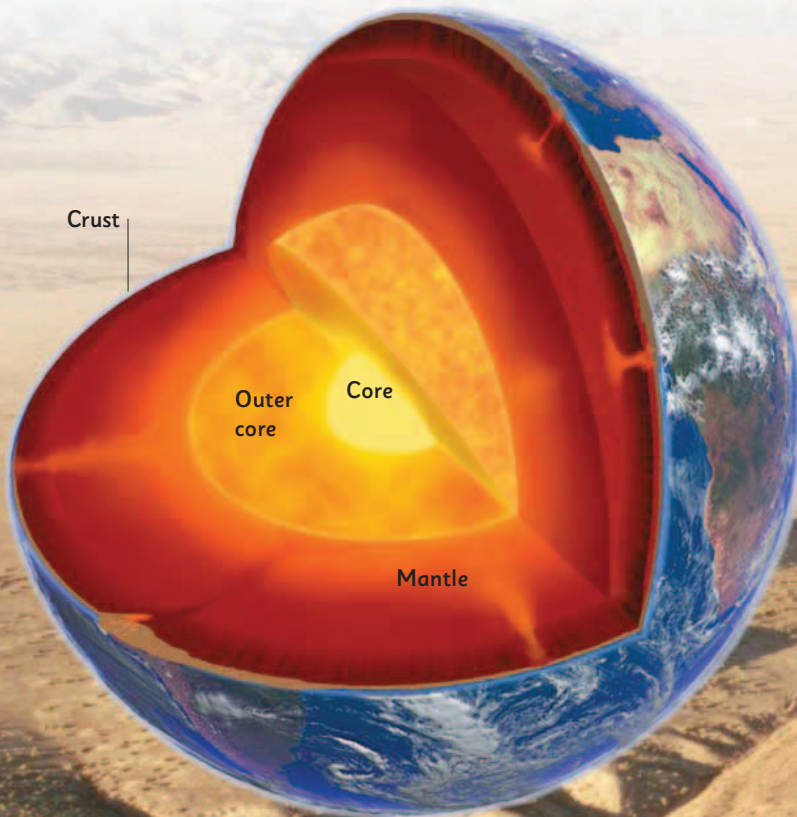


Seen from space, the Earth is a mass of blue oceans and swirling clouds.

The Earth is the only planet in the solar system that can support life because it's just the right distance from the Sun. Our amazing world is a huge ball of liquid rock with a solid surface.

Inside the Earth

If you could cut the Earth open, you'd see it's made up of layers. The thin top layer, where we live, is called the crust. Underneath is a layer of syrup-like rock called the mantle, then an outer core of molten (liquid) iron and nickel. At the centre is a solid iron-and-nickel core.



Life-support systems

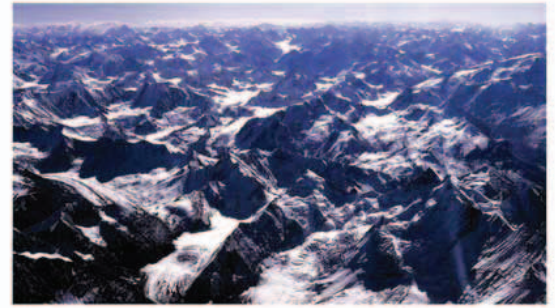
The Earth's atmosphere and its surface water play an important role in supporting life. They help keep our planet at just the right temperature by absorbing the Sun's heat and moving it around the world.





Volcanoes

Volcanoes are openings in the Earth's crust. Sometimes, magma (melted rock) from just beneath the crust bursts through these openings as a volcanic eruption. Lots of ash and dust shoot out too.



Making mountains

The Himalayas started to form 50 million years ago, when two moving plates collided. The mountains are still growing! Mount Everest, the tallest peak in the world, is a part of the Himalayan range and is growing 4 mm ($\frac{3}{20}$ in) each year.

Fault lines

Earthquakes happen when two plates of the Earth's crust rub against each other. The boundary between the plates is called a fault line.

Earthquakes often occur along the San Andreas Fault.

Drifting continents

The world hasn't always looked like it does now. Millions of years ago, all the land was joined together. Slowly, it broke up and the continents drifted apart.



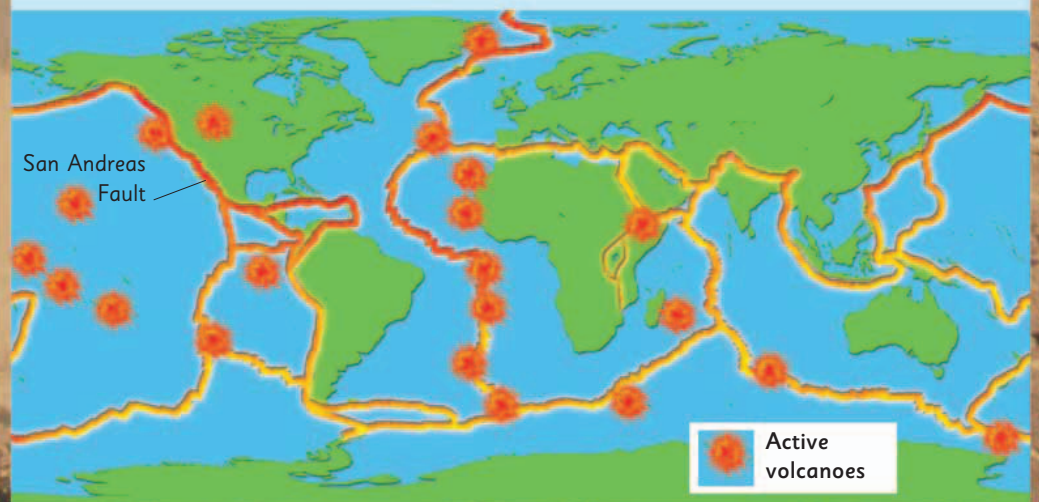
200 million years ago

135 million years ago

10 million years ago

Cracked crust

The Earth's top layer is made up of giant pieces called "plates". These fit together a bit like a jigsaw, but they're constantly moving. Volcanoes and earthquakes often happen in the weak spots where plates move against each other.



San Andreas Fault

Active volcanoes

Rocks and minerals

The Earth's crust is made up of different rocks. Some of these are hard but others are soft and crumbly. They are formed in different ways.

What is a rock?

A rock is formed from minerals. Most rocks are made up of different minerals, but some contain just one. There are three main types of rock: igneous, sedimentary, and metamorphic.

The rock cycle

Over many years, the rocks in the Earth's crust gradually change from one type into another. They are transformed by wind, water, pressure, and heat.

Sedimentary rock

Wind and water wear rocks away. Small pieces wash into the sea. These settle into layers, which pack together to form sedimentary rocks, such as limestone and sandstone.



Igneous rock

When hot molten magma from the Earth's interior cools and solidifies, it forms igneous rocks. Some harden underground, such as granite. Some erupt first as lava in a volcano.

Fossils in stones

Fossils are the remains or imprints of plants and animals that died millions of years ago, preserved in stone.



Serpentine is a mineral that stone carvers use to create works of art.



Gabbro is a rock that is used to make kitchen surfaces and floors.



White mica is a mineral that you can find in some kinds of toothpaste.



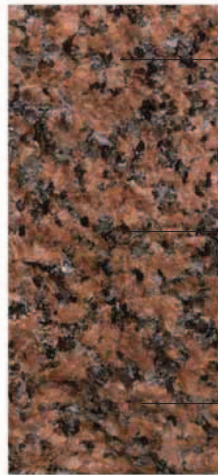
Rock salt is a mineral that is spread on roads in icy weather. It makes the ice melt.

What is a mineral?

A mineral is a solid that occurs naturally. It is made up of chemicals and has a crystal structure. Minerals are everywhere you look. We use minerals to build cars and computers, fertilize soil, and to clean our teeth.

Mineral mixtures

Granite rock is made up of different coloured minerals. The black mineral is mica, the pink is feldspar, and the grey mineral is quartz.



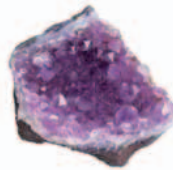
Feldspar is used for glazing ceramics.



Mica is ground up and used in paint.



Quartz can also occur as the gemstone amethyst.



Crystals

Minerals usually form crystals. Crystals have a number of flat surfaces. The largest crystals form when minerals in magma or trapped liquids cool very slowly.



Quartz stalactites form in caves over thousands of years.

Minerals in your home

Minerals make up many common objects.



Halite is the natural form of salt, which we add to our food for flavour.



Quartz from sand is used to make the silicon chips in calculators and computers.



Kaolinite is used to make crockery. It is also used to make paper look glossy.



Illite is a clay mineral and is used in terracotta pots and bricks.

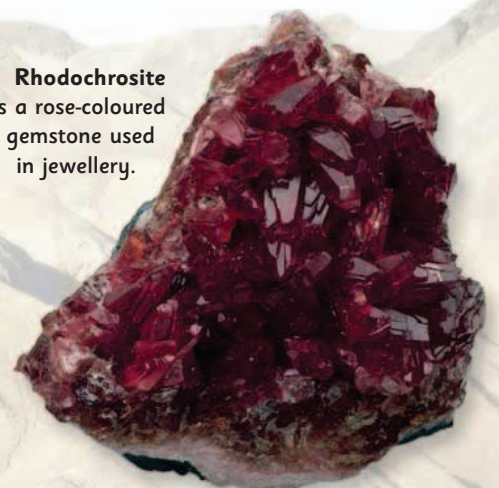


Mica is used to make glittery paint and nail polish.



Graphite is the lead in pencils. It is also used in bicycle brakes.

Rhodochrosite is a rose-coloured gemstone used in jewellery.



Shaping the land

The surface of our planet never stops changing. Over millions of years, land is slowly worn away by wind, rain, and rivers. Floods, volcanoes, and earthquakes can change the shape of the land in just a few hours.



River power

The Grand Canyon formed over millions of years as the Colorado River slowly wore down the rock deeper.

Going underground

Caves form when rain seeps underground and eats away at soft rock such as limestone.



Coastal shapes

Powerful waves shape the coastlines around the world's oceans.



Bays form where waves wear into areas of softer rock along the coast.



Headlands are areas of harder rock that have not been worn away.



Sea arches form when waves open up cracks in headlands.

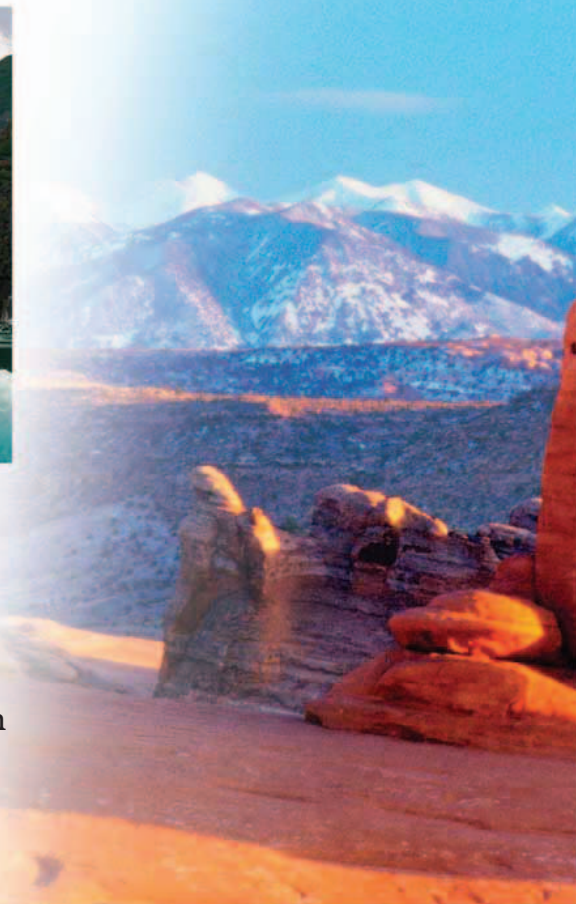


Sea stacks are pillars of rock left in the sea after an arch collapses.



Glaciers at work

Glaciers are huge rivers of ice that flow slowly off snowcapped mountains. Broken rock sticks to the bottom of the glacier, which then wears away the land like sandpaper, carving out a deep, U-shaped valley.





New islands

Some volcanoes are hidden under the sea. When they erupt, they can give birth to whole new islands, like Surtsey in Iceland (left). Surtsey burst out of the sea in 1963.



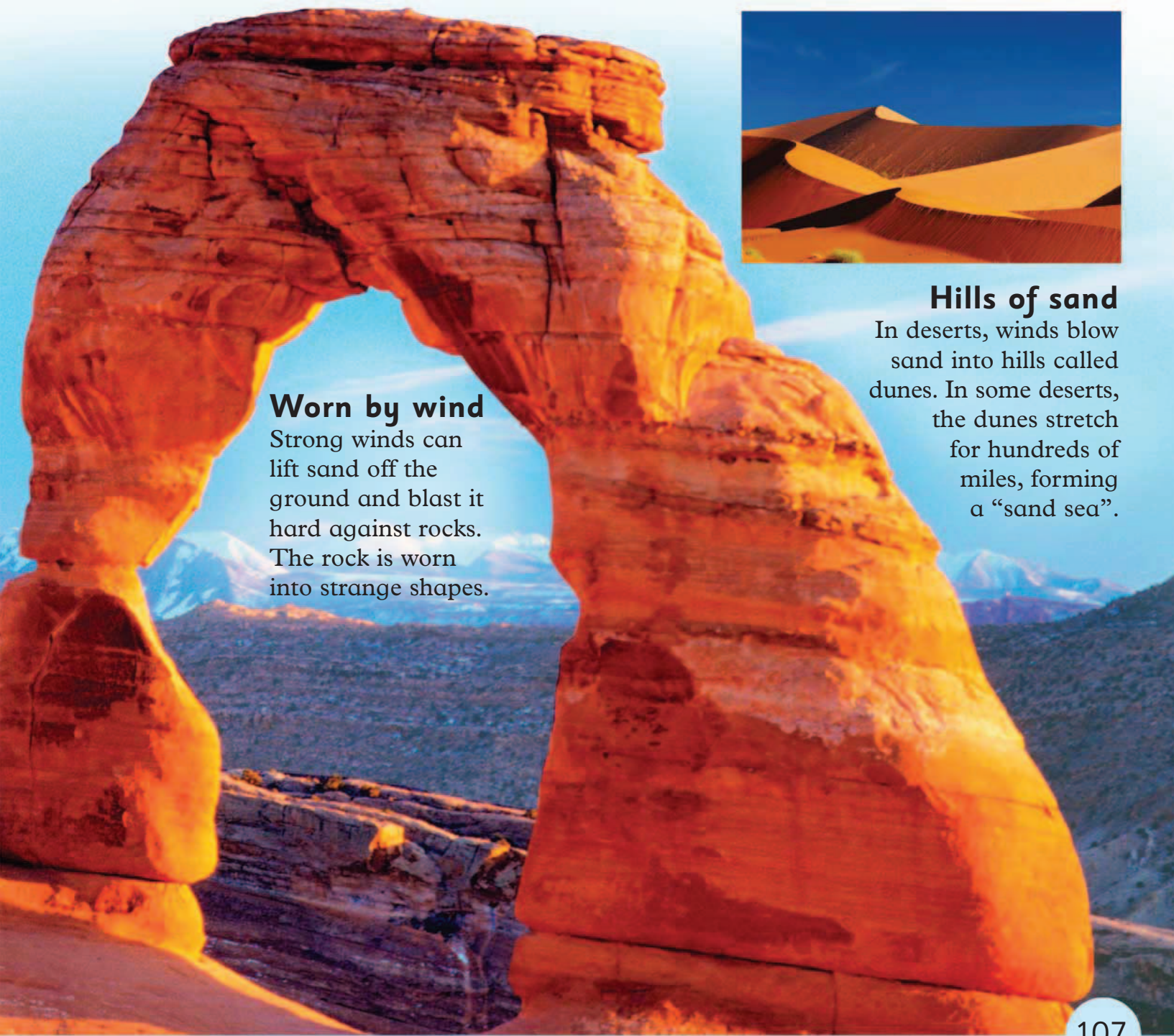
Before flood



After flood

Floods

Heavy rain makes rivers overflow, causing floods. Floods have enormous power and can wreck buildings and reshape the land.



Worn by wind

Strong winds can lift sand off the ground and blast it hard against rocks. The rock is worn into strange shapes.



Hills of sand

In deserts, winds blow sand into hills called dunes. In some deserts, the dunes stretch for hundreds of miles, forming a “sand sea”.

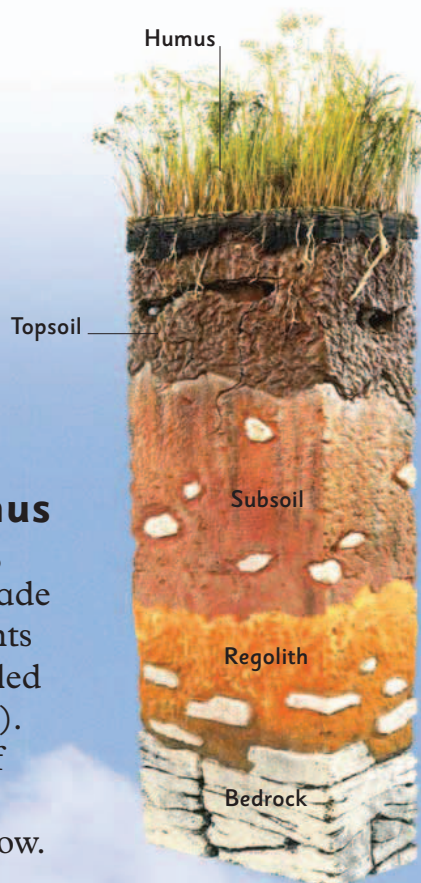
Soil

Soil is the thin layer of loose material on the land. Soil contains minerals, air, water, and decaying organic matter.



Healthy humus

Humus is a dark, rich substance made up of rotting plants and animals (called “organic matter”). It contains lots of nutrients, which plants need to grow.



Layers in soil

Soil builds up in layers over many years. Plant roots grow in the topsoil, which is generally the richest in plant food. The lower layers are rocky. Plant roots do not reach this far down in the soil.

Life underground

Soil is home to thousands of animals, including slugs, ants, beetles, and spiders. Larger animals that spend time underground, such as moles, mix up humus and minerals as they burrow through the soil.



Sizing up soil

Different types of soil have different sized particles.



Sandy soils contain particles about 2 mm (0.08 in) across.



Clay soils have very small particles. Water collects between them.



Loamy soils have a mixture of small and large particles.



Soil erosion

When soil is farmed too much, its nutrients get used up. The topsoil blows or washes away. Not many plants can survive in these areas without the rich topsoil.



Ploughing breaks up soil, to stop it getting hard and solid. This helps keep soil fertile and crops grow more easily.



Important earthworms

Earthworms help to make fertile soil. Their burrows let air into the soil, and create pathways for water to move around more easily. Earthworms also help the remains of plants and animals to decompose. This releases important nutrients into the soil. Earthworm waste is good for soil too!

hands on

Half fill a jar with soil and top it up with water. Put on the lid and shake. Leave for a day. The soil should separate into layers.

Resources in the ground

The ground holds many useful things, from fuels like coal and oil, to drinking water and building materials. These valuable items are known as resources, and we have dug, drilled, and searched for them for many years.

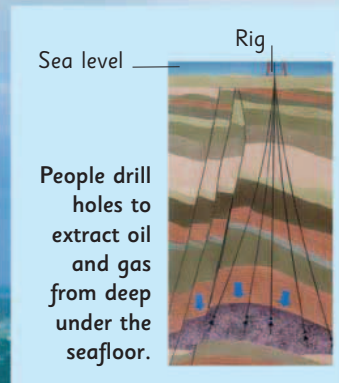
Finding fuels

Oil and gas are often found in pockets deep underground. Sometimes, these are even below the seabed. Coal develops closer to the surface in layers called seams.



Deep drilling

Oil rigs far out at sea use huge drills to extract the liquid oil from the ground. Coal is solid, and is dug out in mines or pits.



In hot water

Water in the ground can get very hot near volcanoes. In Iceland, they use this naturally hot water to heat houses or make steam to turn electricity generators.



Getting gas

Gas is only found in certain places. To get it to where it is needed, it is fed through very long pipes, or changed into liquid and put in special ships.



Glass bottles are shaped from molten glass.

Making glass

Glass is made by melting together sand, soda ash, and ground limestone. People blow or machine-press the red-hot mineral mixture into different shapes. These set hard and clear as the glass cools.

Extracting metals

Most metals are found underground as minerals in rocks called ores. Giant machines dig up the ore. The metal is extracted, or taken out, from the ore using heat.



Metal variety

Different metal resources have different uses.



Aluminium is a soft metal used to make cans, aircraft, and car bodies.



Gold is rare and looks beautiful, so it is often used to make awards and medals.



Iron is strong. It is used to make steel for ships, buildings, and pylons.



Copper prevents barnacles from growing on it, so parts of ships are often coated with it.

Creating concrete

Concrete is an important building material. It is made with water, sand, gravel, and cement. Water, sand, and gravel are found in the ground, while cement is made from limestone, which is also found in the ground.

Fresh and salt water

The Earth is often called the blue planet because 75 per cent of its surface is covered in water. Most of the Earth's water is salt water in the oceans. Less than one per cent of all the water on the Earth is fresh.



The hydrosphere

The hydrosphere is the name for all the water on the Earth. It includes oceans, rivers, and lakes. It also includes water that is frozen, such as icebergs.

Freshwater sources

People get fresh water from different sources on the Earth's surface, including rivers, streams, lakes, and reservoirs.



Rivers and streams flow from mountains down to the oceans.



Lakes are natural dips in the Earth where water collects.



Reservoirs are man-made lakes that are built to store water.



Water for life

All living things must have water to survive. In mammals, including humans, water is part of the blood and of organs, such as the skin and brain. There is water in every cell in your body. In fact, cells contain about two-thirds of the body's water!

Trapped in ice

Less than 33 per cent of fresh water is usable by humans. The rest is frozen in glaciers or icebergs (below), or as huge sheets of ice at the North and South poles.



Salty seas

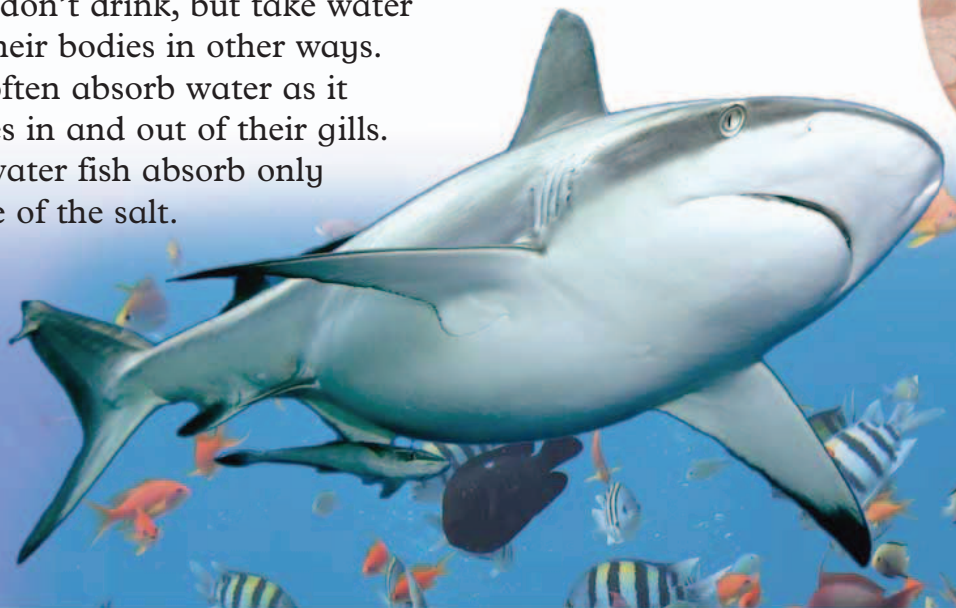
The world's oceans are salty because they contain a lot of dissolved chemicals that scientists call salts. Drinking water also contains salts, but only in small amounts, so you can't taste them.

The Dead Sea, located in Asia, contains so much salt that people can just float on the surface.



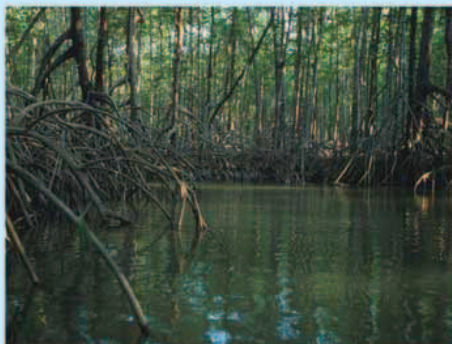
Surviving in salt water

Countless animals live in water. They don't drink, but take water into their bodies in other ways. Fish often absorb water as it washes in and out of their gills. Salt-water fish absorb only a little of the salt.



hands on

Put an egg in a glass of water. The egg will sink. Start stirring in salt until the egg rises. The egg will eventually float because salt water is denser than fresh water.

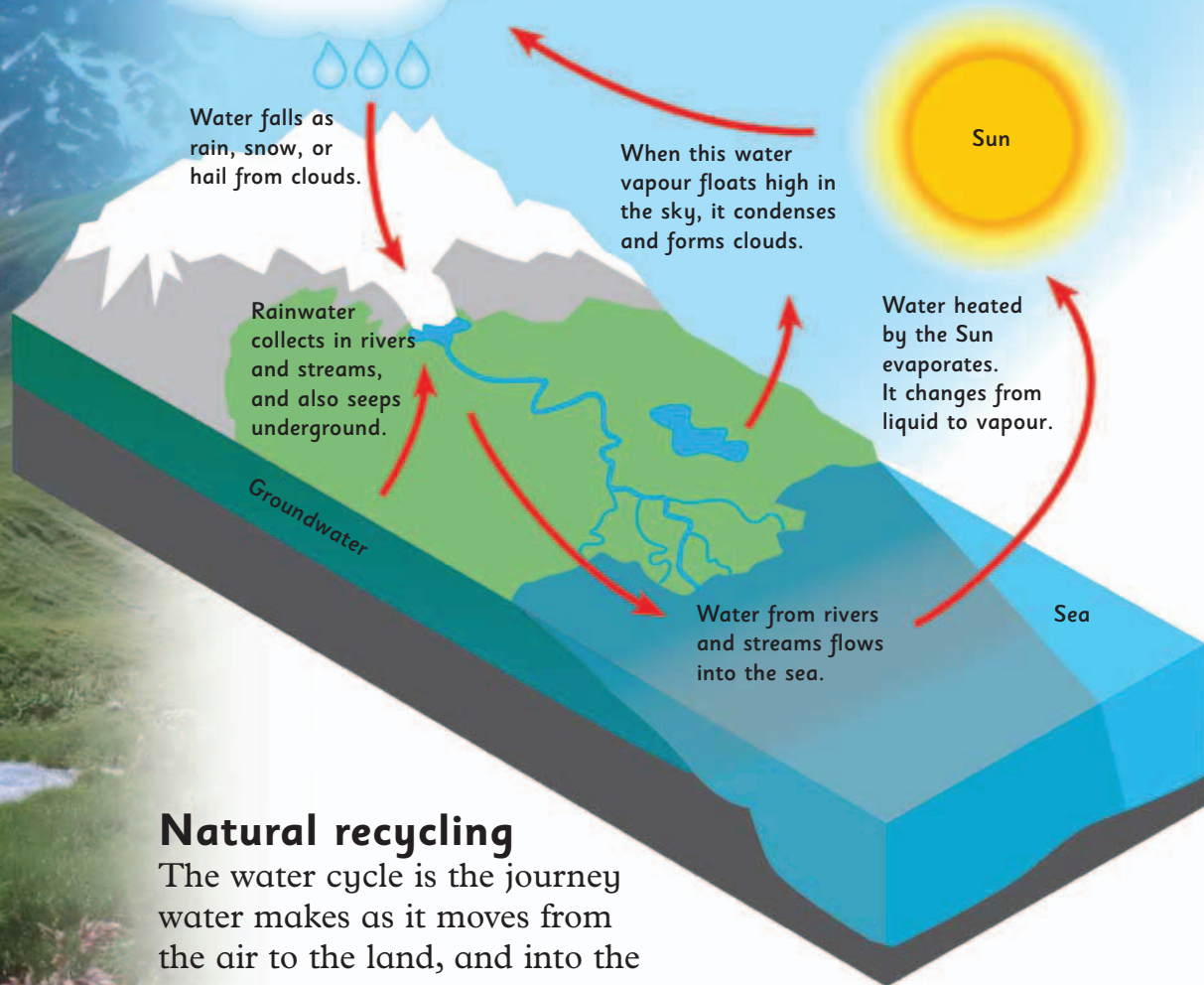


Estuary life

An estuary is the wide part of a river where it nears the sea. When the tide comes in, salt water flows into the estuary. When the tide goes out, the estuary contains mostly fresh water from the river or stream that flows into it. Mangrove trees, like the ones shown here, are able to live in the changing estuary water.

The water cycle

Water is constantly on the move, between oceans, land, air, and rivers. This movement is called the water cycle.



Natural recycling

The water cycle is the journey water makes as it moves from the air to the land, and into the seas, and then back into the air again.

On the dry side

Moisture-laden sea air has to rise when it hits a coastal mountain. Since air cools as it rises, all the moisture condenses and falls as rain. So, on the other side of the mountain, no rain falls. This area is called a rainshadow.





Groundwater

In the water cycle, some water seeps underground, where it collects in rocks and sometimes forms pools in caves. Some groundwater is pumped up and used for drinking or irrigation.



Damp ground

Wetlands form on land in areas where fresh water does not drain away. They provide a habitat for many plants, birds, animals, and fish.

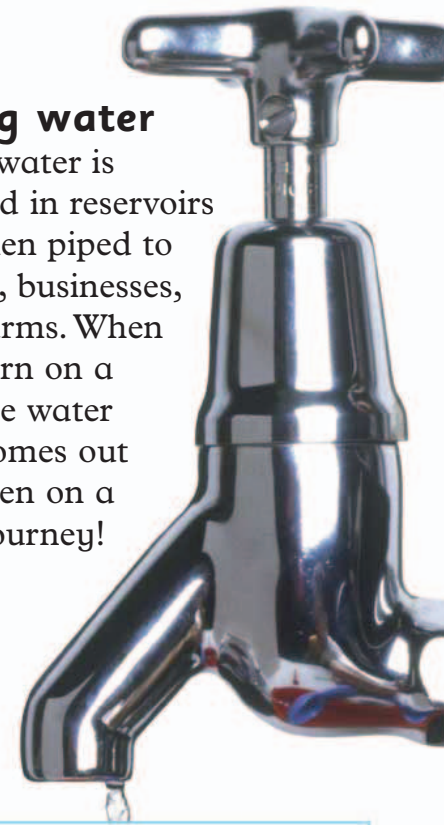
Drought

When very little rain falls, experts call it a drought. Droughts do not occur only in deserts – any area that gets much less rain than usual is said to be suffering from drought.



Using water

Fresh water is trapped in reservoirs and then piped to homes, businesses, and farms. When you turn on a tap, the water that comes out has been on a long journey!



Saving water

There is a limited amount of fresh water on the Earth. If we want to make sure there's enough to go around, it's important that everyone uses less.



Don't keep taps running while you are brushing your teeth or washing.



Flush the toilet only when necessary. Some toilets have two flush controls.



Don't run the dishwasher when it's half empty – wait until it's full.



Take a shower instead of a bath. Showering uses much less water.

The atmosphere

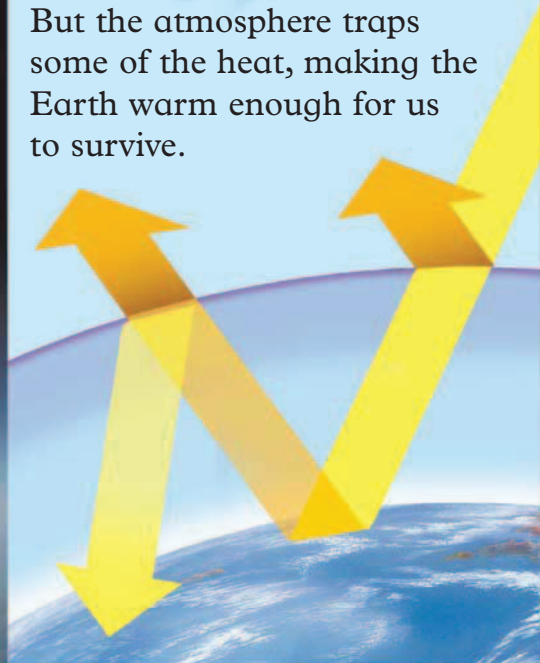
Planet Earth is wrapped in a thin layer of air called the atmosphere. Without this protective blanket of gases, life on the Earth could not exist.

Gases in air

Air is a mixture of different gases, including nitrogen, oxygen, and carbon dioxide. Oxygen is vital for plants and animals as it allows them to breathe. Carbon dioxide is also vital for plants. They absorb it from the air and use the carbon atoms to help build new leaves and stems.

The greenhouse effect

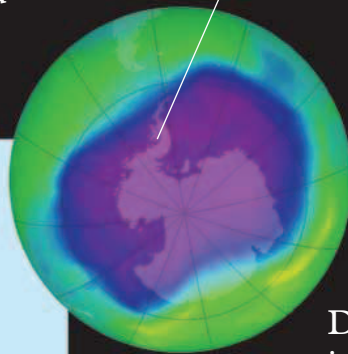
If there was no atmosphere, the Sun's warming rays would bounce off the Earth and disappear into space. But the atmosphere traps some of the heat, making the Earth warm enough for us to survive.



Shimmering particles

The atmosphere is mainly made up of gases, but it also contains tiny particles of dust, pollen, and water droplets. All particles can cause a haze in the air when the Sun shines through them.

The purple area, where the ozone layer is the thinnest, is called the ozone hole.



Protective layer

A gas called ozone in the atmosphere protects the Earth from harmful rays in sunlight. This ozone layer has become thinner because of chemical pollution. During the spring season (August–October) in the Southern Hemisphere, an area of the ozone layer above Antarctica becomes much thinner than anywhere else. This “ozone hole” occurs every year.



Into thin air

Like everything else, air is pulled by gravity. Most air molecules are pulled close to the ground, where the air is thick and easy to breathe. Higher up, air is so thin that climbers need oxygen tanks.

From space, the atmosphere looks like a blue haze over the Earth.



Layers of the atmosphere

The atmosphere is made up of layers, each with a different name. The bottom layer is the troposphere, where clouds form and planes fly. Above this, the air gets thinner and thinner as the atmosphere merges into space.

Light spectacular

Sunlight can create dazzling effects as it strikes the atmosphere and is scattered by air, water, and dust.



Rainbows form when water droplets reflect sunlight and split it into different colours.



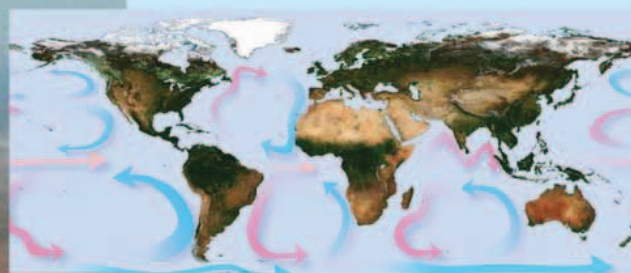
The **sky looks blue** on clear days because air molecules scatter blue light the most.



At **sunset**, only the red and orange light of sunlight make it through the atmosphere.

Moving water

The atmosphere is always swirling around, creating winds. The winds push on the oceans, causing the water to swirl too. These swirling currents carry warmth around the planet.



THERMOSPHERE

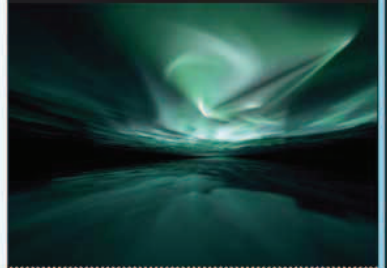
500 km (310 miles)

Satellite



International Space Station

Northern lights



85 km (53 miles)

Shooting stars



MESOSPHERE

50 km (31 miles)

Weather balloon



STRATOSPHERE

10 km (6 miles)

Jumbo jet

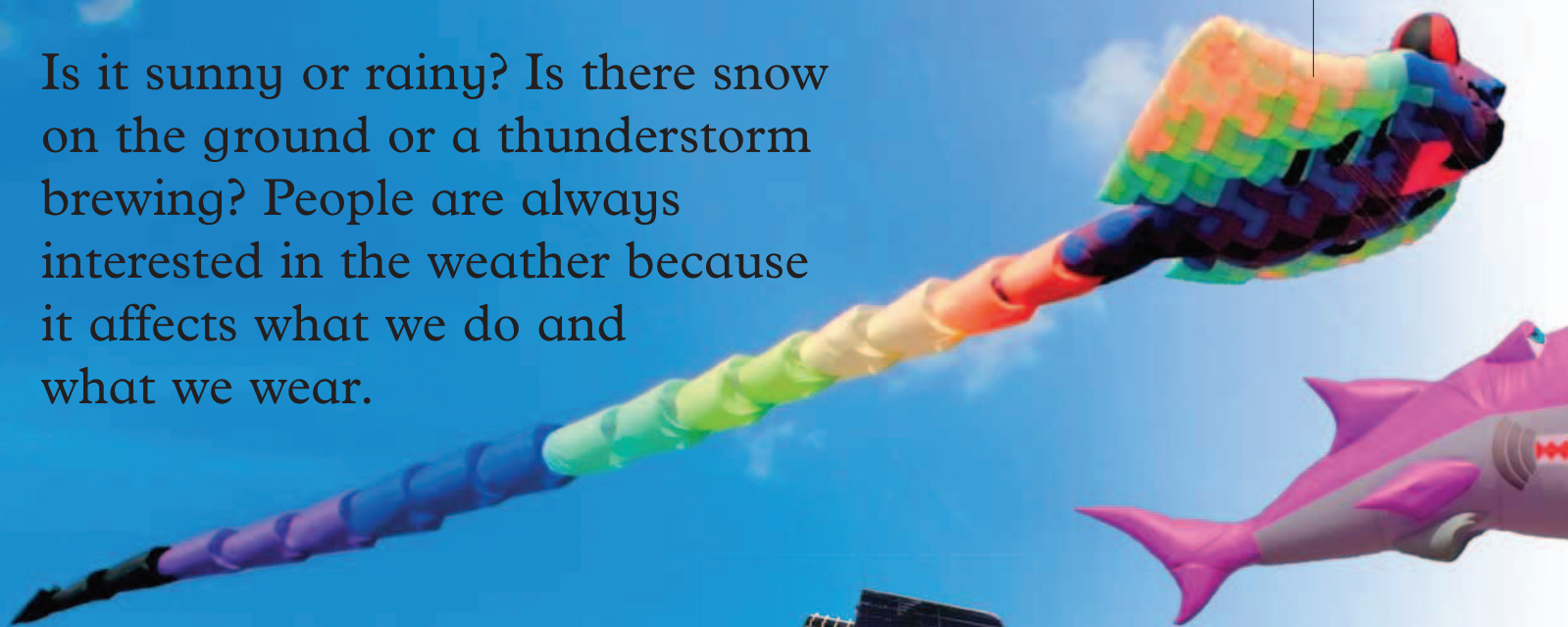


TROPOSPHERE

Weather

Is it sunny or rainy? Is there snow on the ground or a thunderstorm brewing? People are always interested in the weather because it affects what we do and what we wear.

Kites stay high in the air by catching the wind.



Weather words

Here are some main features of the weather.



Sunshine gives us heat and light. It warms the air and dries the land.



Clouds are made from tiny water droplets. Dark clouds mean rain is coming.



Hailstones are balls of ice that grow inside thunderclouds.



Wind is air moving around. Winds can be a light breeze or a strong gale.



Rain is drops of water that fall from clouds. Rain is very good for plant life.



Snow is made from tiny bits of ice. It falls instead of rain when it is very cold.

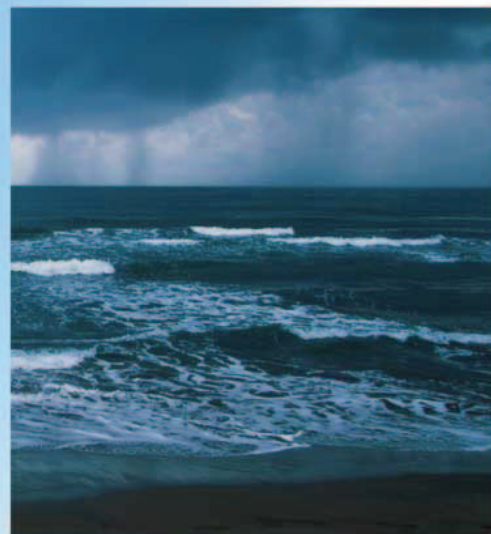


Predicting the weather

Weather forecasters look at pictures beamed back from weather satellites. Computers then help forecasters work out what the weather is going to be like over the next few days.

Rainy days

Rain clouds form when warm, moist air rises upwards and then cools. Droplets of water join together until they become so heavy that they fall. Rain clouds look dark because sunlight cannot shine through the droplets.



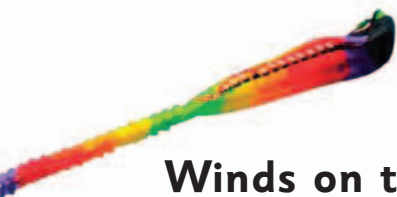


Wildfires

Long periods of hot or dry weather can make plants dry out so much that they catch fire easily when struck by lightning. This can lead to a raging wildfire that burns down whole forests.

Stormy weather

Lightning strikes when electricity builds up in clouds. The electricity is created when ice crystals in the clouds rub against each other. A bolt of lightning heats the air around it so quickly that the air explodes, creating the rumbling noise we call thunder.



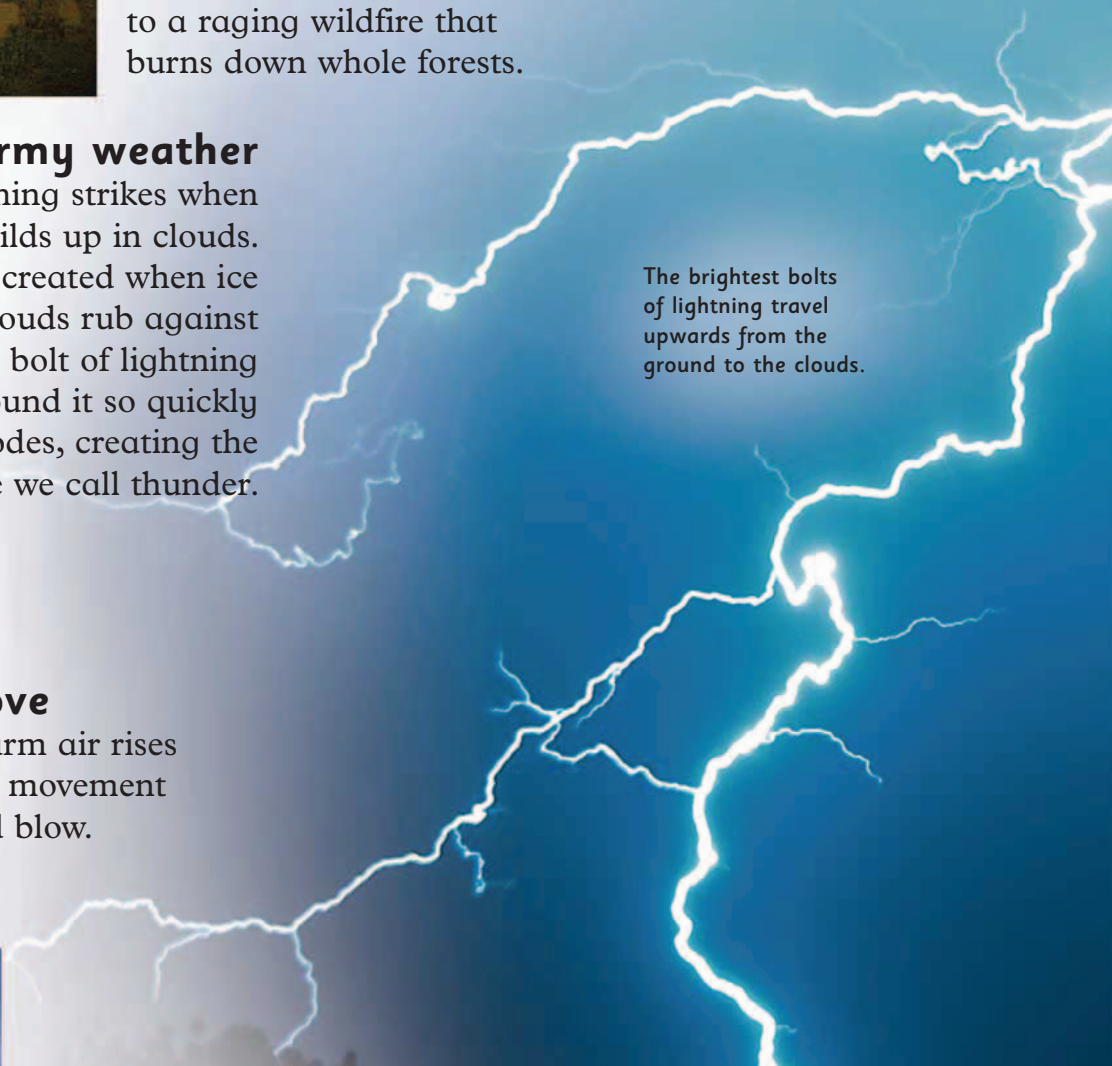
Winds on the move

Wind is moving air. Warm air rises and cool air sinks. This movement is what makes the wind blow.



Twisters

Tornadoes (twisters) are whirling funnels of wind that form beneath massive thunderclouds. The fierce wind can do enormous damage, and the funnel can suck up debris like a gigantic vacuum cleaner.



The brightest bolts of lightning travel upwards from the ground to the clouds.

weird or what?

Hailstones can grow to be enormous in certain conditions. The biggest hailstone weighed nearly 1 kg (2 lb) and was 20 cm (8 in) across!

The energy crisis

People around the world use energy for many different purposes – from powering cars to heating homes. Most of this energy comes from burning coal, oil, and natural gas (fossil fuels). But these fuels won't last forever, and their fumes are damaging the atmosphere.

Global warming

Burning fossil fuels fills the air with greenhouse gases, which trap some of the Sun's heat in the atmosphere. If the Earth becomes too warm, polar ice caps will melt, the sea level will rise, and deserts will spread.

Heat from the Sun enters through the atmosphere.

Greenhouse gases trap heat, although some escapes back into the atmosphere.



Nuclear power stations generate energy by splitting atoms.

Alternative energy

We need to find sources of energy other than fossil fuels – sources which cause less pollution and will not run out. Nuclear power is one option. Other possibilities include energy from sunlight, wind, and waves.



The wind provides a limitless supply of non-polluting energy. However, wind turbines are large and can be costly to set up.

Cleaner cars

Ordinary petrol cars use a lot of oil, and produce harmful fumes. Now car makers are looking for alternatives to petrol. Electric cars do not give off any kind of fumes. Hydrogen engines burn hydrogen gas, and only give off water.



To recharge an electric car, you just plug it in.

Rising energy needs

As the world's population grows, we are using more and more energy. But to stop global warming, we may have to reduce the amount of energy we all use.



Energy-saving homes

This house saves energy by using solar panels and wind turbines to generate its own non-polluting electricity. The walls are thick, so that less energy is needed to heat the house.

To reduce the energy used in manufacturing, it's a good idea to use recycled building materials.

Making a difference

There are lots of small things we can all do to save energy.



Start growing your own vegetables and fruits, even if they're only in pots.



When planning a holiday, remember that trains, boats, and cars use less energy than aeroplanes.



Instead of buying new clothes, swap with a friend or buy them second-hand.



Eat local food that hasn't travelled miles, because transporting food costs energy.



Don't throw away glass, plastics, metal, or paper – reuse or recycle them.



Take your own bags when you go shopping. Making plastic bags takes energy.



Don't leave your TV or laptop on standby – this wastes lots of electricity.



Hang your laundry outside to dry. Don't waste electricity running a dryer.



Ask your parents about **insulating the roof** to prevent heat from escaping.



If you get cold, **put on a jumper** instead of turning up your heating.

True or false?

Can you work out which of these facts are real, and which ones are completely made up?



1 The microscope was built by two Dutchmen.

2 Jupiter has more than 60 moons.



3 Mica is used to make the silicon chips in calculators.



4 Nuclear power stations harness energy from the Sun.



5 Scientists who study fossils are called ecologists.



6 Cream and cheese are made by separating milk.



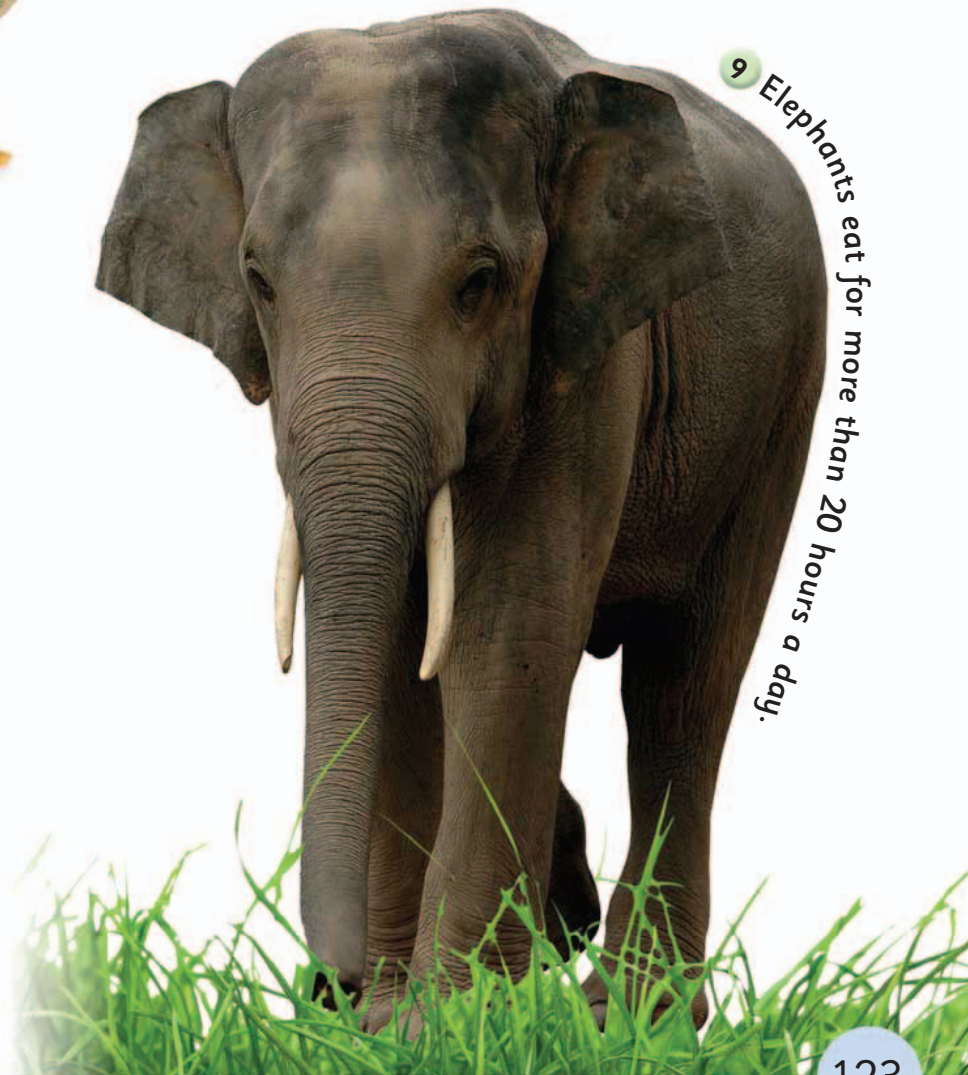
7 Frogs can absorb oxygen through their skin.



8 Glass is made with sand, ground limestone, and soda ash.



9 Elephants eat for more than 20 hours a day.



Quiz

Test your knowledge of science with these quiz questions.

- 1 What is the name of the chemical reaction that makes silver slowly turn grey and dull?



- A: Rusting
B: Tarnishing
C: Photosynthesis
D: Rotting

- 2 Which kind of energy wave is used in hospitals to kill cancer cells?

- A: Gamma rays
B: X-rays
C: Infrared waves
D: Ultraviolet light

- 3 Which one of these minerals can be found in nail polish?



- A: Mica
B: Sulphur
C: Graphite
D: Illite

- 4 What makes objects float?



- A: Gravity
B: Centrifugal force
C: Buoyancy
D: Insulation

- 5 Leaves have a green pigment called...



- A: Pollen
B: Chlorophyll
C: Hyphae
D: Xylem

- 6 When rain seeps underground and eats away at soft rock, it forms...

- A: Sea arches
B: Sea stacks
C: Caves
D: Stalactites

- 7 Which year was Teflon invented in?



- A: 1941
B: 1948
C: 1938
D: 1950

8 What is the wide part of a river where it meets the sea called?

- A: Wetland B: Estuary
C: Reservoir D: Bay

9 A pit viper has heat sensors on its...

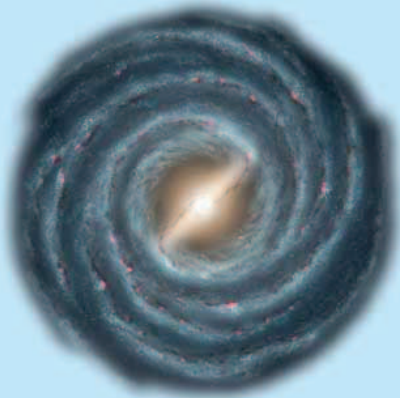


- A. Tongue B. Skin
C. Head D. Tail

10 Which one of these elements is a halogen?

- A. Silicon B. Mercury
C. Cobalt D. Chlorine

11 How many stars are there in the Milky Way?

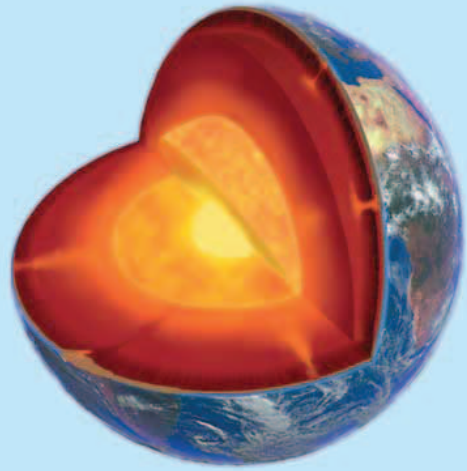


- A: 200–400 billion B: 500–600 million
C: 50–100 billion D: 900 million

12 When a pulley has more than one wheel, the pulling force is...

- A. Increased B. Decreased
C. Divided D. The same

13 What is the innermost layer of the Earth called?



- A: Mantle B: Plate
C: Core D: Crust

14 What is the fastest thing in the Universe?

- A: Sound B: Heat
C: Wind D: Light

15 Butterflies taste with their...



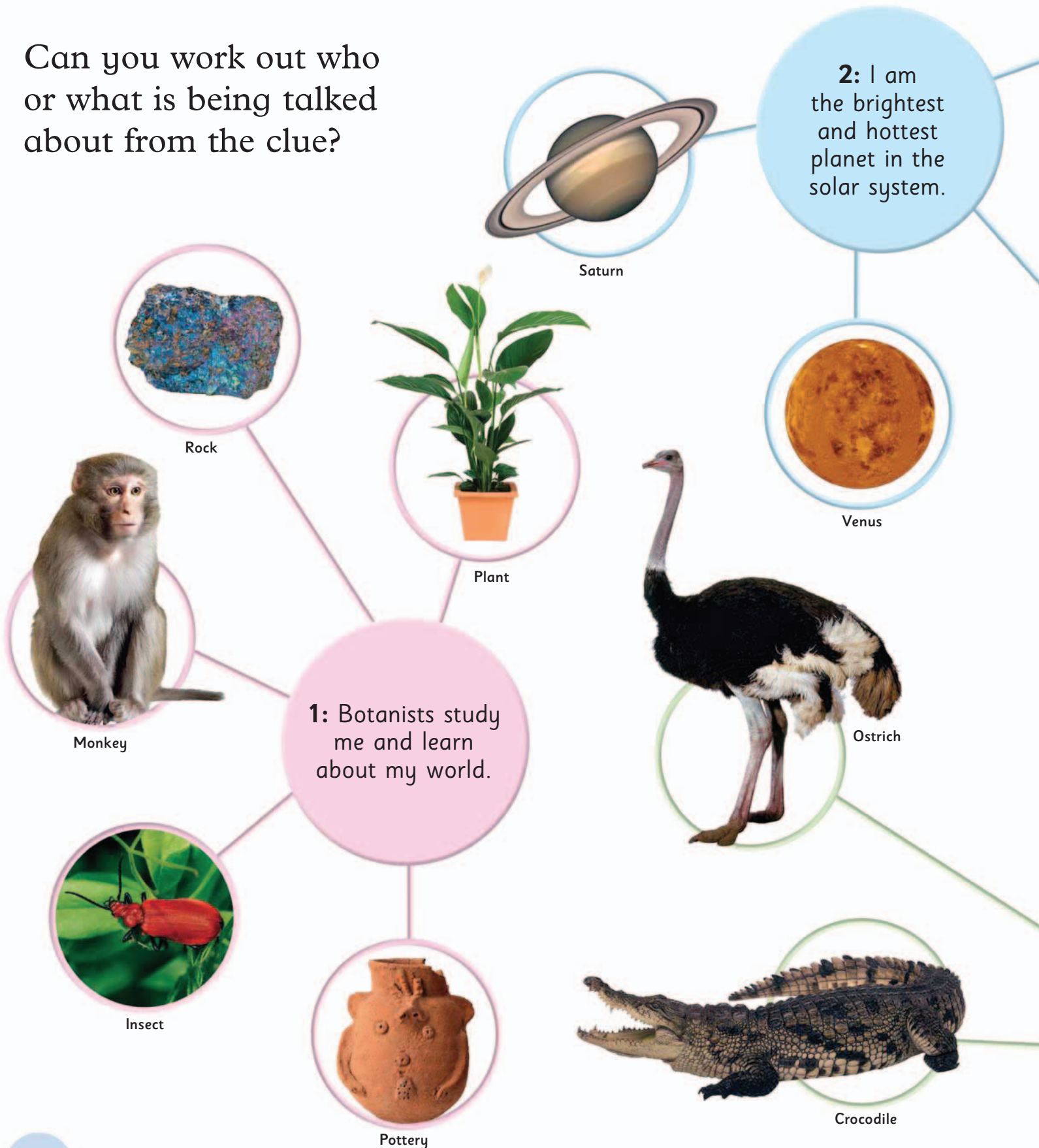
- A. Feet B. Antennae
C. Tongue D. Wings

16 What is the process of the atmosphere trapping the Sun's rays called?

- A. Echolocation B. Greenhouse effect
C. Radiation D. Carbon cycle

Who or what am I?

Can you work out who or what is being talked about from the clue?





Mars



Road-drill



Fireworks

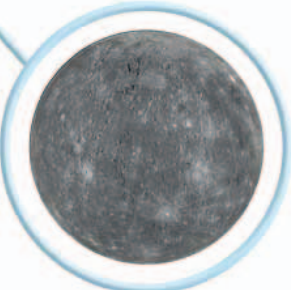


Jet engine

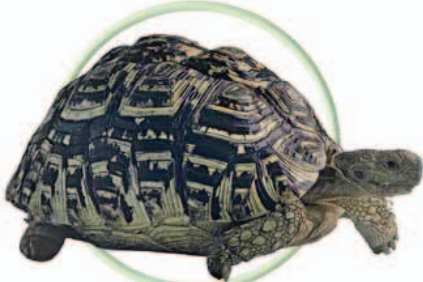
3: I can be as loud as 140 decibels.



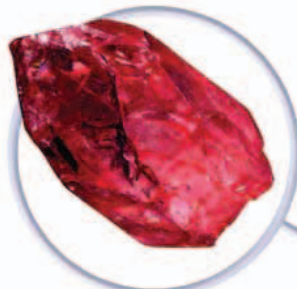
Drums



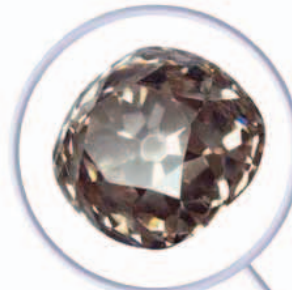
Mercury



Tortoise



Quartz



Diamond



Gold

5: I am the hardest of all minerals.

4: I lay the largest egg in the animal kingdom.



Python



Topaz

1: Located in Hawaii, this is the most active volcano on the Earth.

2: The Grand Canyon was formed due to years of erosion caused by this body of water.

4: This medicine, discovered by the Scottish scientist Alexander Fleming, kills bacteria.

3: This NASA orbiter was part of the Space Shuttle programme that ended in 2011.

5: This was first tested in 1617 by Faust Vrancic, in Italy.

6: This animal lives in the African grasslands and uses its body colour as camouflage.

Where in the world?

Match the description of each of these objects or animals with the pictures, and discover what part of the world each belongs to.



Blood



Mount Kilauea



Sputnik 1



Parachute



Dead Sea



Emperor penguin

7: Austrian scientist Karl Landsteiner discovered that this substance can be divided into four groups.

9: Part of the Himalayas, this is the tallest mountain peak in the world.

10: Launched by the Soviet Union in 1957, this was the first satellite in space.

11: This was created in China in 105 BCE, but was kept a secret for many years.

8: This body of water in Asia is so salty that you can easily float in it.

12: This Antarctic animal has a heat-trapping layer on its body.



The Atlantis



Lion



Colorado River



Penicillin



Paper



Mount Everest

Glossary

atmosphere Mass of air that surrounds the Earth

attraction Force that pulls things together. The opposite ends (poles) of two magnets attract each other

bacteria Tiny one-celled creatures found all around us. Some bacteria are good, but others cause disease

carbohydrate Along with fats and proteins, energy-rich carbohydrates, such as sugar and starch, are one of the three major food groups

carnivore Animal that eats only meat. Lions, wolves, sharks, and crocodiles are carnivores

carrion Remains of dead animals that other animals eat

chlorophyll Pigment in plants that traps the energy of sunlight for photosynthesis and gives them their green colour

circuit Loop that an electric current travels around

compound Chemical made when two or more elements are joined by a chemical reaction

continent One of the Earth's huge landmasses, like Asia. There are seven continents

electromagnet Powerful magnet created by a flow of electricity through a coil

endorphins Chemicals released by the brain that make you feel happy and reduce pain

erosion Wearing down of rock by water or the weather

estuary Wide part of a river where it meets the sea

fertilization Process in which the male and female parts of an animal or plant join together to reproduce

force Push or a pull. Gravity is the force that keeps you on the ground

fossil fuels Fuels that come from the earth and are the remains of living things. Coal, oil, and natural gas are all fossil fuels

genes Chemical instructions in your cells, holding the information that makes you who you are

global warming Slow rise in average temperatures around the world, believed to be caused by the greenhouse effect

greenhouse effect When the atmosphere traps in heat, the Earth becomes warm enough for life to thrive

habitat Area where a particular species of plant, fungus, or animal lives

herbivore Animal that eats only plants. Cows, koalas, and elephants are herbivores

invertebrates Animals that don't have a backbone

laboratory Place where scientists carry out their experiments



limestone Rock made from the skeletal remains of marine animals, built up in layers over thousands of years

migration Movement of animals, particularly birds, from one place to another to find food or warmth

mineral Solid chemical substance usually found as crystals in rock

mixture Two or more substances combined together, but not joined chemically

nerves Threads of tissue that carry high-speed signals around the body

nutrients Foods or chemicals that a plant or animal needs in order to live and grow

omnivore Animal that eats both meat and plants. Pigs, bears, and humans are omnivores

orbit Path taken by an object in space as it moves around another object

ores Minerals that are important sources of metals

organ Group of tissues that form a body part designed for a specific job. The heart is an organ

organic matter Remains of dead plants and animals. Organic matter is an important part of soil because it contains lots of nutrients

organism Living thing that has a number of parts working together as a whole

parasite Organism that lives on or inside another plant or animal, often harming it

particle Very, very small bit of matter, such as an atom or a molecule

repulsion Force that pushes objects apart. The same ends (poles) of two magnets repel each other

reservoir Place where water is collected and stored

satellite Natural or man-made object that moves around another object. The Moon is the Earth's natural satellite. Man-made satellites circle the Earth and send back information on things such as weather



species Type of living thing that can breed with others of the same type

spore Special cell made by organisms such as fungi. Spores can grow into new organisms

temperature Measure of how hot or cold things are

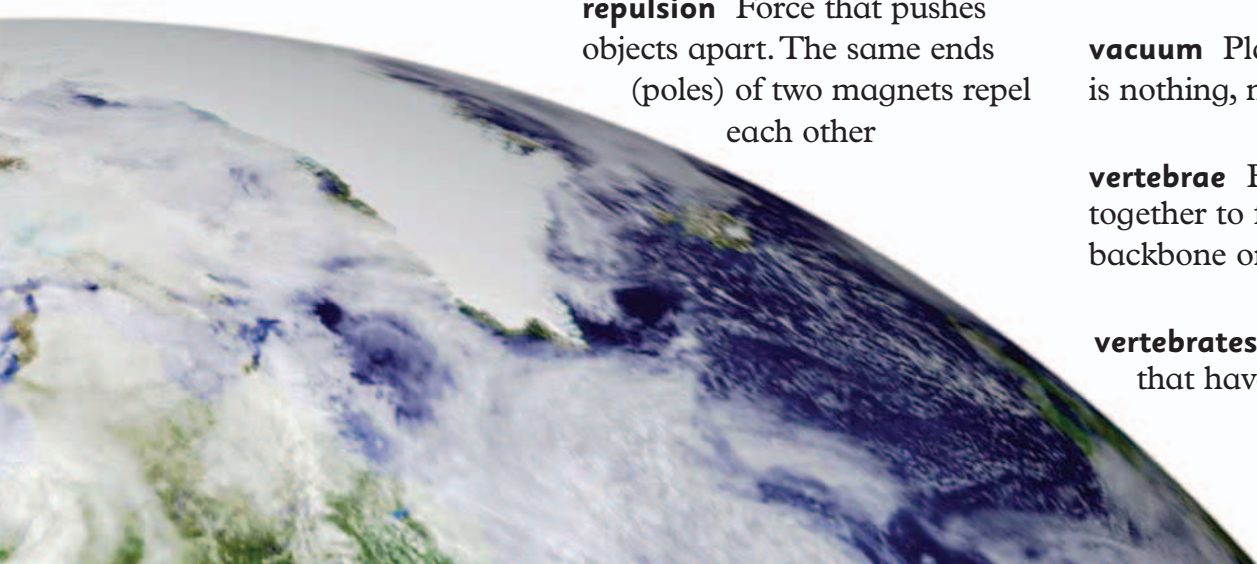
tissue Group of cells that look and act the same. Muscle is a type of tissue

transpiration Evaporation of water from a plant into the atmosphere

vacuum Place where there is nothing, not even air

vertebrae Bones that link together to form an animal's backbone or spine

vertebrates Animals that have a backbone



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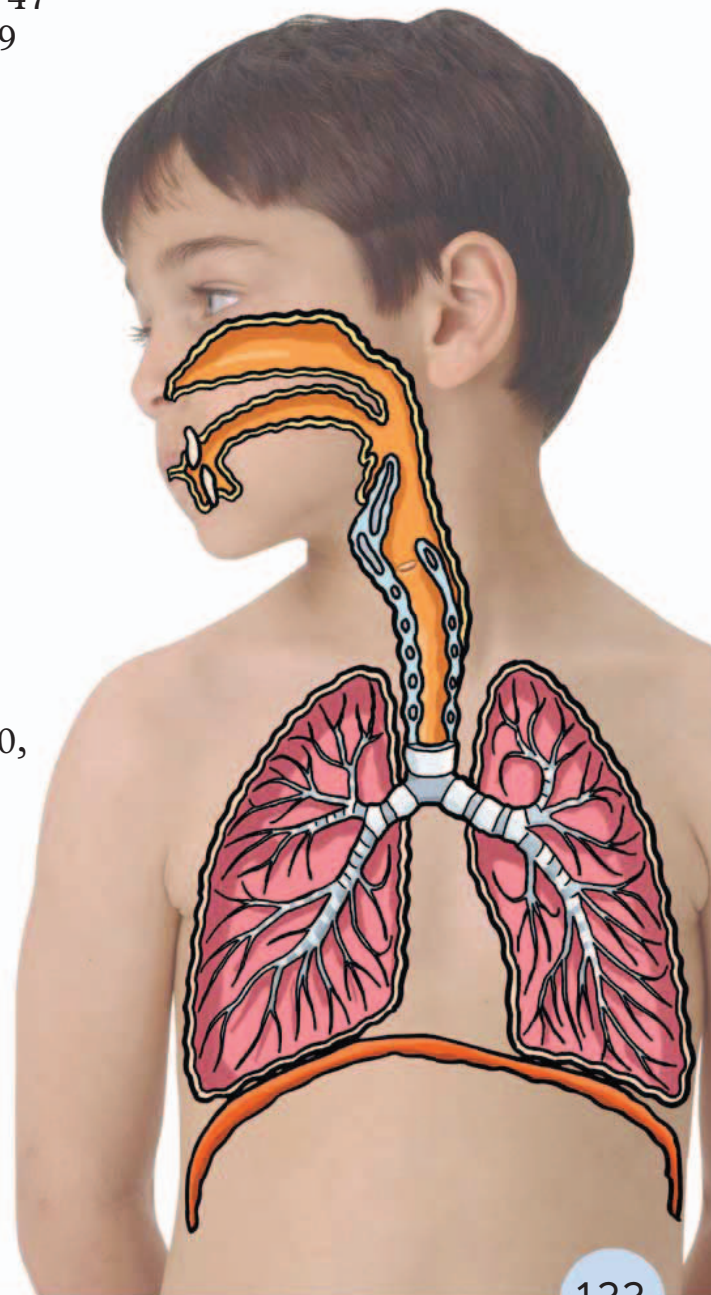
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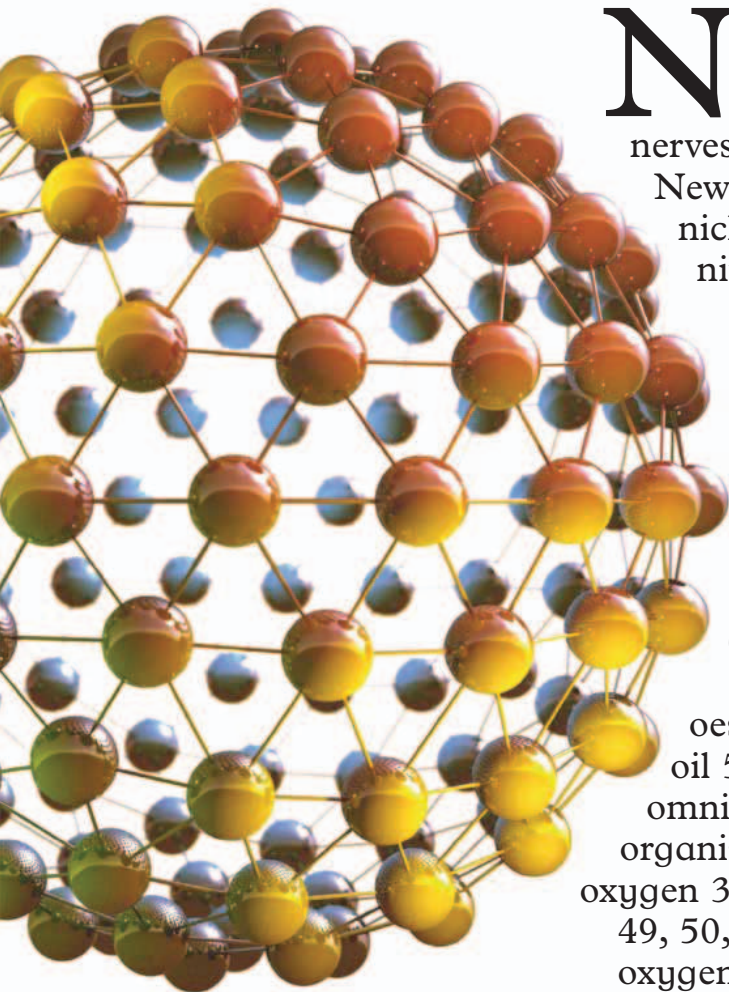
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