

EXPLORING SCIENCE

WORKING SCIENTIFICALLY

Mark Levesley • Penny Johnson • Iain Brand • Sue Kearsey

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HOW TO USE THIS BOOK

71a ENERGY AND CHANGES



There are a lot of things happening in a theme park. Almost everything that happens involves **energy** in some way. For example, your body needs energy to stay alive, and to allow you to move around. Energy is needed to make all the rides in the theme park work. The energy needed is stored in food and in fuels, such as petrol.

B | Food is a store of energy.



- 1 Which of the rides shown in photo A needs the most energy and which the least energy? Explain your answers.
- 2 a) Write down five different things that are happening in photos A and B that need energy.
b) How is energy provided for these things to happen?
- 3 a) Write down five things you did yesterday that needed energy.
b) Which of these things do you think needed the most energy, and which needed the least energy? How do you know?

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Each unit starts with a **Unit opener** page. This introduces some of the ideas you will learn about, by getting you to think about a real-life situation related to the content of the unit and what you already know about the topic.

You should be able to answer the question at the top of the page by the time you have finished the page.

Fact boxes contain fascinating facts for you to think about.

The **Key words** for the page are in bold. You can look up the meaning of these words in the **Glossary**, on pages 199–205.

71c FUELS

WHERE DO FUELS COME FROM?

A **fuel** is a substance that contains a store of chemical or nuclear energy that can easily be transferred. Most fuels are burned to release the energy they store, and the energy is transferred to the surroundings by heating. Burning a fuel does not make energy, it only transfers it. **Nuclear fuels**, such as **uranium**, release energy in a different way. Energy from the fuels used in power stations is transferred to homes, schools, factories and offices using electricity. We say that the electricity is **generated** in power stations.

- 1 a) What is a fuel? b) Name three fuels.
- 2 Write down three things humans use fuels for.

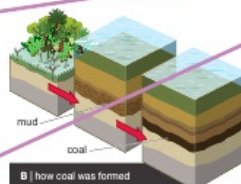


A | The energy for lighting is transferred by electricity from power stations.

FACT

1 kg of nuclear fuel stores around 3 500 000 times as much energy as 1 kg of coal.

Fossil fuels



B | how coal was formed

Oil and **natural gas** formed from tiny animals and plants that lived in the sea millions of years ago. These fell to the sea bed when they died and got buried in mud and sand. More layers of mud and sand fell on top of them and squashed them, turning them into crude oil and natural gas. Fuels such as petrol and diesel are made from oil.

Fossil fuels are made from the remains of **organisms** that died millions of years ago. **Coal** was formed many millions of years ago from plants. When the plants died they became buried in mud, which stopped them from rotting away. More layers of the mud squashed the plant remains. This squashing, together with heat from inside the Earth, turned the mud into rock and the plant remains into coal.

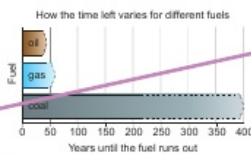
C | The fast food van uses energy stored in the chemicals in the bottled gas. The gas is made from oil.



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Coal, oil and natural gas are **non-renewable** fuels because they cannot be replaced at the rate that humans use them up. It takes many millions of years for them to form and so our supplies will eventually run out.

- 1 Look at graph D.
- Which fossil fuel will run out first?
 - Why do you think the bars on the graph have no definite end?
- 4 a) Write down two similarities between the formation of coal and oil.
b) Write down one difference.



D Scientists are not certain how long the different non-renewable fuels will last. It depends on how fast we use them, and whether more sources are discovered.

Other fuels

Biofuels are made from plants or the wastes from animals. They are **renewable** fuels, because more plants can be grown to make more fuel.

F In some countries, animal wastes are dried to be used as a **solid** fuel. Animal and plant wastes can also be turned into methane, the main substance in natural gas.



Gases such as **hydrogen** can also be used as fuel. At the moment, most hydrogen is made from natural gas, but scientists are trying to find ways of making it cheaply from water.

- 5 A friend of yours says, 'Electricity is a fuel.' Explain why your friend is wrong.
- 6 Fossil fuels are being formed slowly in the Earth today, so why are fossil fuels called non-renewable fuels?



E Crops can be grown to make biofuel. Some biofuels are made out of waste cooking oil, which originally came from plants.



G This car has an electric motor. A fuel cell in the car combines hydrogen with oxygen from the air to produce electricity.

- I can ...
- describe what fossil fuels are and how they were made
 - explain why fossil fuels are described as non-renewable
 - name some renewable fuels.

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Questions are spread throughout the page so you can answer them as you go along.

If you are having trouble finding information about something, use the **Index**, on pages 207–208.

I can ... boxes help you to reflect on what you have learned. Consider each statement carefully and think about how well this applies to you.

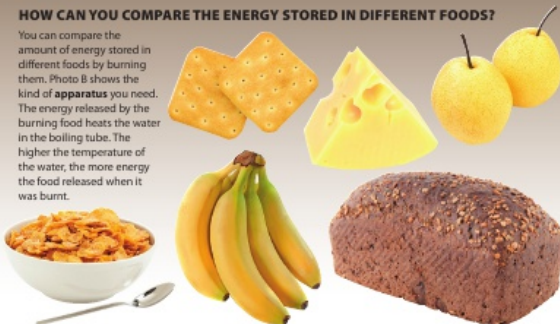
Working Scientifically and **Literacy & Communication** pages give you the opportunity to learn scientific techniques and scientific ways of thinking, and to think about how scientists communicate effectively with each other and the outside world.

Each unit ends with a **Unit closer**. Here you can apply what you have learned, while considering a real-life situation.

71a FAIR COMPARISONS AND RATIOS

HOW CAN YOU COMPARE THE ENERGY STORED IN DIFFERENT FOODS?

You can compare the amount of energy stored in different foods by burning them. Photo B shows the kind of **apparatus** you need. The energy released by the burning food heats the water in the boiling tube. The higher the temperature of the water, the more energy the food released when it was burnt.



A Different foods contain different amounts of energy.



Method

- Find the mass of a piece of food.
- Carefully put the food on a pin (which has its other end in a piece of cork).
- Put 10 cm³ of water into a boiling tube. Record its temperature.
- Light the food using a Bunsen burner, and hold the burning food under the boiling tube. Make sure the flame is touching the boiling tube.
- When the food has finished burning, record the temperature of the water again.
- Let the food cool down, then carefully push what is left off the pin and find its mass. If there is no food left on the pin, write down 0 g for its mass.
- Repeat steps A to F for other foods.

Wear eye protection.
Do not eat any of the foods.
Do not use nubs.

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71e MAKING CHANGES

HOW CAN WE USE LESS FOSSIL FUEL?

The way we live needs a lot of energy – for heating, transport and generating electricity. Almost all of the vehicles on our roads use fuels obtained from oil, and over 75 per cent of our electricity is generated using fossil fuels.



We need to burn less fossil fuel, because this is a non-renewable resource, and because burning fossil fuels is harming the **environment**. But how can we change?

I always use efficient appliances because they use up less of our country's store of electricity.



Anything I change won't make any difference. It's up to the government to change the way the country runs.



If everyone used a bike or walked for short journeys it would make a difference. Climate change will affect all of us – we should all reduce the amount of fossil fuels we use.



Think of all the warm air that escapes through this door, all day! Local councils could help by only allowing buildings that do not waste energy.

- Look at photo A. Describe the energy stores shown in the photo, and the ways in which energy is being transferred.
- Look at photo B. In what way is the person: a) correct b) wrong?
- Why do you think that most of the electricity we use in this country is generated from non-renewable resources? Give as many reasons as you can.
- Explain why we should use less fossil fuel.
 - Look at photo C. Suggest five ways in which the person in the photo could make changes.
- A kettle uses electricity. Starting with the Sun, draw a flow chart to show the energy stores and transfers when you boil the kettle, if the electricity comes from:
 - a coal-fired power station
 - a hydroelectric power station.

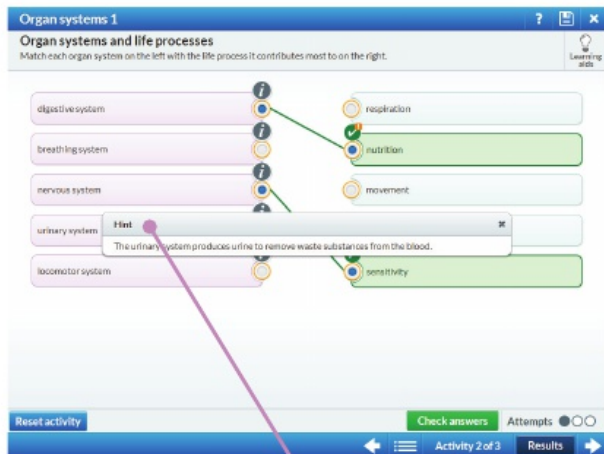
HAVE YOUR SAY

Who should be responsible for reducing our use of fossil fuels – individuals, businesses or the government?

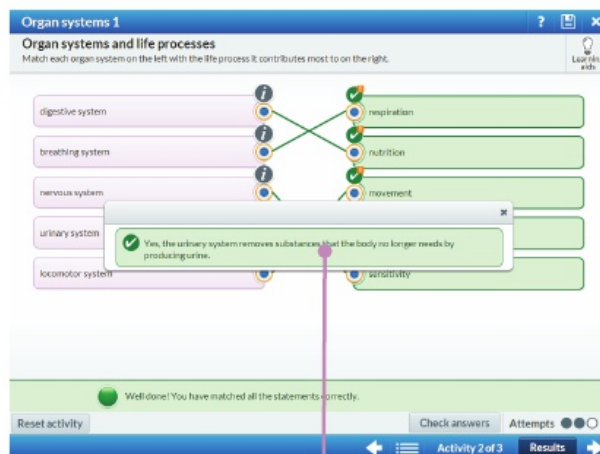
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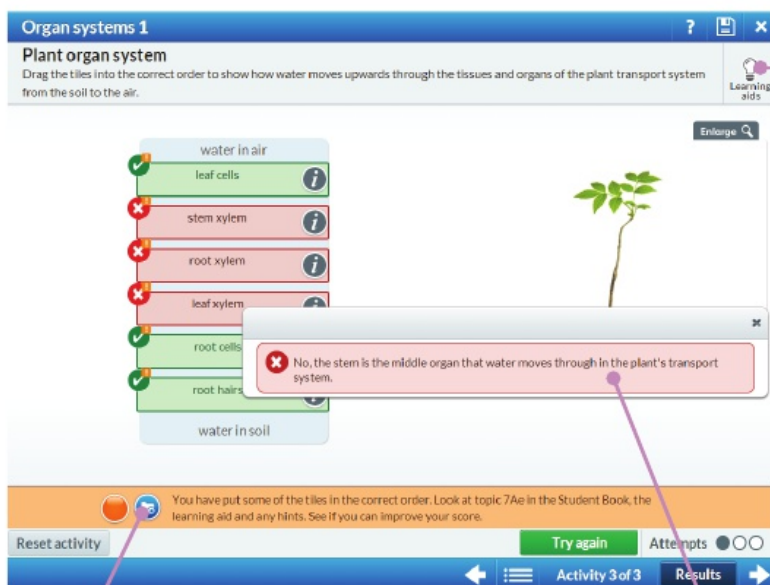
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You can access hints to help you as you work through an activity by clicking on the icons. Hints provide additional information to guide you in your choice of answer.



Once you have completed an attempt at the question, the correct answers are shown in green. You can click on the icons to reveal feedback about the answer choices you made.



You can access learning aids by clicking on this icon.

Further help is given in the form of the activity-level feedback. You are encouraged to read, or revisit, any learning aids or ActiveBook links provided with the activity.

Incorrect choices are shown in red. You can click on the icon to reveal feedback about why the answer is incorrect. With each attempt at the question, more guidance is given to help you reach the correct answer.

7Aa DOCTORS PAST AND PRESENT

For thousands of years people have gone to see doctors when they feel unwell. Some of the ways in which doctors examine patients have not changed! For example, 3000 years ago, Ancient Egyptian doctors knew that if a person's **heart** was not beating as well as usual that person could be ill.

Today, doctors still find out how well your heart is beating. They may also measure temperature and do blood and urine tests to see if there are changes in your body compared to normal. These changes are called **symptoms**. Different problems cause different symptoms. The symptoms of a cold include a sore throat and runny nose.



A | Modern equipment can see **organs** inside our bodies. Scientists have used this equipment on Egyptian mummies and found that many had heart problems.

B | a doctor seeing patients 3000 years ago in Egypt



A doctor sees if there is a match between a patient's symptoms and a known problem. If there is a match, the symptoms are **evidence** that the person has a certain illness.

Luckily, if you need a **medicine** today it won't contain a favourite ingredient of Ancient Egyptian medicine – animal poo!

- 1** a | A patient has a high temperature, a headache and a stuffy nose. Which word in bold on this page best describes these findings?
b | Suggest what illness the patient has.
- 2** A doctor tells a patient that they have acne. Suggest what evidence the doctor has found to make them think this.
- 3** a | Which of the following best describes the heart:
A | an organ B | a cell
C | a tissue D | a system?
b | State one job that the heart does.

7Aa LIFE PROCESSES

WHAT DO ALL LIVING THINGS DO?

The Ancient Egyptians had cures for death, including one made from onions and beer. It is doubtful that this worked! When they died, the bodies of important people were treated to stop them rotting – they were mummified. This was done because Ancient Egyptians believed that living things contained a 'life force' called *ka*, which needed somewhere to live.

Today, we have different ideas about what it means to be alive. We look at what things do. If something can do the following **life processes**, it is a 'living thing' or **organism**:

- move
- grow
- need nutrition.
- reproduce
- respire
- sense things
- excrete waste



A | The tomb of a pharaoh called Tutankhamen was found in 1922. It was full of food, drink and objects for his 'life force' to use.

1 Copy and complete the table below with the items in the list.

car, chair, coal, cow,
daffodil, goldfish,
mouse, octopus, robot,
rock, snake, Sun

Organism	Not an organism

2 A **mnemonic** is a word or phrase that helps you remember a list. It is usually made using the first letters of the words in a list. What mnemonic is spelled out by the first letters of the life processes?

Movement

All living things can either **move** from place to place or move parts of themselves.



B | Arctic poppies move parts of themselves. Their flowers turn to follow the Sun during the day.

Reproduction

Organisms can make more living things like themselves. We say that they can **reproduce**.



C | a baby pig developing inside its mother

3 Suggest one difference between how most animals move and how most plants move.

4 Suggest one thing that many plants do to reproduce but animals do not do.

Sensitivity

Organisms **sense** and react to things around them.



D | This sensitive plant closes its leaves if it senses something touching them.

Growth

Living things increase in size. We say that they **grow**.



E | The blue whale is the largest animal that has ever lived on Earth. An adult can grow up to 30 m long and have a mass of 170 tonnes.

Respiration

Living things use a process called **respiration** to release energy for them to use.



F | Humans, like many living things, need **oxygen** and food in order to respire.

Excretion

Organisms produce waste materials. When they get rid of these waste materials we say that they **excrete** them.



G | waste materials include liquids (urine)

Nutrition

Living things require various substances to help carry out other life processes. We say that they need **nutrition**.

H | Animals eat food but plants make their own food. However, even plants need small amounts of substances from the soil to help them grow well.



- 5** Describe two ways in which you show sensitivity.
- 6** Suggest one difference between how trees grow and how humans grow.
- 7** Suggest one difference between how fish and humans get their oxygen.
- 8** a| In what ways is a car like an organism?
b| Why is a car not an organism?

I can ...

- recall and describe the life processes
- explain the differences between organisms and non-living things.

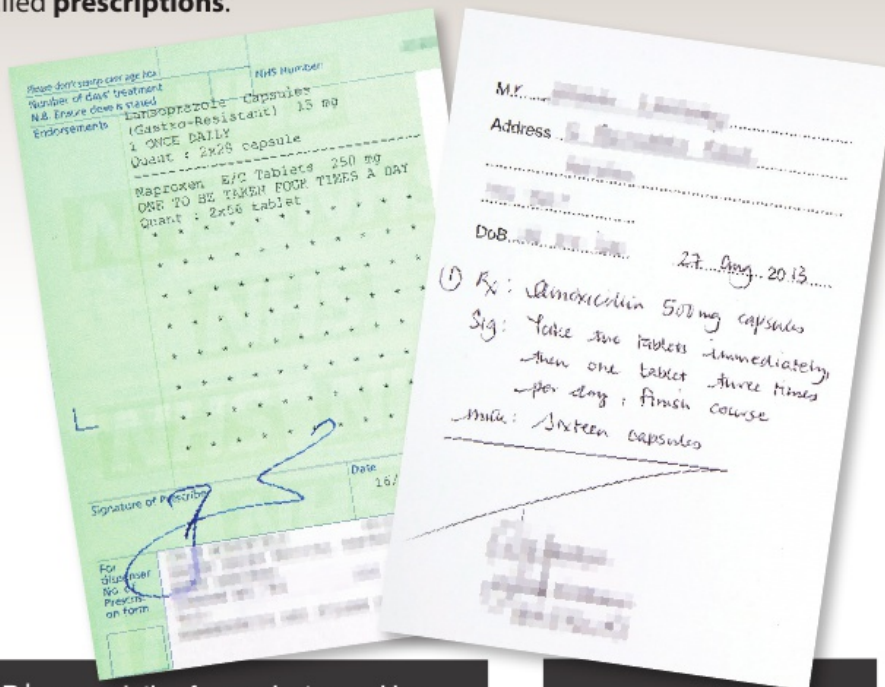
7Ab CONVENTIONS IN WRITING

WHY DO SCIENTISTS USE CONVENTIONS IN THEIR WRITING?

If there is a change in the way that life processes occur in our bodies, it can cause illness. A doctor looks at the symptoms of the illness and uses them as evidence to draw a **conclusion** about what the illness is. This conclusion is called a **diagnosis**.

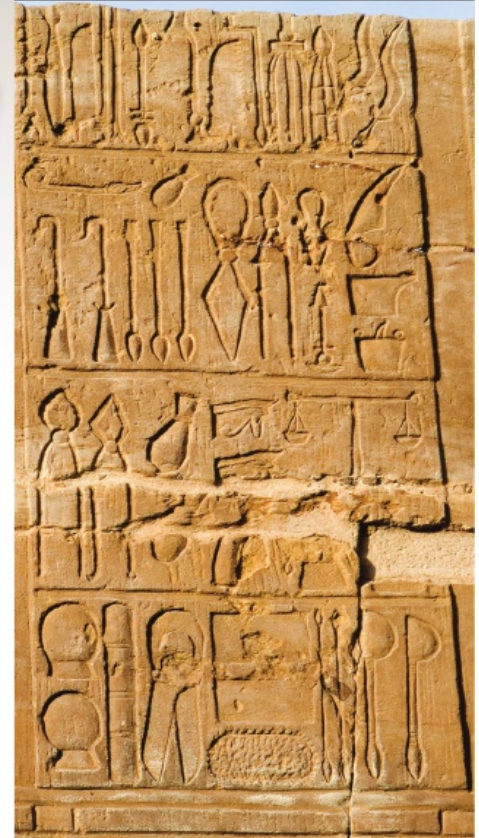
Doctors often suggest medicines to treat an illness. They write out an order for these medicines, which you get from a pharmacy. These orders are called **prescriptions**.

A | Doctors have written instructions for how to treat problems for thousands of years. This Ancient Egyptian carving records the range of instruments and medicines that a doctor used to treat patients. Many of the instruments still look familiar!



B | a prescription from a doctor working for the NHS
mg = milligrams
1000 milligrams = 1 gram (g)

C | a prescription from a private doctor



- 1** Look at photo B.
 - a | What are the names of the medicines in this prescription?
 - b | How many tablets or capsules of each medicine will the patient get from the pharmacy?
- 2**
 - a | How are the prescriptions in photos B and C similar?
 - b | Why is this useful?
- 3** A doctor wants a patient to take one 'Penicillin V' tablet four times each day for 5 days. Each tablet contains 125 mg of the medicine. Write out a prescription.

LITERACY & COMMUNICATION

Doctors and scientists have certain ways of presenting information, called **conventions**. These conventions make it easier to find information, to understand information and to compare information. A convention fixes the:

- order in which the information is given
- type of symbols used (shorthand ways of writing something)
- type of diagrams used.

There is a convention for writing prescriptions. The information is always in the same order and symbols are used for the units showing the amount of medicine.

When you write a report about an experiment that you have done, you will use a convention. This is similar to the convention that all scientists use to write reports. The convention is to split the report into sections.

D | the sections of an investigation report

Growing cress seeds

Aim

Are cress seeds alive?

Introduction

All living things grow. Cress seeds germinate and grow into plants and so cress seeds must be alive. I predicted that if we boiled seeds, then they would not grow.

Method

I used cress seeds, beaker, water, 2 dishes, kitchen towel.

A| I put 50 cress seeds in boiling water to kill them.

B| I put the seeds on some damp kitchen towel in a dish. I did the same with the same number of unboiled seeds.

C| I left the dishes on a window sill.

Results

All the unboiled seeds grew. Three boiled seeds grew.

Conclusion

If you boil seeds they are killed and will not grow. Unboiled seeds grow and so must be alive. This agrees with my prediction.

Evaluation

I would boil the seeds for longer to try to kill them all.

An **aim** is what you were trying to find out. It can be a question or an explanation starting with 'My aim was to ...' or 'I wanted to find out ...'.

You explain an idea that you have and why you have that idea. You may also make a **prediction** – say what you think will happen.

You list the **apparatus** (equipment) you used. You also describe your **method** (what you did) in a series of steps.

You record your **results** (your measurements or observations). Your results are your evidence.

In the **conclusion** you explain what your results show.

In the **evaluation** you say how you could make the experiment better to get better evidence.

- 4 a| What unit symbol is used in the prescriptions in photo B?
b| What does this unit symbol represent?

- 5 Copy the prescription for the first medicine in photo B. Add labels to show the convention.

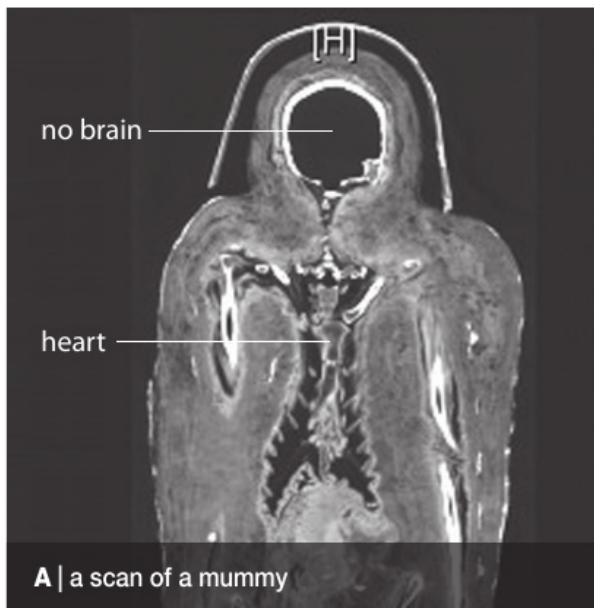
- 6 Why do all scientists write reports in the same way?

I can ...

- describe what a convention is
- explain why conventions are useful
- describe the convention for investigation reports.

7Ab ORGANS

WHAT DO ORGANS DO?

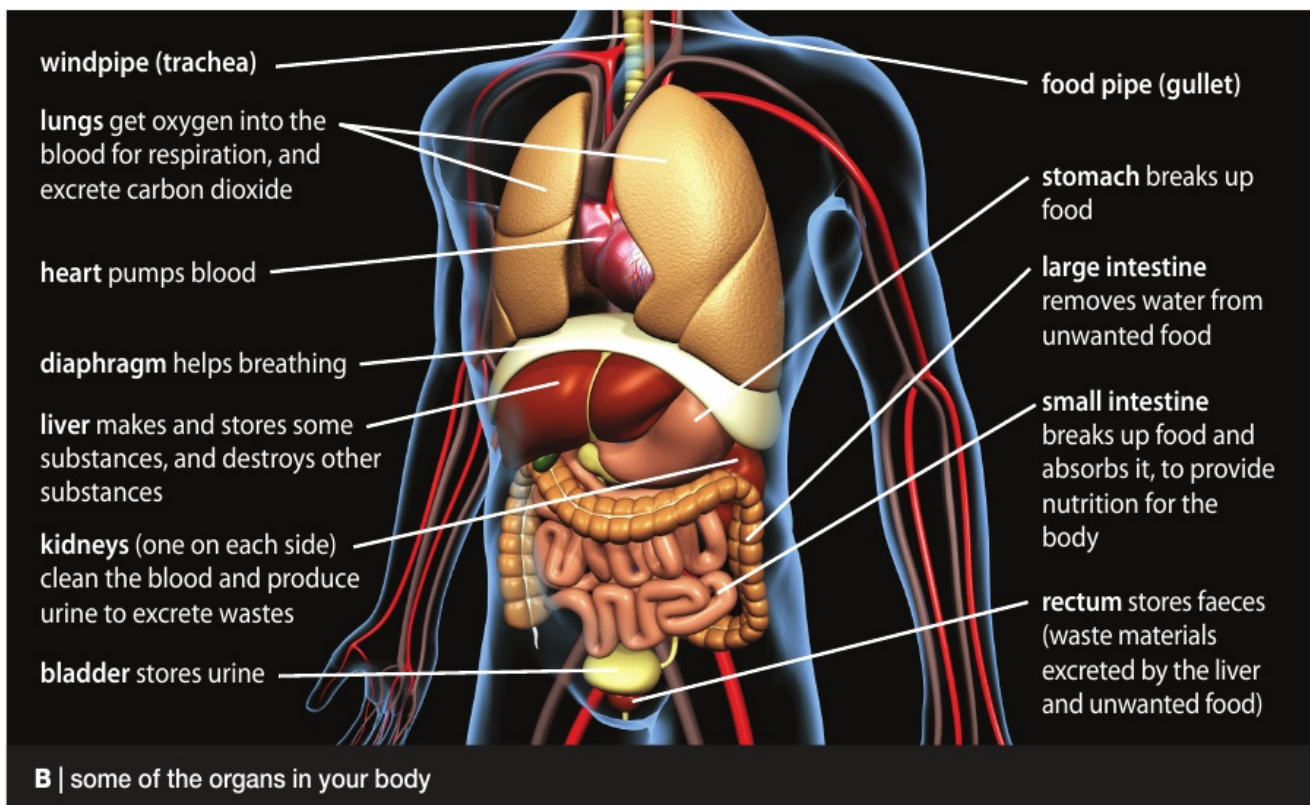


In Ancient Egypt, the heart was thought to be the most important part of a person. When people were mummified, the organs in their bodies were removed but the heart was left in place. The stomach, intestines, lungs and liver were thought to be useful on the person's journey in the afterlife and these organs were stored in jars. They did not think the **brain** was important and so it was thrown away.

Human organs

The heart, stomach, intestines, lungs and liver are **organs**. Every organ has an important **function** (job). We now know that the brain is also an organ and has the very important function of controlling the body!

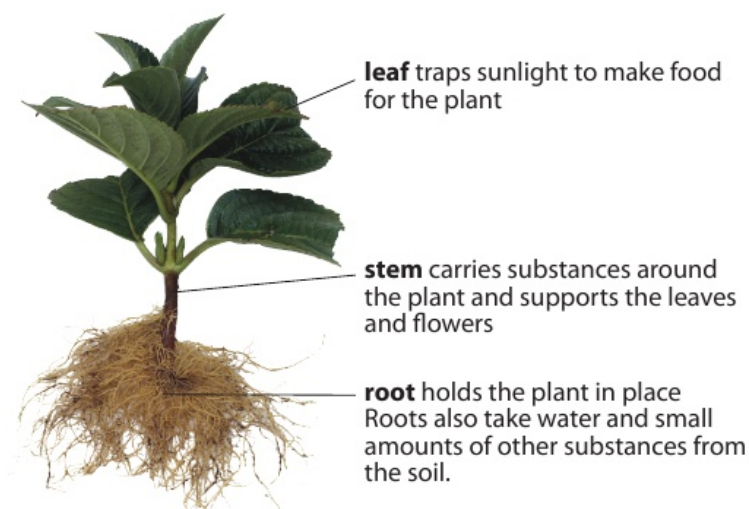
Your body's biggest organ is on the outside. It's your **skin**. Skin is used for protection and sensing things.



- 1 Draw a table to show the functions of five different organs in your body.
- 2 Which organ gets bigger as it fills with air?
- 3 List the organs that help to get nutrition into the body.
- 4 List the organs that excrete waste materials.
- 5 List two organs that store solid or liquid wastes.

Plant organs

Photo D shows some of the main organs in plants.



D | the organs found in most plants

Plants make their own food using a process called **photosynthesis**. This process occurs in the leaves when there is light. Photosynthesis needs **carbon dioxide** from the air, and water. Some plants also have **storage organs**, which they use to store some of the food that they make. Potatoes and carrots are storage organs.

- 6 Which organ is the main organ of nutrition in a plant?
- 7 a) What process produces the food stored in plant storage organs?
b) Why won't a potato grow if the potato plant does not get much light?
- 8 Which human organ is most similar to a plant organ? Explain your reasoning.



© Gunther von Hagens' BODY WORLDS, Institute of Plastination, Heidelberg, Germany www.bodyworld.com.

C | We still preserve bodies today but not by mummification. This body has been preserved by treating it with plastic. He is carrying his skin. Preserved bodies are used for scientific research, for displays and to train new doctors.

FACT



Leaves are plant organs that are designed to collect sunlight. Plants that live in shady areas often have very large leaves. The leaves of the giant water lily can be up to 3 m in diameter.

I can ...

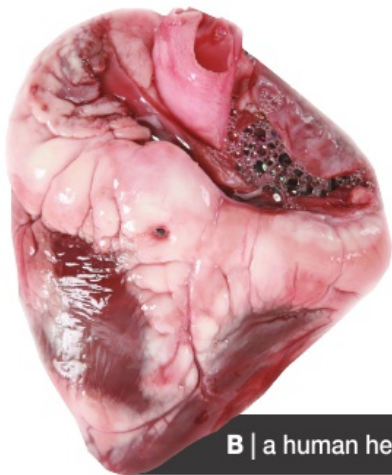
- identify and locate important plant and animal organs
- describe the functions of important plant and animal organs
- describe what happens in photosynthesis.

7Ac TISSUES

WHY ARE TISSUES IMPORTANT?

Many good detective stories have a 'pathologist', who inspects a dead body to look for evidence to help to solve a murder. Pathologists have a long history; dead bodies were examined in Ancient Egypt, Ancient Greece and in Roman times.

Pathologists are fully trained doctors. They examine a body inside and out, looking for changes to organs. One organ that they look at very carefully is the heart.



B | a human heart

A pathologist will look at a heart in detail because it is such an important organ and damage to it often causes death. Its function is to pump blood around the body. The blood carries oxygen and nutrients (from food) for all the different parts of the body to use.

In photo B you can see that the heart has different parts. The whiter parts are fat and the reddish parts are muscle. These parts are known as **tissues**. All organs are made up of different tissues.

Each tissue in an organ has a certain function. For example, the **muscle tissue** in the heart is the part that moves, to pump blood. The **fat tissue** helps to protect the heart.

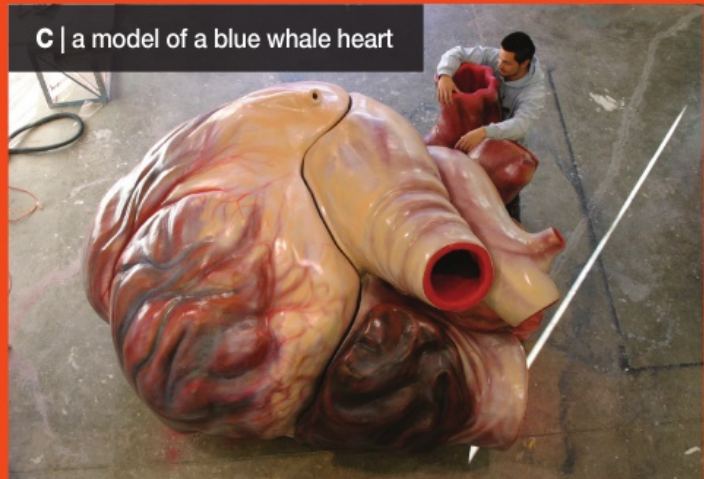


A | The first known pathologist's report is from a doctor called Antistius who studied the body of Julius Caesar, after his assassination in 44 BCE.

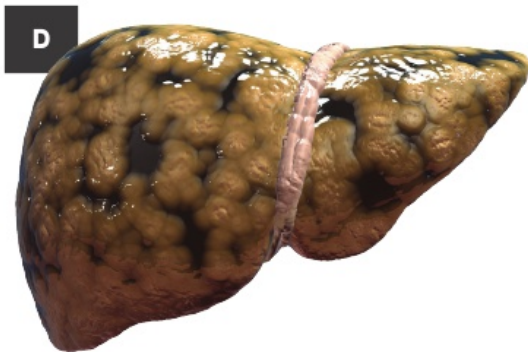
- 1 Antistius reported that Caesar was stabbed 23 times in the face, groin and upper back but that he died from just one stab wound. In which area do you think this was? Explain your reasoning.
- 2 Look at photo B. Describe what a heart looks like.

FACT

C | a model of a blue whale heart



About 20 per cent of the mass of a mammal heart is fat. For an adult human, that's about 60 g of fat. For an adult blue whale that's about 120 kg of fat; a blue whale heart can have a mass up to about 600 kg!

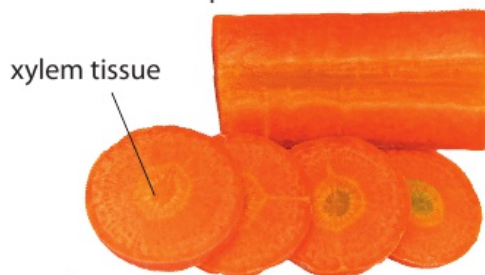


- 3 a | Name two tissues found in the heart.
b | What does each of these tissues do?
- 4 A pathologist says that the liver in photo D comes from someone with 'fatty liver disease'. Compare it with the healthy liver in diagram B on page 12. What evidence supports the pathologist's conclusion?
- 5 Your intestines move, so that food is pushed along. What tissue would you expect to find in intestines?

Plant tissues

Plants also have organs made out of tissues. Many roots, like the one shown in photo E, have hairs on the outside. This is **root hair tissue** and it helps the root to take water out of the soil quickly.

If you cut open a plant organ, you can see more tissues. Photo F shows that a carrot contains different tissues. The tissue in the middle of the carrot is called **xylem tissue** (pronounced 'zy-lem'). Xylem tissue carries water. In a carrot, the xylem tissue carries water up from the roots, through the carrot and on into the rest of the plant.



F | Carrots contain different tissues.



E | root hair tissue on a radish plant



G | a carrot plant

- 6 a | What sort of organ is a carrot?
b | How many tissues does a carrot contain? Explain your reasoning.
- 7 a | Name two tissues you would expect to find in a radish plant root.
b | What does each of these tissues do?
- 8 Name a plant organ that is above ground and contains xylem tissue.
- 9 Which life process does xylem tissue help with?

I can ...

- identify and recall named tissues in human and plant organs
- describe the functions of different tissues in an organ.

7Ac MICROSCOPES

HOW IS A LIGHT MICROSCOPE USED TO EXAMINE A SPECIMEN?

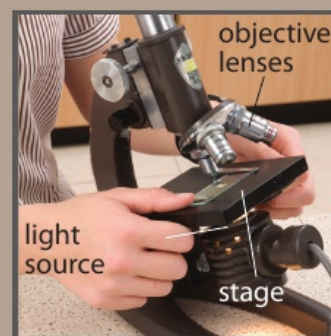
To find out what is wrong with an organ, doctors do tests. Some tests involve taking a small piece of tissue (a biopsy) from an organ and looking at it under a light microscope. Microscopes make things appear bigger; they magnify things. The Method below shows how to use a light microscope.

Method

- A** | Place the smallest **objective lens** (the lowest **magnification**) over the hole in the stage. Turn the **coarse focusing wheel** to make the gap between the objective lens and the stage as small as possible.



- B** | Place the **slide** under the clips on the **stage**. The slide contains the **specimen** (the thing you want to look at). Then adjust the light source so that light goes up through the hole.



- C** | Look through the **eyepiece lens**. Turn the coarse focusing wheel slowly until what you see is in focus (clear and sharp).



- D** | To see a bigger **image**, place the next largest objective lens over your specimen.



- E** | Use the **fine focusing wheel** to get your image in focus again. Do not use the coarse focusing wheel since you can break the slide and damage the objective lens. If you can't see your specimen clearly go back to a lower magnification.



Never point a microscope mirror at the Sun. This can permanently damage your eyesight.

- 1** How many types of lenses are found in a light microscope?
- 2** Write down some rules of your own for:
 - a| using a microscope safely
 - b| taking care of a microscope.
- 3** What part of a microscope makes the image clearer?
- 4** What is a specimen?

WORKING SCIENTIFICALLY

Both of the lenses in a light microscope do some magnifying. How much a lens magnifies is written on its side (e.g. $\times 10$). To work out the total magnification of both lenses working together, we use this formula:

total magnification = magnification of eyepiece lens \times magnification of objective lens

5

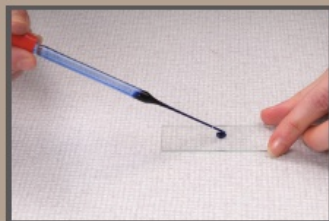
A microscope has a $\times 10$ eyepiece lens and a $\times 15$ objective lens. What is its total magnification?

Preparing a specimen

The specimen on a microscope slide needs to be thin so that light can pass through it. A thin, glass **coverslip** is put on the specimen to keep it flat, hold it in place and stop it drying out. The Method below shows how to prepare a slide of onion tissue.

Method

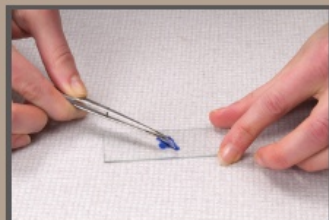
- A** | Take a slide and place a drop of water in the centre. The water may contain a **stain** to make the specimen show up better.



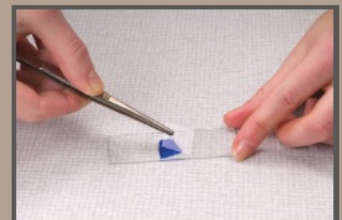
- B** | Use some forceps to peel off the inside layer of a piece of onion.



- C** | Place your onion skin onto the drop of water on your slide.



- D** | Use some forceps to lower a coverslip onto your specimen. If you do this carefully and slowly you will not get air bubbles trapped under the coverslip.



6

Why does a specimen need to be thin?

7

Why do we use coverslips?

8

Suggest the names of two plant and two animal tissues you could examine using a light microscope.

9

Plan an investigation to examine rhubarb stem tissue in detail.

10

Jake sets up a microscope but only sees darkness when looking into the eyepiece lens. What might be wrong? Write down as many things as you can think of.



Wear eye protection when carrying out this method. Slides and coverslips are made of thin glass. Be very careful when using them.

I can ...

- describe how to prepare a microscope slide
- describe how to use a light microscope to examine a specimen.

7Ad **CELLS**

HOW ARE PLANT AND ANIMAL CELLS SIMILAR AND DIFFERENT?

Mummification preserves tissues. In 1825, Dr Augustus Granville tried to work out how a 2500-year-old Egyptian 'mummy' had died. His study included using a microscope to examine tissues. His conclusion was 'cancer'. Technology has now advanced and another examination of the same mummy in 2009 concluded that the person died from a lung disease called tuberculosis (TB).

FACT

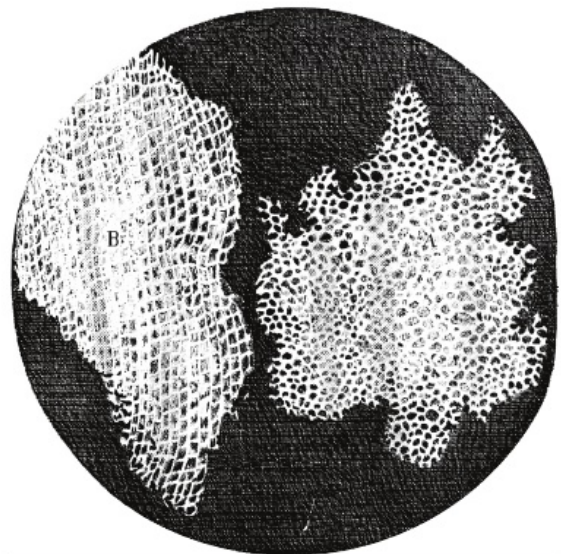
In the Middle Ages it was thought that mummies had healing power. Many of them were ground into powder and sold as medicine!



A | Hooke's microscope (far left) had a total magnification of about $\times 30$. Early 19th-century microscopes magnified to about $\times 200$. Modern light microscopes go up to about $\times 1500$.

Robert Hooke was the first person to study tissues with a microscope. In 1665, he examined the bark of a cork oak tree and saw little box shapes. He thought that they looked like the **cells** (small rooms) in a monastery and so that's what he called them.

Today we know that cells are the basic units from which all tissues and all living things are made. A tissue is a group of cells of the same type working together.



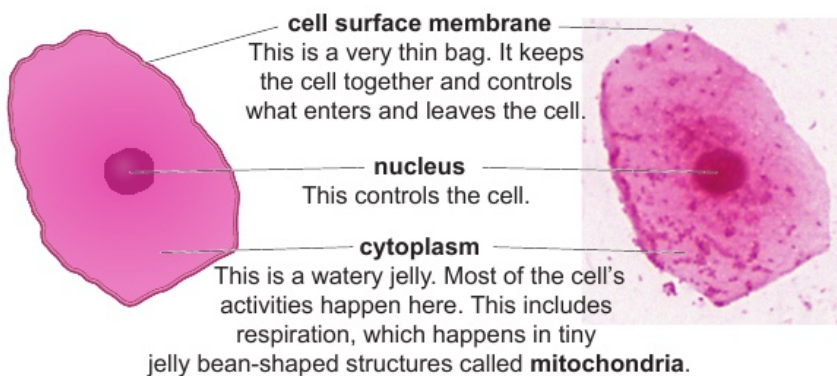
B | Hooke's drawing of cork cells, published in his book *Micrographia*

- 1** What is a cell?
- 2** Granville was able to see much more in the mummy tissues than Hooke saw in the cork tissue. Why was this?
- 3** What do organisms always have that things that have never been alive do not?

Animal cells

Photo C shows a cell from someone's cheek, viewed using a modern microscope. The photograph has a magnification of $\times 600$, which means that it is 600 times bigger in the photo than in real life. The different parts of the cell are labelled.

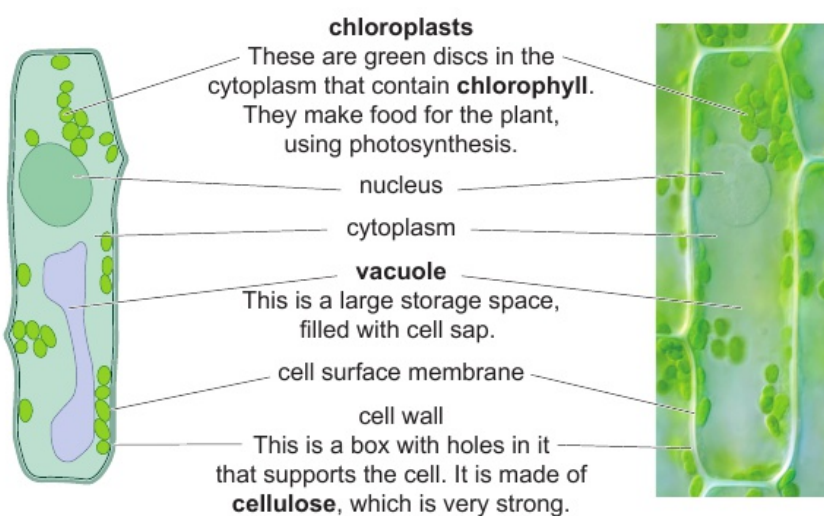
All animal cells have the same basic parts, but cells from different tissues have different shapes, sizes and functions to help them do their jobs. The cells are **specialised**.



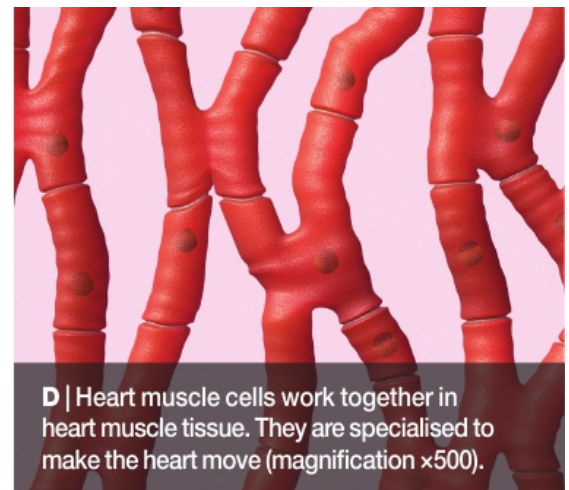
C | a drawing and microscope image of a cheek cell showing its parts (magnification $\times 600$)

Plant cells

Plant cells have thick **cell walls** and may have some other features that are not found in animal cells.



E | a drawing and microscope image of a leaf cell showing its parts (magnification $\times 275$)



D | Heart muscle cells work together in heart muscle tissue. They are specialised to make the heart move (magnification $\times 500$).

- 4**
 - a | Look at photo D. What are the dark blobs?
 - b | What do these structures do?
 - c | What other parts would you find in a heart muscle cell?
 - d | What do these parts do?
- 5**
 - a | Measure the widest part of the animal cell in photo C. Work out its real width.
 - b | Measure the length of the plant cell in photo E. Work out its real length.
- 6** Draw a table to compare the parts that can be found in animal cells and plant cells.
- 7**
 - a | What makes some plant cells green?
 - b | Which are bigger, chloroplasts or mitochondria? Explain your evidence.
- 8** Draw and label a root hair cell.



F | Root hair cells are specialised to take water from the soil (magnification $\times 30$).

I can ...

- identify the main parts of animal cells and plant cells and describe their functions.

7Ae ORGAN SYSTEMS

HOW DO CELLS, TISSUES AND ORGANS WORK TOGETHER?

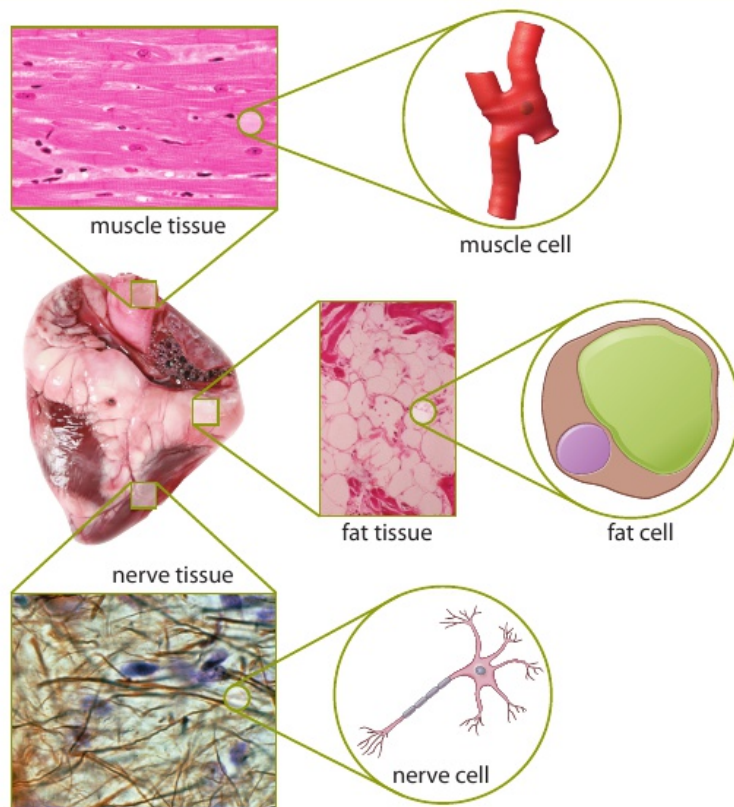
When cells of the same type are grouped together they form a tissue. Different tissues are found grouped together in an organ.

- 1 Name three tissues found in the heart.

Doctors in Ancient Egypt could see that organs were connected but did not understand how or why. For example, they thought that you breathed air into your lungs, your heart and all the tubes going to and from your heart. They could only examine the heart and its tubes in dead bodies when these organs were full of air, and so they thought that they always contained air.

Today we know that the heart and its tubes carry blood around the body. The tubes are called **blood vessels** and work with the heart to form an **organ system** called the **circulatory system**.

An organ system is a group of organs that work together. Other organ systems in humans include the **locomotor** (muscles and bones), **digestive**, **urinary**, **breathing** and **nervous systems**.



A | Organs, such as the heart, are made of many tissues.

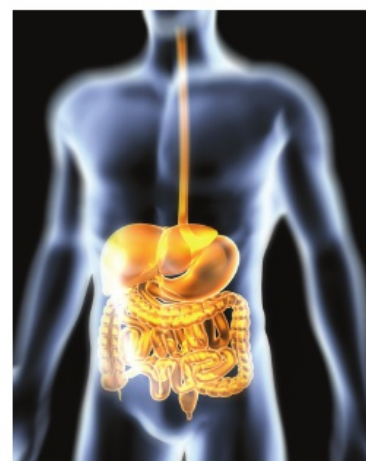
- 2 a) Why did Ancient Egyptians think that blood vessels contained air?
b) Suggest a piece of evidence that we have today that shows this is not correct.
- 3 What is an organ system?

FACT

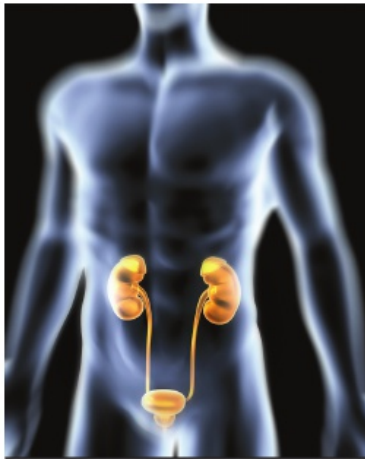
An adult's circulatory system contains over 100 000 km of blood vessels. That's four times around the Earth!



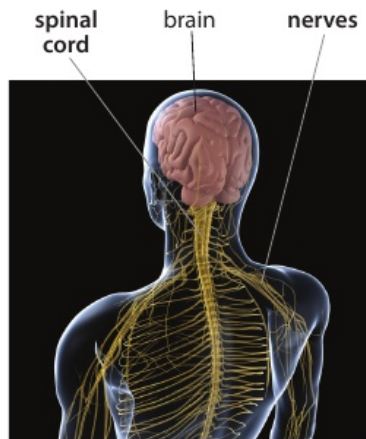
B | The circulatory system carries oxygen and nutrients (from food) around the body.



C | The digestive system breaks down food and takes nutrients from it into the blood.



D | The urinary system gets rid of waste materials produced in the body.



E | The nervous system allows you to sense things.

- 4** What organs are found in the breathing system? (*Hint: You may find page 12 helpful.*)
- 5** Draw a table to show the organs found in each human organ system mentioned on pages 20–21. (*Hint: You may find page 12 helpful.*)
- 6** Which life processes do the organ systems in diagrams C, D and E help with?

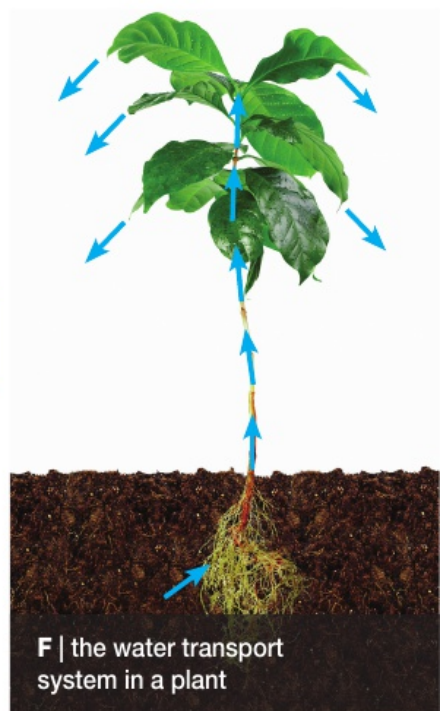
FACT

In your urinary system, your kidneys clean all of your blood every 40 minutes.

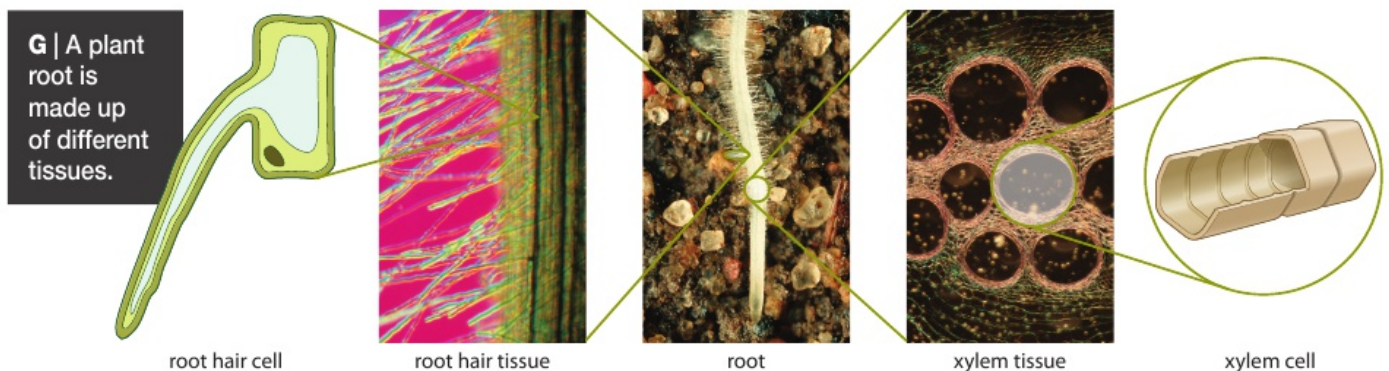
Organ systems in plants

Plants also have organs made up of tissues.

Plant organs work together in organ systems too. For example, the water transport system takes water from the ground up to the leaves. Water is always flowing through this organ system because leaves constantly lose water (by **evaporation**).



F | the water transport system in a plant



G | A plant root is made up of different tissues.

root hair cell

root hair tissue

root

xylem tissue

xylem cell

- 7** a | What are the organs in a plant's water transport system?
b | Name one tissue you would expect to find in all these organs.
- 8** Leaves lose water through small holes. How would you examine a leaf to find out whether more water is lost from its upper or under side? Plan an investigation.

I can ...

- identify and recall the main organs in the plant water transport system
- identify and recall the main organs in the human locomotor, digestive, circulatory, breathing, urinary and nervous systems.

7Ae TRANSPLANTS

WHAT IS AN ORGAN TRANSPLANT?

Doctors today know a lot about cells, tissues and organs. They also have microscopes and other tools to help investigate problems with our bodies.

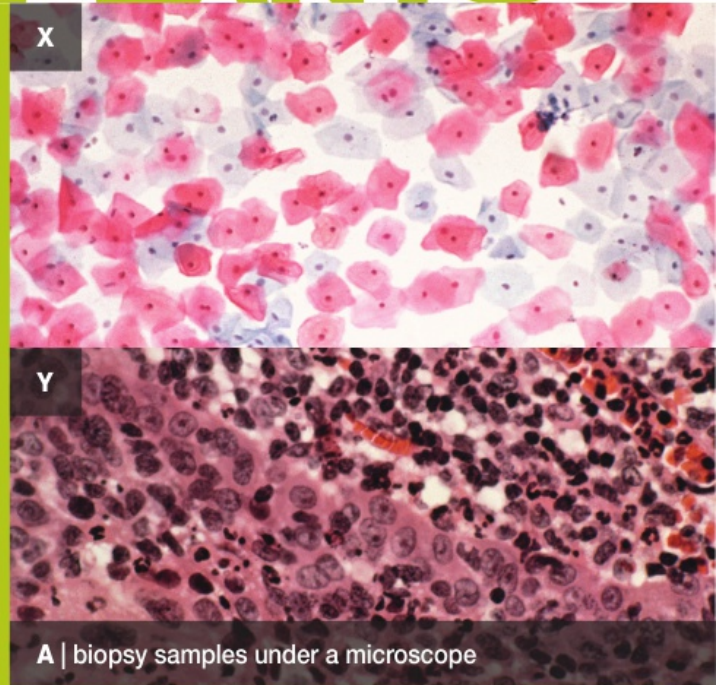
If a doctor thinks there is something wrong with an organ, a biopsy (piece of tissue) might be taken from the organ and examined. This can help to identify the problem and a doctor can plan a treatment.



B | This farmer was given a double arm transplant.

The idea of replacing damaged tissues and organs goes back at least 2700 years to an Indian doctor, called Sushruta. He successfully replaced skin on a part of someone's body using nearby skin from the same person. Today doctors can transplant hearts, lungs, livers, kidneys and even faces, arms and legs between different people.

- 1 a | Draw one cell from biopsy sample X. Label its parts and their functions.
b | In some cancer cells the nuclei become very large. Which biopsy sample (X or Y) shows cancerous tissue?
- 2 Draw a diagram to show how organ systems, organs, tissues and cells are linked. In your diagram use one example from plants and one from humans.



A | biopsy samples under a microscope

Sometimes an organ cannot be treated and doctors may consider doing an **organ transplant**. This is when an unhealthy organ is replaced with a healthy organ (usually from a person who has recently died).

donor card

NHS



NHS Organ Donor Register

C | Many people want their organs to be used for transplants if they die. They may carry a card to show this.

HAVE YOUR SAY

'People should carry cards only if they don't want to donate their organs – the opposite of donor cards.' What you do you think of this idea?

7Ba ESCAPED ZOO ANIMALS

There are reports of large cats, such as panthers and leopards, roaming wild in the UK. One idea is that these cats have escaped from zoos, which often keep rare animals such as large cats to breed them and for visitors to learn about them.

Most of the reports are unlikely to be true because people are mistaken about the sizes of the cats they see. However, there is a little **evidence** that big cats could be found in the UK. The Canadian lynx in photo B was shot in 1903 in Devon after attacking two dogs. This is the only big cat that has ever been found in the UK, dead or alive.

There is good evidence that other animals have escaped from zoos and live in the wild. In the 1970s, a pair of wallabies escaped from Curragh's Wildlife Park on the Isle of Man and now there are about 100 of them living on the island.



A | Is this a panther on Bodmin Moor?



B | This Canadian lynx was shot in 1903.

C | Wallabies are originally from Australia. This photo was taken on the Isle of Man.



- 1 Why are there now about 100 wallabies on the Isle of Man if only two escaped?
- 2 Why do you think there are not large numbers of Canadian lynx in Devon, even though one escaped?
- 3 What evidence supports the conclusion that there are wallabies on the Isle of Man?
- 4 Suggest why most sightings of large cats in the UK are probably cases of mistaken identity.
- 5 Wallabies and cats are both mammals. Suggest two ways in which you would expect their reproduction to be similar.

THE SCIENTIFIC METHOD

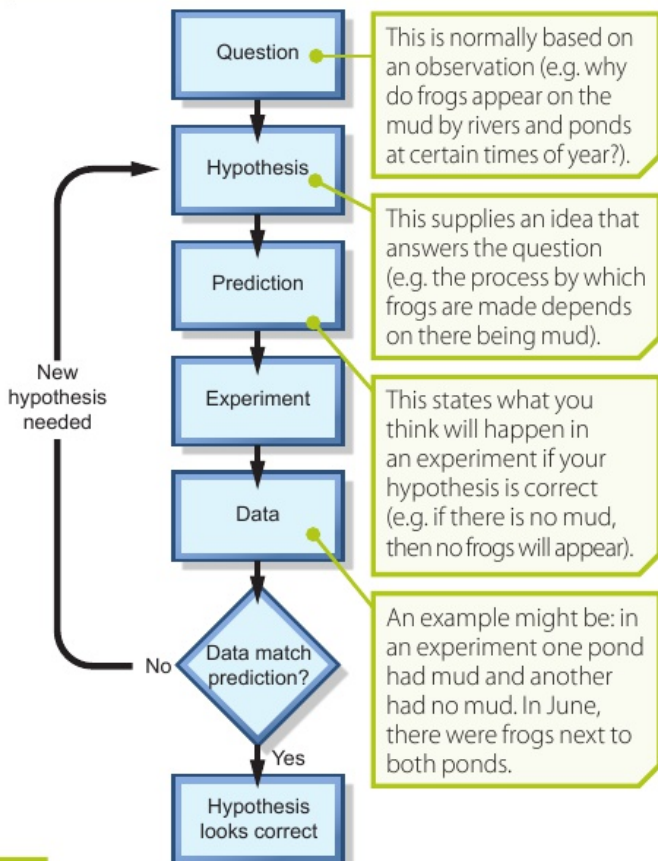
7Ba

A | Socorro doves hatched at Edinburgh Zoo. The birds became extinct in the wild in the 1970s.



- 1** What life process do organisms use to increase their numbers?
- 2** Suggest why people used to think that rotting rubbish produced rats.

B | a common way in which the scientific method is done



WHAT IS THE SCIENTIFIC METHOD AND WHY IS IT USEFUL?

All **organisms** must **reproduce** to increase their numbers and make sure that their type of organism does not die out (become **extinct**). Reproduction is obvious in some animals. Mammals (such as humans) give birth to babies and many other animals hatch from large eggs.

People did not always know how new animals were made! This was especially true for smaller animals whose reproduction could not be seen easily. For example, when some rivers flood in spring they leave areas of mud, which attract lots of frogs. So, people thought that frogs were produced by mud.

Until a few hundred years ago many people thought that rotting rubbish produced rats, that old fruit produced flies and that meat produced maggots.

FACT

This is a 17th-century recipe for mice: Place some sweaty underwear in a jar with some wheat. Wait 21 days. The sweat will turn the wheat into mice.

These sorts of ideas were not scientific. People observed maggots in old meat and so they thought that the meat produced maggots, but they did not test this idea. Today, scientists test their ideas using 'the **scientific method**'. The scientific method is any way of testing that involves collecting information in order to show whether an idea is right or wrong. Diagram B shows how it is often done.

First, you use an **observation** to think up a question that can be answered using experiments. Then you think of an idea to answer your question, which can be tested using experiments. This is called a **hypothesis**.

Next, you say what will happen in a certain experiment if the hypothesis is right. This is called 'making a **prediction**'. The results from an experiment are called **data**. If the data matches the prediction, this is evidence that the hypothesis is correct.

WORKING SCIENTIFICALLY

- 3** Look at diagram B.
- What is a hypothesis?
 - What prediction has been made?
 - Do the results match the prediction?
 - What would the scientist do next?

- 4** Decide whether each of these statements is a hypothesis, a prediction or a result.
- The seeds at the warmer temperature germinated first.
 - The ability of animals to reproduce depends on there being males and females.
 - If people lack vitamin C in their food, then they will get a disease called scurvy.

The following experiment tests the hypothesis that rotten banana peel produces flies.

Method

- Peel a brown banana and place half of the peel in each of two jars.
- Immediately place a piece of gauze over one jar and secure it with an elastic band.
- Stand the jars outside. Small flies will be able to enter the jar that has no gauze covering. After a few hours, cover that jar with gauze as you did for the first jar.
- Bring the jars inside and observe for 2 weeks.

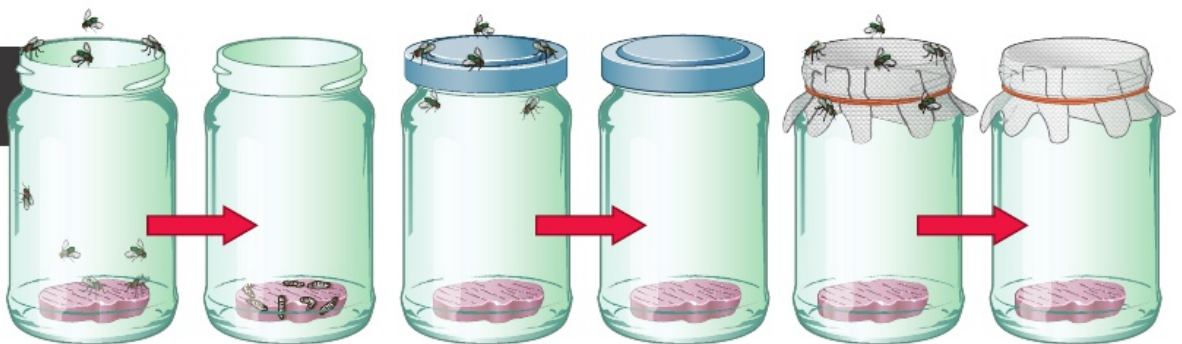


Redi's experiment

In 1668, the Italian scientist Francesco Redi (1626–1697) had an idea that maggots were caused by flies laying tiny eggs on meat. He tested this hypothesis by putting meat into a set of jars. He sealed some of the jars, put gauze over the tops of others and left others open. He put all the jars in an area where there were flies. Maggots were only found in the open jars. This was evidence that his hypothesis was correct.

- 5**
- In the experiment above, what question has been asked?
 - What hypothesis is being tested?
 - Make a prediction.

D | Redi's experiment



- 6**
- What was Redi's hypothesis?
 - Suggest a prediction that Redi might have made.
 - Explain how Redi's results provide evidence to support his hypothesis.

I can ...

- state the purpose of and the common steps in the scientific method.

7Ba ANIMAL SEXUAL REPRODUCTION

HOW DO DIFFERENT ANIMALS REPRODUCE SEXUALLY?

Endangered animals are those that are in danger of becoming extinct because there are very few left. Many zoos try to stop endangered animals becoming extinct by breeding the animals. It is hoped that the **offspring** can be released back into the wild.

Animals living in zoos do not always mate successfully and sometimes their offspring die for unknown reasons. So it is important that scientists study **sexual reproduction** in different animals to work out how to help them breed.

1 What are human 'offspring' called?



A | In 1945, there were only 31 Przewalski's horses left and only in zoos. Thanks to a breeding programme, there are now hundreds of Przewalski's horses living wild in their natural habitat in Mongolia.

FACT

Scientists from all over the world work together at the International Union for the Conservation of Nature and Natural Resources (IUCN) to publish a list of endangered organisms. It is called the 'Red List'. In 2013, there were 10 820 animals on this list.

B | a human egg cell (left) and a human sperm cell photographed using a light microscope (magnification $\times 600$)



Gametes

Sexual reproduction requires two individuals to produce new organisms of the same type. Usually, two types of **specialised** cells are used. These are called **sex cells** or **gametes**. Males make gametes called **sperm cells** and females make **egg cells**.

In a process called **fertilisation**, a sperm cell enters an egg cell and the two **nuclei** of the cells **fuse** (become one). A single **fertilised egg cell** is formed, which can grow into a new organism.

- 2 What type of reproduction needs males and females?
- 3
 - a| Which are bigger in real life, sperm cells or egg cells?
 - b| Calculate the actual sizes of sperm cells and egg cells.
- 4
 - a| In animals, what is the male gamete?
 - b| What happens to this cell during fertilisation?

For fertilisation to happen, the sperm cells must reach the egg cells. **External fertilisation** is when this happens outside the bodies of the animals (e.g. in fish). This usually occurs in water. Other animals use **internal fertilisation**, in which the male **parent** places sperm cells inside the female.

In external fertilisation, some egg cells do not get fertilised because the sperm cells are washed away. Many animals that use external fertilisation do not look after their fertilised egg cells, so a lot of cells are eaten by other animals. Animals that use external fertilisation must produce huge numbers of egg cells to ensure that some of them get fertilised and survive.

Birds and mammals use internal fertilisation. They produce fewer egg cells because sperm cells are more likely to reach the egg cells. These animals also usually look after their fertilised egg cells and offspring. Birds lay their fertilised eggs in nests and protect them. In mammals, the offspring grow inside the mother. Birds and mammals look after their new offspring until they are able to survive on their own.



C | These snapper fish use external fertilisation. The male and female fish swim together and release their gametes.

- 5**
- a| Name an animal that uses external fertilisation.
 - b| Give two reasons why the females of the animal you chose produce many egg cells.



D | Black rhinoceroses, which are hunted for their horns, use internal fertilisation. The offspring develop inside the mother (internally).

E | Birds, like this stone curlew, use internal fertilisation but their offspring develop outside the mother (externally). Numbers of stone curlews in the UK have fallen by over 80 per cent since 1940.



- 6**
- a| Name an animal that uses internal fertilisation.
 - b| Give two reasons why the females of the animal you chose produce only a few egg cells.
- 7** Why is external fertilisation unusual for animals that live away from water?
- 8** A female mouthbrooder fish sucks her fertilised eggs into her mouth, where they hatch. Would you expect mouthbrooder females to produce more or fewer egg cells than other fish of the same size? Explain your reasoning.

FACT

Most animals that use **internal fertilisation** need to get very close to each other. Not so for the paper nautilus. This sea creature (related to squid) detaches its penis, which then swims off by itself to attach to a female.

I can ...

- describe how egg cells are fertilised in animal sexual reproduction
- compare fertilisation and offspring care in fish, birds and mammals.

7Bb REPRODUCTIVE ORGANS

WHAT ARE HUMAN REPRODUCTIVE ORGANS LIKE?

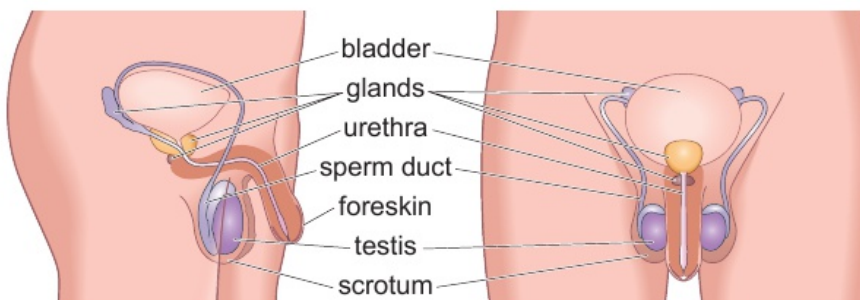
The **reproductive organs** produce gametes (sex cells). They form an organ system called the **reproductive system**.

In some countries, reproductive organs from certain animals are used in traditional **medicines**. The medicines are supposed to help humans have babies but there is no evidence that they work. Killing animals for medicines has helped to make some of them endangered.

Sperm cells are made in the **testes**. The testes hang outside the body in a bag of skin called the **scrotum**. Their position helps to keep the sperm cells at the correct temperature to develop properly. After **puberty**, males produce sperm cells for the rest of their lives.



A | Tigers are endangered. Tiger penis is used in some traditional medicines.

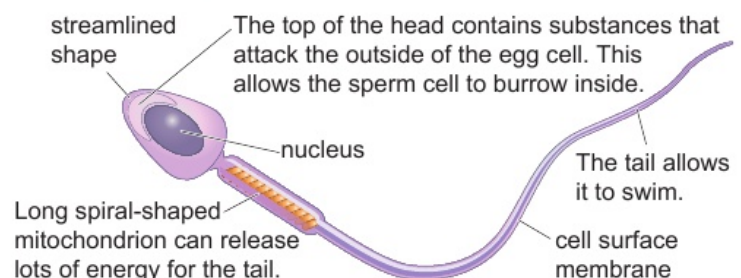


B | the male reproductive system

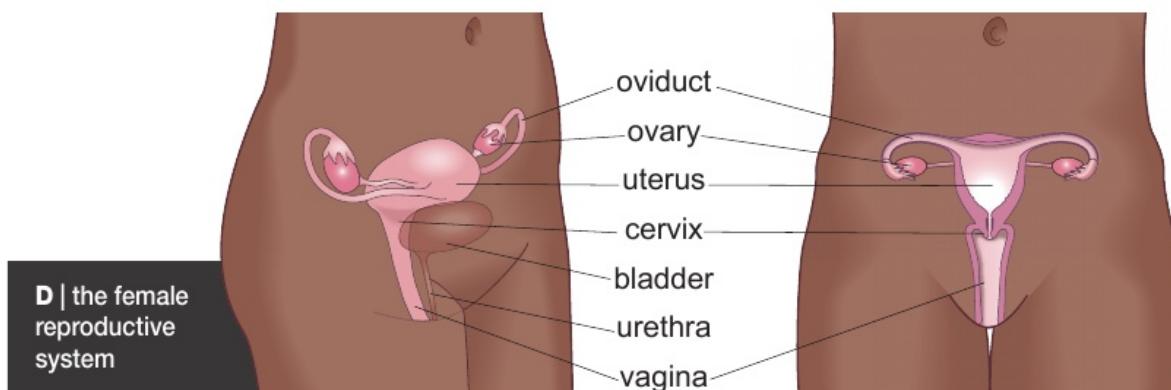
When sperm cells are released from the testes, they travel through **sperm ducts**, where fluids are added from **glands**. The fluids provide a source of **energy** for the sperm cells. The mixture of sperm cells and fluids is called **semen**, which leaves the body through the **urethra**. This tube also carries urine from the **bladder**, but never at the same time as semen.

- 1** Which organ in diagram B is in both the urinary *and* the reproductive systems?
- 2** a| Where are sperm cells made?
b| Do you think sperm cells need to be warmer or cooler than the body to develop? Explain your reasoning.
- 3** Explain how a sperm cell is adapted for swimming.
- 4** The prostate gland (in yellow on diagram B) can sometimes swell up. Suggest a problem that this might cause and explain your reasoning.

The head of the penis is sensitive and is protected by a covering of skin (the **foreskin**). This is sometimes removed, for religious reasons or because it is too tight, in a process called **circumcision**.



C | A sperm cell has certain features to help it do its job. It is **adapted** to its **function**. Adult men produce up to 100 million sperm cells every day.



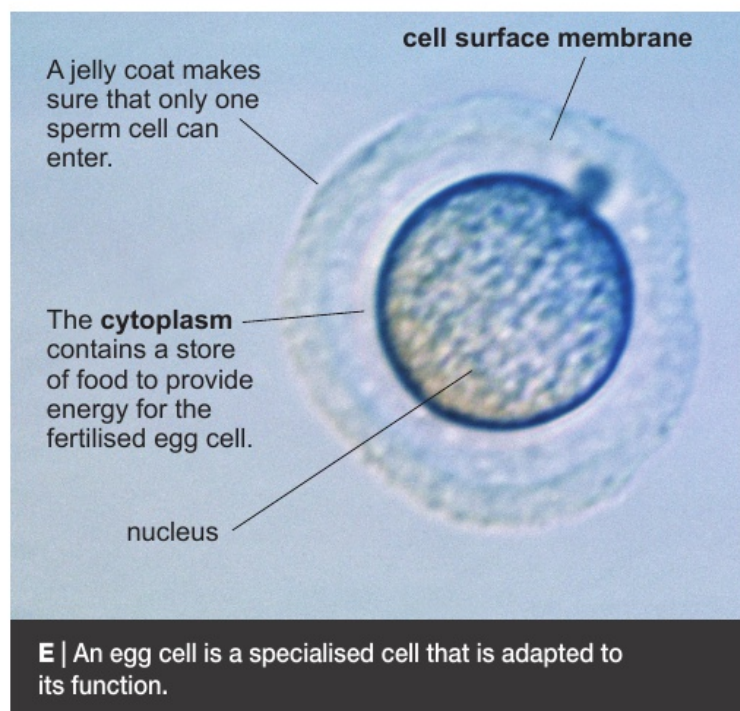
In females, each **ovary** contains small, undeveloped egg cells. After puberty, egg cells start to develop and one is usually released from an ovary every 28–32 days. A woman's ovaries stop releasing egg cells at about the age of 45–55 years – a time known as the **menopause**.

After leaving an ovary, an egg cell enters an **oviduct** (or **Fallopian tube**). The oviducts are lined with hairs, called **cilia**, and these sweep egg cells towards the **uterus**. The uterus is where a baby will develop. It has strong, muscular walls and a soft lining.

The lower end of the uterus is made of a ring of muscle called the **cervix**. The cervix holds the baby in place during pregnancy. The cervix opens into the **vagina**.

- 7** Which female reproductive organs contain muscles?
- 8** How does an egg cell reach the uterus?
- 9** Explain how a developing fertilised egg cell has a supply of energy.
- 10** Anne's ovaries are not releasing egg cells. Why not? Think of as many reasons as you can.

- 5** A woman releases an egg cell every 28 days for 35 years. How many egg cells does she release in total? Show your working.
- 6** Which organ makes and releases female gametes?



FACT

Girls are born with about 100 000 undeveloped egg cells in each ovary.

I can ...

- name the parts of the male and female reproductive systems, and their jobs
- explain how sperm and egg cells are adapted to their functions
- state what happens at the menopause.

7Bc BECOMING PREGNANT

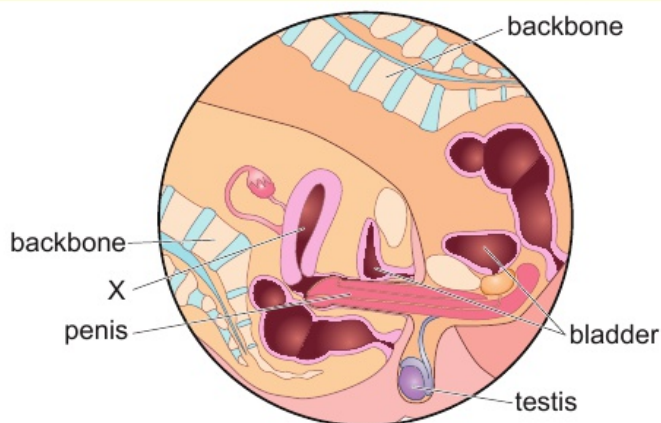
HOW DOES SEXUAL INTERCOURSE LEAD TO A GROWING FOETUS?

In animals that use internal fertilisation, the male must place sperm cells inside the female. Male mammals have penises for this purpose.

As a couple prepare for **sexual intercourse** (or sex), the woman's vagina becomes moist and the man's penis fills with blood, making it stiff (an **erection**). During sex, the penis is inserted into the vagina and the man moves it backwards and forwards. This stimulates the penis to pump semen out into the top of the vagina. This is **ejaculation**.

1 Look at diagram A. Suggest the name of the part labelled X.

2 What is semen?

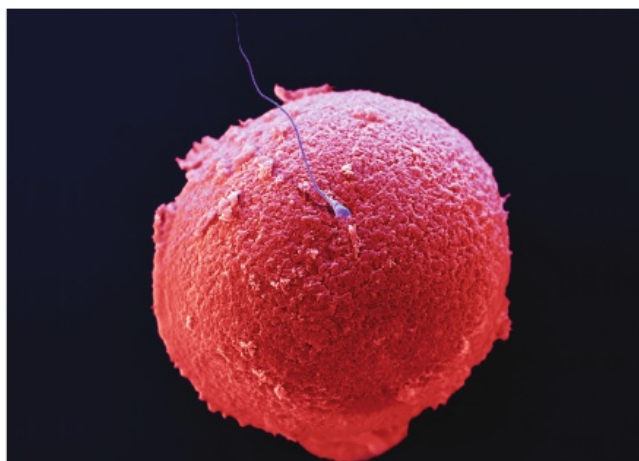


A | sexual intercourse

The semen is sucked up through the cervix. Small movements of the uterus wall carry it to the oviducts. From here the sperm cells swim along the oviducts. If a sperm cell meets an egg cell, the sperm cell can burrow into the egg cell and fertilise it. During fertilisation, the nuclei of the cells fuse. Each nucleus contains half the instructions for a new human and so the baby will have features from both its mother and its father.

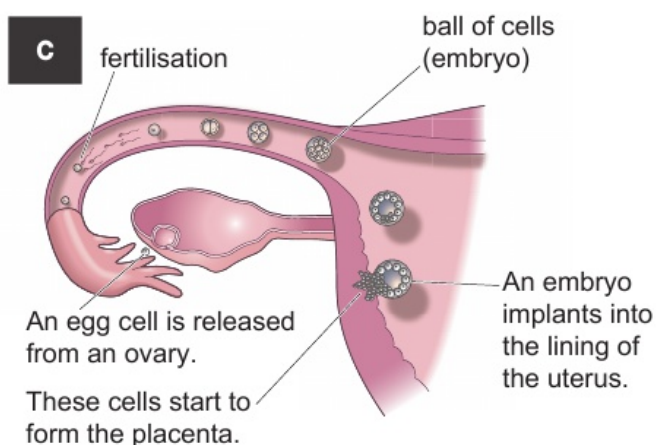
3 Where does fertilisation occur?

4 How is a sperm cell adapted to get into an egg cell? (Hint: Look back at page 28.)



B | a human sperm cell burrowing into an egg cell (magnification $\times 500$)

The fertilised egg cell divides into two. Each of these cells then divides into two again. The cells carry on dividing and form a ball of cells as they travel towards the uterus. In the uterus, the ball of cells (called an **embryo**) sinks into the soft lining. This is called **implantation**. The woman is now **pregnant**.





D | triplets (three children born at the same time)

Pregnancy

After implantation, the embryo continues to grow and becomes surrounded by watery **amniotic fluid**, to protect it. The fluid is contained within a bag called the **amnion**.

A **placenta** also grows. This is a plate-shaped organ that is attached to the uterus lining. Inside the placenta, **oxygen**, water and food from the mother's blood go into the embryo's blood. Waste materials (like **carbon dioxide**) go from the embryo's blood into the mother's blood. The **umbilical cord** carries the embryo's blood to and from the placenta.

The mother's blood does not mix with the embryo's blood. This is because the mother's blood is pumped around her body under a lot of **pressure**, which would damage the **blood vessels** of the delicate embryo.

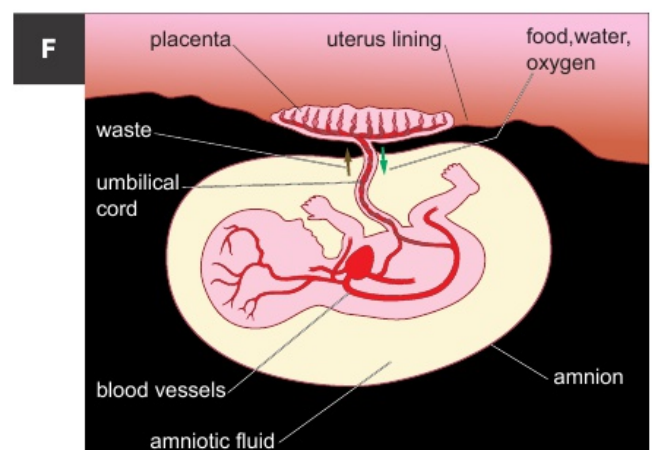
- 7** a| List three substances the embryo needs to grow.
b| Name one substance the embryo excretes.
- 8** Is the placenta made by the embryo or the mother?
- 9** What is the function of:
a| the placenta b| the umbilical cord
c| amniotic fluid?
- 10** As an embryo grows, its cells become specialised. Suggest one type of specialised cell that would be in the embryo in photo E and one type that would not.

Each of a woman's ovaries might release an egg at the same time. If both are fertilised, twins are produced. These twins will not be identical. Sometimes, when a fertilised egg cell divides in two, the two new cells get separated. Both of these cells can grow into embryos and produce identical twins. Having more than one baby is called a multiple birth and most types of animal have multiple births.

- 5** In diagram C, the 'ball of cells' is the result of cells dividing a total of four times. How many cells does it contain? Explain your reasoning.
- 6** a| Which children in photo D are identical?
b| Explain what happened in the mother's body to produce these triplets.



E | This is a 7-week-old embryo. By this stage it has a tiny heart, pumping blood. It is about 2.3 cm long, with a mass of about 2 g.



I can ...

- describe how sexual intercourse can lead to the implantation of an embryo
- describe how an embryo is protected and cared for in the uterus.

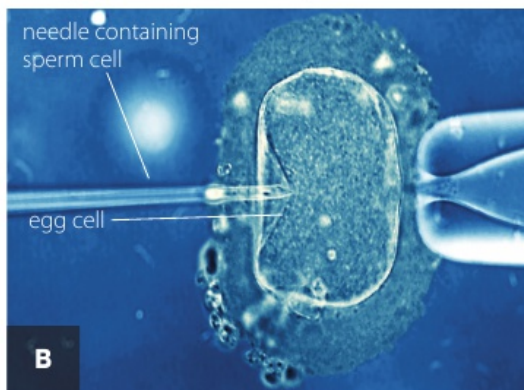
7Bc MAKING NOTES

WHAT WAYS CAN YOU USE TO MAKE NOTES?

For internal development, when offspring develop inside the mother, a complex reproductive system is needed. Various problems can make reproduction difficult.

If a woman's oviducts are damaged or too narrow, then the movement of sperm or egg cells may be stopped. Similarly, the effect of a man's sperm ducts being blocked is that sperm cells can't leave his body. One solution is for doctors to try to widen the oviducts or sperm ducts but this does not always work. Another common answer is **IVF** (in vitro fertilisation), although this treatment can cost many thousands of pounds.

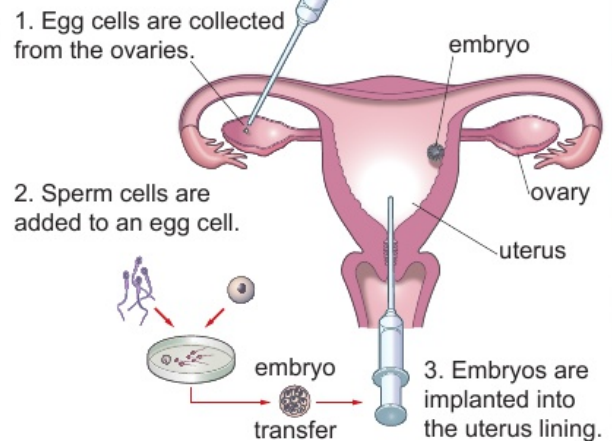
IVF is when egg cells are fertilised in a dish, outside the body. Egg cells can be collected from a woman's ovaries after giving her a medicine to make her produce many egg cells all at once. This can, however, be an uncomfortable experience. In the same way, sperm cells can be taken from a man's testes (if his sperm ducts are blocked). The gametes are put together in a dish and the fertilised egg cells are then implanted in the woman's uterus. Babies born using IVF are often called **test-tube babies**, the first being Louise Brown (born in Oldham in 1978).



Some endangered animals do not breed in zoos, for reasons that are not understood, and so IVF can be very useful. It is also useful when rare animals are in zoos that are a long way apart. It is easier to transport gametes than it is to transport live animals. Sometimes, animals are so rare that it is unlikely that a male and female could be brought together at the same time. Scientists can now freeze the sperm cells and egg cells from these animals and create embryos when the time is right.

In February 2012, Crystal, an endangered African black-footed cat, was born at Audubon Zoo in the USA. Her father's sperm cells had been frozen in 2003 and were used to fertilise egg cells in 2005. The embryos were then frozen until scientists had developed a way to allow the embryos to be implanted and develop in a domestic cat.

A | IVF



Another problem in women is the uterus lining stopping implantation. Again, IVF can be the answer. IVF is also used to help when ovaries do not release many egg cells. There is a similar problem in men when very few sperm cells are made (a low **sperm count**). The solution is to inject a sperm cell into an egg cell using a fine needle. This technique also overcomes the problem of sperm cells that do not swim well.



C | Crystal and her **surrogate mother** are not the same species.

LITERACY & COMMUNICATION

You often need to make notes from long texts, such as on the previous page, or many different sources of information. Start by thinking about what your notes are for:

- writing a summary (see pages 144–145)
- comparing things (e.g. similarities and differences, points for and against)
- showing problems and their solutions
- showing how one thing (a cause) leads to another (an effect) (e.g. when you think up a hypothesis or make a prediction)
- listing information.

Choose a suitable way to organise your notes – for example, a table, flow diagram or concept map.

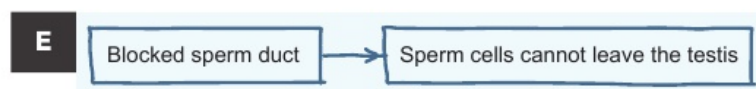
Texts often contain 'signal' words and phrases that make it easier for the reader to understand the information. Look out for these when you read a text. For example, when ideas are compared, typical signal words and phrases are: alternatively, although, as well as, but, however, in contrast to, in the same way, on the other hand, similar to, similarly...

Words and phrases that signal problems and solutions include: difficulty, problem, solution, question, answer, to overcome this...

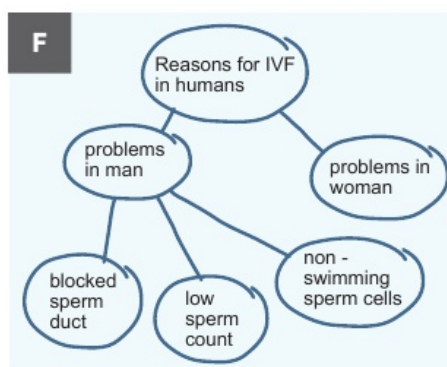
Making notes in a table can be a good way of comparing information or highlighting problems and solutions.

Some texts show causes and their effects. Look out for signal words and phrases like these: as a result of, because, caused by, depends on, due to, if ... then ..., leads to, so that, the effect of ... is that ..., therefore, which in turn...

Making notes in a flow diagram is useful for matching causes and effects.



If you want to list information, try using a concept map. This allows you to see all the items so you can think about the final order of your list. Lists in a text often start with: such as, for example...



1 What is a surrogate mother?

Similar problems in men + women	Different problems in men + women
tubes get blocked	uterus lining stops implantation

2 Copy table D and complete it.

3 From the text on the previous page make notes on the following, using a different way of organising your notes for each one.

- A| Male reproductive system problems and their solutions.
- B| Female reproductive system problems and their effects.
- C| Reasons why IVF is used to breed endangered animals.

I can ...

- make effective notes from texts.

7Bd **GESTATION AND BIRTH**

WHAT HAPPENS DURING THE GESTATION PERIOD AND BIRTH?

The **gestation period** is the time from fertilisation until birth. It lasts about 9 months (40 weeks) in humans. The gestation period is very long in some animals, which can make breeding them in zoos difficult.

Once an embryo has developed a full set of **organs** it is called a **foetus** (pronounced 'fee-tus'). This takes about 8 weeks in humans.

FACT

The endangered black rhino has a gestation period of 16 months.

A | An average 12-week-old foetus is 8.7 cm in length.



A pregnant woman needs a healthy diet since she provides the growing and developing foetus with food, including vitamins and minerals. She should also exercise to keep her muscles strong and her **circulatory system** working well.

Most pregnant women go for **ultrasound scans**, which produce **images** of the foetus. Doctors use scans to work out the stage the baby is at and to check for problems.

- 3 a) A scan shows a foetus is 7 cm long. What can you say about its age? Explain your reasoning.
b) Suggest two advantages of having ultrasound scans during pregnancy.

Alcohol, **drugs**, chemicals from cigarette smoke and some viruses can go through the placenta and harm the foetus.

- 1 About how long does a human spend as a foetus?
2 a) What are the parts labelled X and Y on photo A?
b) Explain the importance of these parts for the developing foetus.



B | Ultrasound scanners usually produce grainy black and white images but some can produce 3D images (such as photo A).

FACT

In the 1950s, a drug called **thalidomide** was given to pregnant women to help them stop feeling sick. It caused many babies to be born with very short arms and legs.

Too much alcohol and some illegal drugs (such as **heroin**) can damage a foetus's **brain**. Doctors also need to be careful about what medicines they give to pregnant women.

The blood of a woman who smokes carries less oxygen than it should, which means that the foetus may not get enough oxygen. A foetus like this is more likely to be **premature** (born small and early).

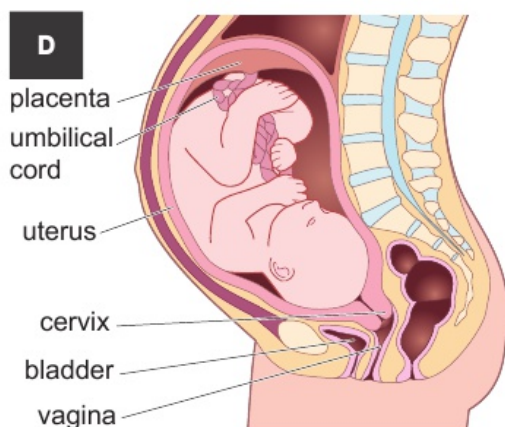
Viruses are tiny microorganisms that can cause diseases. The virus that causes rubella can cause a foetus to become deformed. Girls should be vaccinated against rubella.

4 Describe how a foetus can be harmed by smoking.



C | Premature babies often need help to breathe and keep warm.

Birth



When a baby is ready to be born, the uterus begins to contract (squeeze). This is the start of **labour**. The **contractions** start gently but become more powerful and more frequent. The muscles of the cervix then slowly relax, making it wider. At some stage, the amnion breaks and the amniotic fluid flows out of the vagina.

Once the cervix is about 10 cm wide, the strong contractions of the uterus push the baby through it, usually head first. This is painful and the woman may be given medicine to ease the pain.

When the baby is out, its umbilical cord is cut, leaving a short stump. This falls off after about a week and leaves a scar called the **navel** (or 'belly button').



E | People often train to deliver babies using life-like simulators.



Within 30 minutes after birth, the placenta detaches and passes out through the vagina. This is called the **afterbirth** and marks the end of labour.

A new baby is fed on milk from **mammary glands** in the breasts. This contains nutrients to give the baby energy and help it grow. It also contains **antibodies** – substances that help to prevent diseases caused by microorganisms. After a few months the baby can start eating semi-solid food.

- 5** List the main stages of labour.
- 6** Write a caption for photo F.
- 7** Why does the cervix need to open after contractions start?
- 8** Explain the actions that a woman can take to care for her foetus. Make notes, perhaps using a table of actions and reasons, before writing a paragraph.

I can ...

- explain how a pregnant woman should care for her foetus
- recall the stages of birth and how a newborn baby is looked after.

7Be GROWING UP

WHAT HAPPENS DURING PUBERTY AND ADOLESCENCE?

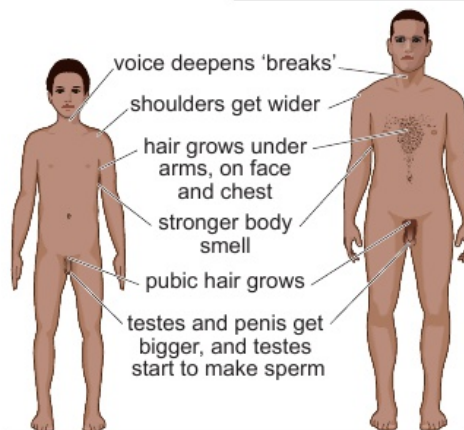
A newborn animal needs to grow and go through puberty before it can reproduce. During puberty, big changes happen in its body, including fast growth and development of the reproductive system.

Puberty in humans usually starts between the ages of 10 and 15 years, with girls often starting before boys. During puberty, the testes begin making sperm cells and the ovaries begin releasing egg cells. Puberty is usually finished by the age of 18.

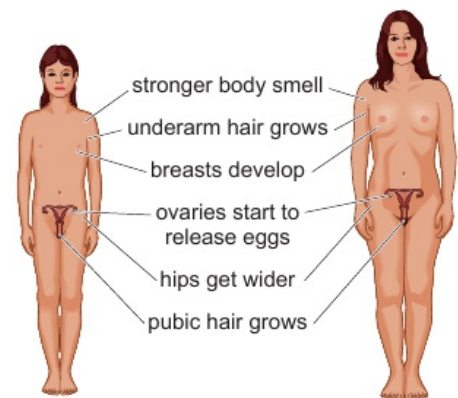
Puberty is started by **sex hormones**, which are substances released by the brain, ovaries and testes. Sex hormones also cause spots (**acne**) and emotional changes, including boys and girls becoming more interested in each other. The time when all these emotional and physical changes occur is called **adolescence**.



A | Obvious changes happen to male mandrills during puberty, starting when they are about 6 years old and ending when they are about 9.



B | changes in boys during puberty

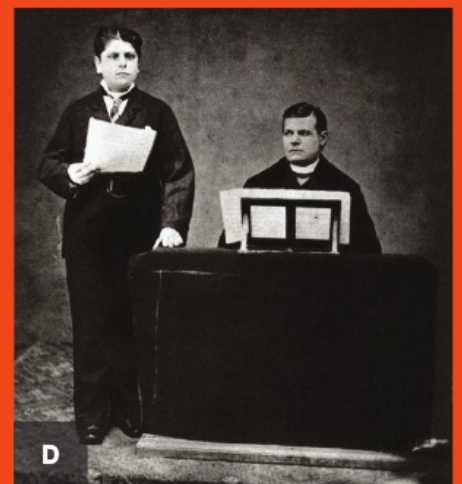


C | changes in girls during puberty

- 1** a) What is puberty?
b) What chemicals control puberty?
c) Where are these chemicals produced in girls?
- 2** What is adolescence?
- 3** Suggest three ways in which the changes during puberty are similar for boys and girls.
- 4** Describe the changes that happen to a male mandrill during puberty.
- 5** Imagine you write a magazine advice column. Somebody asks why they have suddenly got acne. Write a response.

FACT

Until the mid-19th century, choirboys sometimes had their testes cut off (castration) before reaching puberty. This stopped their voices 'breaking' and they grew up to be singers called **castrati**. The last one was Alessandro Moreschi (1858–1922).



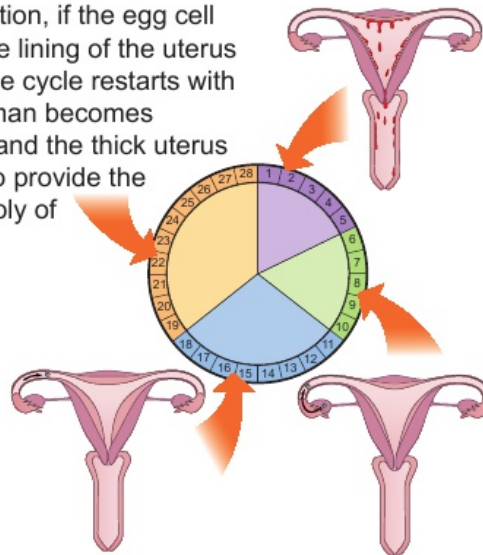
The menstrual cycle

The **menstrual cycle** is a series of events that occur in the female reproductive system. It starts soon after puberty begins and stops at the menopause. Each cycle takes about 28 days and is controlled by sex hormones.

E

About 14 days after ovulation, if the egg cell has not been fertilised, the lining of the uterus breaks apart again and the cycle restarts with another period. If the woman becomes pregnant the cycle stops and the thick uterus lining continues to grow to provide the placenta with a good supply of nutrients and oxygen.

The egg cell is swept along the oviduct towards the uterus. If it meets a sperm cell it can be fertilised. The lining of the uterus helps to support, feed and protect an embryo, so it is replaced every cycle with fresh material to make sure it is in as good a condition as possible. It continues to thicken for about a week after ovulation.



Menstruation ('having a period') is when the soft lining of the uterus breaks apart. It passes out of the vagina along with a little blood and an unfertilised egg cell. A period usually lasts for 3–7 days.

Immediately after menstruation, an egg cell starts to mature in one of the ovaries. While this happens, the lining of the uterus starts to build up again, and to develop a network of blood vessels. About 14 days after the cycle has started, the egg cell is released. This is **ovulation**.

- 6 How long does one complete menstrual cycle usually take?
- 7 Describe what happens about 14 days after menstruation starts.
- 8 How might a woman tell that she is pregnant?
- 9 Why does the lining of the uterus have to become thick?

Periods usually occur once every 28–32 days, but this can vary a lot, especially when periods first start. Sanitary towels or tampons are used to absorb the blood.

Life cycles

The changes in an organism from birth until it can have offspring are called its **life cycle**. Humans have a long life cycle – it takes a long time for offspring to be able to reproduce. Mice have short life cycles – baby mice can reproduce in 5 weeks.

10

Draw out a human life cycle. Label it with information about what happens at the different stages.

I can ...

- describe and explain what happens during adolescence
- describe and explain what happens in the menstrual cycle.



F | sanitary products

7Be THE WORK OF ZOOS

HOW CAN STUDYING REPRODUCTION HELP ENDANGERED SPECIES?

Animals with short life cycles often produce many offspring, which are quickly able to reproduce. This can make it reasonably easy to breed these animals in captivity.

On the other hand, animals with long life cycles can be difficult to save from extinction because they take so long to reproduce and only produce small numbers of offspring. For example, a female Sumatran rhinoceros takes 7 years to become sexually mature. She has one calf at a time with a gestation period of 16 months.

Scientists in zoos try to help endangered animals like the Sumatran rhinoceros reproduce. They care for the animals and their offspring, and help them reproduce successfully by using technology that has been developed for humans.



A | The Panamanian golden frog was last seen in the wild in 2007. A successful breeding programme has produced nearly 2000 of them.



B | There may only be 150 Sumatran rhinoceroses left.

It does not always go to plan. In the 1980s and 1990s, 40 Sumatran rhinoceroses were captured and sent to zoos. By 1997, 36 had died and no live calves had been born. The difficulty was that zoos did not know enough about their diet or reproduction. A solution was found in 2000 and the first calf was born in the USA in 2001, helped by sex hormone treatments. Since then another three calves have been born in captivity.

- 1** Explain why many frogs produce a lot of offspring.
- 2** What is meant by 'gestation period'?
- 3** Suggest one technology developed for humans that is used to help endangered animals breed. Explain how this technology helps.
- 4** Draw a life cycle for the Sumatran rhinoceros. Label it with as much detail as you can.

HAVE YOUR SAY

Some people think we should get rid of zoos and only try to stop animals becoming extinct by protecting the areas in which they live. What do you think of this idea?

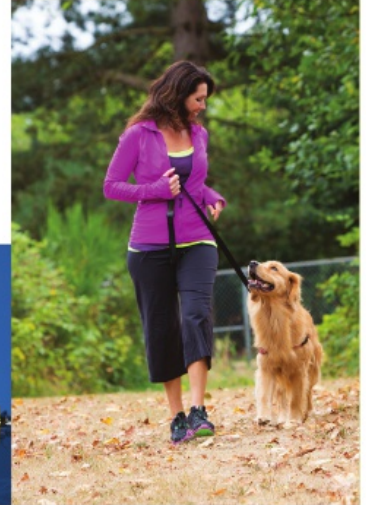
7Ca FITNESS

Being 'fit' means that your body is able to do the activities that your lifestyle demands. This includes things like being able to run upstairs without getting out of breath or being strong enough to lift things.

Fitness therefore means different things to different people, but we can think of fitness being made up of four S-factors: 'suppleness', 'strength', 'speed' and 'stamina'. A gymnast needs to be supple to bend and twist easily, a weight-lifter needs to have strength, a sprinter needs speed, and a long-distance runner needs to be able to keep going for a long time (stamina).

Just being able to do everyday things does not give you any idea of *how* fit you are. Scientists use **criteria** (standards) to work out how fit someone is. For example, how far you can run could be used as a criterion to judge fitness.

People exercise to develop different S-factors and keep their **organs** and **organ systems** working properly.



A | All these people are fit.

windpipe (trachea)

lungs get oxygen into the blood for respiration and excrete carbon dioxide

heart pumps blood

diaphragm helps breathing

liver makes and stores some substances, and destroys other substances

kidneys (one on each side) clean the blood and produce urine to excrete wastes

bladder stores urine

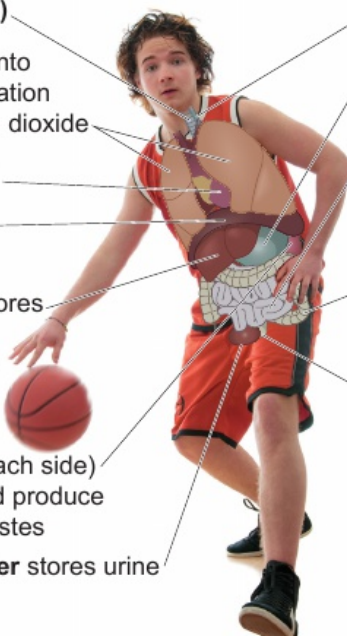
foodpipe (gullet)

stomach breaks up food

small intestine breaks up food and absorbs it to produce nutrition for the body

large intestine removes water from unwanted food

rectum stores faeces (waste materials excreted by the liver and unwanted food)



- 1 Look at the photos above. For each activity write down which S-factor you think is the most important. Explain your reasoning in each case.
- 2 Arrange this list in order of size, starting with the smallest: cell, organ, organ system, tissue.
- 3 The breathing (or gas exchange) system is important for athletes. Name three parts of this system.
- 4 What organ system do each of the organs in photo B belong to? Use a table to show your answers.
- 5 A long-distance runner is training to increase her stamina. Suggest a criterion she could use to judge whether her training programme is working.

B | Working out helps to keep many different organs working properly.

7Ca MUSCLES AND BREATHING

HOW DO MUSCLES HELP WITH GAS EXCHANGE?

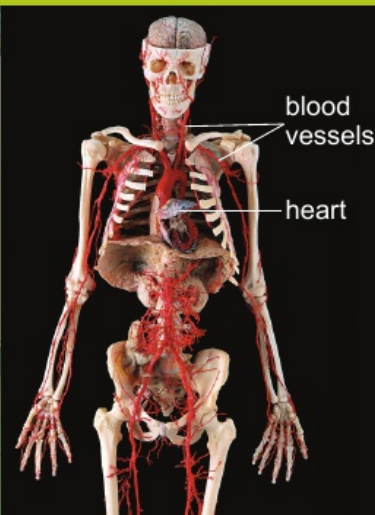
About one-fifth or 20 per cent of the air is **oxygen**. The athlete in photo A is **breathing** 100 per cent oxygen. The idea is that this makes sure all his **cells** get all the oxygen they need, to help him recover quickly from an injury.

You need oxygen for your cells to respire and release **energy**. Energy is needed for everything your body does. Cells get the oxygen they need from your blood. Oxygen enters your blood in your lungs.

Respiration in cells produces **carbon dioxide** gas, which enters your blood. In your lungs, a lot of carbon dioxide leaves your blood and is removed from your body when you breathe out. The carbon dioxide is **excreted**.



A | 'Oxygen therapy' is becoming popular for injured athletes.



B | Your **circulatory system** carries blood around your body.

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FACT

There is a lot of tubing in the lungs. There are about 2400 km of tubes carrying air and another 1600 km of tubes carrying blood!

The gas exchange system

In your lungs, oxygen goes into the blood and carbon dioxide leaves the blood. One gas is exchanged for the other and so this is called **gas exchange**. The organs that help with gas exchange form the **breathing** or **gas exchange system**.

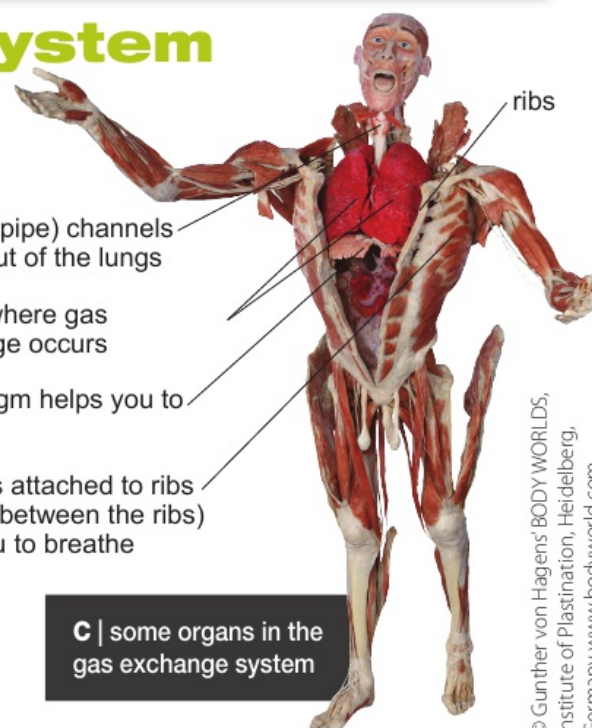
- 1** What does your body need oxygen for?
- 2** List two organs in the circulatory system.
- 3**
 - a) List two gases that are carried around your body.
 - b) How are these gases carried?
 - c) What happens to each of these gases in the lungs?

trachea (windpipe) channels air into and out of the lungs

lungs, where gas exchange occurs

diaphragm helps you to breathe

muscles attached to ribs (mostly between the ribs) help you to breathe



C | some organs in the gas exchange system

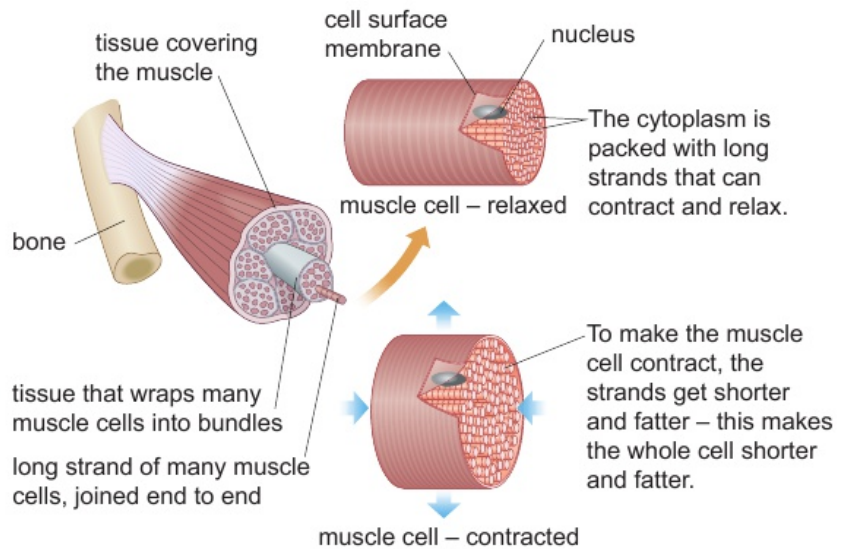
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Breathing

Breathing is when muscles between the ribs and in the diaphragm change the size of the lungs. Muscles contain different types of **tissue**, including nerve tissue and **muscle tissue**. Muscle tissue is made of muscle cells, which can change shape.

A muscle cell can get short and fat. When it does this, we say that it **contracts**. When it goes back to its original shape and size, it **relaxes**.

Cells in a tissue all work together. So, all the muscle cells in muscle tissue contract and relax together, which means that the whole muscle contracts and relaxes.

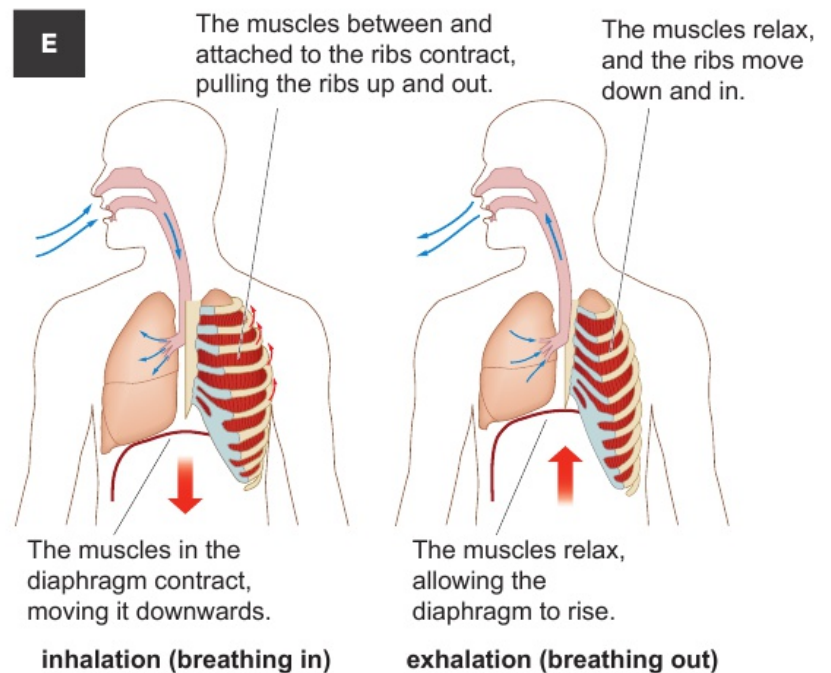


D | Muscle cells are **adapted** to their **function** – they can change shape. These muscle cells are not branched (unlike those in the heart).

- 4 Why is a muscle an organ?
- 5 a | What is the function of muscle cells?
b | How are muscle cells adapted to their function?

When the muscles attached to your ribs contract, they pull the ribs outwards and upwards. When the muscles in your diaphragm contract, the diaphragm moves downwards and flattens out. Both these actions happen together and allow your lungs to increase in size. As they increase in size, air flows into them – you **inhale**.

When the rib and diaphragm muscles relax, the opposite happens. Air flows out of your lungs – you **exhale**. The movement of air into and out of your lungs is called **ventilation**. The number of times you inhale and exhale in one minute is your **breathing rate**.



- 6 Gavin breathes in and out seven times in 30 seconds. What is his breathing rate?
- 7 Guillain-Barré syndrome is a disease in which muscles become weak.
 - a | Explain why someone with this disease may find it difficult to breathe.
 - b | Explain why people with this disease may not get enough oxygen in their blood.
 - c | Suggest how a person with this condition might be helped.
- 8 The gas exchange system is also called the breathing, respiratory or ventilation system. Which of these terms do you think is the least good? Explain your reasoning.

I can ...

- describe how muscles in the gas exchange system allow ventilation
- describe what happens during gas exchange in the lungs.

7Cb MUSCLES AND BLOOD

HOW DO MUSCLES HELP WITH THE CIRCULATION OF BLOOD CELLS?

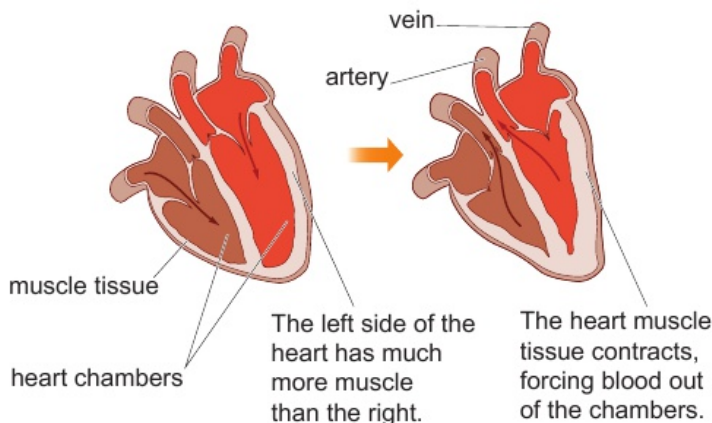
Sports scientists use machines to measure how well an athlete's body copes with exercise. The machines record things like breathing rate and **pulse rate**. The **data** helps the scientists to see if training programmes are working.

Each time your heart pumps blood, it causes a **pulse** that you can feel in places like your wrist. Your pulse rate is the number of pulse beats you can feel in a minute.

Inside the heart there are **chambers** that fill with blood. When the chambers are full, the muscle tissue in the wall of the heart contracts. This makes the chambers smaller, pumping the blood out of them.



A | a sports scientist at work



B | Muscle tissue in the heart contracts to push blood through the heart and into blood vessels called arteries.

- 1 Suggest two measurements that are being taken from the athlete in photo A.
- 2 a| What is a pulse caused by?
b| Hattie counts 16 pulses in her wrist in 15 seconds. What is her pulse rate?
- 3 After blood has left the heart, what must the muscle tissue do so that the chambers can fill with blood again?

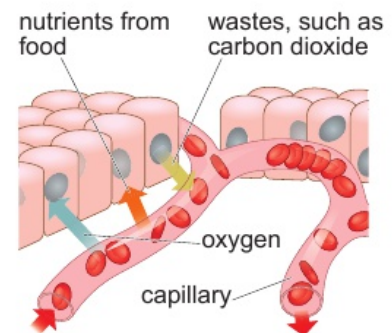
FACT

Fitter people have lower pulse rates than unfit people when resting. Most people have a pulse rate of 60–100 beats per minute. Athletes' pulse rates are often below 50 beats per minute.

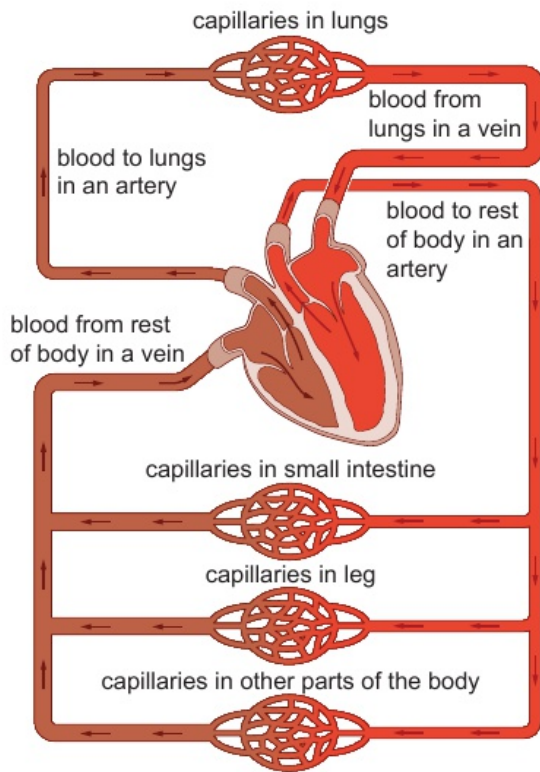
Blood vessels

The blood that is pumped out of the heart enters **blood vessels** called **arteries**. Arteries lead into tiny blood vessels called **capillaries**. Capillaries have very thin walls so that nutrients (from food) and oxygen can leave the blood and get to the cells in all the tissues in the body. Cells use these substances for respiration and to produce new materials for growth and repair.

The blood also picks up waste materials from cells as it travels through capillaries. It then flows into **veins**, which are wider tubes carrying blood back to the heart.



C | Substances can move into and out of capillaries.



D | There are many branches in the circulatory system but only a few are shown in this model. The bright red blood is carrying more oxygen than the dark red blood.

Red blood cells are made inside your bones, in a tissue called **bone marrow**. Blood contains other cells too. **White blood cells**, which are used to fight infections and keep you healthy, are also made in bone marrow.

FACT

A red blood cell only lasts for about 120 days. We need so many of them that an adult produces about 200 000 000 000 (200 billion) red blood cells every day.

- 4** Name one waste produced by cells.
- 5** a | What are the functions of arteries, capillaries and veins?
b | How are capillaries adapted to their function?
- 6** Look carefully at diagrams B and D. Suggest why the left-hand side of the heart has more muscle tissue.
- 7** Why are bones and the blood considered to be organs?
- 8** Suggest why bone marrow has many capillaries in it.
- 9** a | List three main parts of the blood.
b | What does each part do?
c | Where are blood cells made?
d | How are red blood cells adapted to their function?

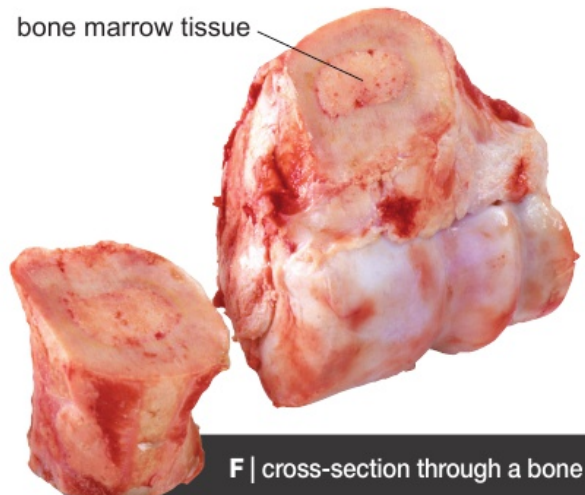
Blood

Blood is mainly a liquid called **plasma**. Nutrients and waste materials are carried by blood dissolved in the plasma.

Oxygen is carried in cells called **red blood cells**. These cells lack **nuclei**, which allows the **cytoplasm** to be packed full of a substance called **haemoglobin** (*hee-mow-glow-bin*). The haemoglobin carries the oxygen. The cells have a curved disc shape, which gives them a large **surface area**. This means that oxygen can quickly get into and out of the cells.



E | red blood cells (magnification $\times 6000$)



F | cross-section through a bone

I can ...

- describe the role of muscles in the heart
- describe the functions of the different parts of blood and where the different parts are made.

7Cb SCIENTIFIC QUESTIONS

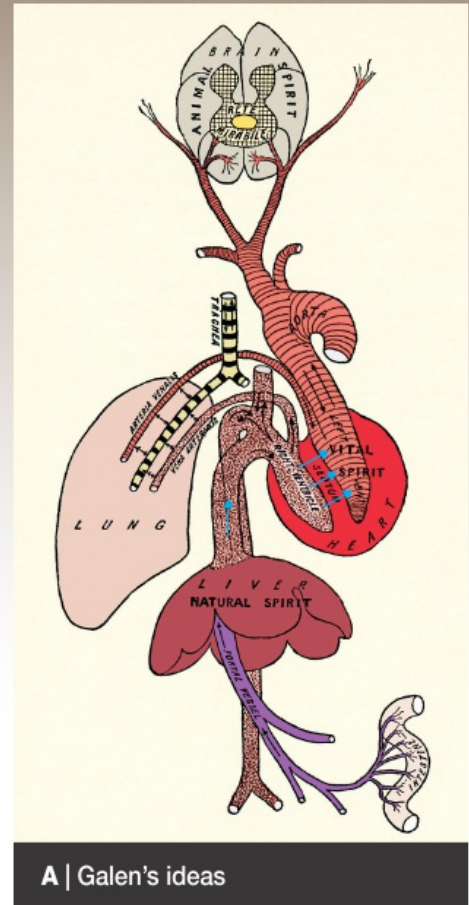
WHAT ARE SCIENTIFIC QUESTIONS?

A Roman doctor called Galen (129–200 CE) said that the liver looked like blood and so blood must be made in the liver. He also thought that the body used up blood and that the heart had to beat in order to ‘attract’ blood into it. Blood in the heart then mixed with oxygen from the lungs and formed a different type of blood that travelled to all the parts of the body, where it was used up. Galen didn’t know about capillaries because they are too small to see without magnifying them. Galen was so famous that people believed him for another 1500 years! Believing what someone says is one way to gain knowledge but it’s not how modern scientists work.

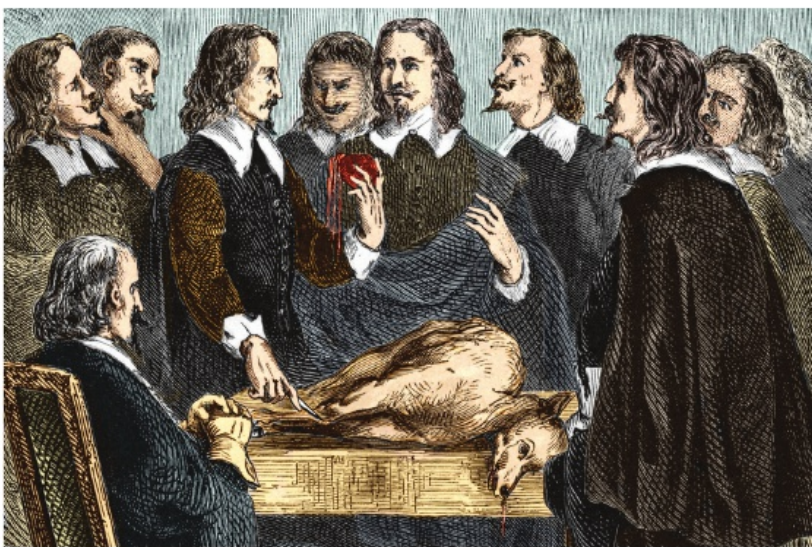
Scientists often use the **scientific method** to gain knowledge (see pages 24–25). They ask questions and come up with ideas (**hypotheses**). They keep testing those hypotheses to see if they are correct or whether they need changing.

Scientists often start by thinking up questions about **observations** they have made. Galen observed hearts moving and asked ‘Why do hearts beat?’

William Harvey (1578–1657) asked the same question but he thought that the heart was a pump. Unlike Galen, he tested his idea. His experiments included cutting into live animals to watch their hearts. He also squashed an animal heart with his hand and made it pump some water. He then did a famous calculation, shown in the Method opposite.



A | Galen's ideas



B | the English doctor William Harvey holding a dissected heart

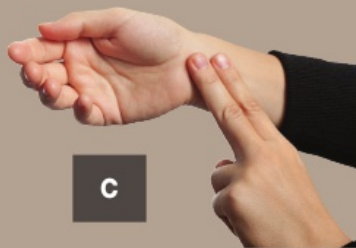
So much blood comes out of the heart each day that it would be impossible for the liver to make it all! Harvey’s work led him to the **theory** that blood was not used up but flowed away from the heart in arteries and then back towards it in veins. This theory of blood circulation predicted the existence of other tubes connecting arteries to veins. Capillaries were later discovered in 1661 by Marcello Malpighi (1628–1694).

1 Where are blood cells actually made?

WORKING SCIENTIFICALLY

Method

A | Hold two fingers firmly on your wrist, as shown in photo C. You should feel your pulse.



B | Count the pulse beats you feel in 15 seconds. Multiply this by four and this gives you your pulse rate in beats per minute.

C | Harvey measured the volume of the big left-hand chamber of the heart in dead bodies. The volume of this chamber in you is about 130 cm^3 . This volume falls to about half that when your heart muscle contracts. Use this information to work out the volume of blood your heart pumps each minute.

D | Now work out the volume of blood your heart pumps each day.

Types of question

The question 'Why do hearts beat?' is a scientific question. However, of the two doctors mentioned here, only Harvey answered it in a scientific way. A scientific question is one that can be answered again and again using information from experiments and investigations.

Some scientific questions have not been answered because we don't yet have the right technology or because we haven't done enough experiments. For example, 'What do the newly discovered MSC cells do in the heart?'

Other questions are not scientific because they cannot be answered using investigations or experiments. These include **ethical questions**, which are questions about what people think is fair or right or wrong.

D | different types of questions



- 2** Jo's pulse rate is 65 beats per minute. Using the information in step C in the Method above, work out the volume of blood her heart pumps each hour. Show your working.
- 3** What prediction did Harvey make using his theory about circulation?
- 4** In what way did Harvey act more scientifically than Galen?
- 5** Think up a scientific question about the liver.
- 6** Say whether each of these questions is a scientific, non-scientific and/or an ethical question.
 - A| Are parts of a taxi driver's brain bigger than average?
 - B| Should William Harvey have cut open live animals?
 - C| Do older people generally have lower pulse rates than younger people?
 - D| Do roses smell nicer than freesia flowers?
 - E| Does exercise affect your pulse rate?

I can ...

- describe the role of scientific questions in the scientific method
- identify scientific, non-scientific and ethical questions.

7Cc THE SKELETON

WHAT ARE THE FUNCTIONS OF THE SKELETON?

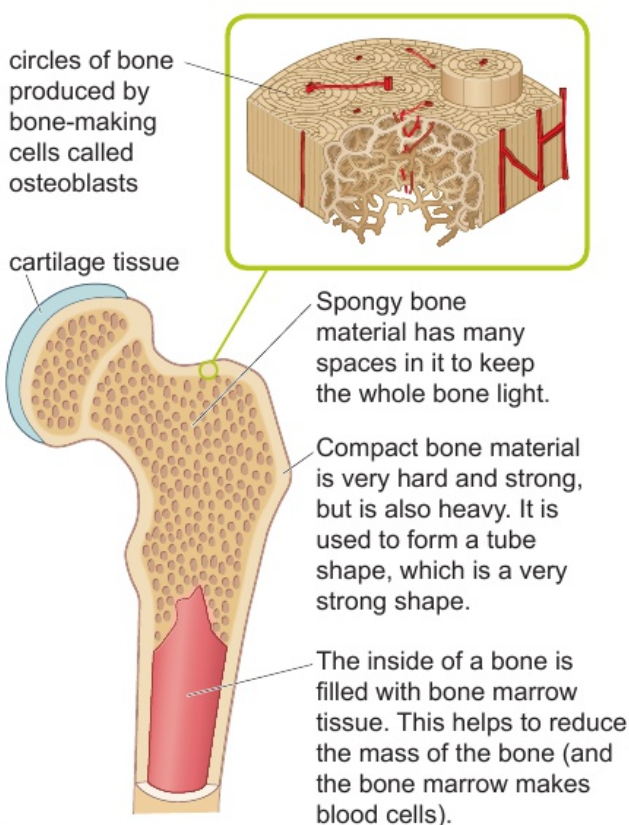
People who do sport for a living need to get treatment quickly if they are injured. Big football clubs spend millions on building specialist treatment centres to ensure their players get the best possible treatment.

Bones

Many people think that bones are not living, but bones *are* living organs. They grow as you grow and repair themselves if they **fracture** (break). Bones are hard and strong so that they can stand up to hard knocks and **pressure**. They are also light so they can be moved easily.



A | Common footballing injuries include broken bones and damage to cartilage, tendons and ligaments.



B | Bone-making cells (osteoblasts) can produce bone material in different ways, forming compact bone and spongy bone.

FACT

Babies are born with about 270 bones but some of them fuse together as they grow. An adult has 206 bones.

- 1 a) State two things that osteoblasts need to stay alive.
b) What process do osteoblasts need these things for?
- 2 Explain why a large bone can be both strong and light.
- 3 How can you tell that the bone in diagram B is an organ?

Support

The bones in your body form your **skeleton**, shown in photo C. Your skeleton makes sure that your body keeps its shape and also supports your body. The **backbone** is made up of smaller bones called **vertebrae** and is the human body's main support.

Some bones help to support organs. For example, your lungs would collapse without your ribs.

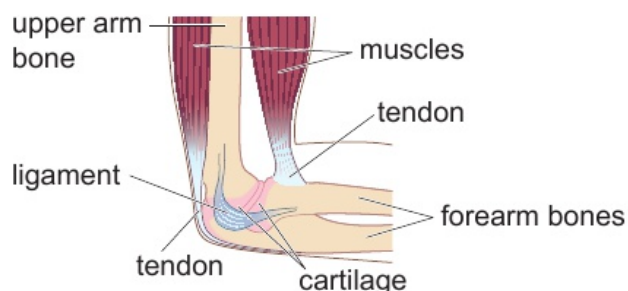
- 4 What do your ribs and sternum form?
- 5 Give one function of the backbone.



Movement

Two bones next to each other can form a **flexible joint**. The bones in a flexible joint are moved by muscles, which are attached to the bones by **tendons**. **Ligaments** hold the bones in a flexible joint together. The ends of bones in a flexible joint are often covered in a slippery tissue called **cartilage**, which helps them slide past each other.

Flexible joints can be damaged when playing sports. A sprain occurs when a ligament is stretched or torn. Sprains can cause dislocations, in which bones in a joint move out of line so that the joint doesn't work. When people 'pull muscles', either a muscle or the tendon that connects the muscle to a bone gets a small tear in it.

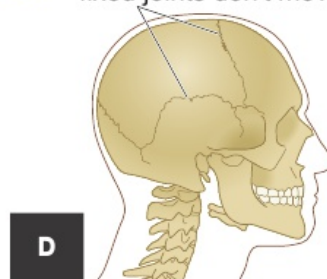


F | An elbow is a type of flexible joint called a 'hinge joint'.

Protection

Some bones protect organs in the body. For example, the **skull** protects the **brain**. The skull is actually made of 22 bones that are joined by **fixed joints**.

fixed joints don't move



- 6** The nervous system includes the brain and the spinal cord. Your spinal cord is a large bundle of important nerves that runs down your back. Which bones protect:
a| your brain b| your spinal cord?
- 7** Which organs are protected by your ribcage?

FACT

The smallest bone in the body is the stapes or stirrup bone in the ear. It's about the size of a grain of rice, and its function is to transfer sound waves into the inner ear.



E | X-rays allow us to see bones inside the body. This is an X-ray of a hip, which is a type of flexible joint called a 'ball and socket' joint.

- 8**
 - a| List three different types of joint.
 - b| Which of these joints allows movement in the most directions?
 - c| What causes the bones to move?
- 9** Describe the different functions of bones.
- 10** Look at X-ray E.
 - a| What bone forms the 'ball' in this joint?
 - b| The joint on the right of the X-ray is normal. What has happened to the joint on the left?
 - c| Suggest how this has occurred.

I can ...

- describe the functions of different bones in the skeleton
- describe some different types of joint.

7Cc SENTENCES

WHAT ARE THE WAYS IN WHICH SENTENCES ARE BUILT?

Scientists write about their experiments. The reports they write are called **scientific papers**. Scientific papers are published in scientific magazines called **journals**. Other scientists read journals. They learn about new discoveries. They also learn about how those new discoveries were made.

Most scientific journals are published in English, so it is useful for scientists to learn to write good English. However, if they struggle with English, there are people who can help by translating scientific papers into good English.

There is a convention for how a scientific report is set out (see pages 10–11). Scientists also need to follow grammatical rules when they write. This makes sure that their papers are easily understood.

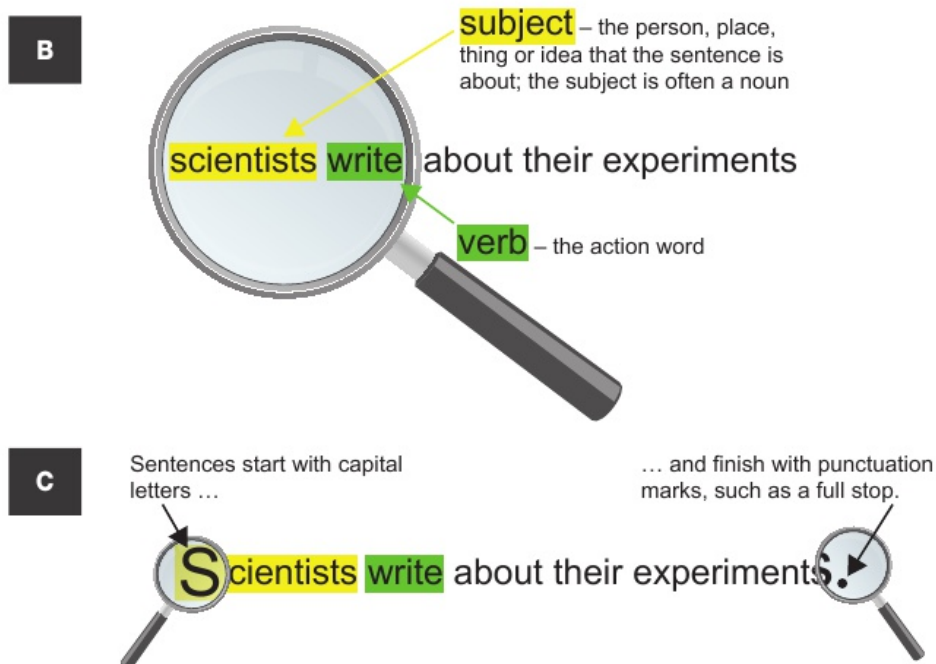
Scientific information needs to be written in clear, accurate sentences. A sentence is made up of **clauses**. A clause contains a **subject** and a verb, as shown in diagram B.

A clause that makes sense on its own is called a main clause. Adding a capital letter and a full stop turns it into a simple sentence, as shown in diagram C.

Short, single-clause sentences are particularly good for writing **topic sentences**, starting and ending reports, and writing a **method**.



A | Papers are published in journals, which are mainly published in English.



LITERACY & COMMUNICATION

- 1 How do you start and finish all sentences?
- 2 What are the subjects and verbs in the following simple sentences?
A| The ribs protect the lungs.
B| Muscles move bones.
- 3 Rearrange the words below to make two simple sentences.
A| pumps heart blood the
B| cells oxygen need your all

even though despite
because if that since which
whenever unless if wherever who
when as while whereas so that
although

D | common subordinating conjunctions used to make complex sentences

Complex sentences

A subordinate clause gives extra information about the main clause. When linked to a main clause a subordinate clause forms a **complex sentence**. Subordinate clauses can be placed in different positions in the sentence. In the following examples, the subordinate clauses are shown in *italic type*.

Muscle cells get shorter and fatter *as they contract*.

As they contract, muscle cells get shorter and fatter.

Muscles cells, *as they contract*, get shorter and fatter.

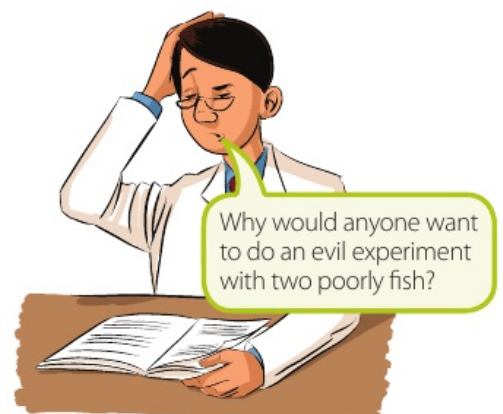
To join the clauses together, you use subordinating conjunctions. Common examples of subordinating conjunctions are shown in figure D.

Our investigation was wicked! We took these two really sick Siamese Fighting Fish ...



- 4 Read the sentences below. Identify the main clause, subordinate clause and subordinating conjunction in each sentence.
A| Blood from the capillaries enters the veins, which carry it back to the heart.
B| Capillaries, so that nutrients and oxygen can get to the cells in all the tissues in the body, have very thin walls.
C| When the diaphragm and rib muscles contract, you inhale.

Why would anyone want to do an evil experiment with two poorly fish?



Slang

Scientists need to explain their work to people all over the world and so they must use both grammatically correct sentences as well as words that all English speakers understand. You may use words in school in ways that give them different meanings from usual. You may also use new, made-up words. You should avoid using words in these ways when writing scientific reports.

I can ...

- write using a variety of appropriate sentence types
- use subordinating conjunctions.

7Cd MUSCLES AND MOVING

HOW ARE MUSCLES USED IN THE LOCOMOTOR SYSTEM?

Skeletons are always changing, and athletes' training programmes are designed to change both their muscles and their bones. These changes help the athletes become better at their particular sports. This doesn't just apply to athletes, though. People who do a lot of manual work develop thicker arm bones than people who work in offices. The thicker bones are needed to support bigger muscles.



A Amir Khan has boxed in the lightweight class (59–61.2 kg) and in the light welterweight class (61.3–63.5 kg).



C | an X-ray of the forearm bones of a professional tennis player showing that playing tennis has changed the bones

The muscles and bones in your body form an organ system called the **locomotor system**. It is this system that allows you to move all the parts of your body. The study of how muscles and bones work together is called **biomechanics**.

FACT

The smallest muscle in your body is attached to the smallest bone. The stapedius muscle is attached to the stapes bone in the ear. The muscle is about 1 mm long.

- 1 a| Match photos A and B to the different boxing classes.
b| How did Amir Khan put on extra mass to fight in the heavier class?
- 2 Look at photo C. In which hand do you think the tennis player holds the racquet? Explain your reasoning.
- 3 Make a fist and tighten your fingers.
a| Where are the muscles that let you tighten your fingers?
b| What happens to them when you tighten your fingers?

Antagonistic muscles

Muscles are organs that can contract. When they contract they get shorter and fatter. So, if a muscle is attached to a bone, it will pull on the bone when it contracts. The muscle will generate a **force** that can be measured, in **newtons (N)**.

D | The force from a muscle or a group of muscles can be measured in newtons using a type of newtonmeter.



4

Name two organs in the locomotor system.

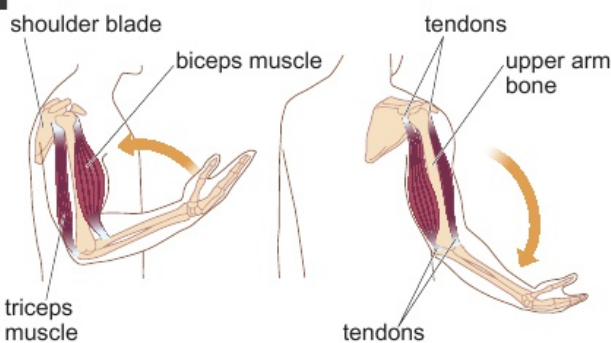
When a muscle stops contracting, it relaxes. This means that it returns to its original size and shape. Muscles do not generate a force when they relax, which means that muscles cannot push on bones – they can only pull them.

For a bone in a joint to be moved in two different directions, it needs to be pulled by two different muscles. Pairs of muscles like this are called **antagonistic pairs**. The **biceps** and **triceps** are an antagonistic pair of muscles in the upper arm, shown in diagram F.

F

When you lift your arm, the biceps muscle contracts.

When you put your arm down, the biceps muscle is stretched.



When you lift your arm, the triceps muscle is stretched.

When you put your arm down, the triceps muscle contracts.

5

When the biceps muscle contracts, what happens to the triceps muscle?

6

Why do muscles work in antagonistic pairs?

7

Look at drawing G. It shows some muscles in the body. You don't need to remember all their names!

G



- Write down all the antagonistic pairs you can see.
- If you point your toes to the ground, which muscle contracts?
- If you raise your toes, which muscle contracts?
- Describe fully what happens just before and during contraction of the biceps femoris muscle.



E | the bite force of a crocodile being measured

FACT

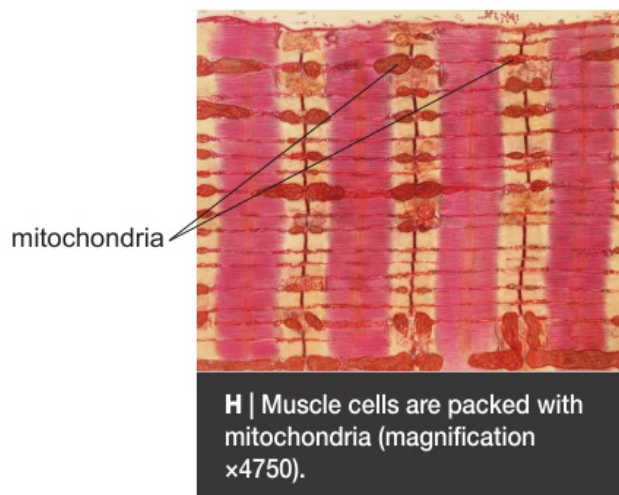
The human muscle that can exert the most force is the masseter or jaw muscle. The maximum force of a human bite is about 2500 N. In dogs it is about 6900 N. Crocodiles have 16 500 N of bite force!

Muscle control

To make a muscle contract, the brain sends electrical messages down the **spinal cord** into **nerves** attached to the muscle. These electrical messages are called **impulses**.

Energy needs

Muscles have to work hard and so their cells need a lot of energy. Respiration releases energy and occurs in tiny structures in cells called **mitochondria**. So, it is no surprise to find that muscle cells usually contain more mitochondria than other cells do.



H | Muscle cells are packed with mitochondria (magnification $\times 4750$).

I can ...

- explain how antagonistic pairs of muscles operate and are controlled, to allow movement.

7Ce DRUGS

HOW DO DRUGS AFFECT OUR BODIES?

Many professional athletes avoid certain substances because of the effects that they have on their bodies. For example, many athletes do not drink alcohol because it can interfere with the way in which muscles grow and recover after exercise.

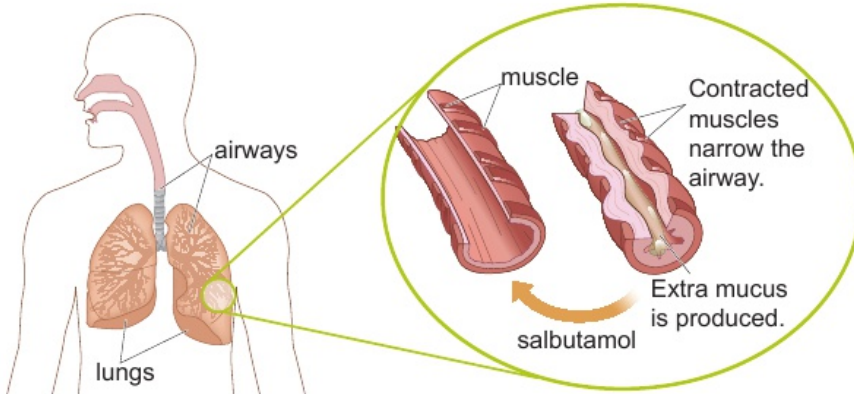
A **drug** is a substance that affects the way your body works. Alcohol is a drug. Some drugs are **medicines**, which help people recover from illness or injury. For example:

- paracetamol reduces pain
- ibuprofen reduces pain and swelling
- decongestants in cold medicines help you breathe more easily.



A | These are all drugs.

During an asthma attack, the muscles surrounding the tubes carrying air contract hard. This makes it difficult to breathe, but a medicine can make the muscles relax.



B | Medicines like salbutamol are used to treat asthma attacks.

- 1 a) Suggest a sports injury that you might take medicine(s) for.
b) What medicine(s) would you take and why?
- 2 In an asthma attack, why is it hard to breathe?
- 3 a) What is the useful effect of paracetamol?
b) What is its side-effect?

Although many drugs are useful, they can have harmful or unpleasant **side-effects**. For example, paracetamol can damage the liver. Drugs often damage the liver because this organ breaks drugs down.

Substance misuse

Some drugs (such as alcohol and **nicotine**) can become **addictive**, which means that people feel they can't cope without them. Addicts often continue using a drug even though they can see the damage it's causing. The harmful use of any substance is called **substance misuse**. Misusing alcohol can cause brain and liver damage.

FACT

In the 1890s, heroin was a major ingredient in a cough syrup.

Recreational drugs

Recreational drugs are drugs taken for pleasure. **Caffeine**, nicotine and alcohol are legal recreational drugs. Others are illegal because of their side-effects. **Cannabis** can cause memory loss and mental illness. **Ecstasy** can cause mental illness, kidney problems, and even death. **Cocaine** is addictive and can cause blocked arteries. **Heroin** is also addictive. It can cause collapsed veins, vomiting and severe headaches.

Stimulants

Drugs often affect the **nervous system**, which controls your body using electrical signals called impulses. Drugs that cause the nervous system to carry impulses faster are **stimulants**. They can decrease your **reaction time**, which is the time it takes you to respond to things happening around you. Caffeine, cocaine and ecstasy are all stimulants.

Depressants

Drugs that cause the nervous system to carry impulses more slowly are **depressants**. Heroin and the **solvents** found in glues and paints are dangerous depressants. Solvents can stop the heart and lungs working and cause severe brain damage.

Alcohol is a depressant and large quantities can change a person's behaviour. People become loud and aggressive because alcohol stops parts of the brain working. Too much alcohol causes vomiting. In very large amounts it can cause death, because it stops the brain sending impulses to the breathing muscles and so breathing stops.

- 6 Explain why some people feel more awake after drinking coffee.
- 7 Complete a table to describe four drugs of your choice. Use the headings 'Name of drug', 'Stimulant or depressant?' and 'Side-effects'.
- 8 a) Where are the muscles for breathing found?
b) Explain how alcohol can stop these muscles working.



C | damage caused by cocaine



Smoking causes immediate damage to your body. For Brandon, it caused Buerger's disease, which cut off blood flow and led to amputation. You can quit. For free help, call 1-800-QUIT-NOW.



D | The man in this advert had his legs removed because of a disease caused by smoking.

- 4 Why do people continue to misuse cocaine even when they see it harming them?
- 5 Look at photo A. Which substances are:
 - a) harmful
 - b) legal to buy at any age
 - c) only legal to buy above a certain age
 - d) illegal?



E | The amount of alcohol in drinks is measured in units. To avoid damaging their bodies, adult men are advised not to drink more than 21 units per week and women no more than 14 units per week.

I can ...

- recall how different drugs affect the body.

7C_e DRUGS AND SPORT

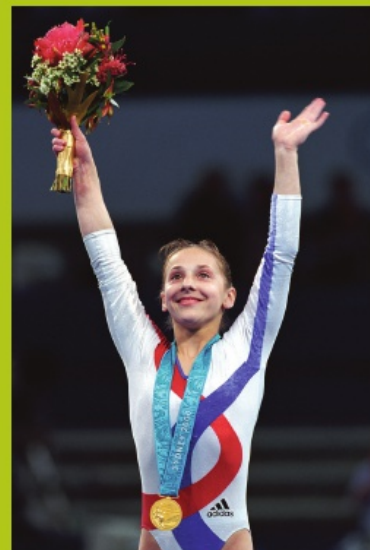
HOW DO ATHLETES TRY TO IMPROVE THEIR CHANCES OF WINNING?

Sports competitors are regularly tested for drugs to try to stop the use of drugs to improve performance. It can, though, be difficult to decide what is cheating and what is not.

In 1964, the Finnish cross-country skier Eero Mäntyranta won two Olympic gold medals. He could ski faster than his rivals because he had more red blood cells than them. His body naturally produced more of a chemical, nicknamed 'epo', which causes red blood cell production. In 1989, a drugs company started making artificial epo to help people with AIDS, but some athletes were soon using it.



A | Frankie Sheahan got a two-year ban from rugby after salbutamol was found in his body. The ban was lifted after he proved he needed the drug for asthma.



B | The gymnast Andreea Răducan lost her Olympic gold medal when a drugs test found a decongestant in her body. She said she had only taken two tablets for a cold.

Some athletes take steroids, such as testosterone, to increase muscle growth. Testosterone is a steroid **sex hormone** made in the **testes** and **ovaries**. Some people naturally produce more than others but it can also be made artificially. A side-effect is increased aggression (so-called 'roid rage').



C | Lance Armstrong won the Tour de France seven times. He was stripped of all his medals when it was found he had used epo and testosterone.

- 1** a | Why are steroids classified as drugs?
b | Suggest a drawback of developing new steroid medicines.
- 2** Suggest why salbutamol is a banned drug in sports competitions.
- 3** Why would using epo give an athlete an advantage?
- 4** Bones can develop 'stress fractures' during exercise. Why are athletes who abuse testosterone more likely to get stress fractures?

HAVE YOUR SAY

Should *all* drugs be banned in sport?

7Da EXPLORING THE WORLD

There are many reasons why people explore our world. Some explorers want to find oil or valuable minerals. Some are interested in searching for undiscovered **organisms**. Other explorers want to make contact with people to find out about how they live and about their languages.

David Good is a biologist and explorer. Unlike most explorers, when he set off in July 2011, to go deep into the Amazon jungle in Venezuela, it was to find his mother.



A | This mammal, called an olinguito, was discovered in 2013 in Ecuador.



B | These people were discovered living in the Amazon jungle in 2008, near the border between Peru and Brazil. They have probably never had any contact with the outside world.

David's father was an American scientist, who travelled to visit the Yanomami people in the Amazon in the 1970s. He was interested in what the people ate. He married a Yanomami woman called Yarima, and they had three children. The family then moved to America, but Yarima was unhappy and returned to the jungle without her children. That was when David was 5 years old. When he returned he was 19.

- 1** Yanomami people hunt deer for food. The deer eat forest plants. Draw a food chain to show this.
- 2** Apart from food, suggest something else that animals need to get from the places in which they live.
- 3** Apart from clothing, jewellery and hairstyles, suggest two things that are often different between humans from different parts of the world.
- 4**
 - a| Suggest one reason why exploration of our planet is a good idea.
 - b| Suggest a problem that might be caused by explorers.



C | David's expedition was a success and he was reunited with his mother.

7Da VARIATION

WHAT IS VARIATION?

The place where an organism lives is called a **habitat**. The Yanomami people live in a jungle habitat.

Each habitat has many different types or **species** of organisms living in it. **Variation** is the word used to describe the differences between organisms. There is often a lot of variation between different species and less variation between members of the same species.



- 1 What habitat do you live in?
- 2 Suggest two habitats in which you might find fish.
- 3 Draw a table to show two similarities and two differences between all the animals in photos A, B and C.
- 4 The zebras in photo C are all the same species. How do they vary?

Continuous and discontinuous

Humans vary in height. If you measure the heights of people in your class, you will find that very few people are exactly the same height. This variation is described as **continuous**, and it means that your measurements can have any value (within limits).



D | Humans all belong to the same species but there is some variation between us.



Some people can roll their tongues and others cannot. This variation is described as being **discontinuous**. This means that there is *not* a continuous range of measurements that can be made and measurements must fall into certain categories.

A good way to think about the difference between continuous and discontinuous variation is to consider foot length and shoe size. The actual length of your foot (measured in centimetres) is an example of continuous variation. Your shoe size is discontinuous because shoes only come in certain sizes.

5 How can you tell if a certain type of variation is continuous?

6 Copy the list of features below and say whether each variation is continuous or discontinuous.

natural eye colour	natural hair colour
length of hair	having a cold
having a scar	having pierced ears
having a tattoo	having naturally curly hair

FACT

Yanomami are quite short people. Yanomami men have an average height of about 153 cm, 20 cm shorter than men living in the capital of Venezuela.



E | tongue rolling

Species and hybrids

A species is a group of organisms that can **reproduce** with one another to produce **offspring** that can also reproduce.

Usually members of two different species cannot reproduce but in rare cases it can happen. The offspring are called **hybrids** but they cannot reproduce. For example, horses and zebras can produce zebroids but the hybrids cannot reproduce.

7 Olinguitos (see page 55) had been discovered before 2013 but people thought they were animals called olingos. One olinguito, called Ringerl, lived in a zoo in the 1970s with olingos. The zoo keepers thought that Ringerl would reproduce but this never happened.

a) Why do you think olingos and olinguitos were thought to be the same? Use the term 'variation' in your answer.

b) Why did Ringerl not reproduce?

8 Ligers are hybrids produced by lions and tigers. Ligers cannot reproduce. What does this tell you about lions and tigers?

FACT

Shoe sizes are based on an old Anglo-Saxon unit of measurement, called the barleycorn. This was originally based on the length of a seed from a barley plant (about 8.5 mm). A size 7 shoe is one barleycorn longer than a size 6 shoe.



F | Horses and zebras are different species.

I can ...

- recall what a species is
- describe variation as continuous or discontinuous.

7Da CHARTS AND GRAPHS

HOW ARE BAR CHARTS AND SCATTER GRAPHS USED?

Variation is the term for the differences between organisms. When we make measurements of variation (such as human height), what we measure is a **variable**. A variable is anything that can change and be measured. You will meet variables in all parts of science.

In an investigation, you choose the values of the **independent variable**. You then measure the **dependent variable**. The values of the dependent variable depend on those of the independent variable.

On a chart or a graph, the independent variable goes on the horizontal (x) axis and the dependent variable goes on the vertical (y) axis.

Chart A is a **bar chart** but it is also a **frequency diagram** because the dependent variable is a number of things that have been counted up (a frequency).

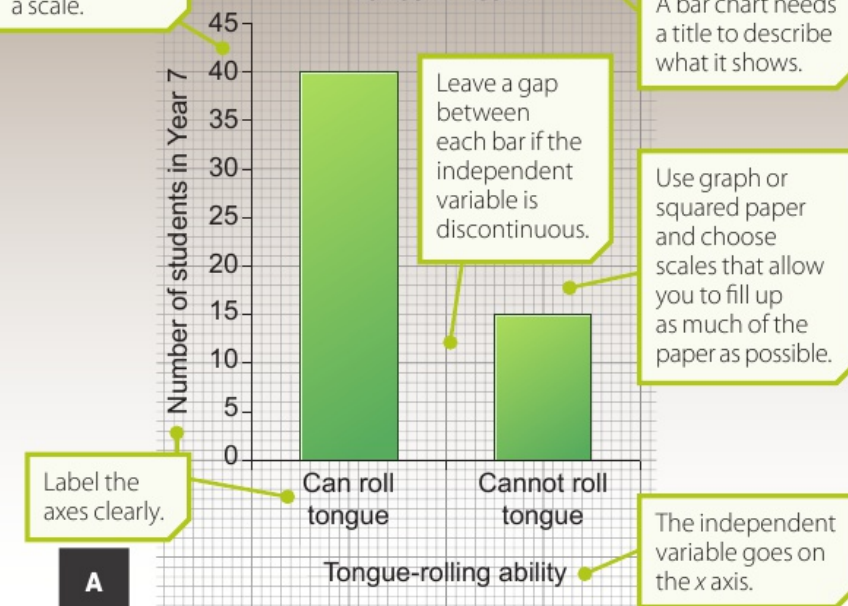
Grouped data

If the dependent variable is *continuous*, we can split the **data** into groups. We then count up the numbers that are in each group, and plot a bar chart but without leaving gaps between the bars.

On bar charts of grouped data, the bars often form a 'bell shape'. This is the pattern we expect to find when the y-axis shows a number of things that have been counted up. So we call this shape **normal distribution**.

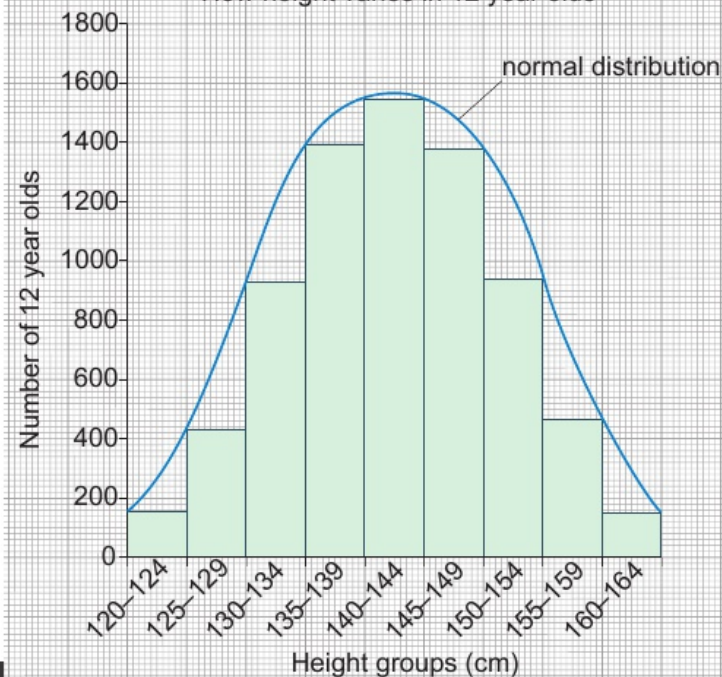
Space numbers evenly to make a scale.

How tongue-rolling ability varies in Year 7



A

How height varies in 12 year olds



B

WORKING SCIENTIFICALLY

1 What are the dependent and independent variables in chart A?

2 Present the data in table C as a bar chart.

C	Number of teeth with fillings	Number of students in class 7K
	0	17
	1	8
	2	2
	3	2
	4	1

3 Table D shows the lengths (L) and widths (W) of some leaves from rose plants.

- Divide the data into groups, using either the widths or the lengths of the leaves.
- Draw a bar chart for the data you have selected in part a.

D	Lengths and widths of some rose leaves (mm)									
	L	W	L	W	L	W	L	W	L	W
	26	20	41	32	54	42	50	36	69	53
	42	31	39	30	51	38	62	47	71	54
	47	37	55	40	56	44	59	45	73	56
	48	37	35	27	79	61	76	58	56	43
	82	62	31	22	65	50	80	64	57	44

Scatter graphs

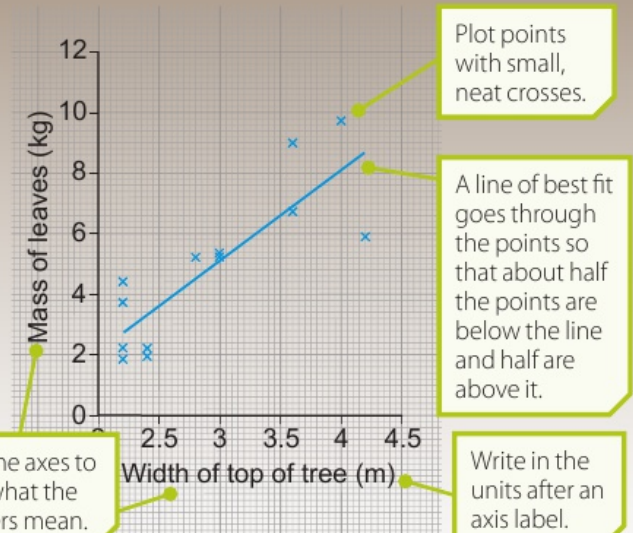
Sometimes we want to know if there is a **relationship** (link) between two variables. In this case we draw a **scatter graph**.

In graph E we can clearly see that there is a pattern in the points. As the width of the top of a tree increases, so does the **mass** of its leaves. A **line of best fit** is often drawn through the points, and it can help to make a relationship look more obvious.

If there is no link between two variables, then there will be no clear pattern of points (see graph F).

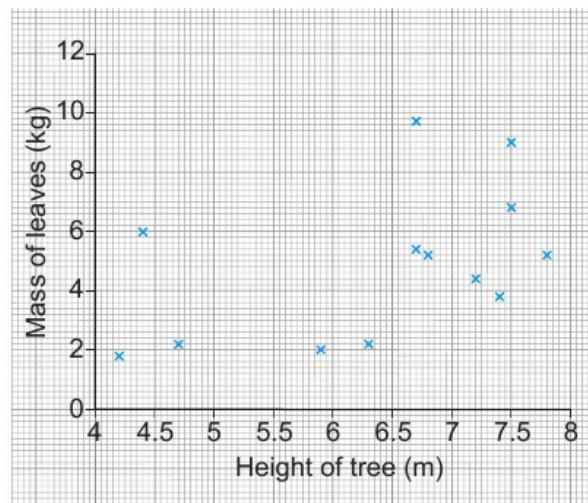
4 Use the data in table D to find out if there is a relationship between rose leaf length and width. Use length as the independent variable.

How the mass of leaves depends on the width of the top of an oak tree



E | A scatter graph is used to see if there is a link between two variables.

How the mass of leaves depends on the height of an oak tree



F | There is no relationship between these two variables (for the same trees as in graph E).

I can ...

- present information as bar charts and scatter graphs
- identify relationships using scatter graphs.

7Db ADAPTATIONS

WHY IS THERE VARIATION BETWEEN AND WITHIN SPECIES?

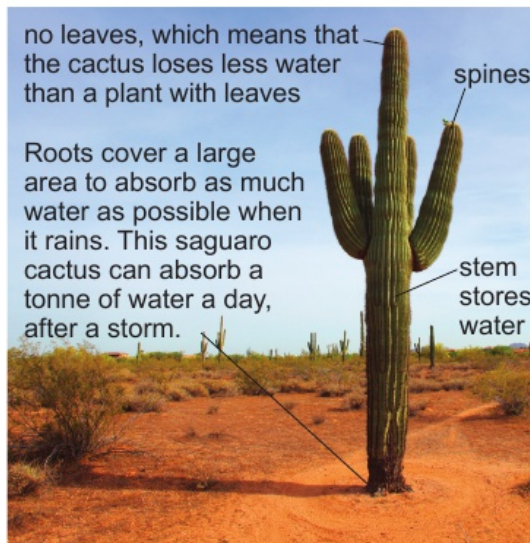
The conditions in a habitat are its **environment**. The conditions are mainly caused by **physical environmental factors**, such as the amount of light, how wet it is, how windy it is and the temperature. The factors are described as 'physical' because they are not alive.

Organisms have features that let them survive in the environments where they live. We say that organisms are **adapted** for their habitats. For example, fish have gills and fins, which are **adaptations** for living in water. Their fins will not let them walk on land and their gills will not let them breathe air. Fish are adapted to living in watery habitats but not on land.

- 1 Which of the following are physical environmental factors:
ant light bird temperature frog tree fungus wind?
- 2 Describe the environment in each habitat in photos A, B and C on page 56.
- 3 Describe your environment at the moment.



A | polar bear adaptations



B | cactus adaptations



C | jack rabbit adaptations

- 4 How are polar bears adapted to the cold?
- 5 A cactus has spines on its stem. Why do you think these are useful?
- 6 Suggest the names of the habitats in which polar bears, cacti and jack rabbits live.
- 7 Look back at page 56. How do you think the length of hair on meerkats and wolverines helps them survive in their habitats?

FACT

Many organisms are adapted to their habitats by both their features and their behaviour (what they do). Vultures in deserts urinate on their legs! The urine evaporates, which cools the birds down.

All the animals and plants that live in a habitat make up a **community**. Members of communities may have similar adaptations to cope with the problems of living in a particular habitat. For example, many organisms that live in fast-flowing rivers have suckers to allow them to attach to rocks and stop them being swept away.

The community of organisms and all the physical environmental factors in a habitat form an **ecosystem**.

8 Draw a design for a plant that could live in the same habitat as a hogsucker fish.

9 Describe the Arctic ecosystem.



D | Hogsucker fish live in fast-flowing water.

Inherited variation

Many of an organism's features come from its parents. These features are **inherited**.

Variation between these features is **inherited variation**. There is a great deal of inherited variation between different species, such as polar bears and meerkats.

There is also inherited variation between members of the same species because of what happens in **sexual reproduction**. All **gametes** contain slightly different instructions for features. A different **sperm cell** and **egg cell** are used to produce each offspring, and so each inherits a slightly different mix of features. The exception to this is identical twins, who both develop from the same **fertilised egg cell**.

10 Name three features you have inherited.

11 Look at photo F, which shows a family group. There are four adult women in the picture. Who are their children? Use the labels to identify them.

12 Janette's mother has blue eyes and blond hair. Janette's father has brown eyes and brown hair. Janette has blue eyes and brown hair. Her brother, Jamie, has brown eyes and brown hair.

- From which parent has Janette inherited her blue eyes?
- Why do Janette and Jamie have slightly different features?



E | David Good with his parents and younger sister. The children inherited features from both parents.



F | All children inherit features from both parents.

I can ...

- identify and describe some adaptations for different habitats
- describe how inherited variation is caused.

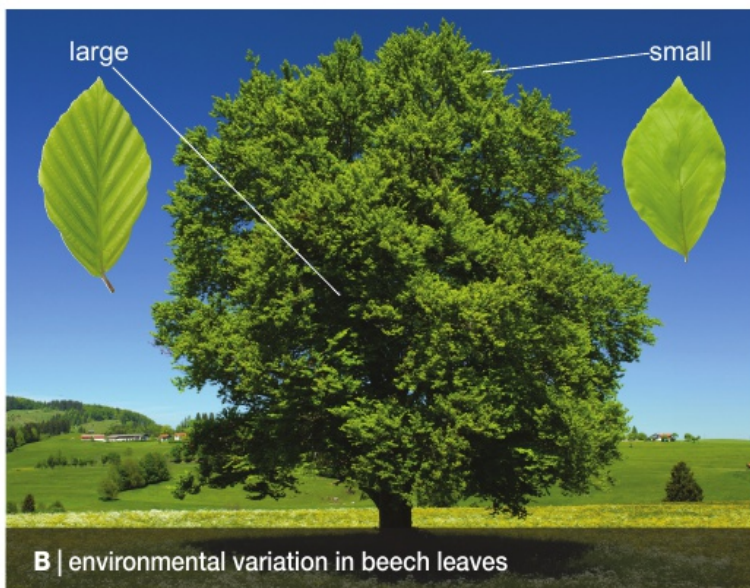
7Dc EFFECTS OF THE ENVIRONMENT

HOW DO ENVIRONMENTS AFFECT ORGANISMS?

In 1534, the French explorer Jacques Cartier sailed to what is now Canada to find gold and look for a way to China. Nearing land, he saw native people and wrote: 'They wear their hair tied up on the top of their heads like a handful of twisted hay'

Cartier was describing an **environmental variation** of the people. Environmental variation is caused by environmental factors. Hairstyles are caused by an environmental factor called fashion!

All organisms show inherited variation *and* environmental variation. The beech leaves in photo B inherited their leaf shape, but not all the leaves are the same size. The leaves that get more sunlight are smaller than the shaded leaves. The environmental factor is light and this causes an environmental variation in leaf size.



FACT

Hydrangea plants are blue in acidic soils and pink in soils of a higher pH.



A | Jacques Cartier (1491–1557) and a tribesman from Hochelaga (present-day Montreal).

- 1 List three examples of environmental variation in drawing A.
- 2 For sentences A–C below, identify:
 - a| the environmental variation
 - b| the environmental factor causing the variation.
 - A| Bill found that the cress seedlings he grew in a dark cupboard were yellow.
 - B| Jayesh discovered that there were very few leaves on the apple tree after the storm.
 - C| Tanya put fertiliser on one sunflower plant. It grew 20 cm taller than the others.
- 3 In what type of soil are the hydrangeas in photo C growing?

Environmental factors affect organisms in other ways too. Organisms inherit features that allow them to change when environmental factors change. Changes during a day are known as **daily changes**, and changes during a year are **seasonal changes**. Organisms are adapted to these changes.

Daily changes

Many animals are adapted to changes in light during a day (24 hours). **Nocturnal** animals are only active at night and have adaptations for this. Many mice are nocturnal and have excellent eyesight. Nocturnal owls have superb hearing and eyesight, and fly silently so they can catch nocturnal animals.



- 4 What change causes dormice to become active?

Seashore organisms are adapted to tides. Sea anemones use tentacles to feed but when the tide goes out they pull in their tentacles to stop them drying out.



E | a sea anemone feeding and (inset) when the tide is out

Seasonal changes

In winter, **deciduous** (*des-id-U-us*) trees lose their leaves because there is not much light for **photosynthesis** and their leaves lose water (which cannot be replaced when the ground is frozen). **Evergreen** trees have tougher leaves that don't lose much water, so they keep their leaves all year round.

Some plants, such as poppies, die completely in the winter. Their **seeds** grow into new plants in the spring. In other plants, such as bluebells, only the parts above ground die. They leave **bulbs** underground that will grow again in the spring.

- 5 Describe one way in which the community of a farmland habitat changes between summer and winter.
- 6 Suggest why a ptarmigan's feathers change colour with the seasons.
- 7 Explain how these organisms are adapted to surviving winter:
- a | hedgehog b | oak tree
c | swallow d | poppy.



F | a ptarmigan in summer and (inset) in winter

Animals are also adapted to seasonal changes. Rabbits grow longer fur to help them keep warm in winter. A ptarmigan's feathers change colour with the seasons.

Some animals, such as hedgehogs, become inactive in winter so that they don't need food when there is less food available. This is **hibernation**. Many birds fly to warmer places for the winter to find food. This is **migration**. Swallows migrate to southern Africa in October and return to farmland and other habitats in the UK in April.

I can ...

- identify causes of environmental variation
- describe adaptations to daily and seasonal changes.

7DC PARAGRAPHS

HOW ARE IDEAS ORGANISED AND SHAPED USING PARAGRAPHS?

Scientists need to understand how to write good paragraphs. Scientists write about their experiments in **scientific papers**, which are published in **journals**. They may also write books, or scripts for documentaries on radio or television. So it is important that they write in such a way that people can easily understand their ideas.

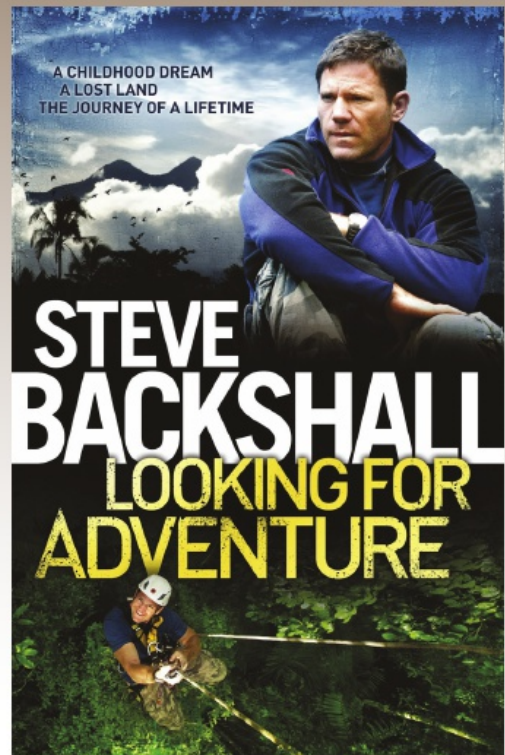
The purpose of paragraphs

We use paragraphs to show where different ideas are introduced. Changes in time, people, topic or place (remember 'TiPToP'!) generally have new paragraphs. If there are no breaks in a text, it makes it hard to see the different ideas and makes the text more difficult to understand.

1

Read the book extract below.

- a| Suggest an advantage of dividing the text into paragraphs.
- b| What are the three main topics covered in the text?
- c| Suggest places to split the text to make three paragraphs.



A | Steve Backshall has written many books and TV scripts about his adventures and his studies of different species.

Most animals make changes for survival in winter. Colder temperatures mean that mammals and birds need to spend more energy keeping themselves warm. However, there is less food at this time of the year for them to eat, which provides the energy they need. Many animals would die if they did nothing to prepare for winter. One strategy is hibernation. This is when an animal finds a sheltered and warm place and enters a period of inactivity ('sleep'). To prepare for this, the animals eat a lot in the summer and autumn and add fat to their bodies. This not only keeps them warm but it also provides a store of energy to use while hibernating. Even though they are very inactive, and their body temperatures and heartbeat rates drop right down, the animals still need a source of energy. Other animals leave the country. They spend the winter months in warmer parts of the world where there is a source of food. This is called migration. Swallows, for example, leave the UK and fly to Africa in September and October, returning in April and May.

The structure of paragraphs

Paragraphs often start with a short **topic sentence**. It sums up one main idea, which the rest of the paragraph will explore in more detail, for example: 'Most animals make changes for survival in winter.'

After the topic sentence there are supporting sentences. They are called supporting sentences because they describe or explain the main idea in more detail. They often do this by providing examples and evidence to back up the main point.

Longer paragraphs usually end with a summary sentence. This sentence links together all the ideas in the paragraph.

Topic sentence

Supporting sentences

Summary sentence



B | You can often think of a paragraph as being like a hamburger!

- 2 Here are three topic sentences for the same topic. Which one is best? Explain your reasoning.

- A | Polar bears like to eat seals, which they can creep up on without sinking into the snow because they have really wide feet, but the seals have excellent hearing and can often hear the polar bears coming.
- B | Polar bears have adaptations for snow.
- C | Polar bears have feet.

- 3 Write a topic sentence for a paragraph that explains why some trees are deciduous.

- 4 Reorder the sentences below into a paragraph that makes sense. You only need to write the order of the letters A–E.

- A | These amazing feats help this mammal to survive the long, cold winters.
- B | Its heartbeat rate is able to drop to as low as 5 beats per minute.
- C | The ground squirrel is well adapted for winter.
- D | As well as this, it can hibernate for 6 months!
- E | It is also the only mammal that can survive if its body temperature falls below 0 °C.

I can ...

- split text into paragraphs
- give paragraphs a structure.

7Dd EFFECTS ON THE ENVIRONMENT

HOW DO ORGANISMS AFFECT THEIR HABITATS?

To survive and grow, organisms need **resources** from a habitat. Animals need resources such as **oxygen**, space, shelter, food, water and mates. Plants need light, air, water, warmth, mineral salts and space to grow. If any of these are missing, the numbers of an organism (its **population**) will go down.

- 1 a| State three resources scientists would need to take into the habitat in photo A.
- b| Suggest why the landscape in photo A looks the way it does.



A | Scientists studying this habitat bring resources with them because there are very few natural resources.

B | Easter Island



- 2 What organism caused the Easter Island palm to become extinct?
- 3 a| Why did the human population decrease on Easter Island?
- b| Suggest two reasons why birds died out on the island.

Island problems

Easter Island in the Pacific Ocean was named by the Dutch explorer Jacob Roggeveen, who came across it on Easter Sunday 1722. He described it as a land with huge standing statues but no trees.

Scientists have found evidence that the island was once covered in trees. Over hundreds of years, the people cut down trees for building materials, to make fires and to build fishing boats. By about 1600, all the trees were gone and the people started to starve. Birds also disappeared from the island at this time.

The islanders affected their habitat, which caused many populations to decrease. The Easter Island palm tree died out altogether – it became **extinct**.

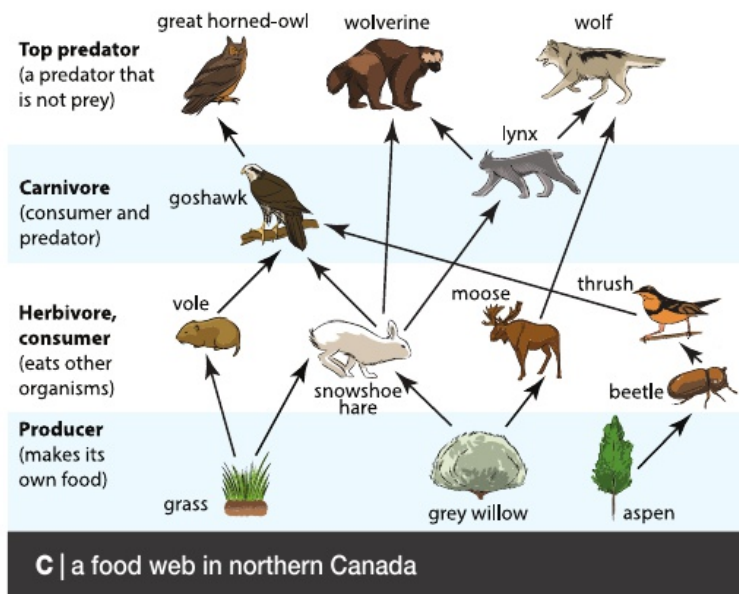
Competition

We can see what eats what in a habitat by looking at a **food chain** like this:

grass → hare → lynx

Organisms are in **competition** with one another for resources. The organisms with the best adaptations to get the resources are more likely to survive and reproduce. The others may move away or die.

Food chains can be added together to form **food webs**, which will show how some animals compete with each other for the same food. In food web C, you can see that goshawks compete with lynxes for hares. If the goshawks get a disease and die, there will be more hares. The population of lynxes may then increase.



The organisms in an ecosystem all depend on one another for many things, not just food. We say that they are **interdependent**. For example, birds use trees for shelter and plants use animal waste to help them grow (the waste contains mineral salts).

- 4** a | Write out the longest food chain in food web C.
b | Choose one or more of these words for each organism in your food chain: carnivore, consumer, herbivore, omnivore, producer, top predator. Explain your choices.
- 5** Why are goshawks and wolverines in competition with each other?
- 6** Use food web C to predict what would happen to the vole population if:
 - a | the snowshoe hares all died
 - b | there was no rain for a long time.

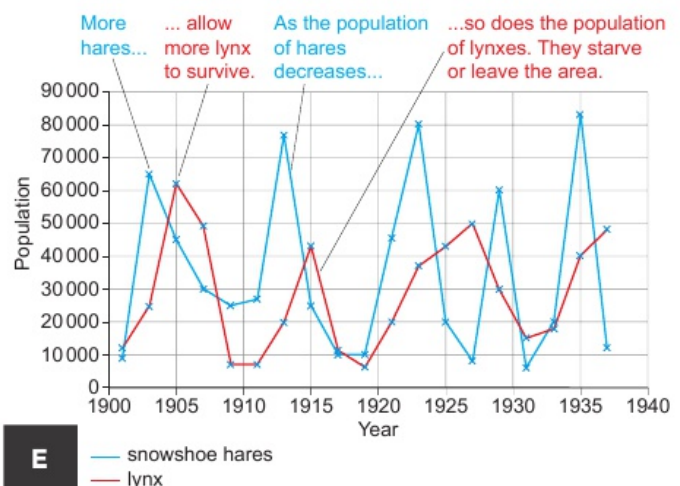


Population changes

Populations change depending on how much food is available. In northern Canada, the lynx is a **predator**. Its main **prey** is the snowshoe hare. When there are a lot of hares, the lynxes have lots to eat. They reproduce successfully and their population goes up. When there are fewer hares, the lynx population decreases – some starve (including newborn offspring) and others move to a different area.

- 7** Look at graph E.
 - a | Which animal is the predator and which is the prey?
 - b | Suggest one reason why the hare population might increase.
 - c | Suggest three reasons for lynx population decrease.

How snowshoe hare and lynx populations changed with time



I can ...

- describe ways in which organisms affect their habitats and communities
- describe how organisms compete
- use a food web to make predictions.

7De TRANSFERS IN FOOD CHAINS

HOW DO ENERGY AND POISONS MOVE THROUGH FOOD CHAINS?

Organisms contain **energy** stored in the substances that make up their bodies. The arrows in food chains and webs show how this energy passes from organism to organism. Normally there are fewer organisms as you go along a food chain because energy is lost at each stage.

A | The arrows in a food chain show energy flow.

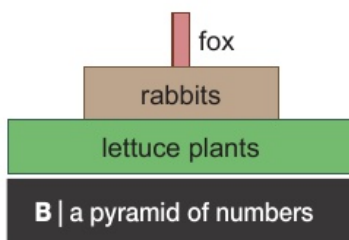
A lot of energy stored in food is released by respiration to let animals move and keep warm.

Only some of the energy in food becomes stored in new substances in an animal. Only the energy stored inside the rabbit can be passed on to the fox.

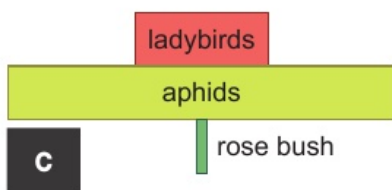


Pyramids of numbers

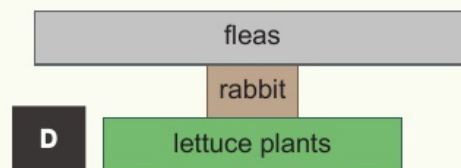
Energy losses at each stage of the food chain mean that hundreds of lettuce plants feed a much smaller number of rabbits. These rabbits feed an even smaller number of foxes. The numbers of different organisms at each stage of a food chain can be shown using a **pyramid of numbers**.



Pyramids of numbers do not look like pyramids if the organisms have very different sizes. For example, many aphids can feed on one rose bush.



- 1** Why do organisms respire?
- 2** a) What does the red arrow on the left of diagram A show?
b) Why does the fox not get all the energy that was in the lettuces eaten by the rabbit?
- 3** Look at food web C on page 67.
a) Draw a food chain from the food web, starting with grass.
b) Sketch a pyramid of numbers for this food chain.
- 4** Look at the food chain below.
grass → grasshopper → frog → grass snake
100 000 500 5 1
a) Draw a table to show the top predator, the consumers, the producer, the herbivore and the carnivores.
b) Sketch a pyramid of numbers for this food chain.
- 5** Explain why diagram D is not shaped like a pyramid.



Poisons

Pesticides are poisons that kill **pests** (organisms that cause problems). However, these poisons can kill other organisms as well.

The Australian explorer Frederick Hasselborough discovered Macquarie Island, halfway between New Zealand and Antarctica, in 1810. It soon became a base for fishermen, who brought in cats, rats and rabbits. The cats ate young birds, the rats ate bird eggs and the rabbits destroyed nesting sites. Various species of bird became extinct.

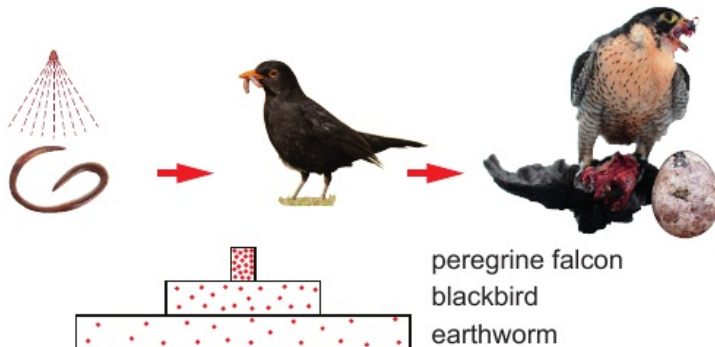
In 2000, scientists removed the last cat but removing cats caused a big increase in the populations of rats and rabbits. In 2010, poison was put down for rats and rabbits, but it killed many birds, including **endangered** species. The poisoning was stopped and a virus disease was introduced to kill most of the rabbits. This meant that less poison needed to be spread over the island in 2011. Now the island is clear of these pests.

Some poisons kill organisms they are not intended for because the poisons are not broken down in nature (they are **persistent**). This means that they can be passed along food chains. DDT is a persistent pesticide used to kill insects. It was used a lot in the UK in the 1950s and 1960s but it caused the shells of top predator birds to be weak and break easily. DDT was banned in the UK in 1984.

Fields are sprayed with DDT to kill pests. It soaks into earthworms in the ground.

Blackbirds eat many earthworms so get a lot of DDT but not enough to cause much harm.

Peregrine falcons eat many blackbirds so get a very large dose of DDT. This causes their eggs to break.



F | Each dot represents a dose of DDT. The poison gets more concentrated further along the food chain.



E | Poison on Macquarie Island killed giant petrels. The wingspans of these birds can be over two metres.

FACT

Farmers in the UK use about 16 000 tonnes of pesticides each year.

- 6 a) What effect did removing cats from Macquarie Island have?
b) Why did it have this effect?
- 7 Suggest what has happened to the populations of birds on Macquarie Island since 2011. Explain your reasoning.
- 8 Look at food web C on page 67. Beetles can kill aspen trees. To save the aspens in an area it has been suggested that the beetles be poisoned.
a) Suggest a problem with using poison.
b) Predict the effects of the poison on the thrush and aspen populations.
- 9 Explain why the peregrine falcon population in the UK decreased in the 1970s.

I can ...

- use pyramids of numbers to describe how energy is lost in a food chain
- explain why pesticides need to be used carefully.

7De NOMADS

HOW DO SOME HUMANS COMPETE WITH ONE ANOTHER?

Nomadic people move from place to place. In Bhutan, the Layap people herd yaks. In summer they build camps up in the mountains where the yaks graze on grass and shrubs. They protect the yaks from animals like snow leopards. In the winter they move down to warmer areas, selling their products in villages.

Nomads in parts of Mongolia herd sheep and goats in the valleys in summer and then move to the mountains for the winter, into areas protected from the harsh winds. However, copper has now been found in the mountains and mines are being built. These provide employment and money for this very poor country, but the nomads worry that the mines will use up the scarce water supplies.



A | a Bhutanese yak herder



B | a winter encampment in Mongolia



C | People living in the Xingu National Park in Brazil inspect the activities of a farmer near their reserve.

Some Amazon rainforest people were traditionally nomads, moving to new areas as resources started to run out. Today this may not happen because farmers move in and clear land to grow grass for cattle. There are also problems with illegal logging and mining. The outsiders bring diseases, like colds and measles, which kill the local people. They also destroy the habitats of animals that local people rely on for food.

- 1 Give the name of one predator on this page, and its prey.
- 2 a| Describe how seasonal changes affect the Layap people.
b| How is this similar to the effect on some birds, such as swallows?
- 3 Is having measles an example of continuous or discontinuous variation? Explain your reasoning.
- 4 Describe one example of inherited variation and one of environmental variation in photo C.
- 5 Explain one way in which yaks are able to survive in their habitat.
- 6 Sketch a pyramid of numbers that links three organisms on this page.

HAVE YOUR SAY

Should exploration in certain areas of the world be banned?

7Ea MIXTURES AND SEPARATION

To remain healthy, we need water. Your body loses water all the time and you can only live for a few days without drinking. Water for drinking must be clean, because dirty water can contain harmful substances and microorganisms.

In many dry parts of the world, people struggle to get enough suitable drinking water. Even in the UK there has sometimes not been enough rain to keep water reservoirs filled. Hosepipe bans can limit the water we use and make sure enough water is left for essential needs, such as drinking.



A | Around 780 million people in the world do not have clean water that is safe to drink.

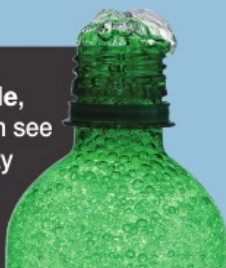


B | Thirlmere Reservoir in the Lake District supplies water for drinking and other needs to the north west of England. In 2010, rainfall levels were so low that the reservoir was at risk of running dry.

Water is a **liquid** in which many different substances can **dissolve**. Sources of water, such as rivers and streams, may also carry **solids** such as sand, gravel or mud. To make water safe and suitable for drinking, water must be treated in different ways to remove unwanted substances.

- 1** a| Give an example of a solid, a liquid and a gas.
b| Describe how you can tell the difference between solids, liquids and gases.
- 2** A sample of water is collected from a stream. Suggest how you would separate out each of the following from the water:
a| gravel b| sand.
- 3** Sea water is a solution of water and dissolved substances, such as salt.
a| Explain what 'solution' means.
b| Describe how you would separate salt from sea water.
- 4** a| Dissolving is a 'reversible change'. What does this mean?
b| Give one other example of a reversible change.

C | **Gases**, such as **carbon dioxide**, can also dissolve in water. You can see this when you open a bottle of fizzy drink and the gas is released from solution.



7Ea WRITING A METHOD

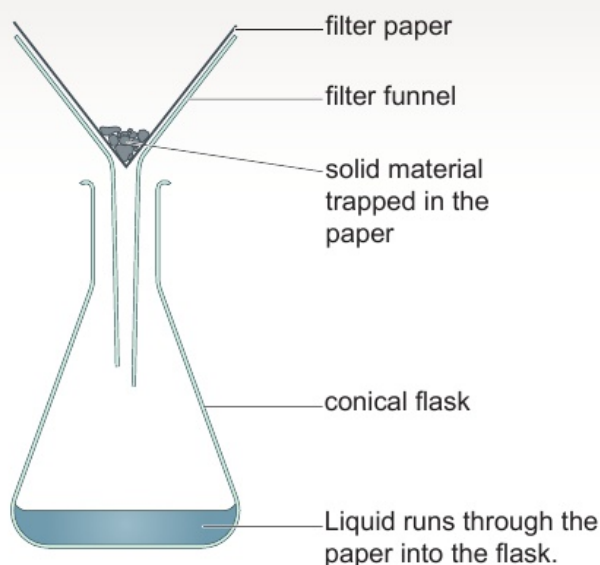
HOW WOULD YOU WRITE A GOOD METHOD FOR AN EXPERIMENT?

When scientists write about their work, they need to show clearly how they carried out their experiments and what they found out. This makes it possible for others to spot the strengths and weaknesses of an experiment, and to do the experiment themselves to check the **results**.

An important part of an investigation report is the **method**, which describes how an experiment is carried out. As well as written instructions, it may include a diagram of the **apparatus** and how it was set up.



A | This apparatus separates an **insoluble** solid, such as sand, from a liquid, such as water. The liquid that runs through the filter paper is called the **filtrate**.



B | a diagram of the apparatus shown in photo A

A method presents instructions for how to carry out the experiment in a series of steps. Numbering or lettering the steps makes the steps easier to follow and each step must be presented in the correct order, or sequence. Everything that was done to complete the experiment must be included.

When methods are given for people to follow they should be written using imperative verbs. Imperatives are 'commands to do something'. The method opposite, for filtering a **mixture** of sand and water, is written for someone to follow and uses imperative verbs.

LITERACY & COMMUNICATION

Here is a method for filtering a mixture of sand and water.

Method

A | Fold a circular filter paper in half.

Each step describes one action during the experiment.

B | Fold the filter paper in half again to form a triangle shape.

Use imperative verbs to keep the sentence structure simple and the language clear.

C | Open out one layer of the paper to form a cone.

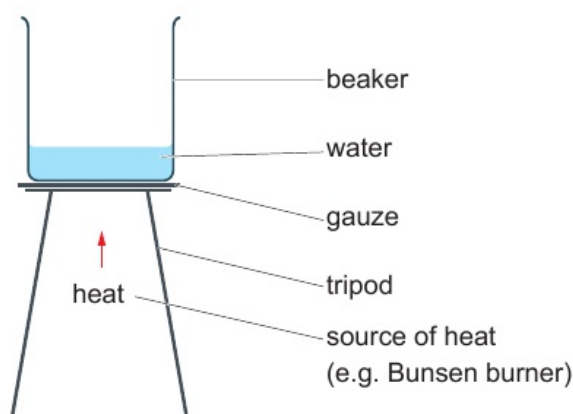
D | Place the filter paper cone into a filter funnel.

E | Place the filter funnel into the neck of a conical flask.

Use the correct names for apparatus and correct scientific terms where appropriate.

F | Stir the sand and water mixture so that all the sand is suspended in the water.

G | Pour the sand and water mixture into the filter paper.



C | apparatus for heating water

- 1** What is the purpose of the method when writing up an investigation report?
- 2** Suggest why showing information using a diagram in a method can be useful.
- 3** Why is it important for scientists to describe the method they use when they write about their work?
- 4** 'Open' in step C is an imperative verb, which is a verb that tells you what to do. Identify three other imperative verbs in this method. Explain your answer.
- 5** Identify one example of a scientific term in the method.
- 6** Suggest a part of this method that could be made clearer by using a diagram rather than words.
- 7** Write a method to explain to someone how to set up the apparatus in diagram C. Remember to use all the rules for writing a good method. Include a diagram to make it easier to see how to carry out one of the steps.

I can ...

- structure a method in a clear manner
- use diagrams to draw apparatus.

7Ea MIXTURES

WHAT KINDS OF MIXTURES ARE THERE?

Water that carries waste materials needs to be treated in a water treatment plant so that it does not harm people or the **environment**. Waste water is a mixture of water and solid substances.

Mixtures are classified (grouped) depending on whether the substances in them are solids, liquids or gases, and on how the substances can be separated.

- A **suspension** is a mixture of two substances that separate if the mixture is not stirred. These two substances are often a solid and a liquid. When they are mixed, we say that one substance is suspended in the other. An example is sand mixed with water.
- In a **colloid**, one substance is **dispersed** in another substance and the two substances will not separate easily. Either substance may be a solid, liquid or gas. A colloid is cloudy or **opaque**, so it is easy to see that it is a mixture. Milk is a colloid of different milk solids dispersed in water.
- A **solution** is a mixture where the solid dissolves in the liquid. This makes the mixture clear or **transparent**.

Many mixtures we use are colloids, such as hair spray, hand cream, Styrofoam™ cups, paint and gel inks. Different kinds of colloid have properties that make them useful in different ways.

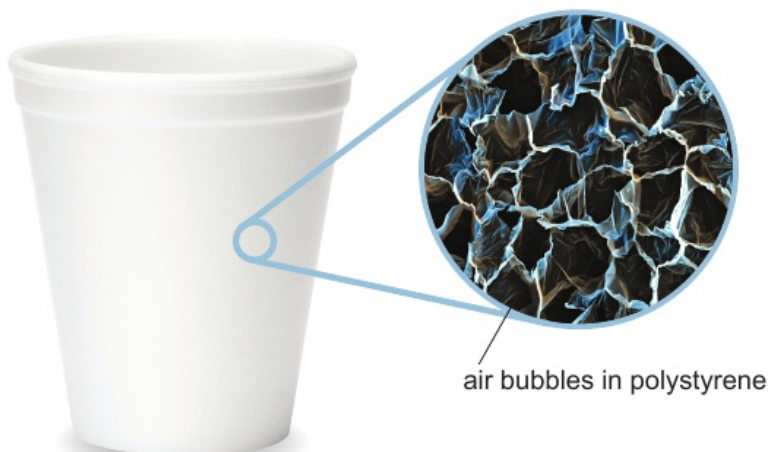


A | Waste water from homes, offices and street drains contains large solids such as leaves, rubbish and lumps of human waste, as well as smaller solids. In the first stage of treatment, waste water passes through a screen, which acts as a **sieve**.

- 1** Why is waste water an example of a mixture?
- 2** a| Suggest what is removed from waste water during the first stages of water treatment.
b| Explain how you worked out your answer to question 2a.
- 3** Describe one difference between a suspension and a solution.
- 4** What kind of mixture is the waste water that enters a water treatment plant? Explain your reasoning.

FACT

Fog is a colloid of water droplets dispersed in air.



air bubbles in polystyrene

B | Styrofoam™ is a solid colloid of air and polystyrene.

After waste water has been screened at a water treatment plant, it is passed through fine **filters** or left to stand in large 'settlement ponds'. This stage removes smaller suspended solids that eventually settle out when the water is still.

The water from the settlement ponds is not clean because very small solids are still dispersed in it. Special substances are added to make these solids clump together. This makes it easier to separate them from the water.

Water that has been filtered or left in a settlement pond still contains dispersed solids.



D | The beaker on the left contains water after it has left a settlement pond. On the right is the same water after substances have been added to clump the solids together.



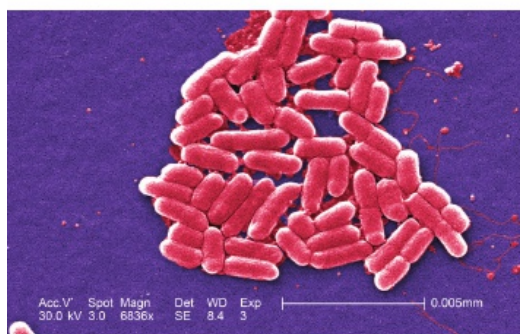
C | Water, without solids suspended in it, pours from the surface of a settlement pond. This water may still contain dispersed and dissolved solids.

5 Explain why the Styrofoam™ cup in photo B is an example of a colloid.

6 Look at photo D. What kind of mixture is shown in the left-hand beaker? Explain your answer.

7 Suggest how waste water is cleaned after the special substances have been added to clump the remaining solids together. Explain your answer.

8 Draw a flow chart to summarise the stages of water treatment described on these pages. For each stage, give the name of the process used to clean the water.



E | Disease-causing microorganisms are too small to be removed by filters or settlement ponds. Drinking water may be treated with chlorine to kill them.

I can ...

- classify mixtures
- describe how insoluble solids can be separated from a liquid.

7E₀ SOLUTIONS

WHY DO SOME PEOPLE USE FILTERS FOR TAP WATER?

Tap water has been filtered and treated to make it safe for drinking but it doesn't contain only water. It is still a mixture, with many other substances dissolved in the water.

Some substances dissolve in a liquid to make a solution. In a solution, the dissolved substance breaks up into pieces so small that light passes straight through the mixture. Because of this, solutions are transparent. A solution may be coloured or colourless, depending on the substances in it.



B | Solutions, such as these, are transparent.

The liquid in a solution is called the **solvent**. The substance that is dissolved is called the **solute**. Water is a good solvent because it dissolves many solids, some gases and even some other liquids.



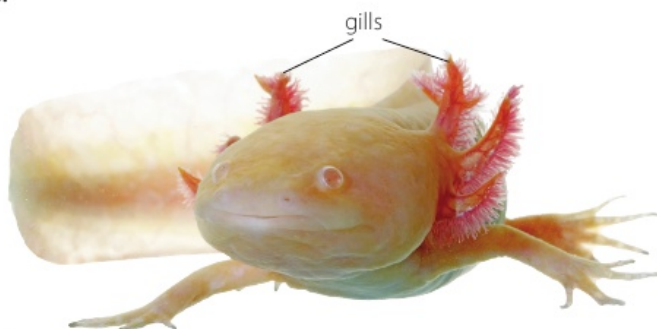
A | A water filter, like the one in the jug, removes some substances that are dissolved in drinking water.

1 What is meant when we say tap water is a solution?

FACT



D Water dissolves substances from the rocks and soil it passes through or over. Different types of rock contain different substances, so the taste of tap water changes throughout the UK. Water tasting tests often show that people prefer the taste of tap water to bottled water.



C | This axolotl uses its gills to absorb **oxygen** dissolved in water.

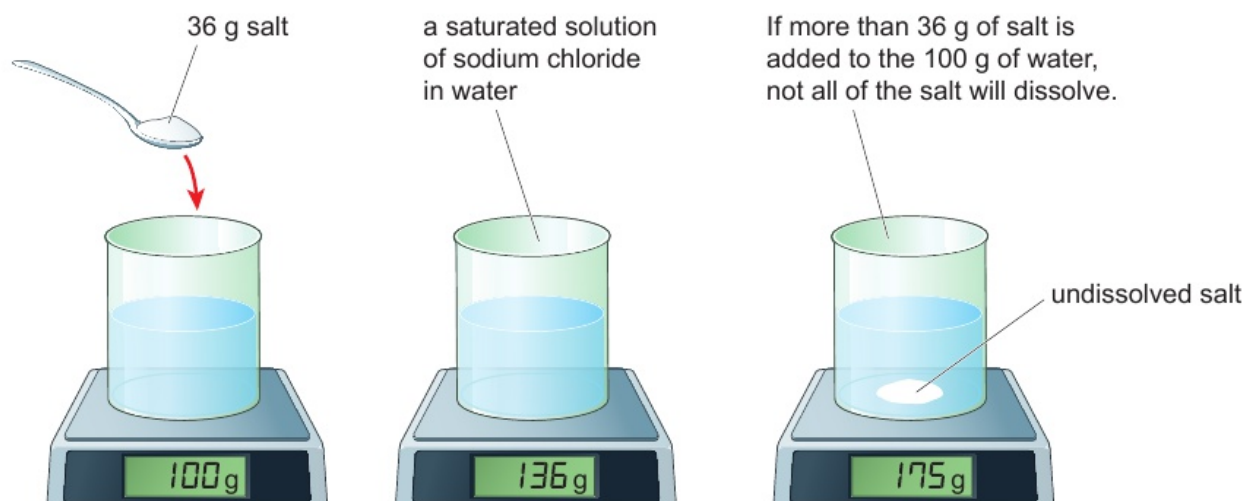
2 Write down the names of two solids and one gas that dissolve in water.

3 Suggest two ways you could tell that a liquid was a solution.

A substance that dissolves in a solvent is said to be **soluble**. Substances that don't dissolve are insoluble. Nail varnish is insoluble in water but is soluble in a liquid called propanone, used in nail varnish remover.

When a solution is formed, there is **conservation of mass**. This means that the **mass** of the solution is the same as the mass of the dissolved substance plus the mass of the liquid at the start.

There is a limit to how much solute you can dissolve in a particular volume of solvent. If you add more solute than this, the extra will sink to the bottom and stay undissolved. This type of solution is **saturated**.



E | A saturated solution is formed when 36 g of table salt is dissolved in 100 g of water.

6 Copper sulfate forms blue crystals. The solubility of blue copper sulfate is 32 g per 100 g of water at 20 °C.

- Which has the higher solubility in water, blue copper sulfate or sodium chloride?
- What is the largest amount of blue copper sulfate that could be dissolved in 500 g of water at 20 °C?
- A saturated solution of blue copper sulfate at 20 °C is cooled to 5 °C. Describe what you would see as the solution cools. Explain your answer.

4 When propanone is used to remove nail varnish, which substance is the solvent and which is the solute?

5 20 g of sugar is stirred into 150 g of tea. What is the mass of the solution formed?

The **solubility** of a solute is the mass that will dissolve in 100 g of a solvent. The solubility depends on the solvent. For example, 36 g of **sodium chloride** will dissolve in water at 20 °C but only 0.1 g will dissolve in ethanol at the same temperature. The solubility also depends on the temperature, usually increasing with temperature: 37 g of sodium chloride dissolves in 100 g of water at 60 °C.

I can ...

- describe how soluble substances can form solutions
- identify the solute and solvent in a solution
- describe the effects of different variables on solubility.

7E^C SAFETY WHEN HEATING

HOW DO YOU HEAT TO DRYNESS SAFELY?

If a solution is left to stand, the solvent will slowly evaporate leaving the solids behind. If the solution is heated, the solvent will evaporate faster.

copper sulfate crystals



A | When the solvent in a solution evaporates, the solid is left behind.

barrel lifts the flame to a suitable height for burning



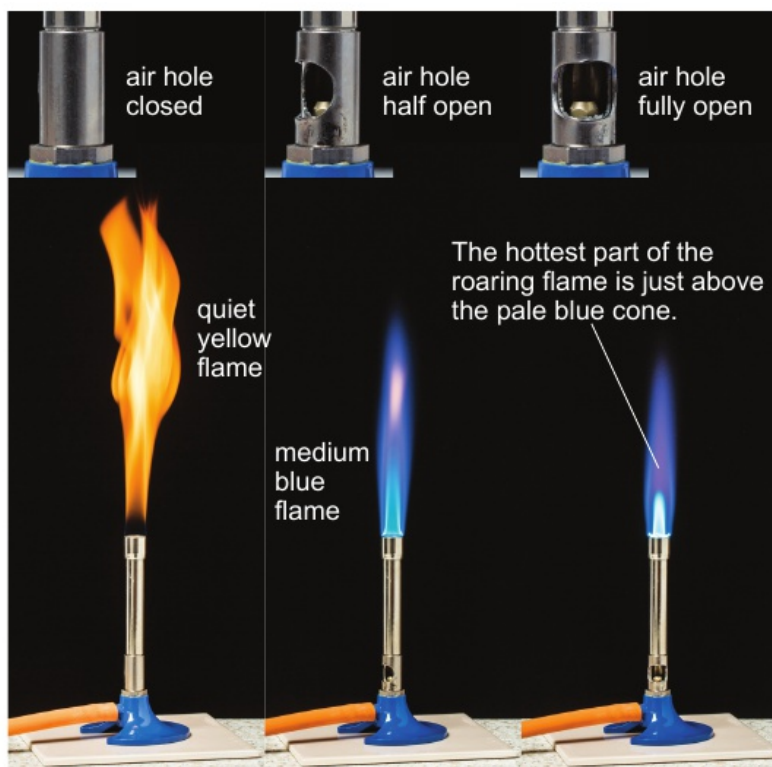
B | The parts of a Bunsen burner have different functions.

Heating a solution until all the solvent has evaporated is known as heating to dryness. In the lab, a Bunsen burner is usually used to heat a solution.

Turning the collar of a Bunsen burner allows different amounts of air to mix with the gas. This changes the temperature of the flame.

Using a Bunsen burner can be hazardous. A **hazard** is anything that could cause harm. When using a Bunsen burner you could burn yourself or others.

A **risk** is the chance that a hazard will actually cause harm. When working with a Bunsen burner you should plan to reduce the chances of burning yourself or others.



C | The 'quiet yellow flame' is a 'safety flame' – it is not used for heating because it leaves a sooty layer on surfaces. The 'medium blue flame' is generally used for heating, especially tubes of liquid. The 'noisy blue flame' or 'roaring flame' is used for heating quickly.

WORKING SCIENTIFICALLY

Using a Bunsen burner safely

Bunsen burners must be used with care. Always follow the Method below to light a Bunsen, so that you work safely.

Method

- A** | Check the gas hose for breaks or holes. If it is damaged, return the burner and tubing to your teacher.
- B** | Tie back loose hair and any loose clothing, such as a tie or scarf. Remove everything from your working area except what is needed for the experiment.
- C** | Wear eye protection.
- D** | Place the burner on a heat-resistant mat, 30–40 cm from the edge of the bench.
- E** | Make sure the air hole of the Bunsen burner is closed.
- F** | Hold a lit splint about 2 cm above the top of the Bunsen burner.
- G** | Turn on the gas at the gas tap to light the burner.
- H** | When you have finished close the air hole so that the flame is yellow, then switch off the gas.

Heating to dryness safely

Heating to dryness increases risks because, when it has lost a lot of solvent, a solution often spits drops of very hot liquid.

The following safety rules help reduce these risks.

- Use a medium flame to heat the solution.
- Wear eye protection while heating.
- Do not fill an evaporating basin more than half-full with solution.
- If heating the liquid in a tube, make sure the open end of the tube does not point towards anyone.
- Always use tongs to hold or move hot things.
- When most of the liquid has evaporated, turn the burner off. Let the rest of the liquid evaporate more slowly.
- Always set the Bunsen burner to a safety flame when not in use and just before turning off.

- 1** What is a Bunsen burner used for?
- 2** Explain why the air hole of a Bunsen burner should be closed before the gas is lit.
- 3** Give two reasons why a medium blue flame is used for heating to dryness.
- 4** Look at photo E.
 - a | Identify the hazards in this experiment when the Bunsen burner is lit.
 - b | How could you reduce the risks of these hazards?
- 5** Plan an experiment to separate salt from salty water by heating to dryness. Include instructions that ensure the experiment is safe.



D | Hot equipment is a hazard when heating to dryness.



E | Working safely in an experiment reduces the risks from hazards.

I can ...

- describe how a Bunsen burner is used
- identify hazards and describe how to reduce risks.

7^{Ec} EVAPORATION

HOW DO YOU GET SOLIDS OUT OF A SOLUTION?

During **evaporation** of a solution, the liquid turns into a gas which escapes into the air. The evaporating liquid leaves behind the solids that were dissolved in it.

Evaporation can happen at any temperature, even when it is cold. However, the rate of evaporation increases as temperature increases.

A | Stalactites and stalagmites form from the water solution that slowly drips through the roofs of caves. Each drop of water that evaporates leaves behind a tiny amount of solid.



Producing salt

The table salt we use in food is a substance called sodium chloride. In some places, sodium chloride is found in thick layers of rock underground. This is called rock salt.

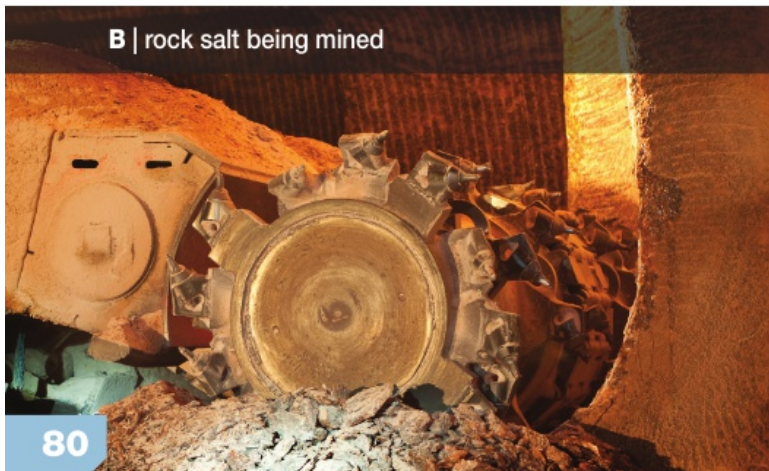
Rock salt can be dug up or mined, or water can be pumped into the layers of salt in the ground, dissolving the sodium chloride. The salt solution is called brine and this is pumped to the surface where it is heated to evaporate the water, leaving behind the sodium chloride.

Table salt can also be made by evaporating sea water.

FACT

Mined rock salt is spread on icy roads in winter. The salt helps prevent ice forming and the bits of rock give extra grip for vehicle wheels.

B | rock salt being mined



C | Sea water is left in shallow ponds to form sea salt.



- 1 Look at photo C. The sea water is left in the ponds for a week or more.
 - a| Describe what happens to the water over this time.
 - b| Explain why the salt is left behind in the pond.
- 2 Would the rate of evaporation of water be greater in the cold cave in photo A or the warm salt ponds in photo C? Explain your answer.
- 3 Draw flow charts to show the two ways in which table salt is produced.

Boiling

Evaporation occurs when a liquid is turning into a gas at the surface of the liquid. **Boiling** is when liquid is turning to gas throughout all of the liquid. When a liquid boils you can see bubbles spread in all parts of it. These are bubbles of gas newly made from the liquid. The temperature at which a liquid boils is its **boiling point**.

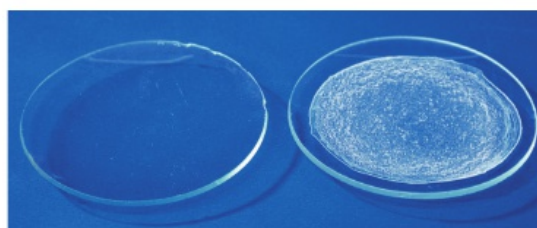
Different liquids have different boiling points. For example, water boils at 100 °C and ethanol boils at about 78 °C, under the same conditions.

In the lab, we can use evaporation to recover solids that have been dissolved in a solution by heating to dryness.



D | This geyser shoots high into the air because water underground is heated to boiling point, forcing the water out of the ground at high pressure.

- 4 Explain why a beaker of water will only boil when heated to 100 °C.
- 5 Explain, as fully as you can, what would happen if you heated a mixture of water and ethanol to a temperature of 80 °C.
- 6 Explain what is meant by heating to dryness.
- 7 Look at photo E.
 - a| Suggest how the two samples were prepared.
 - b| Describe what these samples show.



E | the difference between drinking water from two places in the UK

I can ...

- describe how solutes can be separated from a solution by evaporation
- describe differences between evaporation and boiling.

7Ed CHROMATOGRAPHY

HOW CAN YOU SEPARATE SOLUTES FOR IDENTIFICATION?

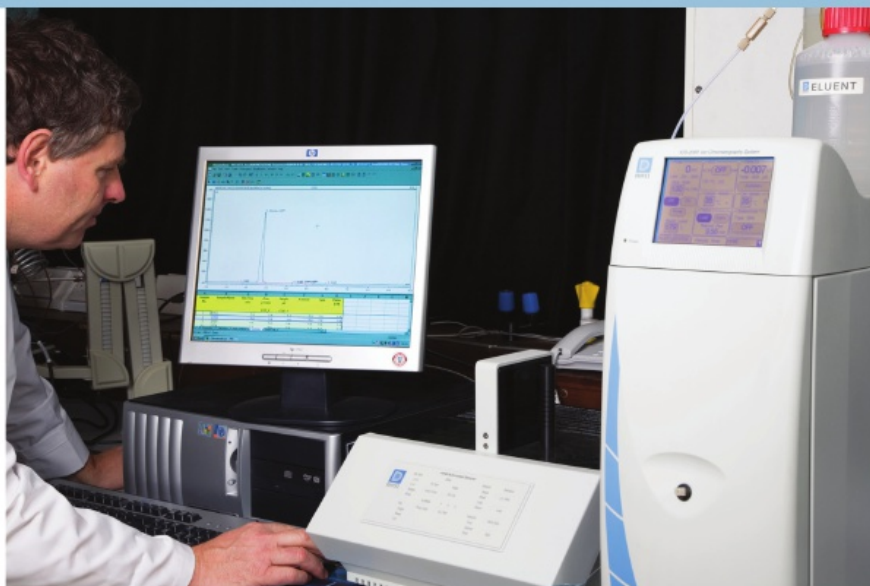
After water has been cleaned at the treatment works, it must be tested before it can be used as drinking water. Tests for many different substances are carried out to make sure the water is safe.

Chromatography is one technique used in water analysis. Chromatography separates substances dissolved in a mixture. This makes it easier to identify and analyse each substance.

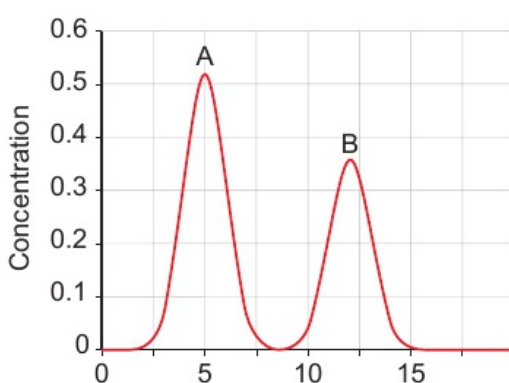
There are many different kinds of chromatography. **Paper chromatography** is the simplest method. It can be used to find out which colours are mixed together in different paints, dyes and inks. A **concentrated** dot of the mixture is placed near the bottom of special chromatography paper. The bottom of the paper is dipped into a solvent. The solvent carries the coloured substances in the ink or paint up the paper to form a pattern called a **chromatogram**.

The basic process of chromatography is the same, whether it is done with paper or by machine. Different substances in a mixture are carried by a gas or liquid solvent. The substances are carried at different speeds, which separates them out from each other.

- 1 What is chromatography?
- 2 Look at diagram B. Which of the two substances had the highest concentration in the original sample? Explain your answer.
- 3 Look at photo C. Describe how this experiment was set up.



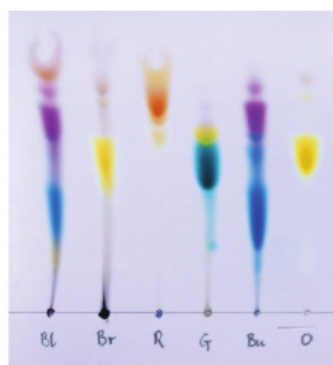
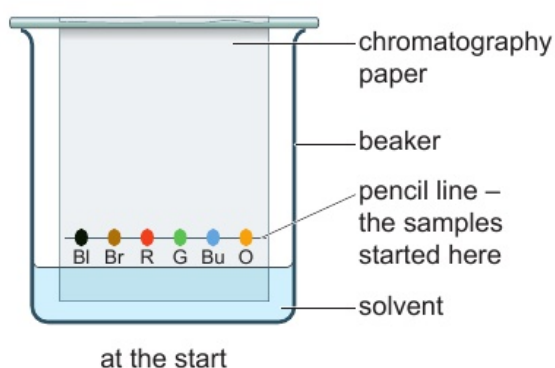
A | Chromatography is often done by complicated machines. The results of this water analysis are displayed as a graph showing a peak for each substance in the mixture. Peak height shows how much of the substance is in the sample.



B | a sample chromatogram from water analysis



C | paper chromatography of two different inks



the chromatogram formed after the solvent has soaked up the paper

D | Six different inks were tested in this chromatography experiment: black (Bl), brown (Br), red (R), green (G), blue (Bu), orange (O).

Chromatography can be done with colourless substances. The chromatogram that is produced is then treated to make the substances coloured. Alternatively, ultraviolet light might make the substances glow. This makes the substances visible so the chromatogram can be analysed.

7 Diagram E shows the results of chromatography on three different orange squashes and some food colourings.

- Which food colourings are found in the three kinds of orange squash?
- Tartrazine is thought to make some children over-active. Which orange squash would be safe to give to an over-active child? Explain your answer.



- Give two examples of how chromatography is used in industry.
- Compare the results of paper chromatography with the results of the water analysis chromatography shown in diagram B.
 - How are they similar?
 - How are they different?
 - Suggest why the method shown in photo A is used to analyse water rather than paper chromatography. (*Hint: Think about why drinking water is analysed.*)

4 Look at diagram and photo D.

- Identify the colours in the different inks.
- Which colour was carried the fastest?

5 Explain why chromatography separates the substances in the mixture.

6 Why can't you just evaporate a liquid to find out which substances were dissolved in it?

FACT

Chromatography is used to identify the contents of many kinds of mixtures, including water, food, urine, blood, sweat, soil and the atmosphere. During international athletic tournaments, chromatography can be used to test blood and urine samples for banned drugs. It is also used in the forensic analysis of crime scenes to identify specific mixtures, such as colours in a lipstick or in a black ink.

I can ...

- describe how chromatography can be used to identify substances in a mixture
- explain how chromatography works.

7Ee DISTILLATION

HOW DO WE MAKE SEA WATER DRINKABLE?

In the UK, most of our drinking water comes from rain water that collects in rivers, lakes and reservoirs. However, many parts of the world do not get as much rain as the UK. They may get their drinking water from other sources.

- 1 Why is rain water usually safe to drink?
- 2 Why do many parts of the world need sources of water different from the ones used in the UK?

Over 70 per cent of the Earth's surface is covered in water. Most of this is sea water, which contains too many solutes to be safe to drink. Drinking water can be made from sea water using a process called **desalination**. Desalination removes most of the salts from the water. This requires expensive equipment and a lot of space, so it is only suitable in some places.



A | Rain water contains only small amounts of dissolved substances. This means it is usually safe to drink.



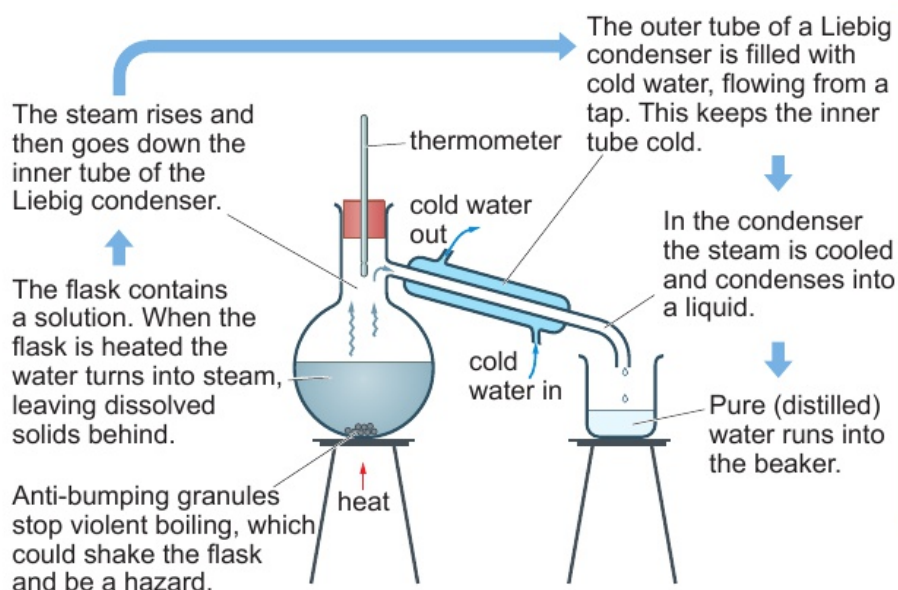
B | The Jebel Ali desalination plant in the United Arab Emirates produces over 800 million litres of drinking water each day.

One of the ways in which sea water is desalinated is called **distillation**. The sea water is heated so that the water evaporates to form **steam**. The steam is collected and cooled so that it **condenses** back into liquid water. This water is **pure**, containing no solutes, because the solutes in sea water cannot evaporate and are left behind.

FACT

Sea water is dangerous to drink because it contains high levels of salt. Salt has the effect of removing water from the cells in your body, which makes you even thirstier!

- 3 What does desalination mean?
- 4 Explain why desalination plants are usually built next to the sea.
- 5 One of the products of distilling sea water is drinking water. Suggest another product from this process. Explain your answer.



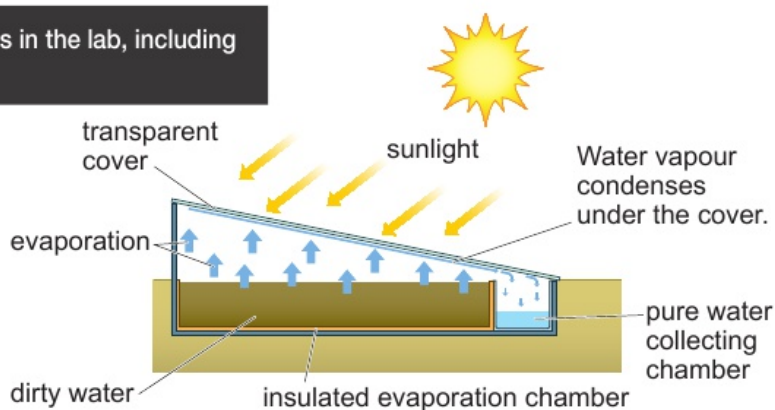
6 Use diagram C to help you draw a flow chart that describes how sea water is distilled in a desalination plant to produce drinking water. Use suitable scientific words in your descriptions.

- 7**
- Identify one hazard when heating liquids to boiling point in a flask.
 - Describe how the risk from that hazard can be reduced.

C | This apparatus can be used to distil mixtures in the lab, including solutions such as salty water.

The apparatus shown in diagram C is sometimes called a still. Stills can use **energy** from the Sun. In 1872, Charles Wilson invented the solar-powered water still, to supply drinking water to a large mining community in Chile, South America. The solar-powered still is a cheap way of providing clean water in poor areas of the world. Diagram D shows how it works.

Today solar-powered stills can be important for providing emergency clean water in remote places and at sea.



D | a basin solar still

8 Explain why a solar-powered water still might be useful:

- on a ship that has broken down at sea
- in a country where the drinking water contains bacteria that cause diseases.

9 Compare the basin solar still in diagram D with the still apparatus in diagram C.

- Identify any similarities and differences in the way they work.
- Suggest which still is better for getting the most pure water out of salty water. Explain your reasoning.



E | An inflatable solar still may be part of the emergency supplies on the life rafts of an ocean-going ship.

I can ...

- explain how distillation can be used to separate a solvent from a solution
- give examples of where distillation is used.

7Ee SAFE DRINKING WATER

CAN WE MAKE SAFE DRINKING WATER FOR EVERYONE?

One in eight of the world's population do not have a water supply that is free from harmful substances and disease-causing microorganisms. Climate change and increases in the number of people may make safe water supplies more difficult to access for everyone, even in the UK.



B | In the developing world, an average of 5 million people each month move into cities to find work. Many live in slum areas where there is no safe drinking water.

C | The filtering system in the LIFESAVER® jerrycan removes dirt and disease-causing microorganisms, and leaves water safe to drink. A smaller bottle system is ideal for emergency situations.



A | Disasters, such as flooding and earthquakes, damage water and waste pipes. A government report suggested that 3.6 million people in the UK could be affected by flooding caused by climate change by 2050. The UK has also had serious droughts, with very low levels of rainfall, in some recent years.

- 1** a| Why is safe drinking water not usually a problem in the UK?
b| Why could safe drinking water become more of a problem in the UK in the future?
- 2** The LIFESAVER® system uses a range of filters to clean the water.
a| Describe how the filters clean the water.
b| One of the filters in the system has extremely small holes. Suggest what this filter removes from the water to make it safe to drink. Explain your reasoning.
c| One of the filters contains a substance that can remove dissolved solids. Explain why this is needed.
- 3** List the different ways in which safe drinking water can be made. Briefly explain how each one works and describe where it might be most useful. Explain your answers.

HAVE YOUR SAY

Can we make sure there is safe water for everyone?

7Fa CHEMISTRY IN THE HOME

Chemical substances are all around us in our homes. In a kitchen, the cleaning products, the pots and pans and containers are all made using chemistry. Even a lot of your food and drink will be made using chemical processes.

Many chemical substances can be dangerous and need to be handled with care. Information to help us use substances carefully is found on their containers. You should use this information to make sure you know how a substance can cause harm and how to prevent this from happening (e.g. by wearing gloves).



B | Bleach is useful because it kills microorganisms that can make us ill. It is also harmful if used wrongly, such as by drinking it or spilling it on your **skin**. In the UK, about 300 children are hurt by bleach every year.



A | Many substances in your home can be dangerous, particularly to young children, and should be kept in places that young children cannot reach.

If a large amount of a dangerous substance is spilt, it could cause harm to a lot of people. Firefighters receive special training in how to deal with spills of dangerous substances.

- 1** Write down the names of two solids and one gas that dissolve in water.
- 2** State two ways in which children might have an accident with bleach.
- 3** Suggest two ways to reduce the risk of children being hurt by bleach.
- 4**
 - a) Why is it useful to have information on the sides of containers about what they contain?
 - b) Even with this information, why must people keep cleaning products out of reach of young children?



C | Firefighters wear protective clothing and gas masks to protect them from the dangers of spilt chemicals as they clear up this spill. The label on the side of the drum shows what the substance is and how to deal with it.

7Fa HAZARDS

HOW DO WE DEAL WITH HAZARDOUS CHEMICALS?

Something that can cause harm is a **hazard**. The type of harm that can be caused is often shown using a hazard symbol.

Acids and **alkalis** are common substances found in homes and laboratories. They can be **corrosive**. This means they can attack certain materials like **metals**, stonework and skin. Great care must be taken when handling corrosive substances as they can destroy living **tissue** and cause permanent damage.



B | Drain cleaner is a corrosive alkali.



C | Katie Piper had undiluted sulfuric acid thrown at her.



A | The sulfuric acid in car batteries is diluted but still corrosive.

Acids and alkalis used in the laboratory are often **diluted** with water to make them less dangerous. Although not corrosive, dilute acids used in the laboratory can be **irritants**. These solutions are unlikely to cause serious injury but can cause skin inflammation and soreness. The vinegar we use on our food contains about 5–8 per cent ethanoic acid in water. It is not a hazard but stings if you get it in a cut. Above 10 per cent, ethanoic acid is an irritant and above 25 per cent it is corrosive.



D | **Concentrated** hydrochloric acid is corrosive. Dilute hydrochloric acid can be an irritant.

- 1** a| How can an acid be diluted?
b| Explain whether car battery acid is a pure substance or a mixture.
- 2** Name an acid used in the laboratory and one used in everyday life.
- 3** a| Name two substances that will be attacked by a corrosive acid.
b| Name one substance that is not attacked by a corrosive acid.
- 4** How is a corrosive chemical different from an irritant?

We like the sour taste of acids and so they are often found in foods and drinks. All fizzy drinks, fruit juices and many sauces and preserves are acidic. In general these acids will not cause damage and so don't carry a hazard symbol. However, these types of food and drink may help cause tooth decay.

The symbols used in photos A, B and D are the European hazard symbols. These are being replaced by a new set of international symbols, shown below.

FACT

In 1949, John Haigh was convicted of murder even though there was no body – he put his victim into concentrated sulfuric acid! In the acid sludge, forensic scientists found a denture, pieces of bone and the handle of a plastic bag, which were not attacked by the acid. This was enough evidence to secure a conviction.



International hazard symbol	Hazard description
	Dangerous to the environment: This can cause long-term damage to animal and plant life.
	Toxic: This is poisonous and can cause death if swallowed, breathed in or absorbed through the skin.
	Corrosive: This attacks certain substances like metals, stonework and skin.
	Explosive: Heating may cause an explosion.
	Flammable: These substances catch fire easily.
	Caution: Although similar to toxic and corrosive this is a less serious hazard, e.g. may cause skin irritation.

G | the new international hazard symbols



F | Many drinks contain natural and artificial acids.

- 5** What do acids in food and drink taste like?
- 6**
 - a) Name an acid found in fizzy drinks.
 - b) Why do acidic foods not carry hazard symbols?
- 7** Which international hazard symbols will be displayed on the following household chemicals:
 - a) turpentine – damages pond life, causes headaches and sickness, can catch fire if heated
 - b) soap powder – causes irritation to the skin?
- 8** Phosphoric acid is delivered to a drinks factory in concentrated form. Why do you think the acid is not diluted before transporting it?

I can ...

- recognise some common hazard symbols
- explain why hazard symbols are necessary
- recognise some common acids.

7Fa CONTROLLING RISK

HOW CAN WE REDUCE RISKS WHEN CARRYING OUT EXPERIMENTS?

A hazard is anything that could cause harm. A **risk** is the chance a hazard will cause harm. By using chemicals carefully and protecting yourself and others, you can reduce the risk of harm. For example, there is always a great risk of splashing when heating an acid. Wearing safety goggles and protective gloves is a sensible **precaution** for reducing the risk of damage to eyes and skin.



A | potential hazards in a school laboratory

- 1** Copy and complete the table below. Name at least six more potential hazards shown in cartoon A. Also describe the risks and the precautions that could be taken to reduce them.

B	Hazard	Risk is increased because ...	Precaution to reduce risk
	Corrosive acid	bottle is at edge of bench and could be knocked over and harm students.	Remove bottle of corrosive acid from bench and store safely.
	Fumes from chemicals	fumes could cause damage to student's nose and lungs when inhaled deeply.	Smell by using hand to carefully waft vapours towards nose.

WORKING SCIENTIFICALLY

Planning for hazards and risks

Here is a set of instructions for a teacher to demonstrate what happens when sulfuric acid is added to sugar. For the experiment, concentrated sulfuric acid is used. 'Concentrated' means that it has very little or no water added to it.

Method

Warning: This method is for teacher demonstration only. Wear goggles or a face shield, use a fume cupboard and wear chemical-resistant gloves.

A | Place a 100 cm³ beaker on a white tile inside a fume cupboard. Add 50 g of table sugar to the beaker.

B | Add concentrated sulfuric acid to just saturate the sugar, and no more.

C | Observe what happens. Beware that sulfur dioxide and carbon monoxide gases are formed. Do NOT touch the carbon that forms.

D | Allow the beaker to cool for at least 20 minutes in the fume cupboard (the beaker will reach temperatures of over 100 °C).



- 2** a) What corrosive substance is used in this experiment?
b) What does corrosive mean?
c) How do you know that substances such as this are corrosive?
d) Suggest a way of reducing the risk of harm from this substance.

- 3** a) What is the hazard in step C?
b) What safety instructions in the method reduce the risk from this hazard?

- 4** a) What is the hazard in step D?
b) What safety instructions in the method reduce the risk from this hazard?

C | Common ways of reducing the risks of harm when using chemical substances include gloves, eye protection, wearing a lab coat and using a fume cupboard.

I can ...

- plan and explain safety precautions
- recognise hazards and explain how the risks can be controlled.

7Fo INDICATORS

HOW CAN WE USE INDICATORS TO CLASSIFY SOLUTIONS?

Red cabbage can be stored in vinegar. The juice from the 'pickled' cabbage is red. If you mix soap with the red cabbage juice, it changes colour and goes blue. If you add some drain cleaner, it changes again and goes yellow-green. The colours from plants that change colour when mixed with different types of substance are called **indicators**.

Testing for acids

Another indicator, litmus, is made from a type of lichen. The word comes from 'lit-moss', which meant 'coloured moss' in medieval English. Litmus can be red, blue or sometimes purple (blue and red mixed together). It can be used as a solution or as litmus paper. Most acids, like vinegar and fruit juices, turn litmus red. Other types of **solution** will turn it blue or purple.



A | Different substances have been dropped into red cabbage indicator.

acidic

alkaline



B | litmus lichen and litmus indicator colours

- 1 Name two plants that can be used as indicators.
- 2 What colour is car battery acid mixed with:
a| red cabbage juice b| litmus?
- 3 A few drops of litmus solution are added to some toothpaste. The litmus turns blue. What does this tell you about the toothpaste?
- 4 Kelly made some red cabbage indicator by crushing up red cabbage leaves with a mixture of water and alcohol. She then needs to separate the juice from the leaves. How could she do this? Draw a diagram to explain how your method works.

Testing for alkalis

In ancient Arabia, people took ashes from fires and mixed them with water. This **liquid** was boiled with animal fats to make the first soap. In Arabic, the ashes were called *al quali*. We use the word alkali to describe a group of substances that feel soapy. However, many alkalis are corrosive and are too dangerous to feel. This is because they attack the natural oils in your skin. Your skin can start to turn into soap!

Alkalis turn litmus indicator blue. Alkalis can be irritants, harmful or corrosive, just like acids, and in some ways they are more dangerous, especially if you get them in your eyes.

Oven cleaners often contain alkalis. The grease in the oven is attacked by the cleaner and the grease turns into soap. This helps the cleaning process.

Many solutions are neither acidic nor alkaline; examples are things like **pure** water, salt and sugar solutions. These are called **neutral**. Neutral solutions do not change the colour of indicators. However, being neutral does not necessarily make a substance safe. Some neutral solutions are **toxic**, and some are corrosive but in a different way from acids and alkalis.

D | Many household cleaners are alkaline.



5 State whether these substances are acidic, alkaline or neutral:

- a| vinegar b| water c| salt solution
d| lemon juice e| sugar solution f| soap.

6 An indicator called methyl orange turns red in acids and yellow in alkalis.

- a| What colour would methyl orange turn with:
i| grapefruit juice ii| oven cleaner?
b| Will the colour of methyl orange change if pure water is added to it? Explain your answer.

7 Asha crushed some purple berries from a bush and mixed them with a little water. When she mixed the juice with some wet washing powder, the colour changed to red. She said: 'This proves that the berries are an indicator and the washing powder is an alkali.' Is she right? Explain your reasons.



C | Ashes from the fire contain alkalis.

FACT



E Lake Van, the largest lake in Turkey, is so alkaline that the water naturally forms a lather and you can wash in it without using soap.

I can ...

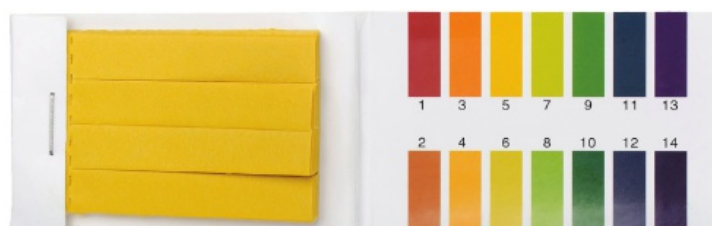
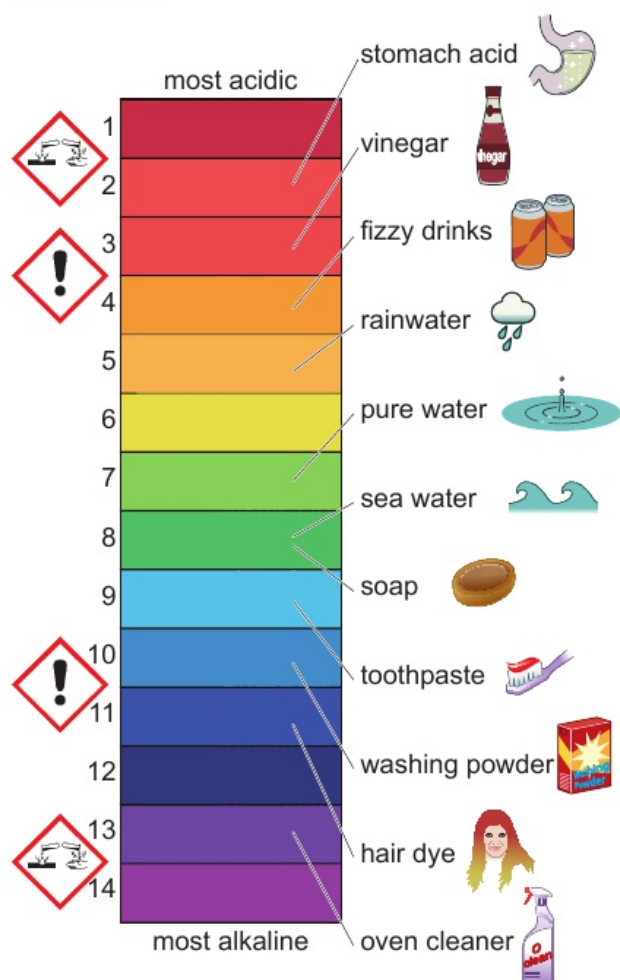
- name examples of indicators made from plants
- describe how indicators can be used to test for acidic, alkaline or neutral solutions.

7F^C ACIDITY AND ALKALINITY

HOW CAN WE MEASURE HOW ACIDIC OR ALKALINE A SOLUTION IS?

An indicator like litmus can show us whether something is an acid or an alkali. However, it cannot tell us how much acidity or alkalinity there is. Søren Peder Sørensen (1868–1939) solved this problem. He was a Danish chemist who worked for the Carlsberg brewery, controlling the quality of beer manufacture. In 1909, he invented the **pH scale** as a way of measuring how acidic the beer was. This scale measures acidity and alkalinity in numbers, which is more precise than describing it in words.

The main pH scale runs from 0 to 14. Substances with a pH of 7 are neutral, while acids have a pH lower than 7 and alkalis have a pH above 7. The lower the pH the more acidic the solution and the higher the pH the more alkaline the solution.



A | The pH of a solution is often measured using a meter or test papers. The pH is written with a small p and a capital H (which stands for hydrogen).

We can use a universal indicator to measure pH. This is a mixture of indicators that gives a range of colours depending on the pH of the solution. The precise colours depend on the indicators in the mix but most brands show red, orange, yellow, green, blue and purple. Using a pH meter like the one in photo A is a more accurate way of measuring pH. However, universal indicator, as paper or solution, is often a quicker and simpler way of estimating pH.

Being able to measure the pH of solutions is important in many industries, not just in brewing beer. Measuring the pH is also important in the environment, where we need to keep a check on rain and water quality. The pH of water is checked regularly to make sure it falls within safe limits. This is particularly important near factories that produce acidic waste. The pollution from them can cause **acid rain** and harm wildlife and waterways.

B | using the pH scale



D | checking the pH of water in marshland

- 1** a| What is the pH of a substance that turns universal indicator orange?
b| Would it be an acid or an alkali?
c| Would the substance be very acidic or alkaline or not very acidic or alkaline?

2 Copy and complete table C.

C	Name of chemical	Colour of universal indicator	Acidic, alkaline or neutral	pH
	hydrochloric acid		very acidic	
				7
	sodium hydroxide	purple		
	carbon dioxide solution		not very acidic	

Many hair products are alkaline. For example, permanent hair dyes usually contain ammonia, which can have a pH of about 11. This can damage the skin. Ammonia can also be toxic and has a bad smell so manufacturers try to produce new hair dyes that don't rely on ammonia. However, they still need to contain an alkali, which helps the dye to penetrate into the hair strand.

- 3** Estimate the pH of:
a| stomach acid b| toothpaste
c| fizzy drinks d| soap.
- 4** Look at chart B. Describe the link between the pH number and the hazard rating of the substances. Give as much detail as you can.
- 5** If you added some washing powder to sea water, would the pH go up, down or stay the same? Explain your answer.
- 6** A sample of river water taken near to a factory shows a pH of 5.
a| Do you think this represents a pollution problem? Give reasons for your answer.
b| What other evidence might you need to consider before reaching a conclusion?
- 7** Suggest a benefit and a drawback of using permanent hair dyes.



E | An alkali is present in permanent hair dyes.

I can ...

- name some common examples of acids and alkalis
- describe the pH scale and how it is useful
- describe how pH can be measured.

7Fc WRITING TITLES

HOW CAN YOU SUMMARISE INFORMATION IN CAPTIONS AND TITLES?

Titles are very important. People will often decide whether they want to read a report based on the title.

Colour-changing lipstick for your perfect shade

Fashion-conscious girls now have a new weapon for perfect lips – a green (yes, green!) lipstick. This lippy undergoes a colour change when applied ... it turns pink! But not just any shade of pink. The 'magic' ingredient, a dye called Red27, turns different shades of pink depending on the temperature and pH of your lips. So is the struggle to choose your best lip colour over? We asked two intrepid testers to find out.

Of our two testers, Sandra was the more impressed. 'It was almost miraculous, watching it change colour to a really nice shade that really suited me,' she said, 'although it does stain your lips and so unlike normal lipstick you have to be very careful when you apply it, since it can last for hours.'



A | As mood influences lip pH and temperature, it can control the final colour of this lipstick.

Tina wasn't quite so taken with it. 'Sandra got a really nice shade of pink with it. But obviously my skin pH is different, and I got a really bright cerise colour, which didn't suit me at all.'

A good title should:

- contain key words (that can be searched for, e.g. on the internet)
- clearly tell the reader what a report is about
- be short (it does not need to be a full sentence).

Titles contain key words from a report. These are often nouns (words that name a person, thing or idea). So the key nouns from a report will sum up what it is about and who is involved.

A noun often has important extra detail added to it (e.g. 'colour-changing lipstick'; 'a really bright cerise colour'). The noun and the extra detail form a noun phrase. So it's helpful to search a title or report for key noun phrases because these will tell you more about the topic or who is involved.

- 1**
 - a) Look at the title of newspaper article A. Which is the key noun that tells you what the topic is about?
 - b) Search the article for the name of the dye. What is the dye called?
 - c) Search the article for the names of the testers. What are their names?
- 2**
 - a) Look again at the article title. Explain why the detail 'colour-changing' has been used to describe the lipstick.
 - b) In the article, what is the noun phrase that tells you who the lipstick is aimed at?
 - c) What does the colour change depend on? Find the phrase that tells you the answer.

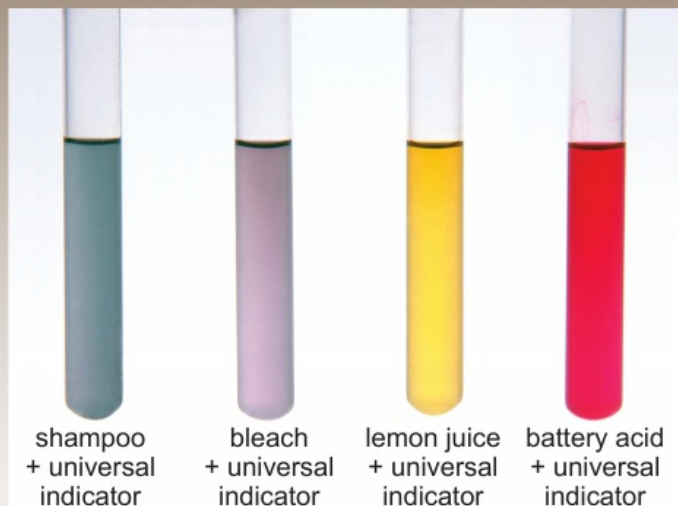
LITERACY & COMMUNICATION

Science titles and captions

In science, key words are often the names of **variables**, or the name of a **method** used in an investigation (e.g. filtration) or what was discovered. Including all the key words in a title will usually make it too long, and so you shorten a title to:

- include only the most important key words
- use short, descriptive noun phrases where you can.

Captions tell you what an **image** shows so that you don't need to read all the text to find out about an image. To write a caption you may need to think up key words to describe what an image shows. A caption often draws attention to a part of an image.

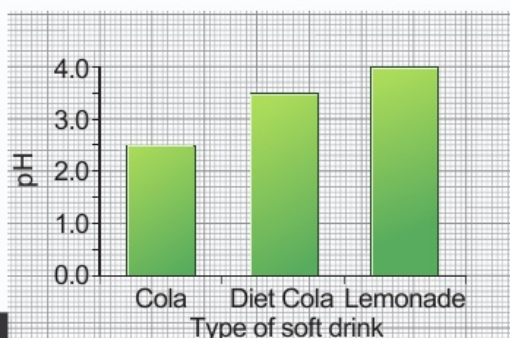


B | different solutions in test tubes

Graph and chart titles

Scientists also write titles for graphs and charts. The variable that is measured in an experiment (the **dependent variable**) is plotted on the vertical axis. The variable that causes the dependent variable to change (the **independent variable**) is plotted on the horizontal axis. The title for the whole chart or graph is often written in the form: How [dependent variable name] depends on [independent variable name].

6 Look at chart C. Give it a title.



C

3 The following headline is taken from a science journal.

Top climate scientists admit global warming forecasts were wrong

- a| Which noun phrase tells you *who* the report is about?
- b| Which noun phrase tells you *what* the report is about?

4 Look at the first paragraph on page 94. Give it a title.

- 5** a| Why is the caption to photo B not very useful?
- b| What key words would you use to describe photo B?
- c| Use some of your key words to write a more useful caption for the photo.

I can ...

- summarise information for titles and captions
- identify key words and noun phrases.

7Fd NEUTRALISATION

WHAT HAPPENS WHEN AN ACID IS ADDED TO AN ALKALI?

Farmers and gardeners test the pH of their soils so they know which types of plants will grow best. Table A shows the best pH for growth in some common crops.

A	Plant	Best pH range
	cabbage	5.6–6.6
	cauliflower	6.0–7.0
	onions	6.2–6.8
	leeks	5.0–6.0
	mushrooms	7.0–8.0
	potatoes	5.8–6.5

If a soil is too acidic then farmers can add an alkali called lime to their fields. The alkali cancels out the acids, making the soil more neutral. This is **neutralisation** and it happens when any alkali and acid are mixed together.

- 1 a) Which pH values indicate an acidic soil?
b) Which pH values indicate an alkaline soil?
- 2 a) Which plants grow well in a neutral soil?
b) Which crop is least likely to need lime in the soil?

Neutralisation can be carried out in the laboratory as shown in photo D. The pH is measured using universal indicator. The alkali is added to the acid. If the solutions are added carefully, you can find the precise amount of acid and alkali needed to obtain a neutral solution.

Flask X in photo D contains hydrochloric acid solution. As sodium hydroxide is added, the pH increases until it reaches 7. The solution is **neutral** at this point. If more alkali is added, the solution will become alkaline.

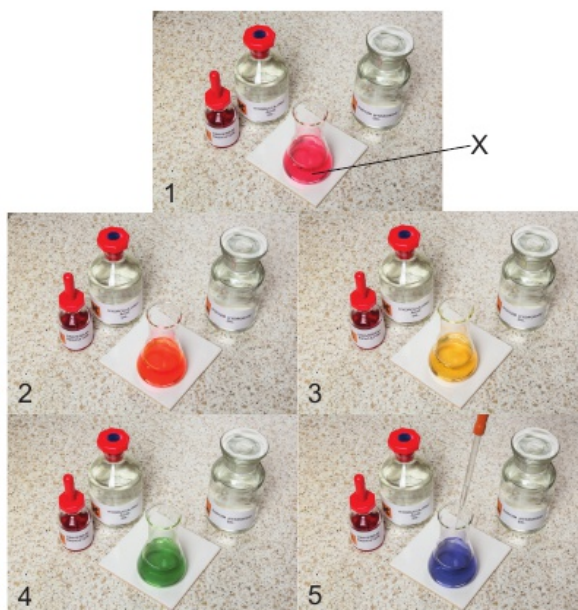
- 3 a) Does flask X contain more acid or more alkali?
b) How can you tell?
- 4 a) What does the precise colour in flask X tell us?
b) What is the approximate pH of the sodium hydroxide solution?



B | testing the pH of soil



C | Lime is used to cure an acid soil.



D | neutralisation in action

The neutralisation of an acid and an alkali forms new substances and is an example of a **chemical reaction**. If the neutralisation of hydrochloric acid and sodium hydroxide is repeated without the indicator, a clear solution is produced.

If we evaporate the solution, we are left with a white solid, which is sodium chloride (common salt). The other new substance produced in the reaction is water.

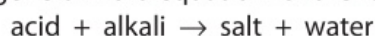
The chemical reaction can be written as:



This is called a **word equation**. Word equations are used to model (describe) chemical reactions. The **convention** (set of rules) for writing word equations is:

- the starting substances, the **reactants**, are written on the left
- then there is an arrow, pointing to the new substances formed
- the new substances, the **products**, are written on the right.

The general word equation for the reaction of acids with alkalis is:



Neutralisation produces substances called **salts**. Different acids and alkalis produce different salts. Hydrochloric acid produces chloride salts, sulfuric acid produces sulfate salts and nitric acid produces nitrate salts. Lithium chloride, sodium sulfate and potassium nitrate are all examples of salts produced by neutralisation. Only **sodium chloride** is called common salt.



E | Sodium chloride solution is formed in a neutralisation reaction.

F | Ammonium nitrate fertiliser is a salt made using ammonium hydroxide and nitric acid.



- 5** a| What pH is neutral?
b| How can you tell when just enough alkali has been added for neutralisation?
- 6** From the word equation for the reaction between hydrochloric acid and sodium hydroxide, select substances that are:
a| alkaline b| acidic c| neutral d| reactants e| products.
- 7** Copy and complete these word equations:
a| lithium hydroxide + hydrochloric acid \rightarrow _____ + _____
b| _____ + sulfuric acid \rightarrow sodium sulfate + _____
- 8** Which acid and alkali would produce ammonium sulfate?
- 9** Suggest how you could make spilled concentrated acid safe to be mopped up.

I can ...

- describe what happens during neutralisation
- write word equations for neutralisation reactions
- explain the pH changes taking place during neutralisation.

7Fe NEUTRALISATION IN DAILY LIFE

HOW CAN WE MAKE USE OF NEUTRALISATION?

An alkali can be described as a **soluble base**. A base is any substance, soluble or **insoluble**, that neutralises an acid forming a salt and water.



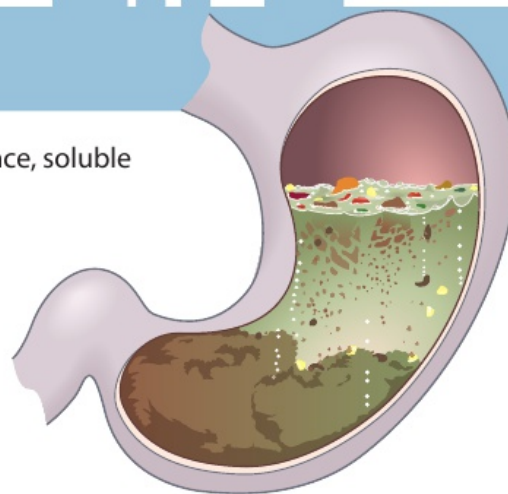
Acids, alkalis and bases are common substances and many neutralisation reactions occur in nature and our homes. It is important we understand these reactions so we can use these substances properly.

The hydrochloric acid in your stomach has a pH of 1 or 2. If you produce too much acid, you may get indigestion or heartburn. Indigestion remedies, such as Milk of Magnesia, are called **antacids**. They contain bases, such as magnesium hydroxide, to neutralise some of the acid and help keep the balance right. For example:



Indigestion remedies are not very alkaline (usually about pH 9) so that they do not lessen the acidity in your stomach too much.

The food you eat produces acids in your mouth that can cause your teeth to decay. Toothpastes often contain bases such as magnesium hydroxide and calcium hydroxide. These bases react with the acids in your mouth to reduce acidity.



A | Stomach acid helps to break down your food.



B | Toothpastes neutralise the acids in your mouth.

- 1** a| What kind of substance is Milk of Magnesia?
b| What might be its pH?
- 2** What do you call the reaction between magnesium hydroxide and hydrochloric acid?
- 3** Why is it not a good idea to use sodium hydroxide, with a pH of 13, to neutralise excess stomach acid?
- 4** Explain why toothpaste might contain magnesium hydroxide.
- 5** Some toothpastes contain aluminium hydroxide. Write a word equation for this base reacting with hydrochloric acid.

Old remedies for bee and wasp stings also used neutralisation. A bee sting, being acidic, was treated with a weak alkali like baking soda. A wasp sting, being thought to be alkaline, was treated with a weak acid like vinegar. In both cases it was understood the pain would be relieved by neutralisation of the acid or alkali in the sting. We now know that these remedies don't really work, as there are many different toxic substances in the stings.

FACT

A bee sting is known to contain acids like methanoic acid and even a single sting can be very painful. It is also estimated that 1100 stings from a honey bee could be fatal. However, it is not really the acids that cause the problem but a combination of some of the 60 other nasty substances in the sting that cause the pain.



C | The sting of some bees stays in their victim and the bee dies.

Acid can be used to clean **metals**. Objects made of iron and steel can rust, forming iron oxide. Sulfuric acid can attack the rust and remove it from the surface via a neutralisation reaction. For example:



Acidic waste **gases** from some industries are neutralised by sprays of calcium hydroxide before they are released into the atmosphere. This reduces the possibility of creating harmful **acid rain**.



D | using acid to clean off rust

E | Power stations that burn coal can release sulfuric acid as a waste gas.



- 6** Explain this memory aid:
Vinegar for wasps
Bicarb for bees
- 7** Why is the man in photo D wearing gloves?
- 8** Write a word equation for the reaction between calcium hydroxide and the acid gas released by power stations.
- 9** Indigestion tablets reduce acidity in the stomach. Write down the steps for an experiment to find out which indigestion tablets work best.

I can ...

- describe some examples of everyday acids and bases
- describe and explain some everyday neutralisation reactions.

7Fe DANGER AT HOME

HOW DANGEROUS ARE CHEMICALS IN THE HOME?



A | The older hazard symbols are still being used widely. They will soon be changed into the new international symbols, which have a diamond shape.

In most houses you will find a range of chemicals with a variety of uses. We buy specialist chemicals for decorating, cleaning, car maintenance, gardening and more. Often we use them just once and store what's left for another day. The problem is that many of these chemicals present particular hazards. We need to understand some of the science behind these chemicals so we can use and store them safely.

- 1** Describe the dangers represented by the four hazard symbols, i to iv in photo A.
- 2** Name a household chemical that could be:
 - a| an acid b| an alkali
 - c| flammable d| corrosive.
- 3**
 - a| Describe how you could test a household chemical to find out its pH.
 - b| What do the pH numbers tell you about a chemical?
- 4** Two of the chemicals Joseph mixed, before they got hot, were sodium hydroxide (drain cleaner) and sulfuric acid (rust remover).
 - a| What was the sign that a chemical reaction had taken place?
 - b| What do you call the type of reaction that occurs between these two chemicals?
 - c| Write a word equation for the reaction that occurs.
- 5** Use the information in this unit to design a safety information leaflet for parents on the dangers of household chemicals.



B | This is Joseph, aged eight. He doesn't know much about chemicals but he has decided to mix some together. Suddenly the glass gets very hot and he drops it. The glass breaks and the chemicals splash across the worktop. Luckily, no damage is done and an adult clears away the mess safely.

HAVE YOUR SAY

A council proposes to ban all household chemicals with a pH higher than 10. Discuss what you think of this statement, listing the advantages and disadvantages of such a ban.

7Ga SORTING RUBBISH

Every year we use more of the world's **resources** to make goods that we throw away. On average each person in the UK produces 500 kg of household waste a year. Industry produces a further 300 million tonnes of waste. Most of our rubbish ends up in landfill sites.

We now recycle more of our waste, to save resources and **energy**. However, we need to do more.



B | The mark tells us the type of plastic (polypropylene). Symbols like this help us to sort rubbish and make recycling easier.



A | aerial view of a landfill site in the state of Veracruz, Mexico

Like all matter, waste comes in different states that have different **properties**. **Solids** are easiest to dispose of in landfill sites, as they stay in one place. **Liquids** are more difficult, as they flow and can leak away. **Gases** are the most difficult, as they can spread out in all directions.



C | Sorting rubbish into groups makes it easier to recycle.

- 1** a| What are the three states of matter?
b| Split up the following materials into three groups depending on their state:
carbon dioxide, cardboard, clothing, cooking oil, copper scrap, food scraps, glass bottles, heated air, methane, milk, paint, petrol, plastic containers, scrap wood.
- 2** Some soluble solids cause problems in landfill sites as they dissolve in rainwater.
a| Explain the meaning of the underlined words in the above sentence.
b| Describe how a soluble fertiliser dumped in a landfill site can get into our water supply.
- 3** How do you think the amount of rubbish produced in the area where you live is likely to change in the future? Explain your answer.

7Ga MAKING COMPARISONS

HOW CAN SCIENTISTS USE LANGUAGE EFFECTIVELY?

If we continue using our Earth's resources as we are, some of them could run out or become too expensive to use. The problems of dwindling natural resources and increasing amounts of waste must be solved. Scientists investigate issues related to waste disposal and **recycling**. However, in order to do so they must be able to use language precisely, so that others can understand the problems and assess the possible solutions.

Measuring, recording, reporting and comparing are important aspects of any science investigation.

Think about the adjectives we use to describe things. Sometimes we need a range of adjectives to make comparisons. For example, look at the propane cylinders in photo B. The adjectives used are *large*, *larger* and *largest*. The adjective *larger* is called a comparative as it compares two things. *Largest* is called a superlative as it is used when comparing more than two things. Comparatives and superlatives are often used to contrast and highlight issues in scientific writing.



A | What could we recycle to save resources?



B | propane cylinders at a recycling centre

1 Write down an adjective, comparative and superlative that fits each of these pictures.

C



LITERACY & COMMUNICATION

Many comparatives and superlatives can be formed by adding -er and -est to the adjective, or by using 'more' or 'most' in front of the adjective.

2 Look at table D.

- Which adjectives form the comparative and superlative by adding -er and -est? Can you think of another example, used in science, that follows this pattern?
- Which adjectives use 'more' and 'most' to form the comparative and superlative? Can you think of another example used in science?

3 Which adjective in table D does not fit the same rules as the others?

Table D gives some examples of adjectives, comparatives and superlatives that are often used in science writing to measure and compare.

Adjective	Comparative	Superlative
acidic	more acidic	most acidic
fast	faster	fastest
full	fuller	fullest
good	better	best
high	higher	highest
long	longer	longest
small	smaller	smallest
useful	more useful	most useful

D

Read magazine article E below. The adjectives, comparatives and superlatives that have been used to measure and compare have been underlined.

It's in the can!

Aluminium, one of our most useful metals, is found in electrical cables, drinks cans, and aircraft bodies. Aluminium is valuable, as it is one of the lightest metals, and a better electrical conductor than iron. It is strong and durable. There are large deposits of aluminium ore, so limited resources are not a problem. However, it is an expensive metal to produce, as enormous

quantities of electricity are required, and this is very costly. Fortunately it is fairly easy to recycle aluminium and this saves 95% of the overall costs.

We use 51 000 tonnes of aluminium cans each year in the UK. So if we could recycle a greater amount of them, we would not only save expensive energy, we would also reduce our use of ugly and wasteful landfill sites.

E | How effective is recycling aluminium?

4 Write down the comparative and superlative of the following adjectives:

a| useful b| thin c| great d| short.

5 Copy the table below.

Adjective	Comparative	Superlative
useful	more useful	most useful

Complete the table using the words underlined in magazine article E and adding the other two related words. The first one has been completed for you.

6 The landfill site at Greengairs in Scotland is the largest in Britain. Write two more superlatives that emphasise the size of the site.

I can ...

- identify adjectives, comparatives and superlatives in sentences
- understand how to use adjectives, comparatives and superlatives to measure and compare.

7Ga SOLIDS, LIQUIDS AND GASES

HOW ARE SOLIDS, LIQUIDS AND GASES DIFFERENT?

The different properties of waste materials have to be considered when recycling or disposing of the waste.

Corrosive, flammable and **toxic** materials present particular **hazards** and have to be handled carefully.

Waste materials exist in all three **states of matter** (solids, liquids and gases) and have different properties. Therefore they have to be handled differently, during recycling and disposal.

Solids

In general, solids do not **flow** or change their shape. Solids stay in one place, unless they are pushed or pulled.

As most of it is solid, most waste going to landfill sites stays where it is put. Solid waste, such as **metals**, paper and plastic, is often easy to transport in open lorries.

The **volume** of an object is the amount of space that it takes up. It can be measured in **cubic centimetres** (cm^3). The volume of a solid does not change a great deal and so, even when squeezed, solids cannot easily be **compressed** (squashed into a smaller volume).

- 1 Describe the properties of a solid.
- 2 What property allows solid waste to be left in piles at landfill sites?

Liquids

Liquids can change their shape and flow. So liquids take the shape of their container. However, liquids don't change their volumes and they cannot be easily compressed.

As they are able to flow, liquid wastes can be pumped along pipelines. It would be very difficult to transport liquids in an open truck like the one in photo B. The liquid would slosh about as it was moved and could spill.



A | Symbols warn of hazardous substances.



B | scrap metal being transported for recycling



C | Waste cooking oil can be converted to biodiesel.

FACT

Waste cooking oil from restaurants can be converted to biodiesel. In the UK all diesel sold must contain at least 5 per cent of biodiesel.

Gases

Gases can change their shape and their volume. They can spread out in all directions and they can also be easily compressed into a smaller volume. The gas cylinders in photo D can contain a lot of gas that has been squeezed into them under **pressure**. They are stored away from other areas in the recycling plant as there could still be gases in the cylinders that are flammable and could cause an explosion or major fire.



D | Gases can be compressed into a small volume.

- 3** Draw a table to show the differences between solids, liquids and gases. Use these headings:

Keeps its shape, Keeps its volume, Able to flow, Able to be compressed.

- 4** Look at photos B and C. Why do solid and liquid wastes need to be transported in different ways?

Many waste gases are released directly into the atmosphere where they can cause harm to the **environment**. Factories and power stations that burn **fossil fuels** produce large amounts of acidic gases. All industries have now taken steps to reduce the amount of harmful gases released and the problem of **acid rain** has almost been solved. It is not always easy to identify the state of a substance using its properties. For example, sand is a solid but it flows like a liquid as it is made up of small pieces.

- 5** A cuboid block of wood measures 4 cm high by 5 cm deep by 10 cm long. What is its volume, in cubic centimetres (cm^3)?

- 6** In the past, acidic gases produced in the UK have affected life in lakes in Norway. Explain why gases produced in one country can become a problem for other countries.

- 7** Look at photo F. How can a sponge be described as a solid if it can be squeezed like this?



E | waste gases released into the atmosphere

I can ...

- name the three states of matter and give examples of each
- describe what the three states of matter are like, based on their properties
- identify materials that are difficult to classify as solids, liquids or gases.

7Gb HYPOTHESES AND THEORIES

HOW DO SCIENTISTS THINK AND WORK?

Many people notice that different items are placed in different areas of a household waste recycling centre because they have different properties. However, a scientist will also ask *why* certain items have certain properties.

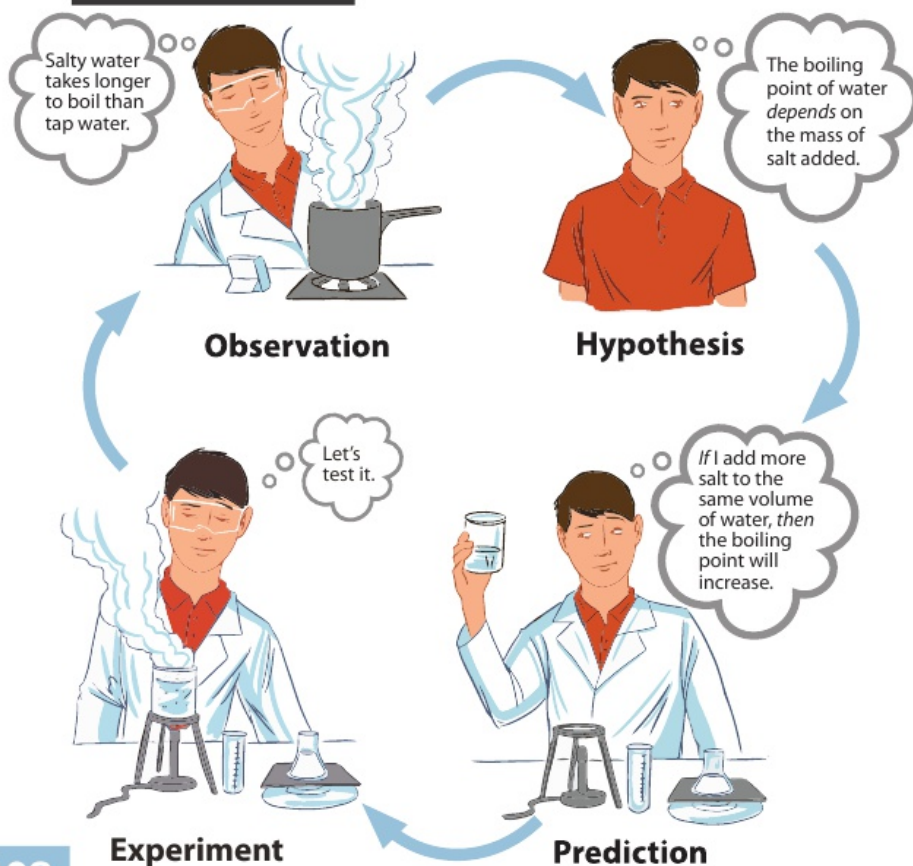
1 Look at photo A. Write down two observations about liquids.

Scientists usually answer their questions using a **scientific method** (see pages 24–25). This may involve a scientist thinking up an idea about how or why something happens. This idea is called a **hypothesis**. The hypothesis can then be used to make a **prediction** about what will happen in an experiment. Sometimes scientists may also use an existing hypothesis or **theory** to make a prediction. An example of how scientists use hypotheses and predictions is shown in figure B. The phrase ‘depends on’ is often used when writing a hypothesis while a prediction can be formed around the phrase, ‘if ... then ...’.



A | How can we explain how liquids change shape?

B | scientific method



After the experiment has been carried out, the **results** can be analysed. If the **data** matches the prediction, this is **evidence** that the hypothesis is correct. We say that the data supports the hypothesis.

Theories

When the data from many experiments all supports a hypothesis, the hypothesis becomes a theory. A theory is a hypothesis or a group of hypotheses with lots of supporting evidence.

However, as more data is collected, a theory may not be strengthened. Some evidence may be found that does not support the theory, and the theory may need to be changed or even scrapped altogether.

WORKING SCIENTIFICALLY

2 Look at cartoon C.

- What is the observation that this person is trying to explain?
- What is her hypothesis to explain the observation?
- How well does her idea explain the observation?



Observation: If you heat ice, it disappears and water runs away from it.



Idea: Ice is made of lots of little boxes with water in them. The heat breaks open the boxes, so the water can run out.

A good theory is one that has been tested, allows us to make predictions and explains **observations**. A theory may be formed from the work of different scientists and may contain many hypotheses.

3 What is the difference between a hypothesis and a theory?

4 Draw a flow diagram to outline the different stages in the scientific method.

Explaining the observations of the different properties of solids, liquids and gases is one of the most important theories in science. Our modern theory about the states of matter combines many hypotheses from many observations, such as those in photos D–G.



D | It is easy to compress a gas.



E | As you dilute an orange drink the colour and the flavour get weaker.

5 What observation is made about photo D?

6 Write down a scientific question about the observation in photo E.

7 Write down an observation and a scientific question for each of the photos F and G.



F



G

I can ...

- identify scientific questions, hypotheses and predictions
- describe how evidence and observations are used to develop a hypothesis into a theory
- explain how evidence is used to support (or not support) a certain theory.

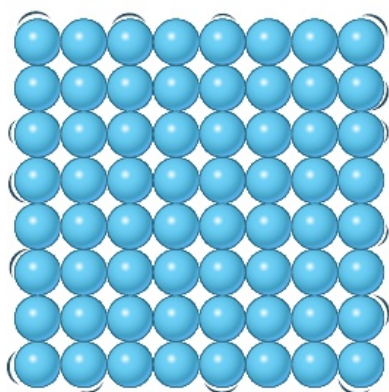
7Gb PARTICLES

WHAT IS THE PARTICLE THEORY OF MATTER?

Scientists have developed a theory to explain the different properties of solids, liquids and gases. This theory has been refined and improved over many years of investigation using scientific methods. It is called the **particle theory** or **particle model** of matter.

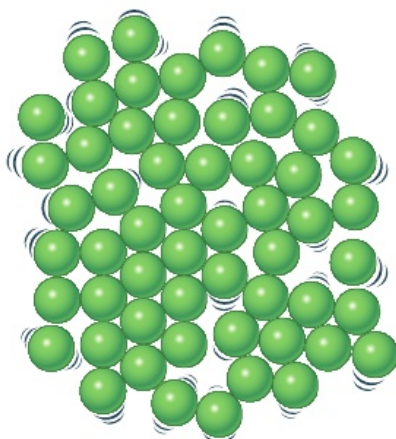
The particle theory states that:

- all matter is made up of tiny **particles**
- the particles are moving all the time
- there are **forces** of attraction holding the particles together
- the forces vary in strength in the different states of matter.



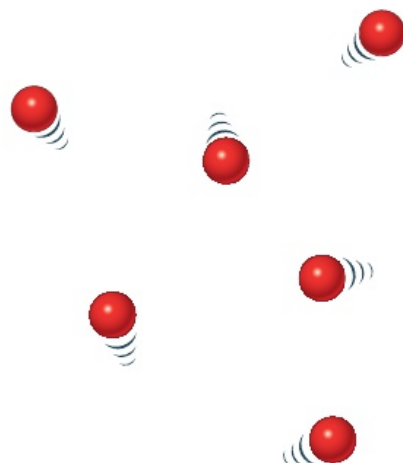
A | solid

In solids the particles are held closely together, by strong forces of attraction. The particles cannot move over each other, but **vibrate** (wobble) back and forth.



B | liquid

The particles in liquids are also held closely together by fairly strong forces of attraction. However, the particles in liquids can move past each other.



C | gas

The particles in a gas are far apart from each other. The forces of attraction between the particles are weak, so gas particles are free to move about in all directions.

- 1 What is all matter made up of?
- 2 What determines whether something is a solid, a liquid or a gas?
- 3 Solids have fixed volumes and shapes. How could you describe liquids and gases in terms of their volumes and shapes?

FACT

At room temperature the particles in air are moving in all directions at a speed of about 500 m/s. That is faster than a jet aircraft.

Using the theory

Solids have a fixed shape as the particles are held closely together by strong forces of attraction. The position of the particles cannot change so the shape stays the same unless a force is applied. The particles are very close together and so solids cannot be **compressed** (squashed into a smaller volume).

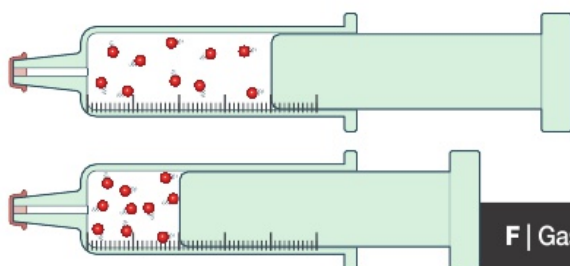
- 4** Most solids, like plastics, can change shape when heated. What do you think heating does to the particles?

Liquids can change their shape because although the particles are close together they can move over each other. This allows the liquid to flow and so it takes the shape of the container. However, the particles are very close together and so liquids cannot be compressed.

- 5** How does the particle theory explain:
- why gases spread out to fill a container
 - the different properties of solids and liquids?

Gases have no fixed shape or volume, as their particles are free to move in all directions. This allows gases to spread out and fill all the space in a container.

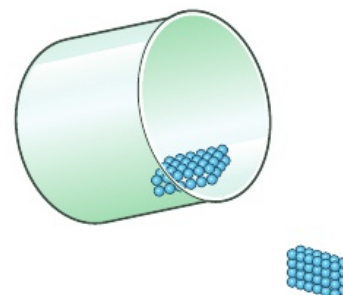
However, gases are fairly easy to compress. Their particles are quite far apart to start with, so they can be squeezed closer together, to reduce the total volume.



F | Gases can be compressed.

Rotting rubbish can involve all three states of matter, as solids break down in time forming different solids, liquids and gases. While the solid waste stays put, the liquids will slowly flow away, and any gases formed will escape into the air so they may be smelled some distance away.

- 6** Describe how the particles move in solids, liquids and gases.
- 7** Explain, using particle theory, how liquids can seep out of rubbish when left in landfill sites.



D | Solids have a fixed shape.



E | Liquids can flow into different shapes.



G | Solids and liquids in rubbish behave differently.

I can ...

- recognise that all matter is made up of particles
- describe, draw and recognise the arrangement of particles in solids, liquids and gases
- use the particle theory to explain the properties of the three states of matter.

7GC BROWNIAN MOTION

WHAT EVIDENCE ALLOWED ALL SCIENTISTS TO ACCEPT THE PARTICLE THEORY?

Scientific theories are always changing. Through new experiments and observations, scientists can improve their ideas and explanations. Sometimes scientists even use the results of experiments from the past to further develop their ideas.

In 1827, the Scottish scientist Robert Brown (1773–1858) was using a microscope to study pollen grains in water. He observed that the pollen grains moved about randomly in different directions. He discussed his observations with other scientists but they couldn't think of an explanation for the movement, which came to be called **Brownian motion**.

Brownian motion has now been observed in many other situations. For example, it can be seen with specks of smoke in air and fine dust in liquids other than water.

If we were to watch one individual pollen grain or smoke speck, we would see it moving jerkily in different directions. Drawing C is a typical **trace** of the movement of a particle showing Brownian motion over a short time interval.

- 1 Describe Brownian motion.
- 2 Why do you think Robert Brown talked to other scientists about his observations?

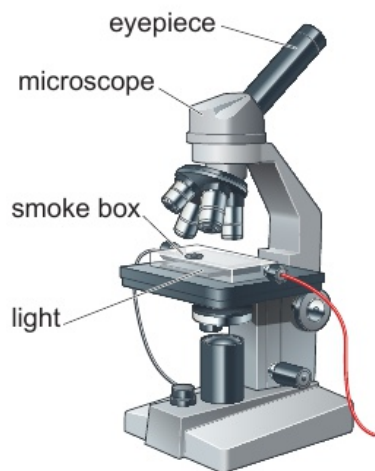


A | Mark Fell and Jonathan Howse turned 'Brownian motion' into music.

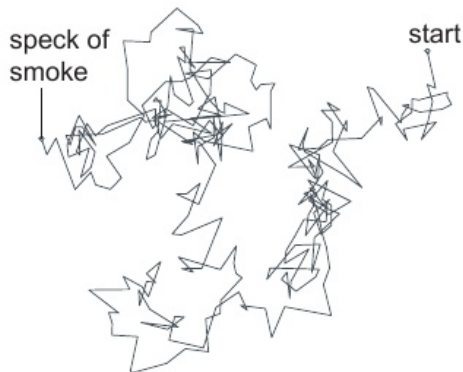
FACT

Photo A shows the collaboration between a chemical engineer and an artist, turning the random movements of Brownian motion into dance music.

Explanation using particle theory



B | observing Brownian motion within air with specks of smoke



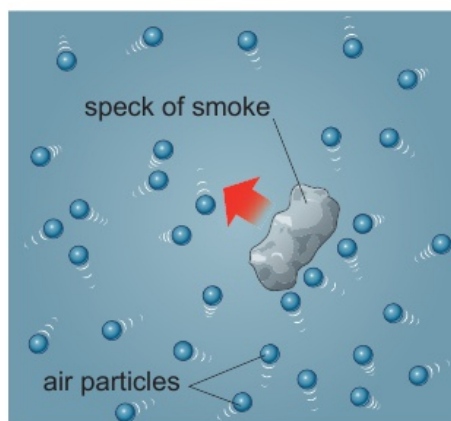
C | the plotted smoke speck tracks, showing Brownian motion

Later scientists, including Albert Einstein (1879–1955), used the particle theory to explain Brownian motion. This added a lot of evidence in support of the particle theory, which had not been accepted by all scientists up to that time.

The particle theory says that air consists of tiny particles, moving about in all directions. Air particles therefore hit specks of smoke. If many particles hit one side of a smoke speck, they push the speck in that direction.

However, the air particles are moving about randomly and so the direction in which a smoke speck is pushed will change all the time. We therefore see Brownian motion as random movements.

The same thing happens with pollen grains in water, with moving water molecules hitting the grains. Einstein developed a hypothesis to explain this. He used his hypothesis to make a prediction about how far a pollen grain would be moved by water **molecules**. This was tested by J.B. Perrin (1870–1942). His data matched Einstein's prediction, which was further evidence in support of the particle theory.



D | The moving air particles are constantly colliding with the speck of smoke, causing it to change direction.

The nanoscale

Although many pollen grains and smoke specks are too small to be seen without a microscope, they are more than 100 000 times larger than the particles in water or air. When dealing with such small particles, we use nanometres as the unit of measurement: 1 nanometre (nm) is 0.000 000 001 metres (m).

FACT

You can fit about 335 000 000 000 000 000 000 000 water particles in a 10 cm³ bottle.

3

Write a letter to Robert Brown explaining Brownian motion. (Remember that he wouldn't have our knowledge of particle theory, so you need to explain this carefully.)

4

How did the evidence from Brownian motion affect another scientific theory?

5

Explain why the moving particles of air do not push us about, like the specks of smoke.

6

How many nanometres are in a metre?

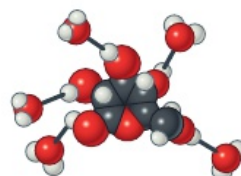
7

Diagram D is a model which can be used to explain how Brownian motion occurs. In what ways does the diagram represent Brownian motion:

a) well b) poorly?



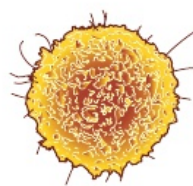
water particle
0.3 nm
(0.000 000 3 mm)



sugar particle
1 nm
(0.000 001 mm)



virus
65 nm
(0.000 065 mm)



pollen grain
20 000 nm
(0.02 mm)



dot on paper
500 000 nm
(0.5 mm)



football
220 000 000 nm
22 cm (220 mm)

E | measuring on the 'nanoscale'

I can ...

- explain how Brownian motion supports particle theory
- explain how scientific theories evolve
- convert between nanometres and metres.

7Gd DIFFUSION

WHY DO SOME THINGS SPREAD OUT?

Much of our household waste in the UK ends up in landfill sites. These sites are costly to run and use up valuable land. They are often ugly and sometimes smelly. Even if you cannot see the rubbish dump you know it's there by the smell!

When waste rots it naturally gives off gases (including smelly ones), which spread through the air even if there is no wind. This happens because the particles of the smelly gas are moving all the time. They move in all directions and mix in between the particles of air. Eventually, they spread out until they reach your nose – that's when we know they are there!

When particles of one substance spread out and mix with the particles of another, we call this **diffusion**. You smell a substance when some of the particles from the smelly substances are inside your nose. This can only happen if the particles of the smelly substances are moving and spreading about in all directions.

Diffusion is an important process inside our bodies. Diffusion allows particles of essential substances in our food to pass through the wall of the **small intestine** and into the blood. The blood then carries them around our bodies, where they diffuse into the **cells** of the body. Waste products are also removed by diffusion.



A | Some councils spray their landfill sites to lessen the smell.

FACT

B | sign banning durian fruit

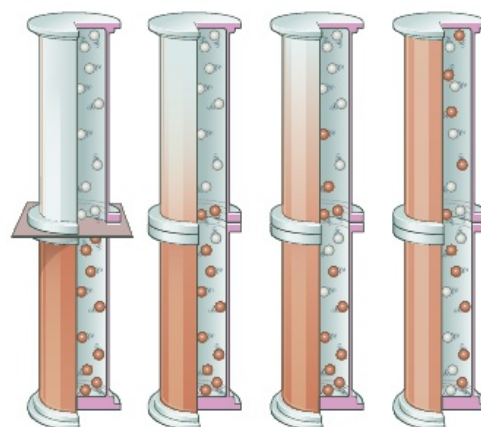


Described as the 'God of fruits' in Asia because of its wonderful taste, durian fruit is banned from most public places because of its disgusting smell, which is described as a mixture of rotten eggs, onions and gym socks.

- 1 a) What is diffusion?
b) Give an example of diffusion in everyday life.
- 2 Describe what happens to the particles of smelly substances in rubbish when you can smell the rubbish some distance away.

Diagram C shows diffusion occurring in the laboratory. The brown gas and the clear gas mix together until the gases in both gas jars look the same. The diagram also shows how the particle theory can be used to explain what is happening during diffusion.

- 3 Explain how diffusion occurs in gases.
- 4 How are models useful to scientists?
- 5 How could you measure the speed of diffusion in gases?



C | We can use the particle theory to model how diffusion occurs in a gas.



D | Liquid pollution can spread through still water by diffusion.

Particle theory states that the particles in liquids are closer together and cannot move as freely as the particles in gases. As diffusion is caused by the movement of particles into the spaces between other particles, using these hypotheses you would predict that diffusion would be slower in liquids than in gases. Scientists have shown that this is what happens, which is more evidence to support the particle theory.

- 6 Use particle theory to explain how the liquid substances from the oil tanker in photo D will spread.
- 7 a) What state of matter is diffusing in photo E?
b) Would diffusion in solids be slower or quicker than in liquids? Explain your answer.
- 8 Explain how observations of diffusion help support the particle theory.



E | The coloured dye has diffused into the icing.

I can ...

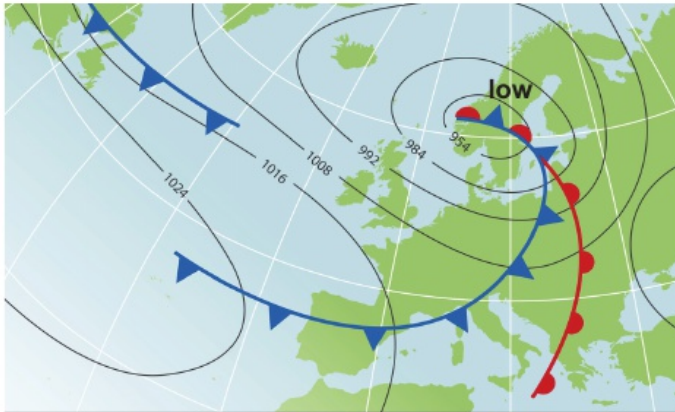
- state what is meant by diffusion and recall some of its effects
- use particle theory to explain diffusion in liquids and gases
- use particle theory to explain why diffusion is faster in some materials than in others.

7Ge AIR PRESSURE

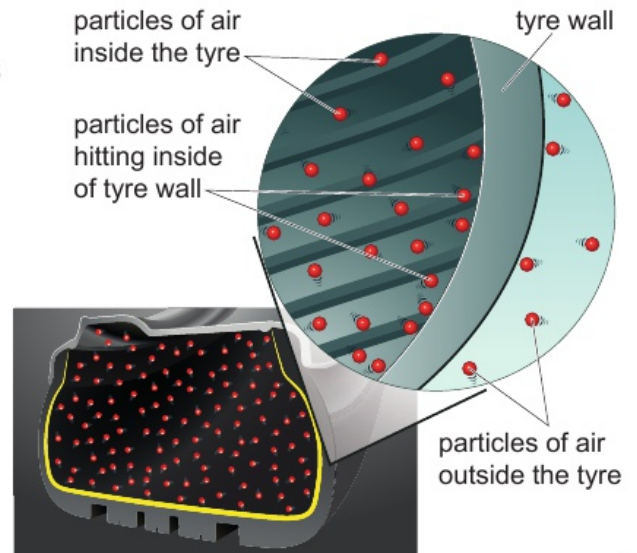
WHAT IS AIR PRESSURE?

We are surrounded by air and its particles are hitting us all the time. **Air pressure** is just the force of these particles hitting a surface. We don't normally feel this pressure but it is always there and we can sometimes see its effects.

For example, the higher air pressure inside a car tyre, pushing out, keeps the tyre inflated. Air pressure can also affect our weather. High air pressure usually means dry settled weather while low air pressure usually means cloudy and unsettled weather.



B | Air pressure measurements are used in forecasting weather.

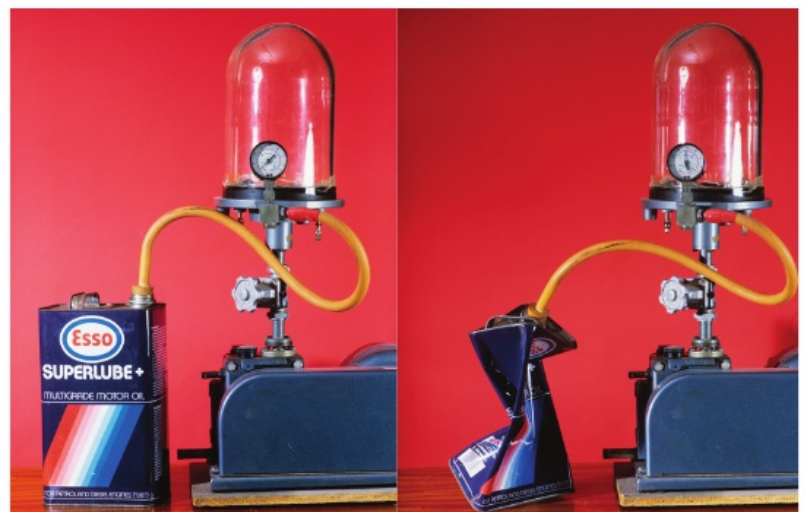


A | The air pressure inside a car tyre is greater than outside the tyre as more air has been pumped inside the tyre.

- 1 How can air produce a pressure?
- 2 Why does air pressure increase when you pump up a tyre?

The vacuum pump in photo C can be used to remove the air from inside a metal can. A **vacuum** does not contain anything, not even air. When the air is removed, the can is pushed in by the air particles hitting the outside of the can.

The outside air pressure was always there, but before the pump was used there was also air inside the can. The inside air pressure balanced the outside air pressure. With the air inside removed, the outside pressure is strong enough to crush the can. This is another example of how the particle theory can explain something we see happening.



C | The can is crushed in by air pressure when air is removed from inside it.

FACT

A 1 litre bottle of most fizzy drinks contains nearly 3 litres of pressurised carbon dioxide gas. This gas pressure can sometimes cause these bottles to explode.



D | gas pressure in action

Many common observations can be explained using air pressure and particle theory. Sucking up liquids through a straw works because of air pressure. When you suck, you reduce the pressure inside the straw. So the air pressure outside the straw acting on the liquid is greater than the pressure inside the straw and the liquid is pushed up the straw.

It's not just air that has a pressure. All gases apply a pressure to the surfaces around them. Rotting waste in landfill sites produces the **flammable** gas methane. This can be dangerous in several ways. As gas particles move in all directions the methane can flow all through a landfill site and collect in pockets. Sparks can cause the gas to explode, or the build-up of gas in a pocket can cause the ground above it to burst open or crack. Therefore, it is important to get the methane out of landfill sites.

5 Explain how methane can crack the ground in landfill sites.

6 Under certain conditions deodorant cans can explode.

- a| How do the particles in the can cause the explosion?
- b| Why is a full deodorant can more of a risk than a half empty one?

7 Use diagram G and the particle theory to explain how a 'sucker' sticks to a smooth surface.



G | When a sucker is pressed onto a surface, some of the air is squeezed out from under it.

3 Use particle theory to explain:

- a| why a tyre gets bigger as you pump it up
- b| why a tyre gets smaller as you let the air out
- c| why the can is crushed in photo C.

4 In your own words, explain how air pressure helps you drink through a straw.



E | Air pressure helps you to suck drinks through a straw.



F | venting and burning off methane at a landfill site

I can ...

- say what is meant by gas pressure and recall some of its effects
- describe the cause of gas pressure using particle theory.

7Ge WASTE

There are many ways in which we can deal with our waste but they all have their problems. Recycling is better for the environment but can be expensive. Landfill sites are good for getting rid of a lot of rubbish but are ugly, take up a lot of space and can cause pollution.

There are other methods of dealing with waste. Incineration burns waste at high temperatures. The energy released can be used elsewhere – to generate **electricity**, for example. However, it is expensive, and the gases produced have to be controlled or they could cause problems.

A | Incineration releases waste gases.



Waste plant material can be composted (rotted down). This can be done on a large scale, and the compost that is produced can be used to improve soil and reduce the use of fertiliser. However, composting can also cause problems. The rotting plant material produces heat and methane gas, which can catch fire.



C | hosing down a compost heap to put out fires



B | Glass can be recycled over and over again.

- 1** a| What is the main advantage of incineration?
b| Explain, using particle theory, why gases released by incinerators cause problems.
- 2** Look at photo B. Explain in terms of particles how the recycled glass can be moulded.
- 3** Explain why soot particles from a fire appear to 'dance' about, when you look at them through a microscope.
- 4** Using the question: 'What makes solids, liquids and gases different?' explain how hypotheses, predictions and experiments can lead to a scientific theory.

HAVE YOUR SAY

Only householders can freely use a recycling centre. Companies need to pay a landfill tax. Some companies just dump their waste – this is called fly tipping. You can be fined up to £50 000 for fly tipping and/or spend 5 years in prison. Do you think this is reasonable?

7^{Ha} OUR MATERIAL WORLD

Our Earth and its atmosphere contain a **mixture** of materials with different **properties**. Over time we have learned to use these materials to make objects to improve our lives. Sometimes, however, we misuse our material world.

Some substances can be used just as they are found, or they can be shaped to make useful objects. Rocks can be used to make building blocks for houses and wood can be formed into furniture.

Sometimes we need to use **physical changes** to separate useful materials from mixtures. For instance, we can get salt from seawater by **evaporation**. Sometimes we use physical changes to make materials into more useful shapes, such as when we mould **metals** into different shapes by melting them. Physical changes do not make new substances and they can often be reversed quite easily.



A | our source of materials



B | Clay can be formed into pots.



C | melting gold to make jewellery

D | Chemical reactions have been used to get metals from rocks for thousands of years.



Chemical reactions make new substances with different properties and different uses. For example, an **alkali** can react with fats to make soap. Chemical reactions always make one or more new substances and they are often difficult to reverse.

- 1 What happens in all chemical reactions?
- 2 State whether the following changes are chemical or physical:
 - a| boiling a kettle to make steam
 - b| mixing sand and water
 - c| frying an egg
 - d| iron railings rusting in the rain
 - e| water freezing in winter.
- 3 Explain why liquid gold can flow while solid gold cannot.
- 4 Describe how you could obtain solid salt from sea water.

7Ha SORTING RESOURCE DATA

HOW CAN WE RECORD AND PRESENT SCIENTIFIC DATA?

Scientists answer questions by carrying out investigations and collecting **data**. The data can be **qualitative** (in words) or **quantitative** (in numbers). Quantitative data can be **discrete** (a limited choice of numbers) or **continuous** (any number between two limits).

To make sense of data it has to be recorded, sorted and presented. The type of presentation used depends on the type of **variable** and what you want to show. Some common types of presentation are shown in table B.

number of tablets added –
quantitative and discrete

temperature of water –
quantitative and continuous

type of salt tablets –
qualitative

volume of water –
quantitative and continuous

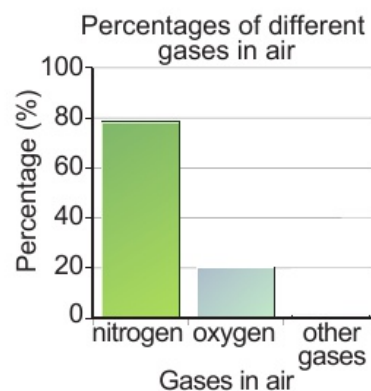


A | different types of data

B	Method of presentation	When used ...
	tables	to show exact values / to order a list / to show best and worst / to sort data into groups
	bar charts	to compare qualitative or discrete variables / to compare grouped continuous data
	pie charts	to show the proportions of a total made up by different items
	line graphs	to show how one variable changes as another linked variable changes (often time)
	scatter graphs	to look for a relationship (link) between two quantitative variables

Gases in air	%
nitrogen	78.08
oxygen	20.95
argon	0.93
carbon dioxide	0.039
neon	0.002
helium	0.0005

The air contains a mixture of **gases**, which have different uses. Different ways of presenting this data are shown in figure C. The bar chart and pie chart are more visual than the table and give an instant impression of the proportions of gases. However, the table shows the exact percentages of the gases and is more useful when there are large differences in the numbers. For example, the table includes data about the other gases that cannot be shown in a pie chart or bar chart.



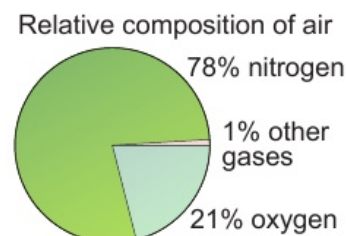
1 Explain why the amount of carbon dioxide in air cannot be shown easily on a pie chart or bar chart.

2 Table D contains information on how long certain metal resources will last if we keep using them at the current rate.

- How could you sort this data in the table?
- Draw a bar chart of the data.
- Explain why you would not draw a line graph of this data.
- Use the data to explain why we should recycle more metals.

Metal	Years left
nickel	90
copper	61
silver	29
zinc	46

D



C | presenting information about air

WORKING SCIENTIFICALLY

Method

- A** | Place a tea light/candle on a heat-resistant mat.
- B** | Light, and immediately, but carefully, place a beaker over the candle.
- C** | Time how long it takes for the candle to go out.
- D** | Record the volume of the beaker and the time for the flame to go out.
- E** | Repeat steps A to D, changing the size of the beaker used.

Investigating air

Candles use the **oxygen** in air when they burn and will go out when the oxygen is used up. The Method given here, and photo E, describe an investigation in which a candle is burned in different **volumes** of air (using beakers of different sizes) to discover how the volume of air affects the time the candle will burn for.

3

The burning candle experiment is looking for a relationship between two variables.

a) Are these variables quantitative or qualitative?

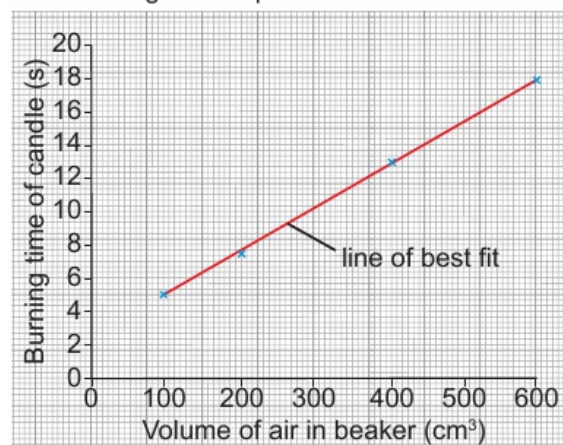
b) Which method of presenting the results would be best to use? Explain your choice.

Results

To analyse the results they are first recorded in a table then converted into a scatter graph.

Volume of air in beaker (cm ³)	Burning time of candle (s)
100	5.1
200	7.5
400	13.0
600	17.9

How burning time depends on the volume of air



F | table and scatter graph of results

E | the burning candle experiment



Conclusion

The points on the scatter graph follow a pattern and so there is a **relationship**. We can make the relationship clearer by drawing a **line of best fit**, as shown in graph F.

4

What is the relationship between the volume of air and the time it takes for the flame to go out?

5

Describe how you draw a line of best fit on a scatter graph.

6

How could you change this investigation to be more sure of the conclusion?

I can ...

- draw, use and interpret tables, bar charts, pie charts and scatter graphs
- identify the best way to present different types of data.

7Ha THE AIR WE BREATHE

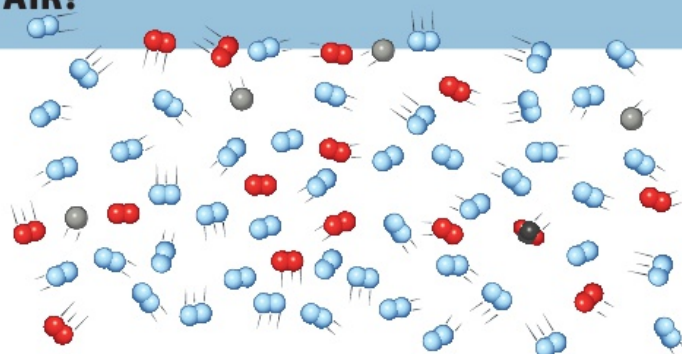
WHAT KINDS OF PARTICLES ARE FOUND IN AIR?

Like all matter, air is made up of tiny **particles**. However, the air we breathe is not **pure**. It contains a mixture of gases, including nitrogen, oxygen, argon and **carbon dioxide**. These different substances have different properties, as they are made up of different types of particle.

The simplest particles of matter are called **atoms**. We can imagine that an atom looks like a tiny ball. Argon gas is made up of atoms like the ones shown in diagram B.

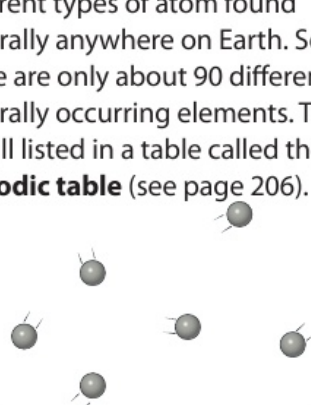
In many substances the atoms are held together in groups called **molecules**. Oxygen and nitrogen are molecules that have two atoms joined together. All the molecules of a certain substance always contain the same type and number of atoms.

All substances are made up of atoms. If they are made up of one kind of atom, like argon, oxygen and nitrogen, they are called **elements**. Atoms and elements are the building blocks of all matter. There are only about 90 different types of atom found naturally anywhere on Earth. So there are only about 90 different naturally occurring elements. They are all listed in a table called the **periodic table** (see page 206).

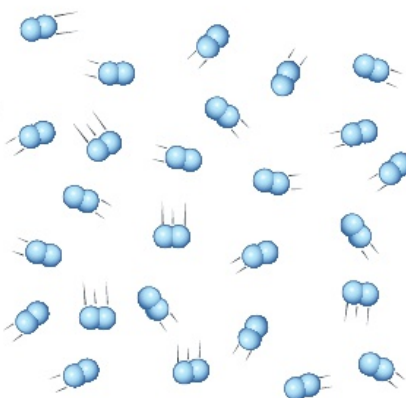


A | Air contains a mixture of particles.

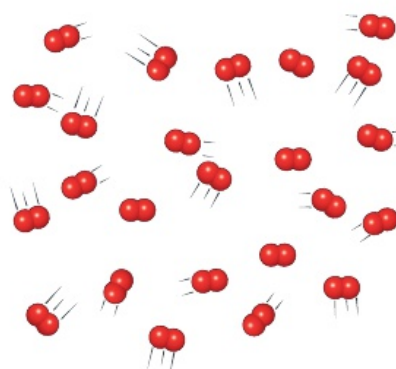
- 1 Describe the arrangement of particles in all gases.
- 2 a) Using the information on page 120, state the percentage of each gas shown in diagram A.
b) Explain why it is wrong to use the term 'pure air' in science.



B | atoms of argon



C | molecules of nitrogen



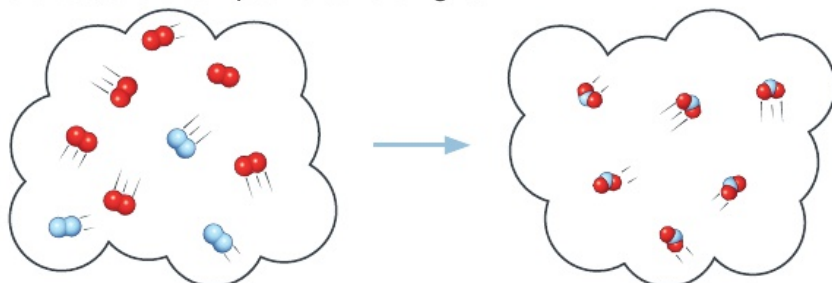
D | molecules of oxygen

The word 'elementary' means simple. Elements are simple substances. You cannot split an element up into anything simpler using a chemical reaction. Most substances, however, can be broken down as they contain more than one kind of atom. If different kinds of atoms are joined together in a substance, the substance is a **compound**. Of the four important gases in air only carbon dioxide is a compound. It contains molecules made up of two elements, carbon and oxygen, joined together.



E | molecules of the compound carbon dioxide

To make a compound, the atoms of the elements have to be joined together. If they are not joined, then it is a mixture of elements. Diagram F shows the difference between a mixture of elements (on the left) and a compound (on the right).



F | A mixture of nitrogen and oxygen can form a compound called nitrogen dioxide.

Although there are only about 90 elements on Earth, there are millions of different substances. The 90 elements join together in different ways to form many different compounds, just like the 26 letters of our alphabet can make millions of different words.

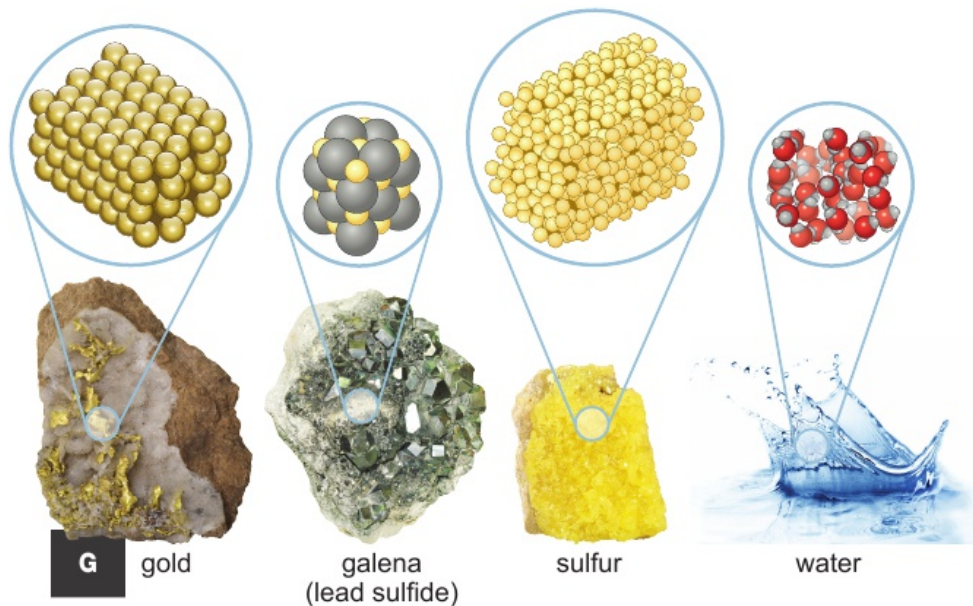
3 Use the periodic table on page 206 to find out which of the following substances are elements: zinc, plastic, sea water, chlorine, gold, lead, wood, magnesium, granite and iodine.

4 Describe the difference between:
a| elements and compounds
b| atoms and molecules.

5 How many different kinds of atom are there in diagram A?

FACT

There are now about 28 manufactured elements to add to the 90 natural elements that have been discovered. The newest element is number 117 in the periodic table. It doesn't have an official name yet so scientists call it ununseptium, which means number 117.



6 Which of the substances in diagram G are elements and which are compounds? In each case briefly explain your choice.

7 The water of our seas and oceans covers over half the surface of the Earth. Each water particle is formed by joining two atoms of hydrogen to one atom of oxygen. The sea also contains dissolved substances, including sodium chloride (salt) and oxygen gas, which supports all sea life.

Using examples of substances from the above passage explain the difference between pure substances and mixtures, elements and compounds, and atoms and molecules.

I can ...

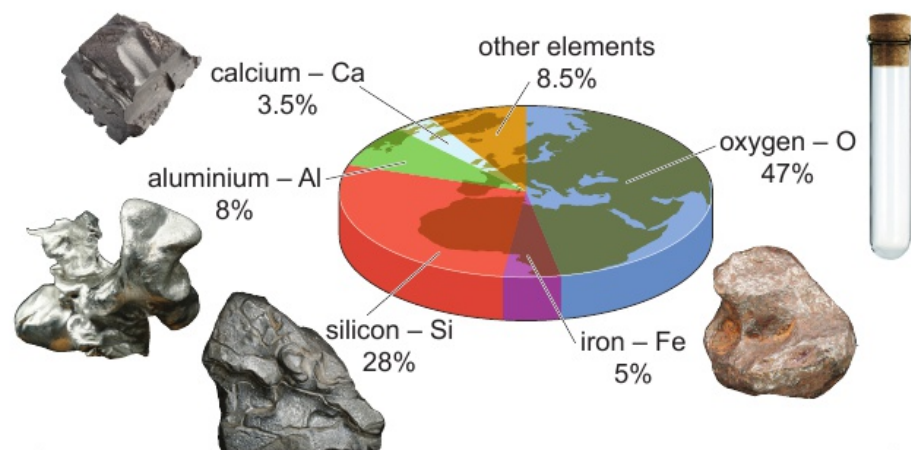
- recognise the difference between atoms and molecules
- identify elements, mixtures and compounds from descriptions and particle diagrams.

7Hb EARTH'S ELEMENTS

WHY ARE DIFFERENT ELEMENTS USED FOR DIFFERENT PURPOSES?

The periodic table, found on page 206, lists the names and **symbols** of all known elements. Chemical symbols have one or two letters, starting with a capital letter. Some are simply the first letter(s) of the element's name. However, as the chemical symbols are international codes, some match the names of elements in different languages.

Diagram A shows the symbols and abundance of elements in the **Earth's crust**.



A | elements in the Earth's crust

Naturally occurring elements are usually found in compounds. A few (e.g. gold) are found on their own. Others (e.g. copper, tin) can be got out of their compounds easily, using simple chemical reactions. These elements have been known and used for thousands of years.

- 1 What is all matter made up of?
- 2 What is the difference between a mixture of elements and a compound?
- 3 What are the symbols for the two elements that make up about 75 per cent of the Earth's crust?

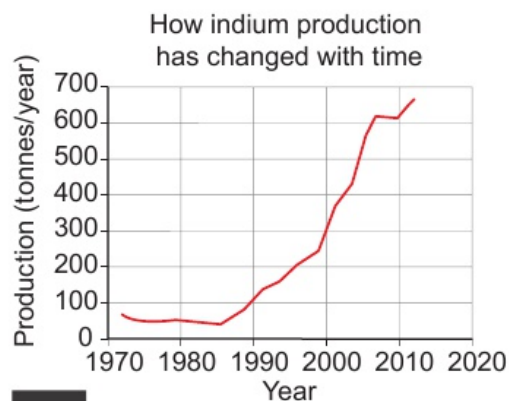
What an element is like, its appearance and how it behaves, is known as its properties. Scientists are finding new properties and uses of elements all the time. Indium was first purified in 1864 and for a long time had only a few uses. In the 1980s, it was found that indium helps make excellent touch screens. Now so much is being used that there may only be about another 20 years' worth of indium in the Earth's crust.

FACT

John Dalton (1766–1844) developed a system of symbols, using circles, marks and letters, to represent the elements. At the time other scientists found his symbols awkward and they weren't widely used.

ELEMENTS			
Hydrogen	1	Strontian	46
Nitrogen	5	Barytes	68
Carbon	4	Iron	56
Oxygen	7	Zinc	56
Phosphorus	9	Copper	56
Sulphur	13	Lead	90
Magnesia	20	Silver	190
Lime	24	Gold	190
Soda	28	Platina	190
Potash	42	Mercury	167

B | Dalton's symbols for elements



C

4 Which elements were described by the following symbols by Dalton:

- a| a circle with a cross
- b| a circle with an upside-down Y
- c| a circle with a dot?

5 Sodium is an element that was discovered in 1807. Iron was probably discovered about 4000 years ago. Suggest a reason for this difference.

Modern technology uses many different elements. Diagram D shows the elements needed to make a smart phone. Some of these elements, like indium, gallium and antimony, are now in short supply. If we continue to use them at the current rate, our sources will run out in the near future. Reducing waste and increased **recycling** is one way of saving our **resources**. For example, it is thought that there are £150 million worth of valuable metals in discarded mobile phones in the UK.

The properties of an element depend on its atoms and how they are arranged. The uses of an element are linked to its properties.

The element carbon can be found in two different forms that contain the same atoms. Diamond is one of the hardest natural substances, while graphite is the soft **solid** used in pencil leads. The different properties are due to the different ways the atoms are joined together.

6 a| Using diagram D and the periodic table on page 206, find two examples where the first letter of an element's name and its symbol are not the same.

b| Explain why the names and symbols of elements don't always match.

7 a| Define an element in two different ways.

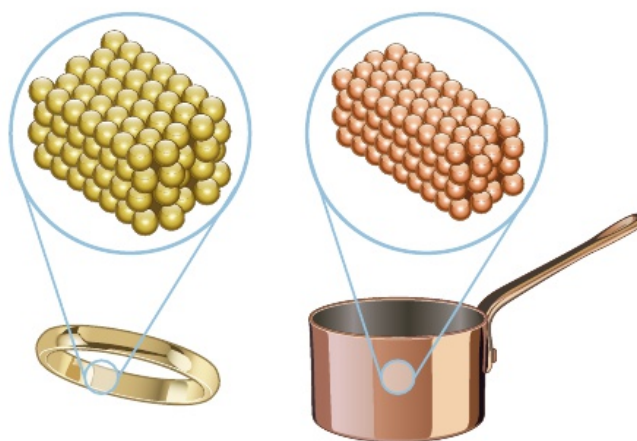
b| Explain, referring to one element, why we must increase recycling.

8 Suggest some properties for the following elements with these uses:

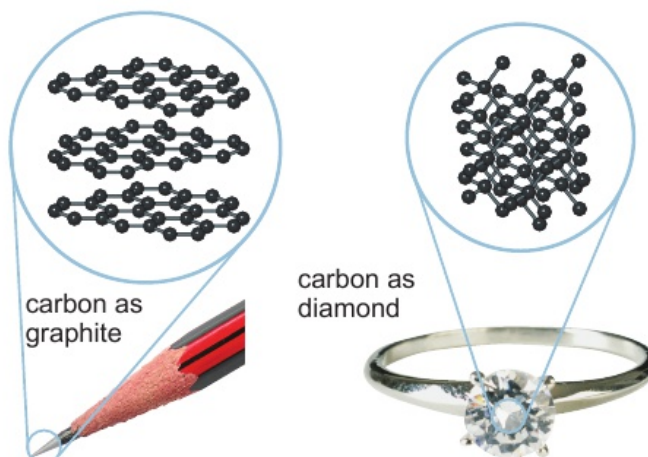
- a| gold to make jewellery
- b| diamonds to make glass cutters.



D | the elements in a smart phone



E | The uses of elements, such as gold and copper, depend on the properties of their atoms.



F | different forms of the element carbon

I can ...

- use chemical symbols for common elements and explain why they are an international code
- recall that different elements have different properties and uses
- explain that our resources of elements are limited and can run out.

7Hc METALS AND NON-METALS

WHAT IS THE DIFFERENCE BETWEEN METALS AND NON-METALS?

Chemists classify elements into two main groups, **metals** and **non-metals**, depending on their properties. Three-quarters of all elements are metals.

When we look at elements we can often guess if they are metals or non-metals. Metals are often grey or silver in colour. However, appearances can be misleading and not all grey solids are metals. Look, for example, at silicon on page 124.

- 1 What is similar about the appearance of most metals?
- 2 Give the names and symbols for three metal and three non-metal elements.



A | The steam train and rails are made from metals, mainly iron. The blackness in the smoke is caused by a non-metal called carbon.

The common properties of most metals are:

- solids with high melting points
- shiny (when polished)
- strong and **flexible**
- good **conductors** of heat
- **malleable**
- good conductors of electricity.

Some metals have properties that others do not have. Most elements are unaffected by magnets but iron, nickel and cobalt can be made to attract each other. They are **magnetic**.

- 3 Write down three properties of most metals.
- 4 What properties make the following suitable for their uses:
a) aluminium for lightning rods b) iron for house radiators?

Non-metals have properties that are very different from metals. Most non-metals are:

- substances with low melting points
- poor conductors of heat
- **brittle** (when solid)
- poor conductors of electricity.
- not shiny

B | These young workers are extracting iron from the sand in Zambales, north of Manila in the Philippines, using large magnets. The extraction of iron here is easy to do but can spoil the beaches.



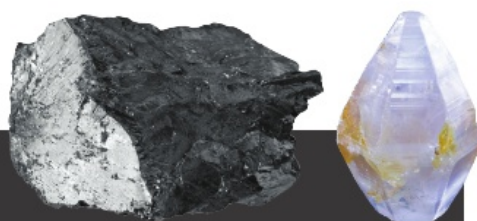
Sulfur, a typical non-metal, is a yellow brittle solid that melts at 115 °C. It is a poor conductor of heat and electricity. Most sulfur is used as compounds like sulfuric acid. Sulfur is also used in matches, where it burns with a pale blue flame to form the acidic gas sulfur dioxide. This is the gas you smell if you strike a match.

- 5** Describe two properties of sulfur shown in photo C.
- 6** Iodine is a dull blue/black non-metal solid, which has several uses in medicine.
Describe three other possible properties of the element iodine.

Every element has unique properties and uses – not all metals and non-metals fit all the general properties of their group. Photos D, E and F show some unique elements.



D | Mercury is the only metal element that is a **liquid** at room temperature. As it remains a liquid over a wide range of temperatures, mercury can be used in thermometers.



F | The two forms of carbon, graphite and diamond, both have very high melting points for non-metals. Unlike most non-metals graphite conducts electricity and is used in batteries and electric motors.

- 7** Choose an element for each of the following uses and describe two properties that make it suitable for that use:
a| wires in electrical cables b| powerful magnets to lift scrap steel.

- 8** The properties of two elements, X and Y, are compared below.

Property	X	Y
melting point	1083 °C	98 °C
boiling point	2567 °C	883 °C
reactivity	unreactive	reacts with water
conductor of heat	good	good
conductor of electricity	excellent	good

- a| Explain how you would know whether elements X and Y are metals or non-metals.
- b| Which element would make better cooking pots? Give two reasons for your choice.



C | Burning molten sulfur flows down the inside of a volcano.



E | Non-metallic silicon can be shiny like a metal. It also has some unique conducting properties that make it useful to make silicon chips for the electronics industry.

FACT

In the late 19th century, aluminium was called the metal of kings as it was more expensive to produce than gold. We now know how to make aluminium cheaply and it is used to make 475 billion drinks cans each year.

I can ...

- describe and identify metals and non-metals by their properties
- relate the use of an element to its properties.

7Hc FACTS AND OPINIONS

WHAT ARE FACTS AND OPINIONS?

We often refer to things that have been shown to be correct over and over again as **facts**. However, in science we must always be prepared for 'facts' to be shown to be wrong! Until about 1780, scientists thought that water was an element. Then Antoine Lavoisier and others showed that it was a compound.

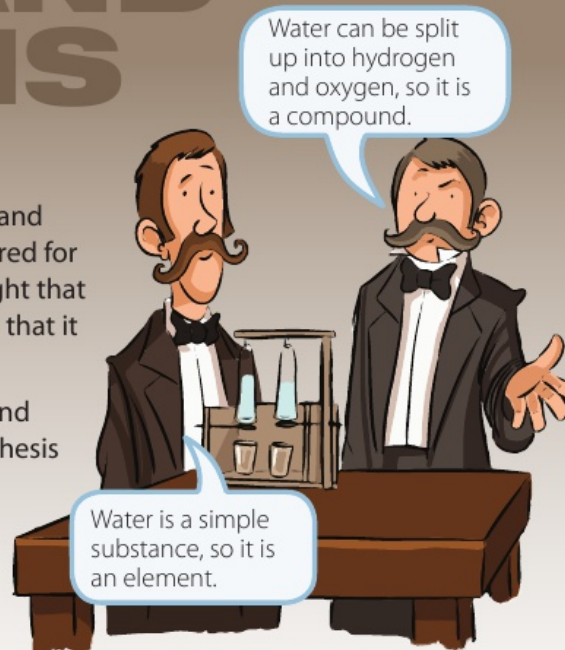
Scientists use experiments to test and develop ideas about how and why things happen. These ideas are called **hypotheses**. If a hypothesis has a lot of **evidence** to support it, we call it a **theory**. And some people may refer to it as a 'fact'. A hypothesis is less certain than a theory. Over time, many theories and hypotheses have to be changed or even replaced altogether.

Opinions are views or judgements about something and are usually formed from our feelings and experiences. They are what we believe to be true but often cannot be proved or disproved.

For example, 'Element X is a metal' is a fact whereas 'Element X looks pretty' is an opinion.

A fact is a statement or **observation** that has been repeatedly shown to be correct.

An opinion is what someone believes to be true and often cannot be proved or disproved.



A | Facts and hypotheses can change.

- 1** a) What is the difference between a fact and a hypothesis?
b) What is the difference between a hypothesis and a theory?
- 2** Look at figure B.
a) Explain why these statements are all opinions.
b) State two facts about metals and explain why they are facts.

We may use facts to support our opinions and persuade others, but even if the facts are true it does not make our opinions correct.

For example, 'Diamonds are made of carbon and so cannot be beautiful' is an opinion that is not supported by a fact.

An **expert opinion** is given by someone who has training and wide knowledge in a certain subject and is like a hypothesis. For instance a doctor's **diagnosis** of a problem is an expert opinion. An expert opinion is more likely to be believed by people than anyone else's opinion. We say that an expert opinion carries more 'weight'.

Facts are often used in advertising to persuade us to buy products or to change the way we live.



B | Scientists will have different opinions.

Recycling aluminium



- Most drinks containers are made of aluminium, an expensive metal.
- Billions of aluminium drinks cans are used each year.
- The metal in drinks cans is 100% recyclable.
- It can be recycled over and over again, to produce more cans or in items such as cars.
- A large proportion of the aluminium ever made is still in productive use today.
- Recycling aluminium cans saves energy and money.

C | Facts can be used to persuade.



E | Sulfur can be found near volcanoes.

- 7** Look at photo E. Write down one fact and one opinion about the element sulfur.
- 8** Explain the following quote, from the American statesman Bernard M. Baruch (1870–1965): 'Every man has a right to be wrong in his opinion. But no man has a right to be wrong in his facts.'

LITERACY & COMMUNICATION

- 3** a) Why might someone's opinion about a car be wrong?
b) Who might give an expert opinion on motor cars?
- 4** Look at poster C.
a) Explain why these statements are all facts.
b) What is the advertisement trying to persuade us to do?
- 5** Look at poster D. List the facts and opinions given in the poster.
- 6** Why do you think advertisers often use quotes from scientists?

The all new Sunshine Demon SD3

The new SD3's angular design looks good in town and country

The SD3 body is lightweight due to its aluminium construction

The leather interior is refined and comfortable

The SD3 can do 0–60 mph in 6.4 seconds

The aluminium content uses mainly recycled metal



D

I can ...

- identify and explain the difference between fact and opinion
- understand why facts and opinions are used to persuade.

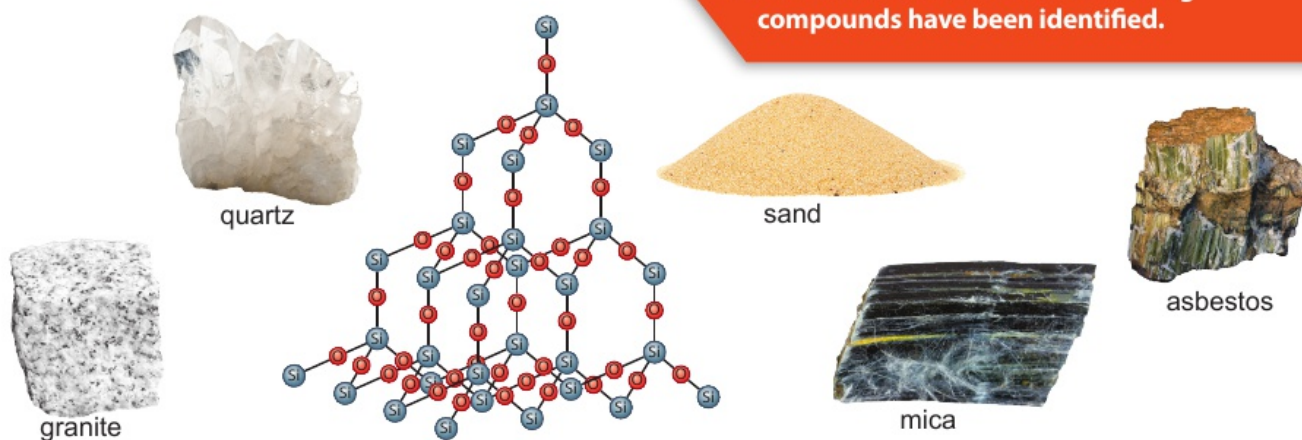
7th MAKING COMPOUNDS

HOW DO ELEMENTS FORM COMPOUNDS?

Compounds make up most of the materials in the land and seas around us. The most common compound in the Earth's crust is silicon dioxide. Like most natural substances, it is usually found mixed with other compounds and has several different forms.

FACT

Carbon makes up more compounds than all the other elements put together. Carbon compounds are the basis of life and over 10 million different carbon-containing compounds have been identified.



A | All these materials are forms of silicon dioxide, which is a compound containing silicon and oxygen atoms. Many of the forms of silicon dioxide are used for building.

Forming compounds

The first stage in forming compounds often involves heating a mixture of elements. Though not all combinations of elements react with one another, many do. For example, iron and sulfur react easily: heat is needed to start the reaction but, once started, you can take the test tube out of the flame and it will keep on glowing and giving out heat. **Energy** is often given out when elements react to form compounds.

During the reaction the atoms of iron and sulfur join together to form a compound called iron sulfide. When the reaction is over, the iron and sulfur atoms are joined together. We say that **bonds** have formed between the atoms and they are now bonded together.



B | The mixture of iron and sulfur glows brightly as the reaction gives out heat.

- 1 What percentage of the Earth's crust is made up of silicon and oxygen? (See page 124.)
- 2 Describe one difference between silicon dioxide and one of its elements.
- 3 After the iron and sulfur are heated, what can you observe that tells you the reaction has started?

Notice in photo C that the atoms in iron sulfide are joined to form a large regular structure. A piece of iron sulfide has billions of atoms bonded together.

Iron sulfide, like most compounds, is very different from its elements. It looks different and has different properties.



C | The reaction between iron and sulfur bonds their atoms together.



covellite, an ore containing a compound of copper and sulfur



cassiterite, an ore containing a compound of tin and oxygen



galena, an ore containing a compound of sulfur and lead

E | These metal ores are used as sources of metals.

- 4** Why is the iron sulfide structure not described as molecules?
- 5** What is different about the iron and sulfur atoms in the mixture and the compound?
- 6** Describe how iron sulfide is different from its elements in terms of:
 - a| appearance
 - b| properties.



D | Iron can be separated from sulfur by using a magnet. Iron sulfide is not magnetic.

Most of the compounds found on Earth, including useful compounds like **metal ores**, were formed millions of years ago.

Naming compounds

Compounds are often named after their elements:

- if one of the elements in the compound is a metal, its name goes first
- the non-metal at the end of the compound's name has its name changed so that it ends in *-ide*.

For example, chlorine reacts with copper to form copper chloride. Silicon and hydrogen are both non-metals and they react to form silicon hydride.

- 7** Why are metal ores useful?
- 8** What are the chemical names of the metal ores shown in photo E?
- 9** When some powdered aluminium is mixed with crystals of iodine, nothing happens. If a few drops of warm water are added, flames and purple fumes are produced and a white solid is left.
 - a| What tells you a reaction has occurred?
 - b| What is the name of the compound formed?

I can ...

- describe changes you might see when compounds are formed
- identify elements, compounds and mixtures from descriptions and particle diagrams
- name simple compounds.

7He CHEMICAL REACTIONS

HOW CAN WE USE CHEMICAL REACTIONS?

A **chemical reaction** always forms one or more new substances. Typical signs of a chemical reaction include: a colour change, a gas being given off, a solid forming or heat being given off. We can use these signs as **criteria** to decide whether a chemical reaction has occurred.

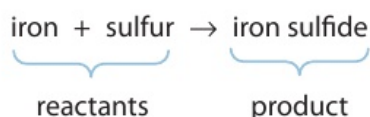
Many chemical reactions occur in everyday life. Some work just by mixing the right substances together. Others need an input of energy to get them started or a constant supply of energy to keep them going. Photo A shows some chemical reactions.

- 1 What happens in all chemical reactions?
- 2 Which of the reactions shown in photo A:
 - a| needs a constant supply of energy
 - b| just needs energy to start it off
 - c| works without any energy input?



A | the reactions involved in burning, cooking and rusting

Chemical reactions can be described using models called **word equations**. The **reactants** (what you start with) are shown on the left. An arrow points to the **products** (the new substances formed) on the right. The word equation for the reaction between iron metal and powdered sulfur is:



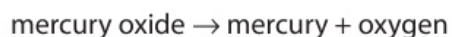
Notice that only the chemical names are included in a word equation.

- 3 Write word equations for the following reactions:
 - a| hot copper metal reacts with chlorine gas to form solid green copper chloride
 - b| non-metal carbon burns in oxygen gas to form only carbon dioxide gas.

Thermal decomposition

Elements can form compounds in chemical reactions and the reverse can also happen. When heat is used to break down a compound the reaction is called a **thermal decomposition**. This type of reaction is used in many industries, including the extraction of metals from their compounds (in ores).

When mercury oxide is heated (as in photo B) beads of liquid mercury can be seen on the side of the test tube and oxygen gas escapes from the tube. The word equation for the reaction is:



4 What are the products in the reaction shown in photo B?

- 5 a) How would you thermally decompose silver oxide?
b) Write a word equation for the reaction.

Some compounds can decompose to form other compounds. Metal **carbonates** do this. They are compounds containing a metal, carbon and oxygen. Many metal carbonates are found naturally and have many uses. For example, calcium carbonate is found in limestone, chalk and marble.



The **apparatus** used to investigate the thermal decomposition of copper carbonate is shown in photo D. The limewater turns milky if carbon dioxide is formed. (This is the test for carbon dioxide.) The word equation for the reaction is:



Many metal carbonates break down to form similar products.

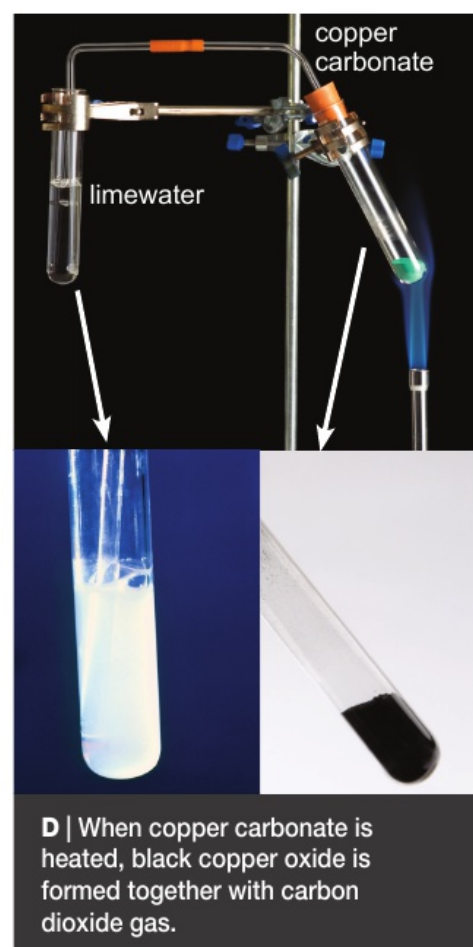
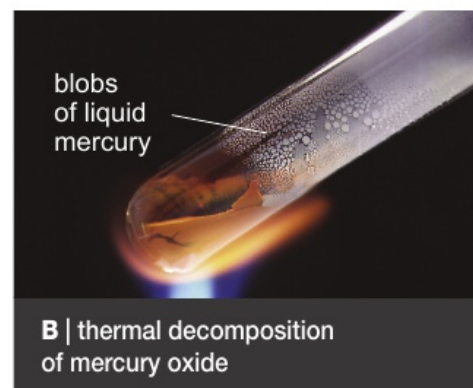
More about names

If a compound contains two elements plus oxygen, then the ending of the name of one element is changed to *-ate*. The *-ate* means 'with oxygen'. For example, a compound containing zinc, sulfur and oxygen is called zinc sulfate.

- 6 a) What are the products of the reaction in photo D.
b) Describe two signs that a chemical reaction has occurred in photo D.

7 What elements are in:
a) sodium phosphate b) lead nitrate?

8 Write a word equation for the thermal decomposition of calcium carbonate.



I can ...

- use and understand word equations for chemical reactions
- describe examples and uses of decomposition reactions.

7He PROBLEMS WITH ELEMENTS

WHAT PROBLEMS CAN ARISE FROM USING ELEMENTS?

The mining and extraction of metals is vital for many developing countries as it provides income for the economy and work and training for the **population**. It also introduces new technologies and brings about improvements to transport systems and services like water and **electricity** supplies.



Lead, which is mainly used to make batteries, is produced in many developing countries. Its ores usually contain lead sulfide or lead oxide and the extraction involves several stages. It includes chemical

B | Lead is also used as a roofing material.



A | Workers in lead production are exposed to lead dust and other poisons.

reactions that remove impurities like sulfur and free the lead metal from its compounds. Extremely high temperatures are used to isolate the **pure** lead, and in the process lead dust and smoke are released. Slag waste is also produced, which is contaminated with lead and other **toxic** metals like arsenic and mercury.

- 1** a| Name all the elements and compounds mentioned in the passage on the right.
b| What is the difference between an element and a compound?
- 2** Write a word equation for the reaction between lead sulfide and oxygen forming solid lead oxide and sulfur dioxide gas.
- 3** What do you call a reaction that breaks down a compound using heat?
- 4** Why is the slag produced during the isolation of pure lead so dangerous?
- 5** What are the benefits and problems of lead production in a developing country? Write your ideas in a table like the one below.

D	Benefits of lead production	Problems of lead production



C | In some countries, children work in metal production and face hazardous conditions.

HAVE YOUR SAY

Some people think that the mining and extraction of metals in developing countries takes advantage of workers. Do you think that we should find alternative sources for these metals?

71a ENERGY AND CHANGES

A



There are a lot of things happening in a theme park. Almost everything that happens involves **energy** in some way. For example, your body needs energy to stay alive, and to allow you to move around. Energy is needed to make all the rides in the theme park work. The energy needed is stored in food and in fuels, such as petrol.

B | Food is a store of energy.



- 1 Which of the rides shown in photo A needs the most energy and which the least energy? Explain your answers.
- 2
 - a| Write down five different things that are happening in photos A and B that need energy.
 - b| How is energy provided for these things to happen?
- 3
 - a| Write down five things you did yesterday that needed energy.
 - b| Which of these things do you think needed the most energy, and which needed the least energy? How do you know?

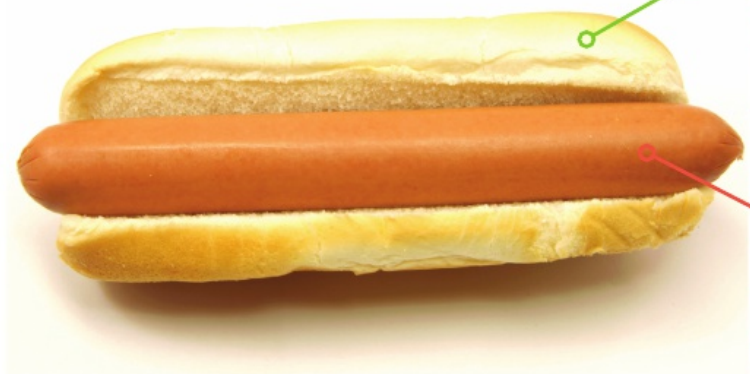
71a ENERGY FROM FOOD

HOW DO OUR BODIES USE ENERGY?

Humans and other animals need energy to live. We need energy to help us to grow and repair our bodies, and to move and keep warm. Our bodies use food as a source of energy.

The unit for measuring energy is the **joule (J)**. The amount of energy needed to lift an apple from the floor onto a table is about 1 J. Most foods contain a lot more energy than this, so we usually measure the energy in foods using **kilojoules (kJ)**. 1 kJ = 1000 J.

Nutrition Information		
Typical values	Per bun (65g)	Per 100g
Energy	544 kJ/130 kcal	837 kJ/200 kcal
Protein	6g	9.2g
Carbohydrate (of which sugar)	21g (4g)	32.3g (6.2g)
Fat (of which saturates)	2.5g (0g)	3.85g (0g)
Fibre	1.2g	1.8g
Sodium	0.2g	0.3g



Nutrition Information		
Typical values	Per hot dog sausage (50g)	Per 100g
Energy	628 kJ/150 kcal	1256 kJ/300 kcal
Protein	9g	18g
Carbohydrate (of which sugar)	0.8g (0g)	1.6g (0g)
Fat (of which saturates)	15g (4g)	30g (8g)
Fibre	0g	0g
Sodium	0.4g	0.8g

A | Nutrition information labels show how much energy is stored in food.

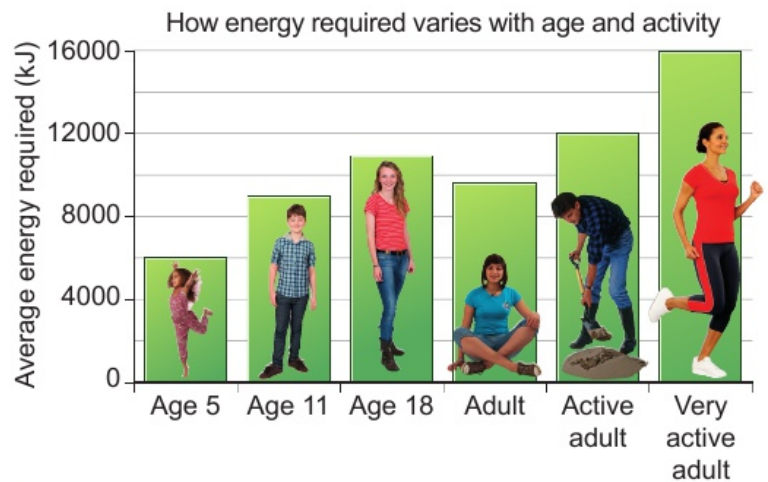
- 1** Why does your body need food?
- 2**
 - a| How much energy does 100 g of hot dog sausage contain? Give your answer in kilojoules.
 - b| Mark eats two hot dogs (each hot dog is one sausage in a bun). How much energy is in the food he eats?

Different people need different amounts of energy. Your body needs energy to help it to grow. You also need energy to move around. If you do a lot of exercise, you need more energy than if you spend most of your time watching television.



B

A good **diet** should provide only the amount of energy that a person's body needs. If the diet contains more energy than the person needs, the body will store the energy in fat and the person will gain **weight**. If the diet does not contain enough energy the person will lose weight and become thinner. A good **balanced diet** also provides all the **nutrients** that the body needs for health, and includes a **mixture** of different foods.



D | Mountaineers need to take their food with them when they climb mountains. They need to take food that will give them about 19 000 kJ per day.

FACT

E



Koalas live in Australia, and feed on eucalyptus leaves. The leaves do not provide much energy, so koalas sleep for around 20 hours every day.

C | Different people have different daily energy needs.

- 3 a) Suggest why a teenager needs more energy than a 5-year-old child.
b) Why do you think a pregnant woman needs more energy from food than a woman who is not pregnant?
- 4 a) Write down these people in order of the energy they need, starting with the one who needs the least energy: baby, fire-fighter, secretary, 11-year-old child.
b) Explain your answer to part a.
- 5 a) A 5 year old only eats buns. How much would he have to eat each day to get the energy he needs?
b) If he only ate sausages, how much would he have to eat each day?
c) Why shouldn't you always eat only one type of food?
- 6 Explain the link between the amount of food someone eats, the amount of activity they carry out and the amount of weight they gain.
- 7 Look at photo E. How will the amount of time koalas spend asleep affect the amount of food they need to find?
- 8 Scientists can measure the amount of energy stored in different foods. How can this knowledge help mountaineers and explorers?

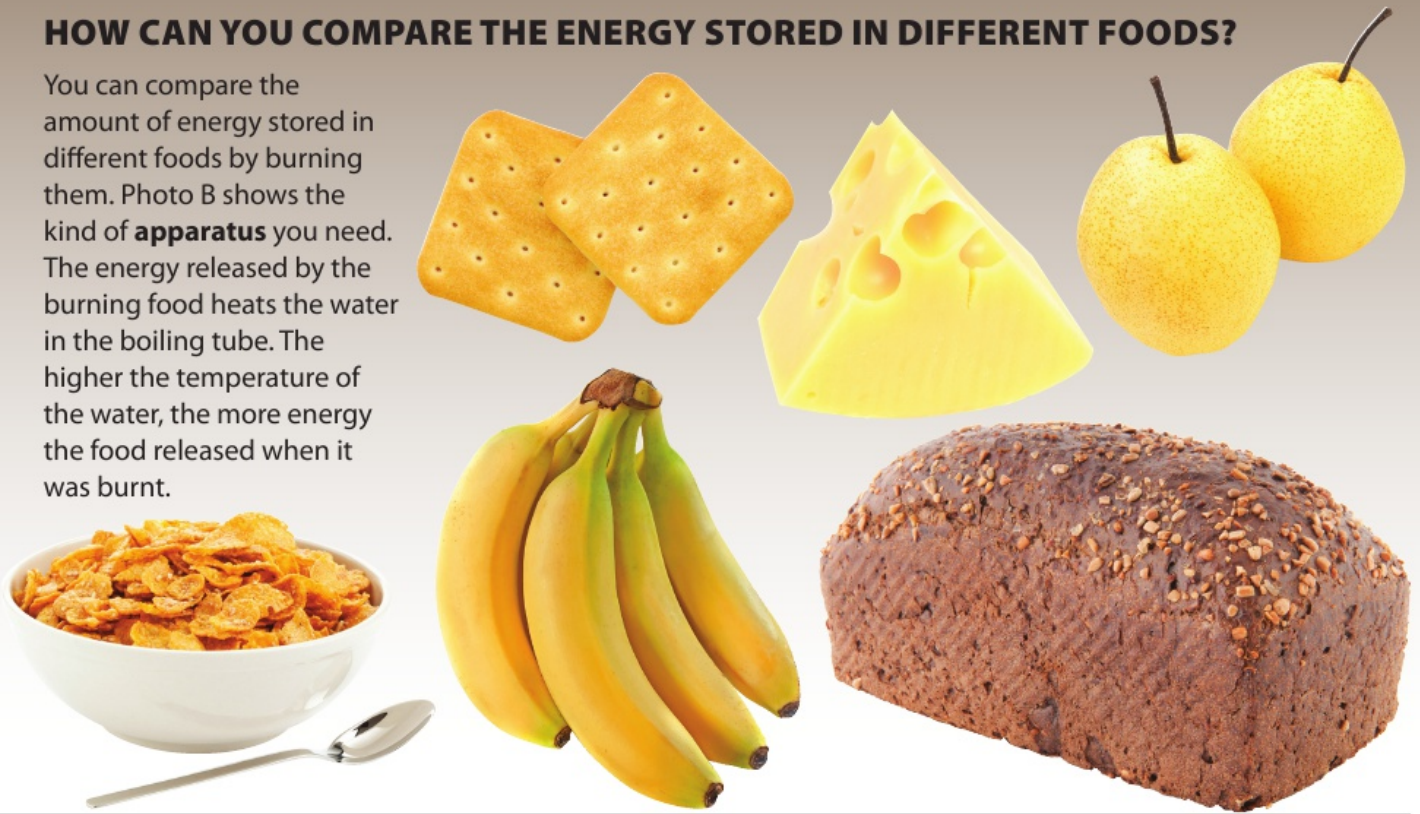
I can ...

- recall that our bodies need energy, which we get from food
- explain why different people need different amounts of energy from food
- recall that the units for measuring energy are joules (J) or kilojoules (kJ). 1 kJ = 1000 J.

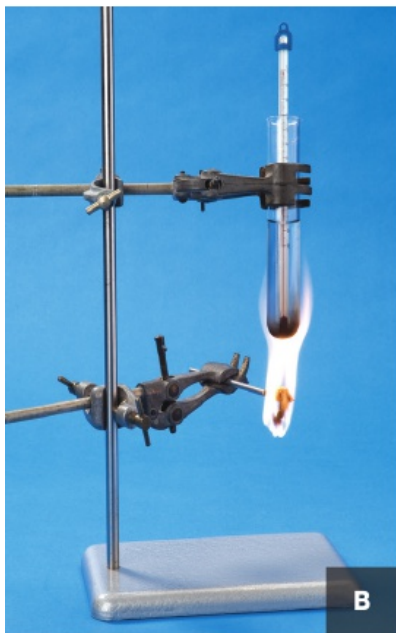
71a FAIR COMPARISONS AND RATIOS

HOW CAN YOU COMPARE THE ENERGY STORED IN DIFFERENT FOODS?

You can compare the amount of energy stored in different foods by burning them. Photo B shows the kind of **apparatus** you need. The energy released by the burning food heats the water in the boiling tube. The higher the temperature of the water, the more energy the food released when it was burnt.



A | Different foods contain different amounts of energy.



Method

- A** | Find the mass of a piece of food.
- B** | Carefully put the food on a pin (which has its other end in a piece of cork).
- C** | Put 10 cm³ of water into a boiling tube. Record its temperature.
- D** | Light the food using a Bunsen burner, and hold the burning food under the boiling tube. Make sure the flame is touching the boiling tube.
- E** | When the food has finished burning, record the temperature of the water again.
- F** | Let the food cool down, then carefully push what is left off the pin and find its mass. If there is no food left on the pin, write down 0 g for its mass.
- G** | Repeat steps A to F for other foods.



Wear eye protection.
Do not eat any of the foods.
Do not use nuts.

WORKING SCIENTIFICALLY

Table C shows the results of an investigation. The student has used the masses of food at the beginning and end to work out the **mass** of each food burnt, and has also calculated the change in temperature.

C	Food used	Mass of food burnt (g)	Temperature rise (°C)
	bread	2.0	4.0
	cheese	4.0	16.0
	cornflakes	4.0	14.0
	crackers	1.0	4.5

Burning 4 g of cheese made the temperature of the water rise by 16 °C. What would be the temperature rise if only 1 g of cheese had been burnt?

Comparing results

Table C shows that burning the cheese produced the greatest change in water temperature. However, it is not a fair test because different masses of each food were burnt.

We can make a fair comparison of the results by working out the temperature rise for each **gram (g)** of food burnt. We do this by dividing the temperature difference by the mass of food. Table D shows the results of this calculation.

D	Food used	Temperature rise per gram of food (°C/g)
	bread	2.0
	cheese	4.0
	cornflakes	3.5
	crackers	4.5

- 1 a) Look at tables C and D. Write down the foods in order of the temperature rise, starting with the lowest (bread).
- b) Now write down the foods in order of the temperature rise per gram of food.
- c) Which list is the best comparison of the amounts of energy stored in the different foods? Explain your answer.

Ratios

Ratios can help us to compare the energy stored by different foods. The investigation shows that 1 g of bread raises the temperature of the water by 2 °C, and 1 g of cheese raises it by 4 °C. We can write these numbers as a ratio like this:

temperature rise for 1 g bread (°C)	temperature rise for 1 g cheese (°C)
2 : 4	
1 : 2	

It is easier to understand the ratio if one number is a 1. Simplify the ratio by dividing *both* sides by the smallest number needed to make one side become 1.

So we can write the ratio as 1:2. This shows that cheese raises the temperature of the water by twice as many degrees as bread.

- 2 The student also tested diet crispbreads in the investigation. The temperature rise per gram was 1.0 °C. What is the ratio of the temperature rise caused by the crispbreads compared with:

a) the bread b) the cheese?

- 3 A student says 'I would get the same energy from eating 50 g of bread or 25 g of cheese.' Is the student correct? Explain your answer.

- 4 Pears store 175 kJ of energy per 100 g of fruit, and bananas store 350 kJ per 100 g. Calculate the ratio of the energy stored in the two kinds of fruit.

I can ...

- make a fair comparison of results
- calculate ratios.

71b ENERGY TRANSFERS AND STORES

HOW IS ENERGY STORED AND MOVED?

Energy can be stored. For example, energy is stored in the chemical substances in food, petrol and **cells** (batteries). We call this **chemical energy**. Things happen when energy *moves* from a store. We say that the energy is **transferred**.

This can happen by:

■ heating ■ light ■ sound ■ **electricity** ■ **forces**.

1

Write down three things that:

- a| transfer energy by heating or light
- b| transfer energy by sound
- c| use energy transferred by electricity.

Many machines allow energy stores to be transferred into energy stored in other ways. For example, moving objects store energy. We call this **kinetic energy**.



energy stored in the chemical substances in diesel fuel

fairground ride transfers energy by electricity and forces

energy stored in the moving people and ride ('kinetic energy')

B | This ride is powered by a diesel generator. Energy is stored in the substances that make up the diesel fuel. Energy from the burning fuel is transferred by electricity and forces to the ride. The flow diagram represents the energy transfers.



A | The chemical substances inside the firework rocket store energy. When the firework goes off, energy is transferred by light, sound and heating.

When energy is transferred, it is not used up. Energy cannot be created or destroyed; it can only be transferred and stored in different ways. This is called the **law of conservation of energy**.

2

Diesel fuel is a store of energy in chemicals. Write down three other things that store energy in chemicals.

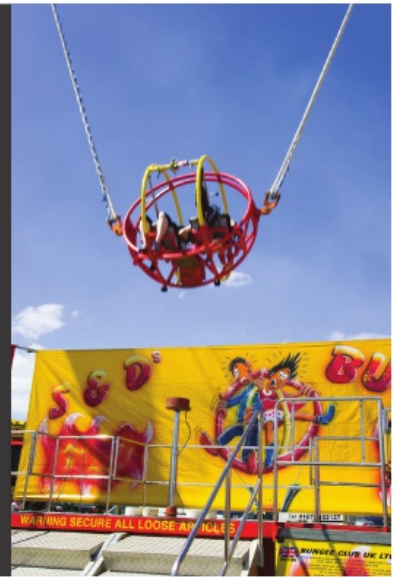
Energy can be stored in other ways. A hot object can be a store of **thermal energy**.

Energy is stored whenever something springy is squashed, stretched, bent or twisted. We call this **strain energy**, or **elastic potential energy**. A stretched elastic band is storing energy in this way.

Anything in a high position stores energy. We call this **gravitational potential energy**. It took energy to move the object up to its high position, and this energy can be transferred again when the object falls.

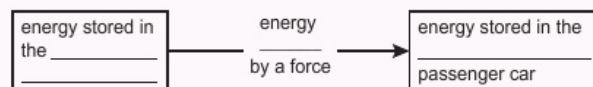
Energy is stored inside all materials. Some materials can transfer this energy in nuclear power stations. We call this **nuclear energy** (or **atomic energy**). This energy store cannot be transferred by burning. Nuclear power stations use this energy to produce electricity. The Sun also contains a store of nuclear energy, some of which is transferred to the Earth by heating and light.

C | The passenger car is attached to two bungee (elastic) cords. The car is pulled down so that energy is stored in the stretched bungees. This energy is transferred by forces to a store of movement (kinetic) energy when the bungee is released.

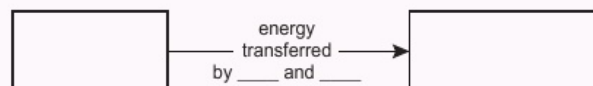


3 Write down three different ways in which energy can be stored as strain energy.

4 Look at photo C. Copy and complete the flow diagram below to show the energy transfers.

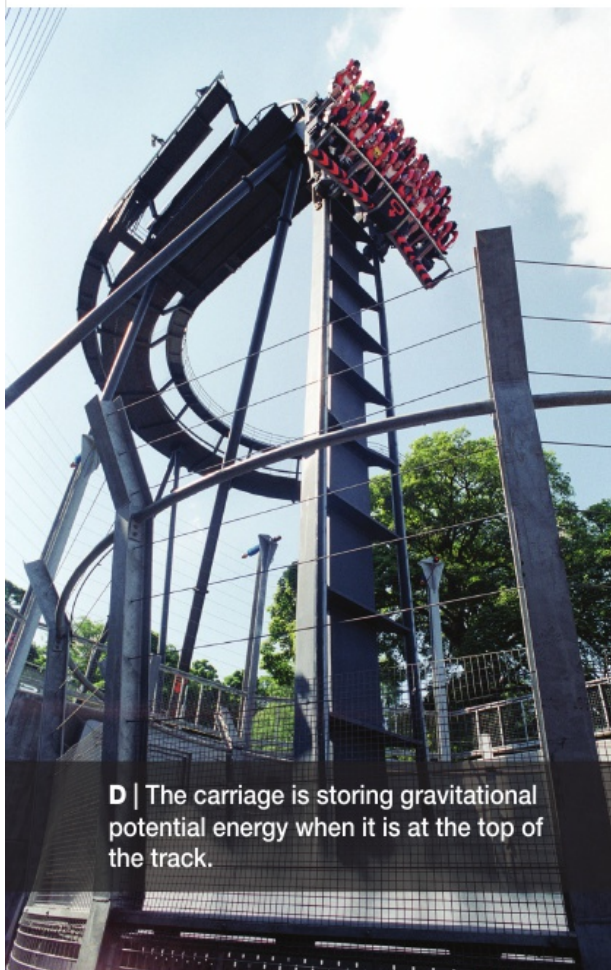


5 The flow diagram below shows the energy changes and transfers for a room being heated by an electric fire. The electricity comes from a nuclear power station.



- Copy the diagram and label the two energy stores (in the squares) and the energy transfers (on the arrow).
- 2000 J of energy goes into the electric fire every second. How much energy is transferred out of it? Explain your answer.
- Draw a similar diagram for a car travelling along a motorway.

D | The carriage is storing gravitational potential energy when it is at the top of the track.



I can ...

- describe the different ways in which energy is transferred
- describe different ways in which energy is stored
- recall the law of conservation of energy.

71c FUELS

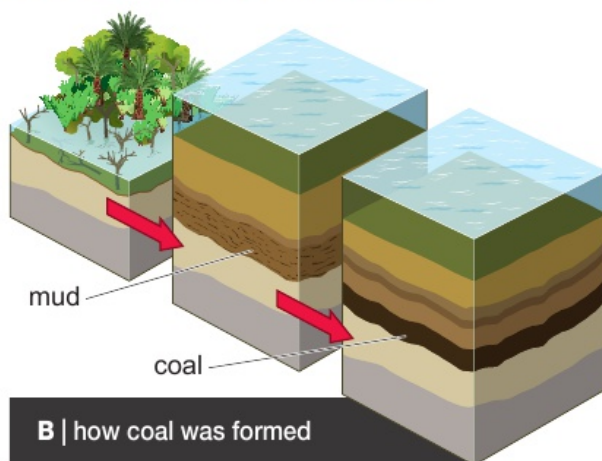
WHERE DO FUELS COME FROM?

A **fuel** is a substance that contains a store of chemical or nuclear energy that can easily be transferred. Most fuels are burned to release the energy they store, and the energy is transferred to the surroundings by heating. Burning a fuel does not make energy, it only transfers it. **Nuclear fuels**, such as **uranium**, release energy in a different way.

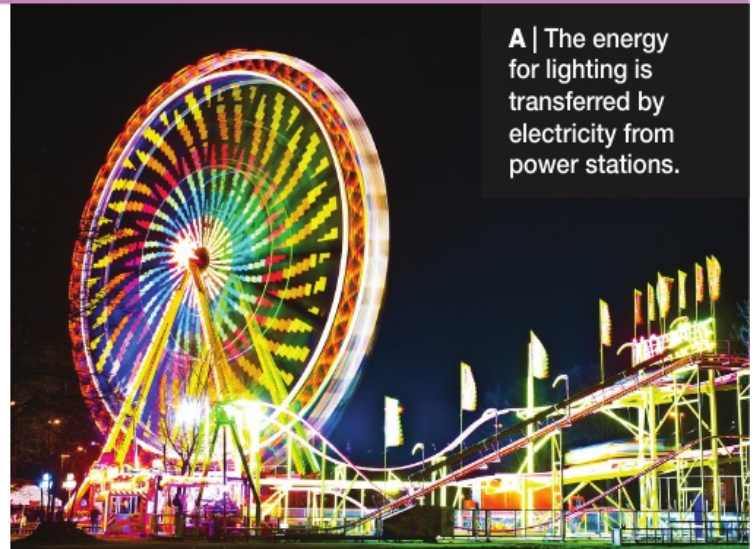
Energy from the fuels used in power stations is transferred to homes, schools, factories and offices using electricity. We say that the electricity is **generated** in power stations.

- 1 a| What is a fuel? b| Name three fuels.
- 2 Write down three things humans use fuels for.

Fossil fuels



Oil and **natural gas** formed from tiny animals and plants that lived in the sea millions of years ago. These fell to the sea bed when they died and got buried in mud and sand. More layers of mud and sand fell on top of them and squashed them, turning them into crude oil and natural gas. Fuels such as petrol and diesel are made from oil.



FACT

1 kg of nuclear fuel stores around 3 500 000 times as much energy as 1 kg of coal.

Fossil fuels are made from the remains of **organisms** that died millions of years ago. **Coal** was formed many millions of years ago from plants. When the plants died they became buried in mud, which stopped them from rotting away. More layers of the mud squashed the plant remains. This squashing, together with heat from inside the Earth, turned the mud into rock and the plant remains into coal.

C | The fast food van uses energy stored in the chemicals in the bottled **gas**. The gas is made from oil.



Coal, oil and natural gas are **non-renewable** fuels because they cannot be replaced at the rate that humans use them up. It takes many millions of years for them to form and so our supplies will eventually run out.

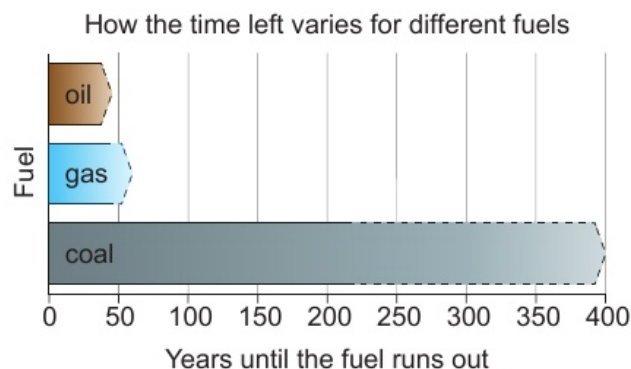
3

Look at graph D.

- a) Which fossil fuel will run out first?
- b) Why do you think the bars on the graph have no definite end?

4

- a) Write down two similarities between the formation of coal and oil.
- b) Write down one difference.



D | Scientists are not certain how long the different non-renewable fuels will last. It depends on how fast we use them, and whether more sources are discovered.

Other fuels

Biofuels are made from plants or the wastes from animals. They are **renewable** fuels, because more plants can be grown to make more fuel.

F | In some countries, animal wastes are dried to be used as a **solid** fuel. Animal and plant wastes can also be turned into methane, the main substance in natural gas.



E | Crops can be grown to make biofuel. Some biofuels are made out of waste cooking oil, which originally came from plants.

Gases such as **hydrogen** can also be used as fuel. At the moment, most hydrogen is made from natural gas, but scientists are trying to find ways of making it cheaply from water.

5

A friend of yours says, 'Electricity is a fuel'. Explain why your friend is wrong.

6

Fossil fuels are being formed slowly in the Earth today, so why are fossil fuels called non-renewable fuels?



G | This car has an electric motor. A fuel cell in the car combines hydrogen with **oxygen** from the air to produce electricity.

I can ...

- describe what fossil fuels are and how they were made
- explain why fossil fuels are described as non-renewable
- name some renewable fuels.

71c SUMMARISING

HOW CAN WE SUMMARISE INFORMATION?

Scientists report their work by writing a **scientific paper**. This is published in a **journal**. All scientists read scientific papers to find out about what other scientists have done.

A paper starts with an **abstract** (a summary). Other scientists use the abstract to find out what the paper is about, without having to read all of it. They can then decide quickly whether or not the paper is going to be useful to read.

Vol 7, Issue 4 June 2014

Energy released by different fuels

Amy Stephens & Zack Trent

Abstract

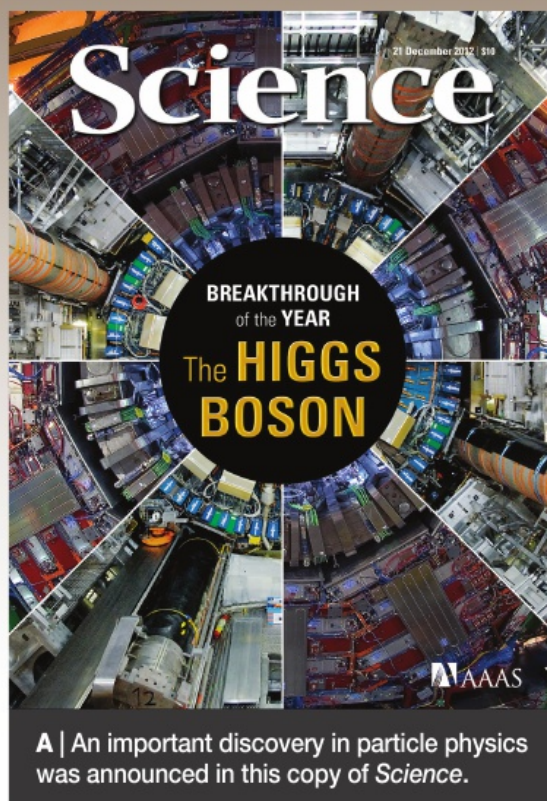
Various liquid fuels are available that can be used in spirit burners or camping stoves. These release different amounts of energy per gram of fuel burned. This investigation measured the energy released by four different fuels and also noted other factors that affect their suitability for use in camping stoves. It was found that the petrol released the most energy per gram of fuel

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B | Scientific papers start with an abstract.



Summarising information is useful in other ways, too. It can help you to make notes for revision, or to remember the important ideas from a video or a magazine article.

Identifying the key ideas

To summarise a piece of text, you first need to identify the key ideas in the text. There are several ways you can do this.

- Scan the text to get a general idea of what it is about. Look for the main nouns which will tell you *who* or *what* the text is about.
- Look for the **topic sentence** in a paragraph that you need to summarise. The topic sentence gives you the main point of a paragraph, and is usually the first sentence.
- Use a highlight pen or coloured pencils to underline key words or phrases that are important, or jot down a list of bullet points to show the main ideas.

1

- Why do scientific papers always start with an abstract?
- Give one other way in which summarising a text can be useful.

LITERACY & COMMUNICATION



Local residents oppose the plans of a UK oil and gas company to search for gas underground. Our reporter asked some local residents about their opinions of the plans for exploration near Nether Overton, deep in the countryside. 'It's going to be an eyesore,' said Mrs Jemima Smith (47). 'We are going to write to our MP about it.' Mr Ingleton (35) said, 'Having enough gas to supply homes is important, but the countryside and wildlife are also important.' 'My Bed & Breakfast business is struggling,' said Miss Fetherton. 'The last thing my visitors need is a building site while they build the thing, and then a huge gas rig outside the window.'

This first sentence is the topic sentence. It gives you the main point of the paragraph.

Local residents object to the proposed gas extraction site, saying that it will spoil views from the village and damage the tourist trade.

The newspaper article can be summarised like this. The important ideas are given, but not examples or extra information.

Writing your summary

- d| Combine your bullet points into a single paragraph.
- e| Start with a topic sentence that gives the main point of the paragraph.
- f| Link the main points together using words like 'but', 'however', 'therefore', 'so'.
- g| Check that you have included all the important ideas, but not examples or any extra information.
- h| Make sure your summary is shorter than the original!

The summary of the newspaper article is very short, because there are only a few ideas to be included. Summaries can sometimes be much longer than this.

2 What is a topic sentence?

3 Read the first three paragraphs on page 144 again. Write a short paragraph of two sentences to explain why summarising is a useful skill.

4 Read page 142 and the first paragraph of page 143. Write a short paragraph of 75 words or less to summarise the information.

I can ...

- summarise the key points in a piece of text.

71d OTHER ENERGY RESOURCES

WHAT OTHER ENERGY RESOURCES ARE AVAILABLE?

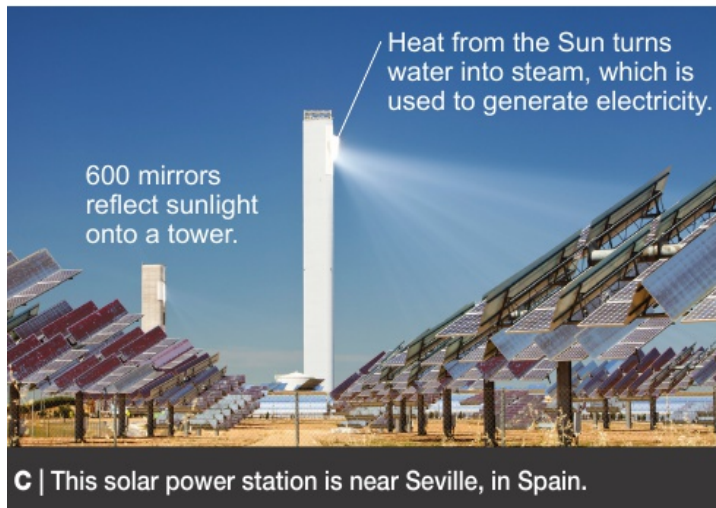
Biofuels are a renewable energy **resource**. Some biofuels are used in cars and other vehicles, and some are used for heating, cooking or generating electricity.

1

Why can biofuels be described as renewable resources?

Other renewable energy resources can be used for heating, but most are used to generate electricity.

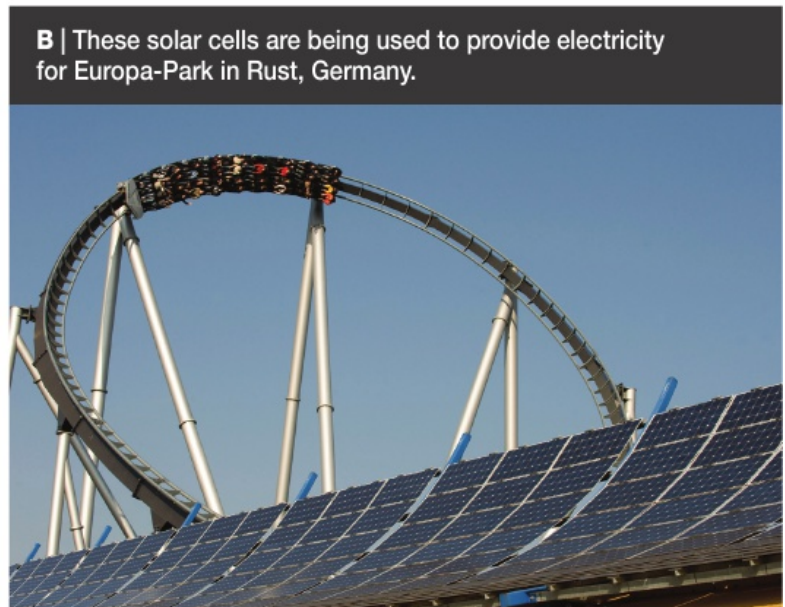
Solar power uses energy transferred from the Sun. **Solar panels** consist of tubes full of water, which heat up. These can be mounted on roofs and the hot water used to heat the building or to provide hot water for washing. **Solar cells** use energy transferred by light to produce electricity directly. Electricity can also be produced using solar energy by using mirrors in a **solar power station**.



C | This solar power station is near Seville, in Spain.



A | This ride runs on biodiesel.



B | These solar cells are being used to provide electricity for Europa-Park in Rust, Germany.

FACT

Wind turbines would need to cover an area the size of the Isle of Wight to produce the same amount of energy as one nuclear power station.

Wind turbines use the wind to turn large blades, and the blades turn a generator. Moving water can be used to generate electricity in a **hydroelectric power** station. Waves and tides can also be used to generate electricity.

In some places, rocks under the ground are hot. Water can be heated by pumping it through the rocks. This is called **geothermal power**.

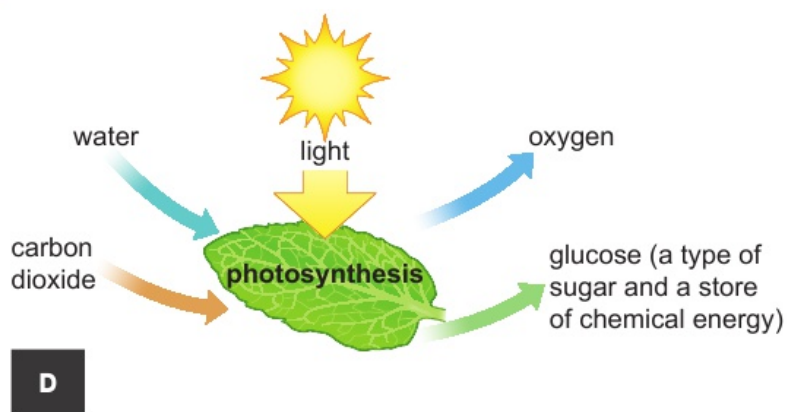
Most renewable resources are not available all of the time, because they depend on the weather. Only hydroelectricity and geothermal power are available at any time; however, these resources can only be used in locations with a suitable place for a reservoir or hot rocks underground.

- 2 Write down three ways in which solar power can be used.
- 3 Write down three examples of using water to generate electricity.

Nuclear energy from the Sun

Nearly all the energy stored in our energy resources originally came from the Sun. The Sun is a store of nuclear energy, and some of this is transferred by light and heating. We use some of this energy directly in solar panels and solar cells.

Sunlight also provides the energy for plants to grow. The energy is needed for **photosynthesis**. This is the process by which plants make their own food using **carbon dioxide** from the atmosphere.



The energy in fossil fuels came from the bodies of the plants and animals from which the fuels were formed. The animals got their energy from the plants that they ate, and the plants got their energy from the Sun.

Clouds form from water evaporated by the heat of the Sun. Eventually the water falls back to Earth as rain. Hydroelectric power therefore depends on the Sun. Energy from the Sun also causes the wind and waves. The only energy resources we use that do not depend on the Sun are nuclear fuels, tidal power and geothermal power.

FACT

E



Energy from the Sun can even be used to power an aeroplane.

- 4 The energy stored in a bowl of cornflakes and milk originally came from the Sun. Explain how the energy got into the cornflakes and milk.
- 5 Bunsen burners use energy stored in natural gas. Explain where this energy came from originally, and how it came to be stored in the gas.
- 6 Most renewable energy resources are not available all of the time. Write down the renewable resources that:
 - a| depend on the weather
 - b| are available at any time
 - c| are only available at certain times of the day or night.

I can ...

- give some examples of renewable energy resources
- explain how the Sun is the original source of energy for most of our energy resources
- recall which energy resources do not depend on the Sun.

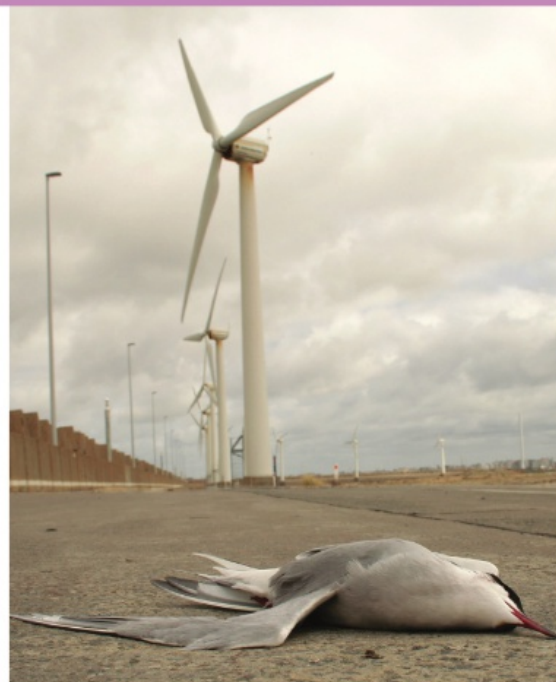
7^{1e} USING RESOURCES

WHICH ENERGY RESOURCES SHOULD WE USE?

Energy resources are stores of energy that we can use. There are advantages and disadvantages to renewable and non-renewable resources.

Energy resource	Advantages	Disadvantages
fossil fuels (used to generate electricity, to power transport and for heating)	<ul style="list-style-type: none"> ■ cheap compared with other resources ■ convenient to use in cars and other vehicles 	<ul style="list-style-type: none"> ■ release polluting gases when they burn ■ non-renewable
nuclear (used to generate electricity)	<ul style="list-style-type: none"> ■ no polluting gases 	<ul style="list-style-type: none"> ■ power stations are very expensive ■ produces dangerous waste materials ■ non-renewable
renewable resources (mainly used to generate electricity)	<ul style="list-style-type: none"> ■ no polluting gases ■ renewable 	<ul style="list-style-type: none"> ■ most are not available all of the time

A | Some of the advantages and disadvantages of different kinds of energy resource.



B | Some people object to wind farms because they say they kill a lot of birds.

Climate change

Most of the energy we use in the UK comes from burning fossil fuels. Most scientists who study the climate think that fossil fuels are helping to make the Earth warmer because a gas called carbon dioxide is produced when they burn. Extra carbon dioxide in the atmosphere makes the Earth warmer.

We can reduce the amount of carbon dioxide we add to the atmosphere by using less fossil fuel. This will also help to make our supplies of fossil fuels last longer.

- 1** What does non-renewable mean?
- 2**
 - a| Name two renewable energy resources that are not available all the time.
 - b| Explain why they are not available all the time.



Wear a jumper instead of keeping the house very warm in winter.

C



Walk, cycle or use public transport instead of using a car.

Using less ...



Use efficient appliances when you can. Labels on appliances show you how efficient they are.



Insulate homes so that less energy escapes by heating.

3

- Describe three ways in which we could use less fossil fuel.
- Give two reasons why it is important to use less fossil fuel.

Efficiency

Energy cannot be created or destroyed, but not all the energy transferred by a machine ends up as useful stores of energy. Some of it is wasted. The carriages in photo D are being moved to the top of the ride using an electric motor. Flow diagram E shows the energy transferred.

Energy cannot be created or destroyed, so all the energy transferred by the electricity is still there. The wasted energy is spread out in the surroundings.

Efficiency is a way of saying how much of the energy transferred by a machine is useful. An efficient machine does not waste much energy. If you use a more efficient machine there will be less wasted energy. This means that less fossil fuel will be burnt to produce the electricity to run it, and your electricity bills will also be cheaper.

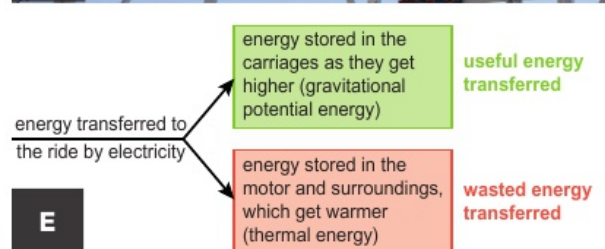
4

Mr Smith buys some solar panels to heat the water for his house. Explain how this will:

- help to cut his gas bills
- help the environment.

5

Two light bulbs receive 20 J of energy every second. Bulb A transfers 18 J of energy by light every second, and bulb B transfers 4 J by light every second. Which bulb is the most efficient? Explain why.



E

I can ...

- describe advantages and disadvantages of different energy resources
- describe some ways of using less fossil fuel
- explain what efficiency means.

7^{1e} MAKING CHANGES

HOW CAN WE USE LESS FOSSIL FUEL?

The way we live needs a lot of energy – for heating, transport and generating electricity. Almost all of the vehicles on our roads use fuels obtained from oil, and over 75 per cent of our electricity is generated using fossil fuels.



We need to burn less fossil fuel, because this is a non-renewable resource, and because burning fossil fuels is harming the **environment**. But how can we change?

I always use efficient appliances because they use up less of our country's store of electricity.



Think of all the warm air that escapes through this door, all day! Local councils could help by only allowing buildings that do not waste energy.



Anything I change won't make any difference. It's up to the government to change the way the country runs.



If everyone used a bike or walked for short journeys it *would* make a difference. Climate change will affect all of us – we should all reduce the amount of fossil fuels we use.

- 1 Look at photo A. Describe the energy stores shown in the photo, and the ways in which energy is being transferred.
- 2 Look at photo B. In what way is the person:
 - a| correct b| wrong?
- 3 Why do you think that most of the electricity we use in this country is generated from non-renewable resources? Give as many reasons as you can.
- 4 a| Explain why we should use less fossil fuel.
 - b| Look at photo C. Suggest five ways in which the person in the photo *could* make changes.
- 5 A kettle uses electricity. Starting with the Sun, draw a flow chart to show the energy stores and transfers when you boil the kettle, if the electricity comes from:
 - a| a coal-fired power station
 - b| a hydroelectric power station.

HAVE YOUR SAY

Who should be responsible for reducing our use of fossil fuels – individuals, businesses or the government?

7Ja

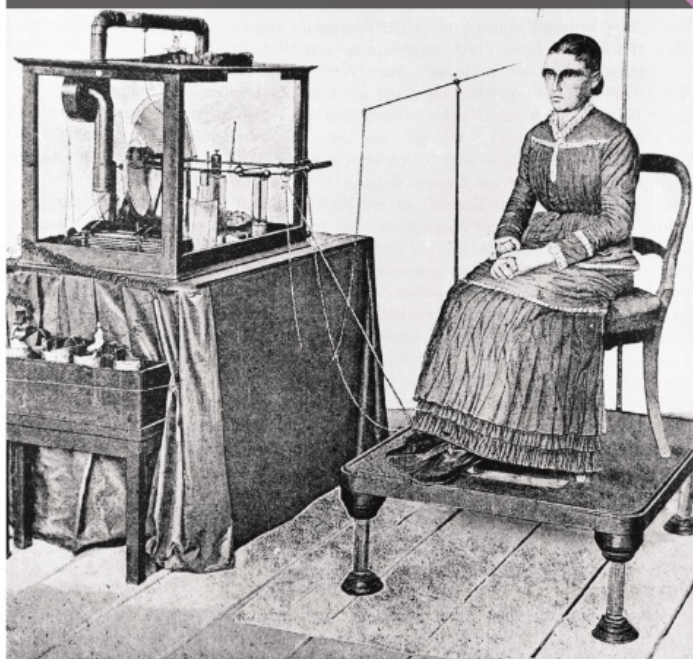
DISCOVERING ELECTRICITY

People have known about the effects of **static electricity** for thousands of years. The ancient Greeks knew that you could charge up certain materials by rubbing them. They also used electric shocks from catfish and other animals to try to cure headaches and some other illnesses.

Early scientists carried out some experiments with **electricity** using lightning, but this was very dangerous. In the 1600s, scientists invented machines that could produce static electricity. Some of these machines were used for scientific research, but some were used for entertainment or for medical treatments. It was not until Alessandro Volta invented the electrical **cell** in 1800 that scientists had a constant supply of electricity to experiment with.

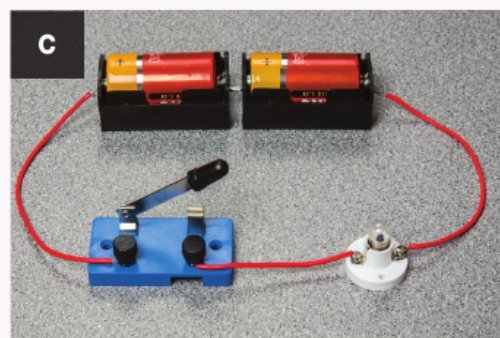
Today almost everything we do depends on electricity in some way. You can investigate electricity at school by making circuits and using cells or **power packs** to provide the electricity.

B | This illustrates electricity being used to treat a patient with a nervous disorder in 1882.



A | Static electricity is making this child's hair stand up. This happened as their clothes rubbed against the slide.

- 1** The wires used in electric circuits are made of metal, with a coating of plastic on the outside. Explain why these materials are used.
- 2** Photo C shows a circuit that can be used to turn a bulb on and off.

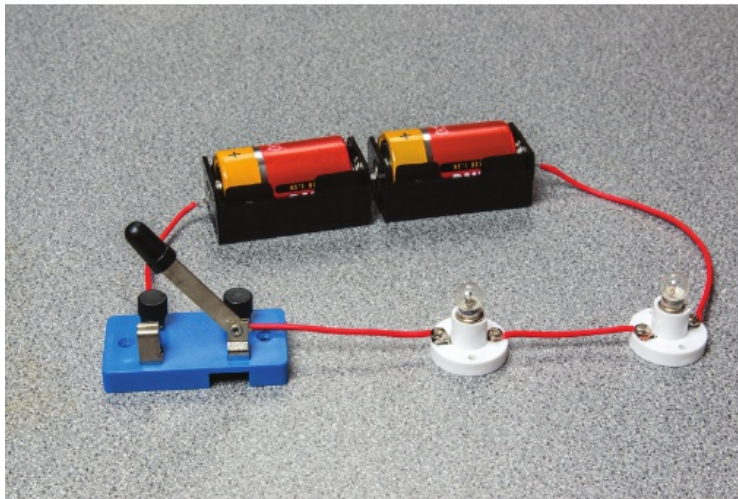


- a| Write a list of the apparatus used to make the circuit.
- b| Use standard symbols to draw a diagram of the circuit.

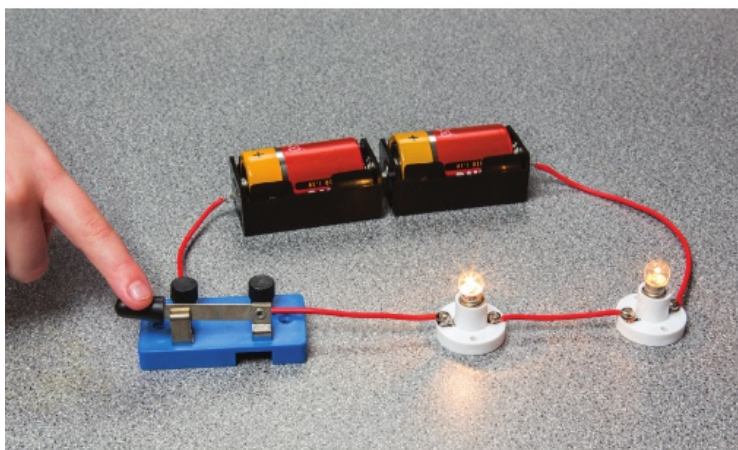
7Ja SWITCHES AND CURRENT

HOW DO WE MEASURE ELECTRICITY?

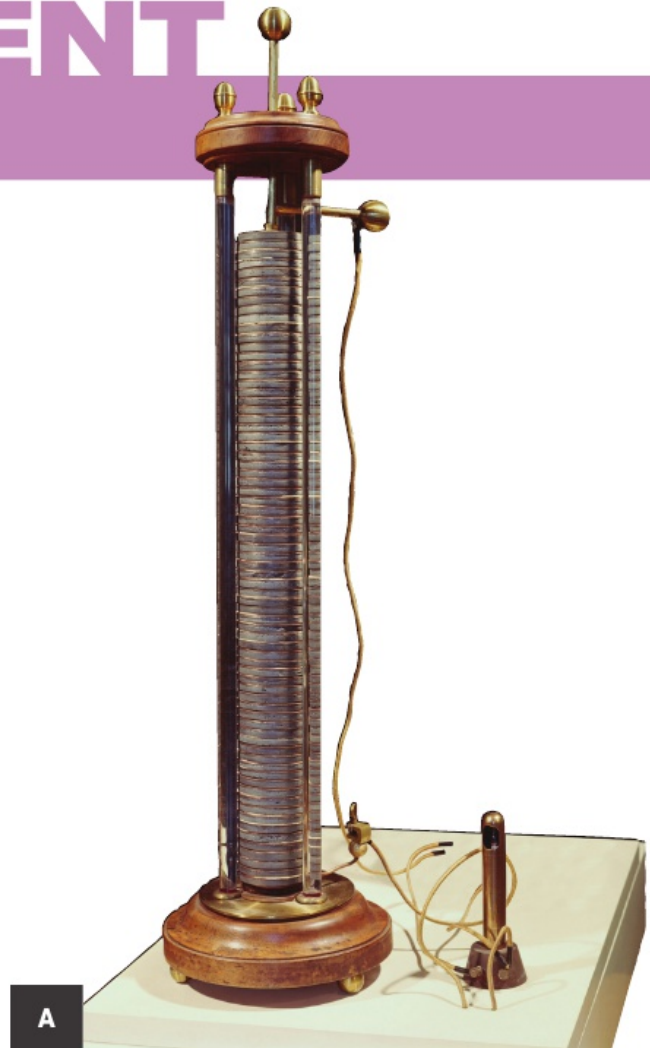
The **current** is the amount of electricity that is flowing around a circuit. The current carries **energy** to bulbs or other **components**. In electricity experiments the current in a circuit is provided by a cell or power pack. There must be a complete circuit or the current will not flow.



B | The bulbs are not lit because there is a gap in the circuit.



C | Pressing the switch joins the metal wires and a current can flow around the circuit. Both of the bulbs come on.



A

FACT

The original cell was invented by Alessandro Volta in 1800.

If one of the bulbs in circuit C breaks, the other bulb will go out. This happens because the broken bulb makes a gap in the circuit.

- 1 Look at circuit B. Explain how the switch works to turn the bulbs on and off.
- 2 Look at circuit C. What will happen if you take one of the bulbs out of its holder and then press the switch?

Bulbs light up because the electricity flowing through them makes the **filament** glow. If you add more bulbs to the circuit, all the bulbs in the circuit will be dimmer.

D | The current in a bulb has to flow through a very thin piece of wire called the filament.



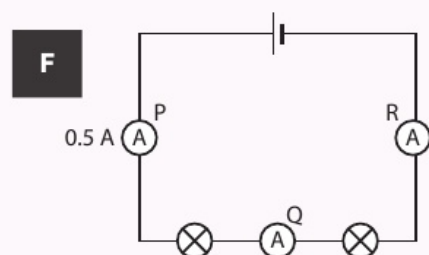
Measuring current

We measure the current using an **ammeter**. The units for current are **amperes (A)**. It does not matter where the ammeter goes in the circuit. Current is not used up as it goes around the circuit, so the current is the same everywhere.

5 a) What does an ammeter measure?

b) Draw the symbol for an ammeter.

6 Look at circuit F.



a) What current will ammeter Q show?

b) What current will ammeter R show?

7 A torch is not working. Write down all the things that could be wrong with it.

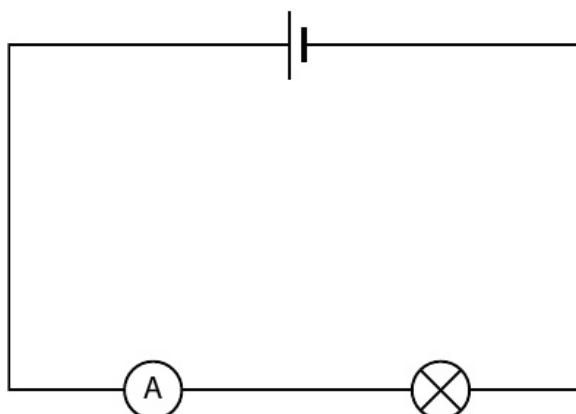
3 Describe how you could carry out an investigation to show how the brightness of bulbs changes when you add more bulbs to a circuit. Include a list of the apparatus you need.

4 Look at circuit C. Another circuit (circuit X) is identical but has one less bulb.

a) How will the brightness of the bulbs compare in the two circuits?

b) What will happen to the brightness of the bulbs in circuit C if another bulb is added to it?

c) One of the bulbs in circuit C breaks. Explain what happens to the other bulb.



E | An ammeter in a circuit. The diagram shows the symbol for an ammeter.

I can ...

- explain how switches work
- describe what happens when the number of bulbs in a circuit is changed
- describe what a current is and how it is measured.

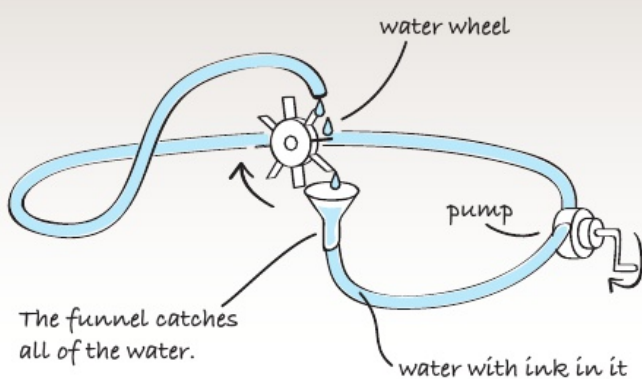
7Jb MODELS IN SCIENCE

HOW ARE MODELS USED IN SCIENCE?

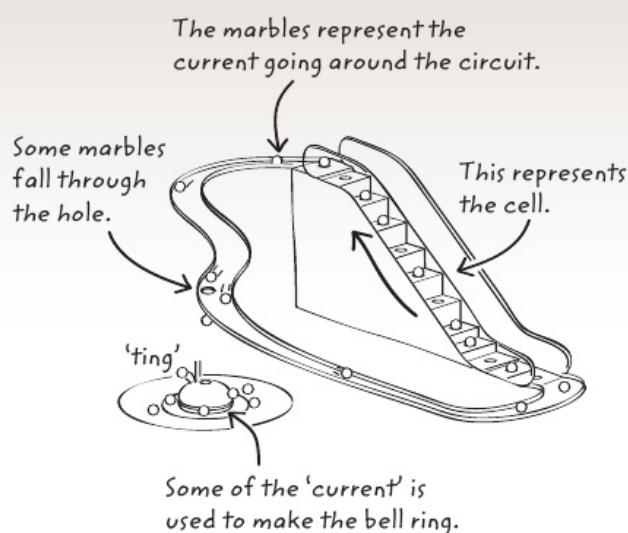
If someone asks you to explain what a **model** is, you may think of a model aeroplane or someone who is photographed wearing new clothes. These are both models, but there are many other kinds of model. A model is a way of showing or representing something. In science we use models to help us to think about complicated ideas.

We can use models to help us to think about what happens in electric circuits. The drawing shows two models that students want to build to help them to think about electrical current. The different parts represent different parts of an electrical circuit.

A | Sam's model



B | Nat's model



1 Look at drawing A. Which part of Sam's model represents:

- a| the cell
- b| the current
- c| a bulb or motor?

2 Explain your answers to question 1.

3 Describe what happens to the size of the 'current' as it goes around:

- a| in Sam's model (drawing A)
- b| in Nat's model (drawing B).

A good model behaves like the real situation. In this case, the 'current' in the better model will do what current does in a real circuit. Scientists can use a good model to make predictions about what they will find in investigations.

WORKING SCIENTIFICALLY

Testing models

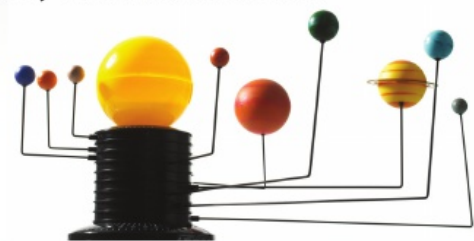
Sam and Nat need to check what happens in a real circuit to find out which model is the best.

- 4 Describe an investigation that Sam and Nat could carry out to find out which model is best.
 - a) Write a list of the apparatus they need.
 - b) Draw a circuit diagram to show how they should set up their apparatus.
 - c) Describe the method they should use. Write a separate instruction for each step in the method.
- 5 Predict the results that Sam and Nat should get in their investigation:
 - a) if Sam's model is the best one
 - b) if Nat's model is the best one.
- 6 Use what you know about current in circuits to explain which model is the best one.



C | Sam and Nat could use some of this apparatus.

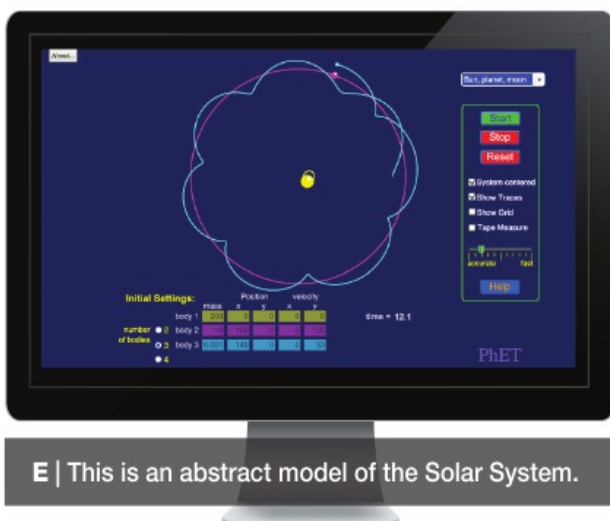
An **analogy** is a model in which you compare something complicated with an everyday thing that is easier to understand. These models for circuits are both analogies. When young children investigate the attraction between two magnets they often use the analogy that the magnets 'like' each other. It is important to remember that analogies are only a way of thinking about things. Magnets do not have feelings, so they cannot like each other!



D | This type of physical model of the Solar System is called an orrery.

Physical and abstract models

The model circuits that Sam and Nat want to build are **physical models**, because you could build them and touch them. Photo D shows a physical model of the Solar System. It helps people understand how the planets move around the Sun.



E | This is an abstract model of the Solar System.

Models that cannot be touched and only exist inside people's minds or on computer screens are **abstract models**. Photo E shows an abstract model of the Solar System.

- 7 Dan uses balls of different sizes to model the Earth and the Moon. Explain whether this is a physical or an abstract model.

I can ...

- identify when physical or abstract models are being used
- identify what the parts of a physical model represent
- plan an investigation to help to evaluate a model.

7**Jb** MODELS FOR CIRCUITS

HOW CAN WE USE MODELS TO HELP US TO THINK ABOUT ELECTRICITY?

Until just over 100 years ago, scientists thought of electricity as a **liquid** that flowed through wires, although they did not know what that liquid was. This model changed in 1897 when a British physicist called J.J. Thomson discovered that electricity was tiny **charges** moving through metals.

An electric current is a flow of charges, and carries energy from the cells (or electricity supply) to the components.

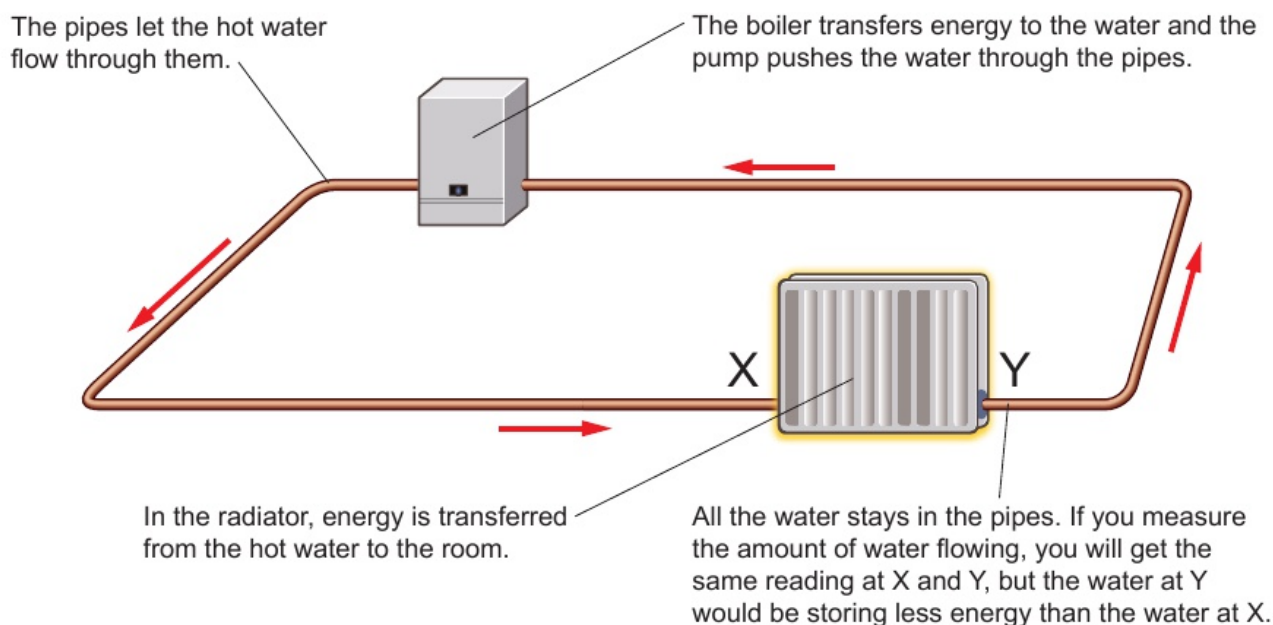
Metals are **conductors** because the charges can move around easily inside them. Charges cannot move around easily inside **insulating** materials.

It is difficult to think about these charges because they are too small to see, even with a very powerful microscope. We can, though, use models to help us to think about electricity. One of the models we can use is very similar to the one used by scientists before the charges were discovered (figure A).

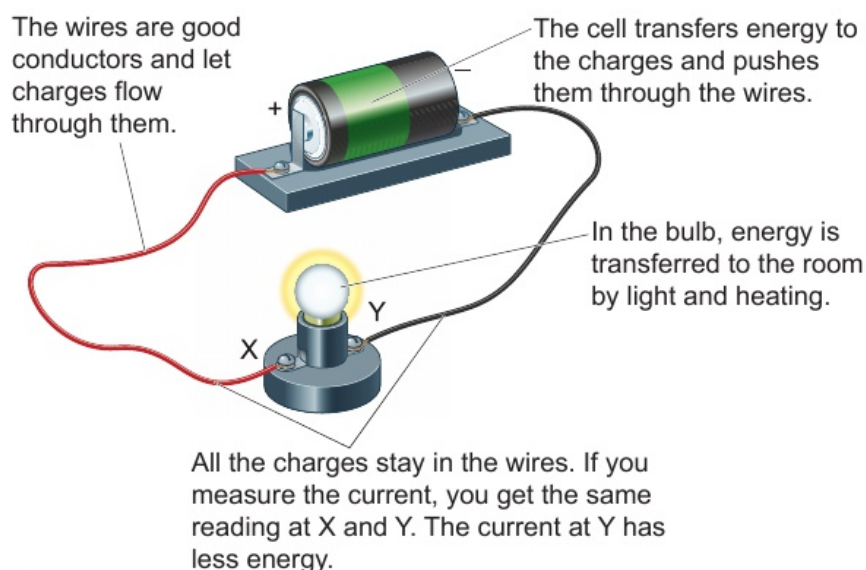
FACT

A current of 1 ampere means there are 6 250 000 000 000 000 000 charges going past every second.

- 1 What is an electric current?
- 2 Why can metals conduct electricity?



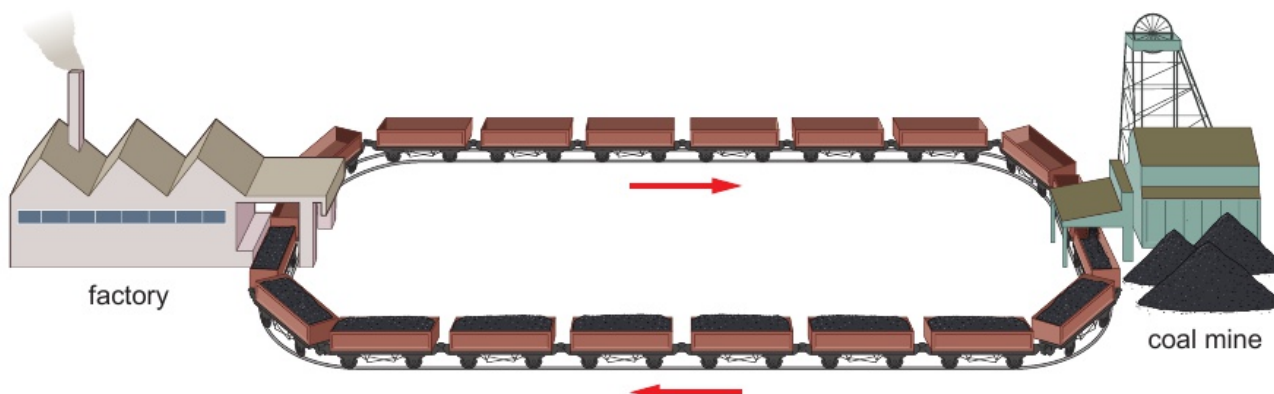
A | A central heating system can keep your home warm. This is a physical model of the electric circuit in diagram B.



B | This circuit transfers energy to its surroundings.

- 3** Why do we need to use models to help us to think about electricity?
- 4** Use the central heating model to help you to explain:
 - a| why a central heating boiler (with a pump) is like a cell
 - b| why a radiator is like a light bulb.
- 5** How is the central heating model *not* like an electric circuit?

Diagram C shows a different model for helping you to think about electricity.



C | This is a model for thinking about a circuit in terms of a train, coal and a power station.

- 6** Look at drawing C. What do you think these things represent:
 - a| the coal mine b| the factory
 - c| the train d| the coal?
- 7** How is the model *not* like an electric circuit?
- 8** Which of the models on these pages is the best to help you to think about electricity in a circuit? Explain why you think the model you have chosen is best.

I can ...

- explain why models are used
- identify what the parts of a physical model represent
- use a physical model to help explain electric circuits
- evaluate a physical model
- state what is meant by current.

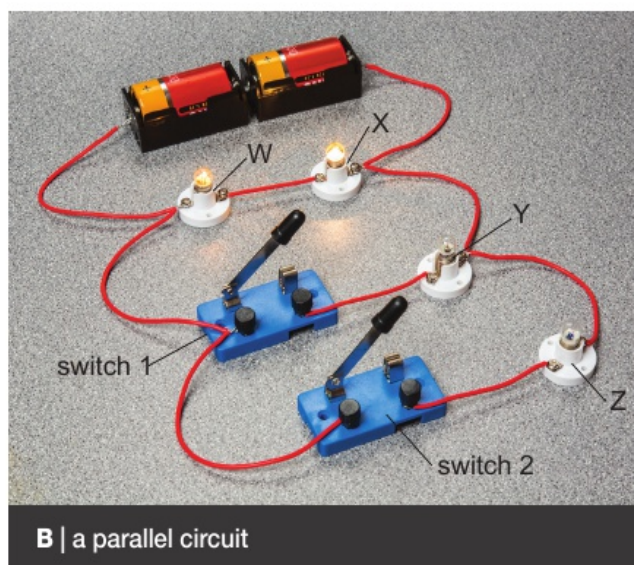
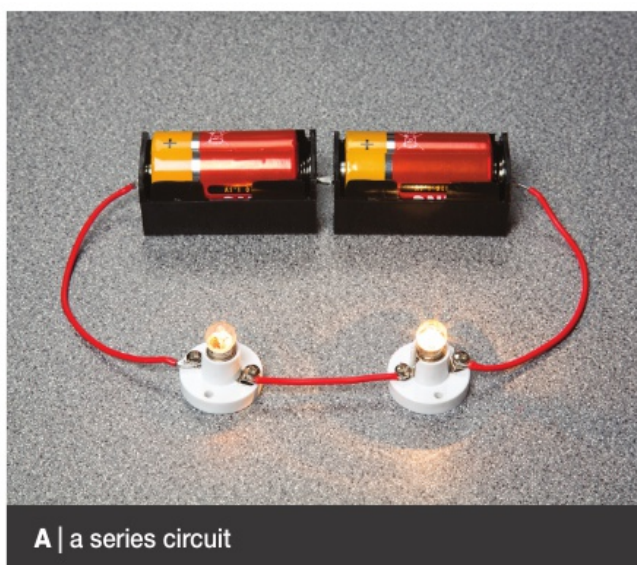
7Jc SERIES AND PARALLEL CIRCUITS

WHAT ARE THE DIFFERENCES BETWEEN SERIES AND PARALLEL CIRCUITS?

A circuit like circuit A, with all the bulbs in one loop, is called a **series circuit**.

If the bulbs are on separate branches of a circuit, it is a **parallel circuit** (circuit B).

A parallel circuit can have lots of branches. Each branch can have more than one component in it.



Parallel circuits are useful because each light can be switched on and off separately from the others.

In circuit A, both bulbs are on all the time. In circuit B, bulbs W and X are on all the time. Bulb Y only comes on if you press switch 1. If you want all the bulbs to come on you have to press both switches.

The two types of circuit behave in different ways.

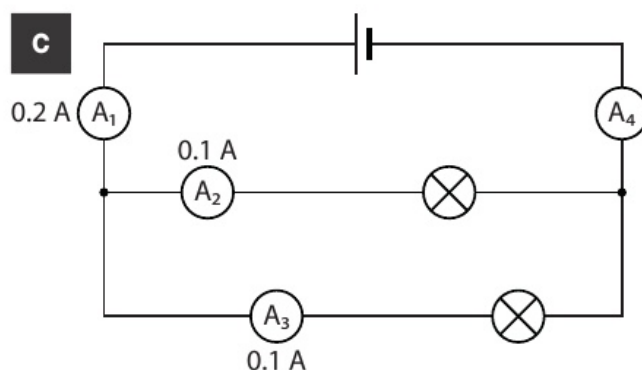
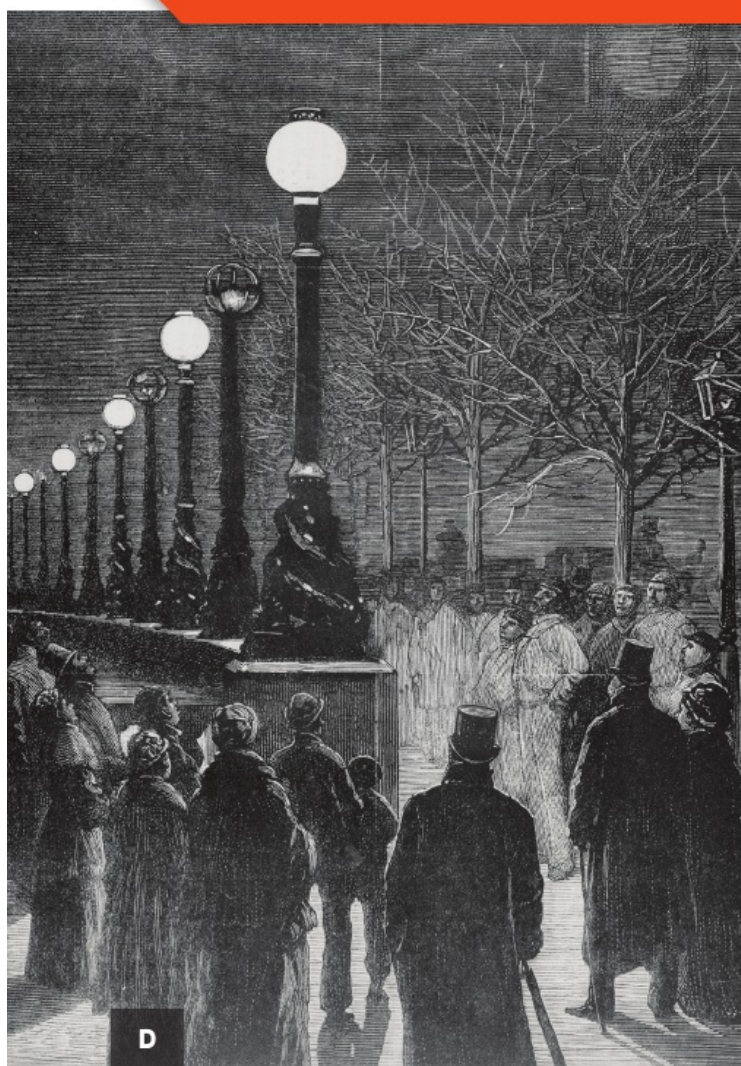
- In a series circuit, if one bulb breaks all the others go out, because the broken bulb makes a gap in the circuit.
- In a parallel circuit, if one bulb breaks the bulbs in the other branches stay on.

- 1 What is the difference between a series circuit and a parallel circuit?
- 2 Do you think the lights in your house are on a series or a parallel circuit? Explain your answer.
- 3 Write a plan to show how you could investigate what happens to the brightness of bulbs if you put more of them into a parallel circuit.

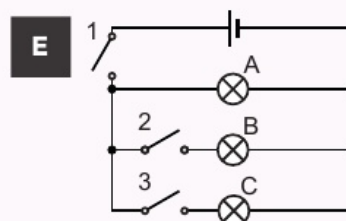
- The current is the same everywhere in a series circuit, but in a parallel circuit the current from the cell splits up when it comes to a branch. The currents in all the branches add up to the current in the main part of the circuit (see circuit C).
- If you add more bulbs to a series circuit the current gets smaller and the bulbs get dimmer. In a parallel circuit, if you add more branches with bulbs in, the bulbs stay bright. It is easier for the current to flow with more branches, because there are more ways for the charges to go. The current in the main part of the parallel circuit increases.

FACT

The first electric streetlights in the UK were along the River Thames, in London. They were installed in 1878.



- 4** Look at circuit E.



- Which switches have to be closed for bulb A to come on?
- Which bulbs will come on if you press switches 1 and 3?

- 5** Look at circuit C.

- What will be the reading on ammeter 4?
- How will the brightness of the bulbs change if you add another branch with a bulb in it?

- 6** Mrs Jones has some Christmas tree lights, and one bulb is removed. They will not come on until she has replaced the bulb. Are the lights connected in series or parallel? Explain your answer.

- 7** All the streetlights in a town need to be on or off at the same times. Explain which type of circuit should be used to connect them.

I can ...

- state what is meant by a series circuit and a parallel circuit
- explain how switches can control different kinds of circuit
- describe how changing the number or type of components in a circuit affects the current
- describe the differences in how current behaves in series and parallel circuits.

7Jc USING TABLES





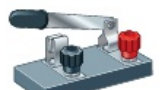

HOW ARE TABLES USED IN COMMUNICATING SCIENCE?

Scientists often have a lot of information to communicate. Putting the information in a table often makes it easier to read and understand.

If **data** or information is mainly in numbers it is said to be **quantitative**.

If the information is mainly in words, it is **qualitative**.

A | This table contains qualitative information.

Names	Drawing	Symbol
Bulb		
Cell		
Switch		

Each column has a clear heading.

The items are in alphabetical order.

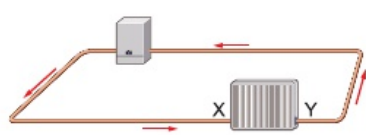
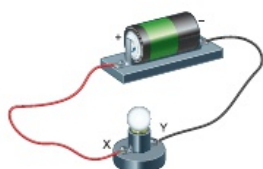
B | This table contains quantitative data.

Number of bulbs	Current (A)
1	0.40
2	0.20
3	0.13
4	0.10

When you are presenting the results of an investigation, the variable that you change usually goes in the left-hand column. This is the independent variable. The numbers usually go in ascending order.

Units can go in the column heading.

Tables can also be used to help you to compare different things. For example, on pages 156 and 157 you looked at a model for electricity. The model could have been presented as shown in table C.

C	Central heating model	Electricity in a circuit
		
	The boiler <i>transfers</i> energy to the water and a pump <i>pushes</i> the water through the pipes.	The cell <i>transfers</i> energy to the charges and <i>pushes</i> them through the wires.
	A central heating system can keep your house warm.	This circuit transfers energy by light.

This row contains things that are similar in the model and the circuit.

This row shows something that is different between the model and the circuit.

LITERACY & COMMUNICATION

When you present any kind of information in a table:

- a| give each column a heading
- b| decide how you are going to order the **data**. Usually the left-hand column is in ascending order (for numbers) or alphabetical order (for names or other words), but this may not always be the best way.

If you are presenting quantitative data:

- c| put the unit in the heading
- d| use the left-hand column for the **variable** that you changed (this is called the **independent variable**)
- e| the numbers in the left-hand column should usually be in ascending order.

For qualitative data:

- f| think about the order of the information in each column. Tables can be used to help you to spot patterns in data, so sometimes you may want to order the data using the **dependent variable** or one of the other columns.

If you are comparing different things:

- g| each row should show something that is similar (or something that is different) between the two things.

1 Look at table C. Is this presenting qualitative or quantitative data?

2 Look at drawing C on page 157. Draw up a table to show the similarities and differences between an electric circuit and the coal-train model of a circuit. *Hint:* Your answers to question 6 on page 157 should help you.

3 Pages 158 and 159 explain some of the differences between series and parallel circuits.

a| Draw up a table to compare series and parallel circuits.

b| Look at your table, and at the way the information is presented on pages 158 and 159. Describe some of the benefits of presenting the data in a table.

4 A student has carried out an investigation to find out how the current in a series circuit changes when she changes the settings on the power pack. She tested settings of 1 V up to 6 V, in 1 V steps. Draw up a table ready for her to present her results.

I can ...

- describe the benefits of organising data
- organise data in a table in a suitable way
- identify qualitative and quantitative data.

7Jd CHANGING THE CURRENT

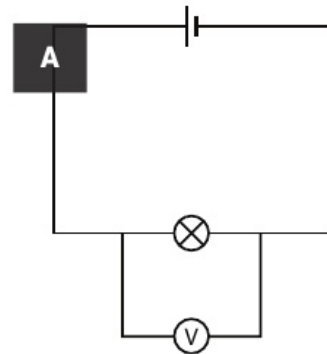
HOW CAN WE CHANGE THE CURRENT IN A CIRCUIT?

The size of the current in a circuit depends on the **voltage** of the cells or power pack, and on the components in the circuit.

The voltage provided by a cell or power pack helps to push the charges around the circuit. The higher the voltage of the cells in a circuit, the more charges it can push around. This means that increasing the voltage of cells or power packs increases the current.

We measure the voltage using a **voltmeter**, and the units are **volts (V)**. The voltmeter is connected **across** a component (e.g. a cell or a bulb), as shown in diagram A.

The current transfers energy to components in the circuit. The voltage across a component is a way of measuring how much energy is being transferred by the current.

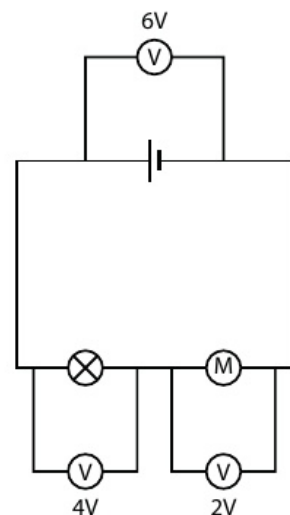


- 1 a) What does a voltmeter measure?
b) Describe the difference between the ways ammeters and voltmeters are put into circuits.
- 2 Look at circuit B. Explain how the current in this circuit will change if you change the cell to a 3 V cell.

If you add more bulbs to a series circuit, the bulbs get dimmer. It is difficult for the current to flow through the thin wire in the filaments of the bulbs. The more bulbs there are, the harder it is for the current to flow and so the current gets smaller.

FACT

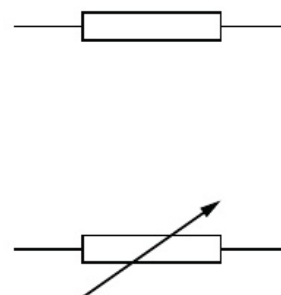
Air is normally an insulator, but at very high voltages electricity can jump across an air gap. The voltage between a cloud and the ground in a thunderstorm can be up to 100 000 000 volts!



B | The current is transferring more energy to the bulb than to the motor (M).

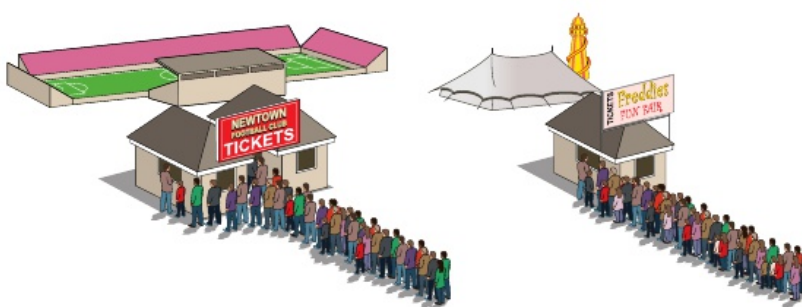
Components (including bulbs) that make it more difficult for a current to flow around a circuit have a high **resistance**. Components that do not make it difficult for the current to flow have a low resistance. Connecting wires have a low resistance.

Sometimes we only need a very small current in a circuit. We can make the current smaller by using a **resistor** in the circuit. A resistor has a high resistance and makes it harder for electricity to flow.



- 3 What happens to the current in a circuit if the resistance of the components in the circuit is increased?

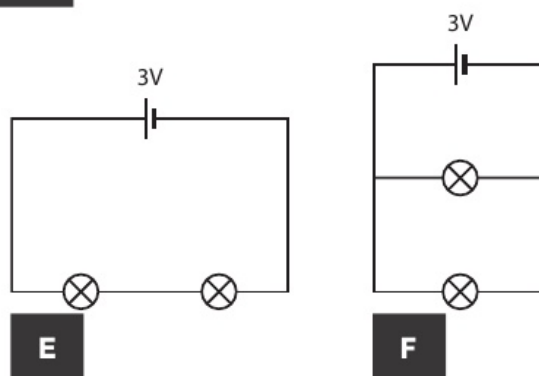
C | This shows resistors and their symbols. The resistance of a **variable resistor** (bottom) is changed by moving the slider.



D | queues of people waiting to get into a fairground and a football match

When you add bulbs to a circuit in parallel, the brightness of the other bulbs does not change. As you add more branches, the current flowing from the cell increases. It is easier for the current to flow when there are more branches because there are more ways for the current to go. The overall resistance of the circuit is less. Drawing D shows a model to help you to think about this.

- 4 Look at drawing D.
- Which queue will move faster? Explain your answer.
 - What do the people represent in this model of a circuit?
 - What do the entrances represent?
 - How does this model help you to think about resistance in a parallel circuit?
- 5 Look at circuits E and F. The bulbs in the circuits all have the same resistance.
- Explain which circuit will have the highest current.
 - Explain what will happen to the current in circuit E if you add another bulb in series.
 - Explain what will happen to the current in circuit F if you add another bulb in parallel.



I can ...

- describe how changing the number or type of components in a circuit affects the current
- describe how a voltmeter is used
- explain why the current increases when the voltage of the supply is increased
- describe the relationship between resistance and current.

7Je USING ELECTRICITY

HOW DO WE USE ELECTRICITY SAFELY?

The first public power station was opened in London in 1882. Since then many more power stations have been built and almost every home in the country has been connected to the mains supply. Although electricity is very useful, it is also a **hazard** (it can cause harm). Mains electricity has a higher voltage than cells, so there is a greater **risk** that it will cause harm.

Electricity flowing through a wire can cause the wire to heat up. This is useful in electric heaters and cookers, but if other components or wires become too hot they may cause fires. Electricity can also be harmful if it flows through the body, causing burns or even causing the heart to stop working.

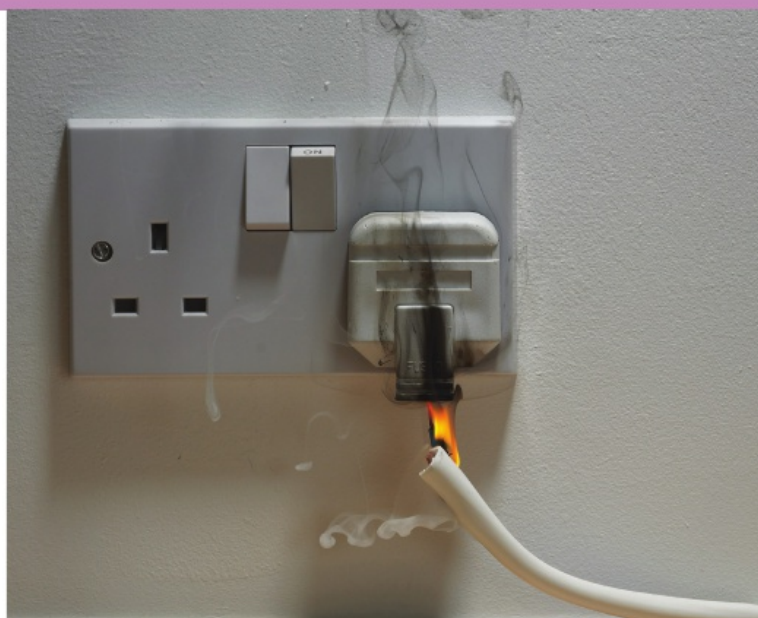
Reducing risks

If people obey some simple safety rules, the risks of harming themselves are reduced.

- Never touch the bare metal parts of plugs.
- Never poke things into sockets.
- Keep electricity away from water, and don't use switches with wet hands.
- Do not plug too many things into one socket.
- Never use something that has a damaged wire.

1 Describe three ways in which electricity can be a hazard.

2 Explain why you should never poke things into sockets.



A | an electrical fire caused by faulty wiring

FACT



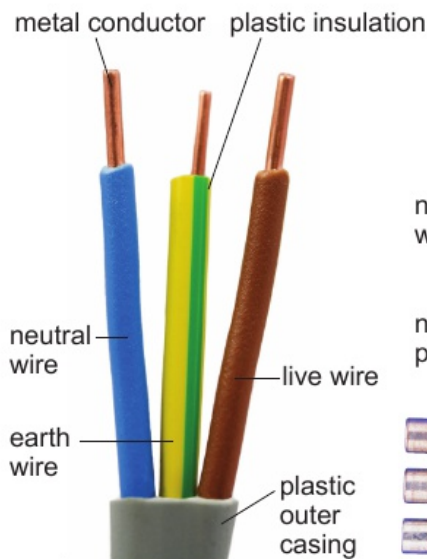
B | electrical burns

Over 2 million people in the UK receive an electric shock from the mains each year, and over 300 000 of these people are seriously injured.

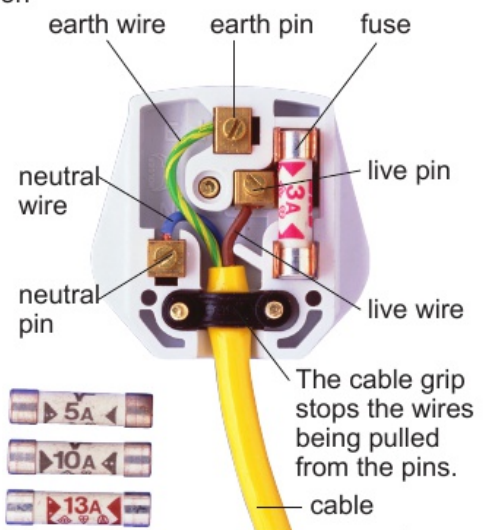
Electrical equipment is designed with safety in mind. Plugs on appliances are fitted with a **fuse**, which is designed to melt and break the circuit if the current is higher than it should be. Fuses have different **ratings** depending on how much current they are designed to carry without melting.

Many appliances need a cable with three wires inside it. The **live** and **neutral wires** are part of the circuit that makes the appliance work. The **earth wire** is there for safety.

A **circuit breaker** is another safety device that cuts off the current if too much current flows. Circuit breakers work in a different way from fuses, and they are used to protect 'rings' of sockets in a house (often called a **ring main**).



C | a three-core electrical cable



D | The photo shows different fuses used in the UK.



E | The wire at the bottom of this box is where electricity is coming into the house. The different circuits in the house are protected by circuit breakers.

3 The three wires inside a cable have different coloured coatings.

- Draw up a table to show the colours and names of the three wires.
- Suggest why the wires need to have standard colours.

4 What could happen if the current in an appliance was too high?

5 Photo D shows four standard types of fuse. Explain which one should be used for an appliance that has a current of 6 A.

6 How could you find out how much current can flow through a piece of fuse wire before it melts? Write a plan for your investigation, including the apparatus you will need and a circuit diagram.

7 Sometimes the wire to an appliance may become damaged.

- Suggest what could happen if the appliance is used with a damaged wire.
- Explain how electrical equipment is designed to stop this happening.

I can ...

- explain some safety precautions to be followed when using electricity
- describe the job that fuses and circuit breakers do
- explain how a fuse works
- recall how the different wires are connected in a plug.

7Je A WORLD WITHOUT ELECTRICITY

HOW HAVE IDEAS ABOUT ELECTRICITY CHANGED THE WAY WE LIVE?

The first power stations were built near the end of the 1800s. The electricity they produced was originally used for lighting. Later, scientists and engineers developed motors and electronic components. Today, we use electricity for many different things in everyday life.

Many of the things we do today could be done without electricity, but there are some things we do that are only possible using electrical equipment.

A | entertainment in a living room before electricity



B | Before gas was piped to homes in the 1800s, candles or oil lamps were the only sources of light.



C | The 'electric chair' was first used to execute prisoners in 1890, and is still used in some states of the USA.



1 Describe the advantages and disadvantages of using electricity for:

- a| making tea and toast
- b| washing and drying clothes.

2 We use electricity for many different things. Suggest how our use of electricity would be different if all circuits had to be series circuits. Use as many ideas from this unit as you can in your answer.

HAVE YOUR SAY

Are people's lives better since electricity was developed?

7Ka FORCES

Our life is full of **forces**. We cannot see them but we can see how they affect things. All sports involve forces. You use a force when you kick a football, when you ride a bike and when you run.

When you take part in certain sports you need special equipment to protect you from some forces or to help you to produce bigger forces. Many sports would not be possible without modern technology.

Some sports appear to be dangerous but people doing these sports wear helmets or special clothing to protect them if there is an accident. All the equipment they use for the sport must be designed so that it does not break when it is used.

Engineers who design sports equipment must know about all the different forces involved in the sport. This helps them to make sure the equipment can be used safely.



A | This climber is using ice axes and spikes on her boots to help her climb the ice. She is wearing a helmet and using a rope to reduce the risk of harm.



B | This sport is called fourcross.

- 1** a | Write down five sports that you can play using only simple equipment such as a ball.
b | Write down five sports that need more specialised equipment.

- 2** a | What is the force pulling the climber downwards in photo A?
b | The fourcross bike in photo B has brakes to help slow it down. What force is produced in the brakes?

- 3** The climber is pulling on the ice in order to move upwards. This is a contact force.
a | Name one other contact force.
b | Name two non-contact forces.

- 4** Climbers can now climb much steeper ice and rock than they could 50 years ago. Suggest why this is.

7Ka DIFFERENT FORCES

WHAT CAN FORCES DO?

A force is a push or a pull. Forces can change the shape of something, its speed, or the direction that it is moving in.

For many forces, the thing providing the force needs to touch an object before the force can affect it. These are called **contact forces**. For example, when you throw a ball, you need to touch the ball to exert a force on it. When you go down a steep hill on a bicycle, the brakes need to touch the wheel to produce **friction** to slow you down. Contact forces include friction, **air resistance**, **water resistance** and **upthrust** (the force that makes things float).

Some forces can affect an object from a distance. These are called **non-contact forces**. **Gravity** is a force that pulls objects downwards (photo A). **Static electricity** can attract things (photo B). In photo C, the man is climbing the side of a ship using magnets. Magnets have **magnetism**, which attracts objects made of iron and some other metals. Magnets can also repel other magnets.



Forces can be big or small. The unit for measuring force is the **newton (N)**. The direction in which the force is acting is important so we use arrows to show forces. The direction of the arrow shows the direction of the force; a bigger arrow shows a bigger force.

- 1 Write down three ways in which a force can affect a football.
- 2 Write down the names of three:
 - a| contact forces b| non-contact forces.
- 3 What are the units for measuring forces?
- 4 Look at photo D.
 - a| Which bike has the biggest force on it?
 - b| How do you know this from the photo?
 - c| What will happen to the two bikes as a result of these forces?

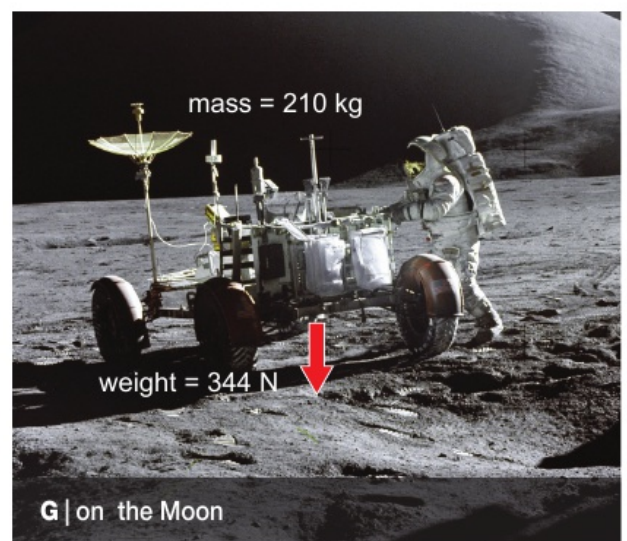
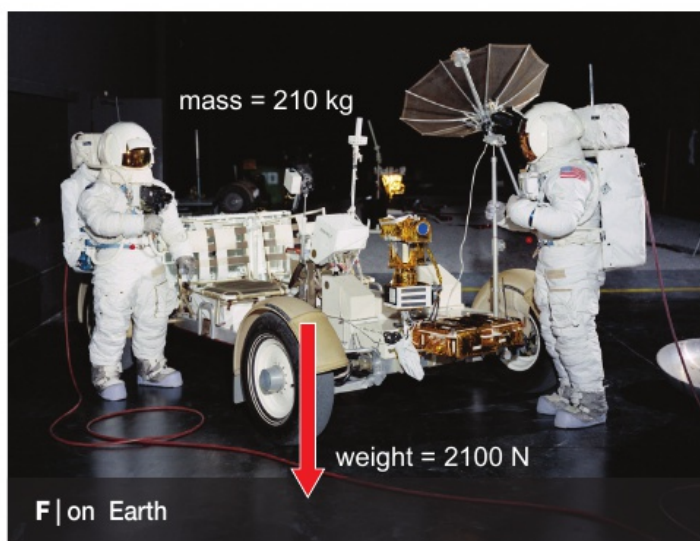
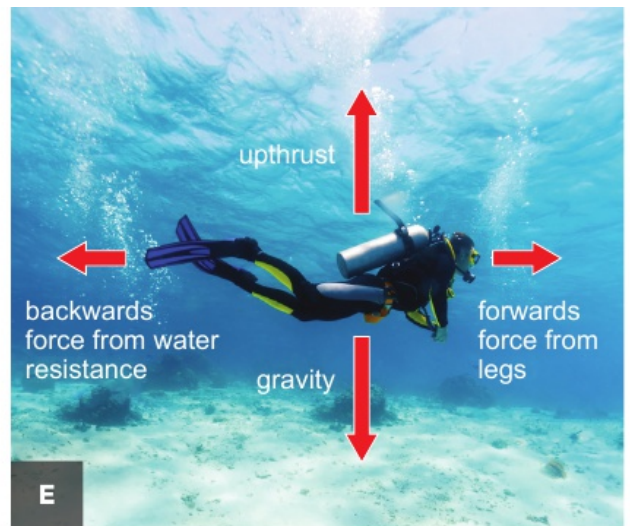


Sometimes there are a lot of forces acting on something. There are four forces acting on the diver in photo E.

Weight and mass

Your **weight** is the force of gravity pulling on you. Weight is a force so its units are newtons (N). If you talk about something being '10 kilograms' you are talking about its **mass**. Weight and mass are two different things.

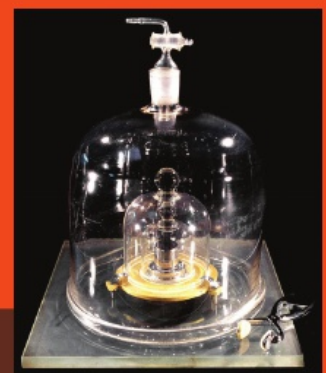
Mass is the amount of matter that makes up an object. The units for measuring mass are **grams (g)** and **kilograms (kg)**.



The force of gravity is greater on the Earth than it is on the Moon. The lunar buggy in photo F has the same mass wherever it is but it has a greater weight on the Earth than on the Moon. The Earth's gravity pulls on every kilogram with a force of about 10 N, so something that has a mass of 2 kg has a weight of 20 N.

FACT

The 'true' kilogram mass is kept in a safe near Paris. All other kilogram masses are measured against this one.



- 5 a| What is weight?
b| What are the units for weight?
c| What is mass?
d| What are the units for mass?

6 Why would you weigh less on the Moon than you do on the Earth?

7 Why do you think it is important that scientists in different countries all check their ways of measuring a kilogram against the same standard mass?

I can ...

- recall the effects of forces on an object
- name forces and classify them as contact or non-contact forces
- recall how to measure forces and masses and their units.

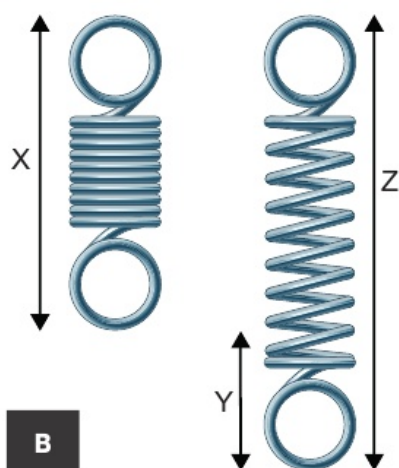
7Kb SPRINGS

HOW CAN SPRINGS HELP US TO MEASURE FORCES?

Materials and objects can be **stretched** (made longer) or **compressed** (made shorter). The amount of stretch or compression in the material depends on the type of material and the size of the force. It takes a very big force to change the size of some materials.

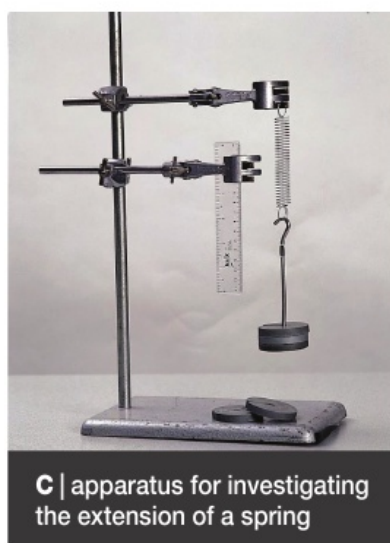
Most **springs** are made from coils of wire. The **extension** of a spring is the difference between its original length and its stretched length. The spring is **elastic** because it will return to its original length when the force is removed.

- 1 What does elastic mean?
- 2 Look at diagram B. Which arrow shows the extension of the stretched spring? Explain your answer.



- 3 Look at photo C. Explain how you would use this apparatus to find out how much the spring stretches with different forces on it.

The **apparatus** shown in photo C is being used to investigate the extension of a spring. Graph D shows that the extension is **proportional** to the force up to a certain point, called the **limit of proportionality**. This means that for every 1 N increase in the force, the spring stretches by the same amount. The idea that the extension is proportional to the force is **Hooke's Law**. Hooke's Law does not apply to all elastic materials.

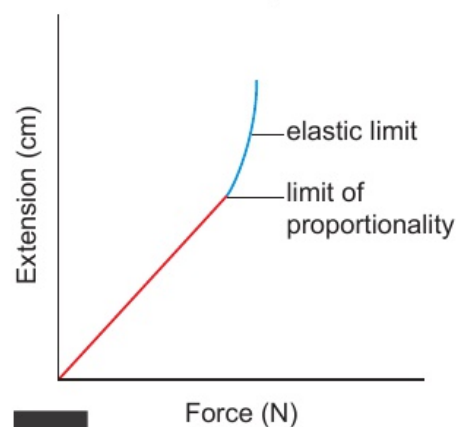


C | apparatus for investigating the extension of a spring



A | Xpogo is a sport where people use pogo sticks to jump up to three metres in the air and perform tricks. The pogo stick has a spring inside it.

How extension depends on force



D

E | It is not just springs that are elastic. A bungee cord will stretch and then pull the jumper upwards again. However, bungee cords do not follow Hooke's Law.



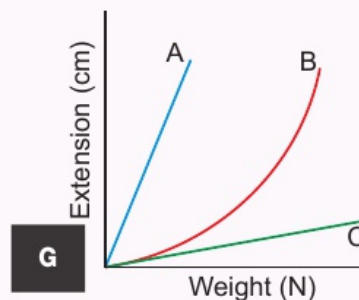
If enough force is applied to a spring, it will pass its **elastic limit**. The spring will then no longer return to its original length. Materials that do not return to their original shape when a force is removed are **plastic** materials.

4 A spring stretches 2 cm when a 10 N weight hangs on it. How far will it stretch with a weight of 20 N?

- 5** a| What is the difference between an elastic and a plastic material?
b| Name one plastic material.

Springs are used inside **force meters** (photo F). If the meter is measuring a small force, the spring inside only stretches a little way. If it is measuring a bigger force, the spring stretches further and the pointer moves further along the scale.

6 Graph G shows how far different materials stretch when a weight is hung on them.



- a| Which material stretches the most for a certain weight?
b| Which material(s) could be used for making a force meter? Explain your reasoning.
c| Explain which material would be best for making a force meter to measure small weights.

7 Look at the force meters in photo F. Explain why the springs inside them are different.

FACT

Hooke's Law is named after Robert Hooke (1635–1703) who studied how metals behave when they stretch. His work led to the invention of the force meter. However, the units for measuring forces were named after his rival and enemy, Isaac Newton!

I can ...

- describe how the extension of a spring depends on the force applied.

7Kb MAKING NOTES

HOW CAN YOU MAKE NOTES ON A VIDEO OR PRESENTATION?

Bungee jumping – slide A

'Bungee jumping is a much older sport than many people think. Young men in Vanuatu, in the Pacific Ocean, have been 'land diving' for centuries. This custom is based on legend and takes place from a tower made only of wood and vines – no nails. The men climb the tower and then tie vines to their ankles before jumping off. The right length of vine is crucial – too long and they will hit the ground, too short and they may just swing into the tower. The jumps are used as a rite of passage, undertaken by boys to show that they are ready to become men.'



Bungee jumping – slide B

'In 1979, men in the Dangerous Sports Club had seen a film about the land divers and wanted to have a go. They couldn't afford to go to Vanuatu, so they decided to use the Clifton Suspension Bridge instead; this would give them a 250ft drop. Climbing harnesses were used to attach the men to the rubber cords. They carefully worked out the length and the strength of the ropes they would need. They could not get permission to jump from the bridge but that didn't stop them! On 1 April 1979, they managed to get all their equipment onto the bridge and jumped safely, and were then arrested.'



Bungee jumping – slide C

'Today bungee jumping is a popular activity for thrill-seekers. The rubber bungee cord is attached to straps around the ankles so that the jumper plunges head first towards the surface – usually a river or pond. There is sometimes a body harness as a back-up. You can jump off bridges or from platforms on cranes.'



These slides are from a presentation on bungee jumping. When you are watching a video or a presentation, you have to make notes *while* you are watching and listening and you often cannot go back to check things. This means that you need to be able to make notes quickly.

LITERACY & COMMUNICATION

Ideas to help you to make effective notes.

- Think about what you want to make notes about before you start. You cannot write down everything so concentrate on the important points.
- You can divide up your page, ready to make notes. For example, you could make a table so your notes will be organised as you go along, or write headings and subheadings.
- If the presentation is describing a process, you could write your notes as a flow chart with arrows to show the order in which things happen.

- Abbreviations will save time. These can be standard ones (such as kg for kilogram) or you can make up your own.

Table D shows some commonly used abbreviations.

D	Symbol	Meaning
	=	equals, is the same as
	≠	is not equal to, is not the same as
	∴	therefore, thus, so
	∵	because
	+	and, more, plus
	>	more than, greater than
	<	less than, smaller than
	-	less, minus
	→	gives, causes, leads to
	↗	rises, increases
	↘	falls, decreases

If your notes are untidy, make a neat copy of your notes as soon after the presentation as you can, while you can still remember what you watched.

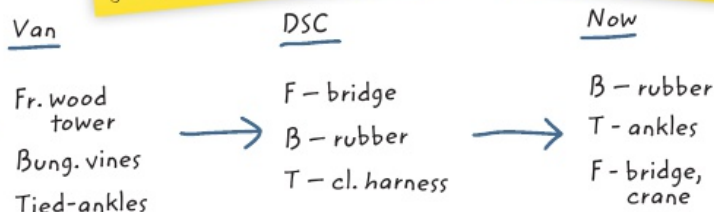
Mike started by making a rough table with headings for his notes.

when	who	where	why
centuries	Y.men	Pac.Oc	rite (men)
1979	students (men)	UK	fun
↓ now	all	all over	fun

E | Mike's notes. Mike was interested in the history of bungee jumping and why people do it.

Sunita has used her own abbreviations: Fr or F stands for From (what they jump from); Bung or B is the bungee cord; T is how the jumpers are tied on.

Sunita's notes are set out as a timeline.



F | Sunita's notes. Sunita was interested in how the way people jump has changed since bungee jumping started.

- 1 a | In figure E, what do you think Mike's abbreviations Y.men and Pac.Oc stand for?
b | In figure F, what do you think Sunita's abbreviations Van and DSC stand for?

- 2 Sunita could have made her notes in a table. Rewrite Sunita's notes in a table.

- 3 Look back at pages 170–171. Make notes on how springs are used to measure forces. Try to use some of the abbreviations in table D in your notes.

I can ...

- summarise information from a presentation or video
- use abbreviations to help me to make notes.

7Kc FRICTION

HOW CAN WE CONTROL FRICTION?

Friction is the force between two touching objects. It can slow things down or make things stay still. The friction between your clothes and a chair stops you from sliding off the chair. Walking would be very difficult without the friction between your feet and the floor – you would slip and slide everywhere.

B | This woman is abseiling. She is using friction to control how fast she goes down the cliff.



Friction helps the abseiler to control the rope.

We can increase friction by using certain materials. For example, rubber produces a lot of friction. The rubber tyres of a Formula One racing car stop the car from sliding off the road as it speeds round sharp bends.



A | Rock climbing shoes are made from special rubber that increases friction to give a good grip.



C | Downhill skiers wax the bottom of their skis to make them very smooth. This reduces friction and allows them to ski faster.

Friction is not always useful. Sometimes we want things to move easily. For example, a bicycle is very difficult to ride if there is too much friction in the axles. We can reduce friction by making surfaces smooth or by using **lubricants** such as oil or grease. Adding a lubricant is called **lubrication**.

- 1** Give one example of friction making something stay still.
- 2** Explain why rubber bath mats are useful.
- 3**
 - a | Why should you oil the axles of a bicycle?
 - b | Why must you never put oil on the brake blocks of a bicycle?
 - c | Explain why bicycle brakes do not work well in the rain.
- 4** The tread on bicycle and car tyres is designed to allow water to escape from under the tyre on wet roads. Explain why this is important.

Friction can wear things away. The brake pads on a bicycle eventually wear away and so do car tyres. Parts of your clothes get thinner as friction wears them away. Friction also produces heat and noise. If a car engine runs without any oil in it, the large amount of friction between the moving parts causes it to overheat and stop working. Rusty door hinges squeak and make a door difficult to open.

Friction due to **gases** and **liquids** can also cause things to slow down. Air resistance and water resistance can be reduced by having smooth surfaces and smooth shapes.

FACT

The tyres used on racing cars wear out during each race and have to be replaced. The average Formula One tyre only lasts for about 120 km and costs over £1000. The racing team choose different tyres depending on the conditions on the track.

E



5

- a| Why do car owners have to replace their car tyres regularly?
b| Suggest why racing car tyres do not last as long as the tyres on normal cars.

6

How could you stop a door hinge squeaking?

7

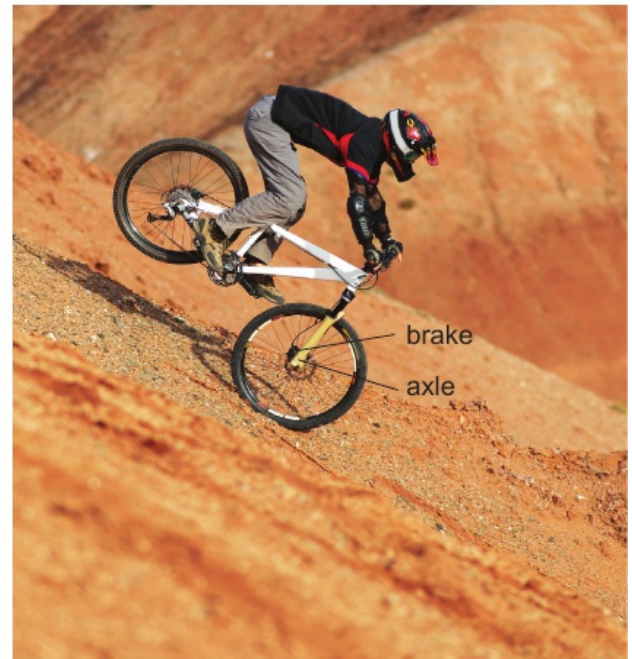
Write down three effects of friction between moving objects.

8

Describe as many ways as you can in which friction is useful to you in your everyday life.

9

In a science fiction story, a lubricating mist creeps up on a town. Think of three effects this would have on life in the town and write a paragraph of the story in 150 words.



D | Some parts of a bike are designed to increase friction and some parts are designed to reduce friction.



F | This drag racer has a smooth shape so it can move easily through the air while it is racing. The parachutes are released at the end of the race to increase air resistance to help to slow the car down.

I can ...

- recall the effects of friction
- explain some ways in which friction can be changed
- identify situations in which friction is helpful or not helpful.

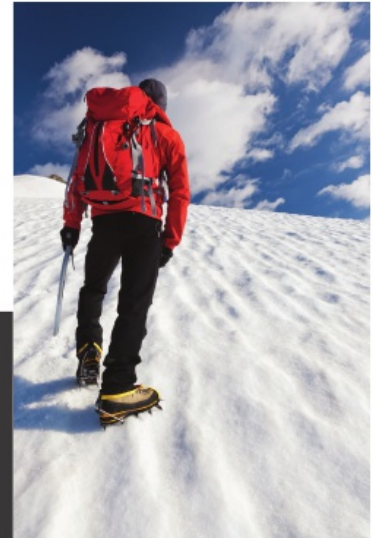
7Kd PRESSURE

HOW IS PRESSURE USED IN SPORTS?

Pressure is the amount of force pushing on a certain area. Pressure is important in many sports.



A | The walker is wearing snowshoes to spread his weight. The snowshoes reduce the pressure under his feet, to stop them sinking into the soft snow.



B | This mountaineer is walking on hard snow and slippery ice. The crampons on her boots have spikes to concentrate her weight. The points stick into the ice and stop her slipping. The crampons increase the pressure of her feet on the ice.

If there is a high pressure beneath a person's feet, or beneath a vehicle, it is more likely to sink into snow, mud or sand. The size of the pressure depends on the size of the force and the size of the area it is pushing on.

If you keep the size of the force the same:

- for a larger area, the pressure will be lower
- for a smaller area, the pressure will be higher.

If you keep the area the same:

- for a larger force, the pressure will be higher
- for a smaller force, the pressure will be lower.

Pressure affects everyday things as well. It is easier to cut something with a sharp knife than with a blunt one. The sharp knife has a smaller edge, so the force you put on the knife is more concentrated over a smaller area on the object you are cutting.

1

Look at the vehicle in photo C.

- Is the pressure under the wheels high or low?
- Explain why the tyres need to be so large.



C

2

The person in photo A puts on a larger pair of snowshoes. Explain how the pressure under his feet will change.

3

- Explain why a drawing pin is easier to push into the wall if the point is sharp.
- Explain why the drawing pin has a large head for you to push on.

We use this formula to calculate pressure:

$$\text{pressure} = \frac{\text{force}}{\text{area}}$$

Force is measured in newtons (N) and area is measured in square metres (m²), so the units for pressure are newtons per square metre (N/m²). This unit is also called a **pascal (Pa)**. 1 Pa = 1 N/m².

If the area being measured is small, you can measure it in square centimetres (cm²). The unit of pressure will then be N/cm².

The points on Alex's crampons have a total area of 0.2 cm². To calculate the pressure under the points:

$$\begin{aligned} \text{pressure} &= \frac{\text{force}}{\text{area}} \\ &= \frac{800 \text{ N}}{0.2 \text{ cm}^2} \\ &= 4000 \text{ N/cm}^2 \end{aligned}$$



FACT



In 1991, a preserved body was found in a glacier. The body was from about 5300 years ago and was named Otzi. His shoes may be the oldest examples of snowshoes. Photo F shows a reconstruction of his normal shoes and his snowshoes.



E | The wide tracks and the skis stop the snowmobile from sinking into the snow. The lugs that stick out of the tracks dig into snow or ice to give grip.

- 4** How could you find the pressure under your shoes when you are standing up? List the apparatus you will need and explain how you would use it.
- 5** Look at photo D. Calculate the pressure under Sam's snowshoes.
- 6** Look at photo E. Explain how the tracks and the lugs work. Use ideas about pressure in your answer.

I can ...

- calculate pressure and recall its units
- describe the effects of high and low pressure in simple situations.

7Kd SI UNITS

WHAT ARE THE STANDARD UNITS USED IN SCIENCE?

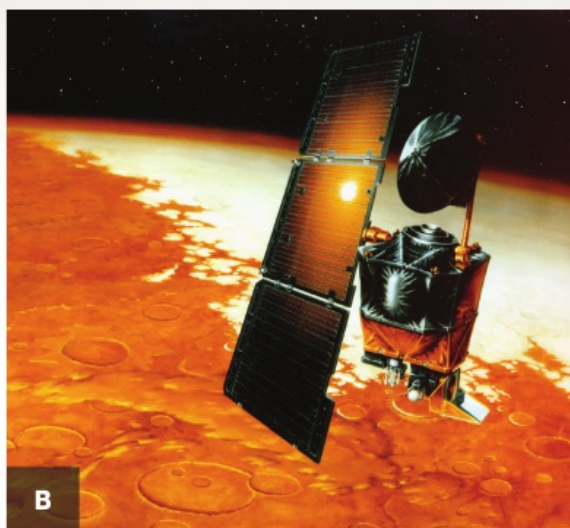
The road sign in photo A shows the speed limit on a road. If you are driving in the UK, this sign means that you should not travel faster than 50 miles per hour (mph). If you are driving in France and you see this sign, it means you must not go faster than 50 kilometres per hour (km/h) – which is about 31 mph.

Sometimes using different units can have very serious consequences. Figure B is an artist's impression of the Mars Climate Orbiter. This spacecraft crashed when it reached Mars. It went wrong and disintegrated in the atmosphere of Mars because two teams of engineers designing it used different sets of units.

Scientists from all over the world often work together, so it is important that they all use the same units. **SI units** are used by scientists all over the world.



A



B

Table C shows some of the standard units in the SI system.

Quantity	Unit name	Symbol
length	metre	m
area	metre squared	m ²
volume	metre cubed	m ³
mass	kilogram	kg
time	second	s
force	newton	N
pressure	pascal	Pa (1 Pa = 1 N/m ²)
energy	joule	J
speed	metres per second	m/s

C | Some of the units in the SI system.

Sometimes these units are not a convenient size. For example, the amount of energy the average teenager needs per day is around 10 000 000 **joules (J)**. It is easier to understand this number if it is written as 10 000 **kilojoules (kJ)**. 1 kJ = 1000 J. 'Kilo' is a **prefix** that tells us when a larger or smaller version of the unit is being used.

Prefix	Symbol	Meaning	Example
mega-	M	1 000 000	1 megajoule (MJ) = 1 000 000 J
kilo-	k	1000	1 kilogram (kg) = 1000 g
deci-	d	$\frac{1}{10}$ (one tenth)	1 cubic decimetre (dm ³) = $\frac{1}{1000}$ m ³ ($\frac{1}{10}$ m \times $\frac{1}{10}$ m \times $\frac{1}{10}$ m)
centi-	c	$\frac{1}{100}$ (one hundredth)	100 centimetres (cm) = 1 m
milli-	m	$\frac{1}{1000}$ (one thousandth)	1000 milligrams (mg) = 1 g
micro-	μ	$\frac{1}{1\,000\,000}$ (one millionth)	1 000 000 micrometres (μ m) = 1 m
nano-	n	$\frac{1}{1\,000\,000\,000}$	1 000 000 000 nanometres (nm) = 1 m

D | Prefixes used in the SI system.

WORKING SCIENTIFICALLY

Other units

There are some units that are still commonly used but do not fit the standard pattern.

E	Quantity	Standard unit	Other units still used
	time	seconds	minutes, hours, days, years
	length	metres	miles
	pressure	Pa	newtons per square centimetre (N/cm ²)
	speed	m/s	kilometres per hour (km/h), miles per hour (mph)
	volume	m ³	litres (1 litre = 1000 cm ³ = 1 dm ³), millilitres (1 ml = 1 cm ³)



F | Champion snail racers can move at speeds of up to 0.003 m/s or 3 mm/s. Millimetres per second is not a standard unit for measuring speed but it helps to give us a better idea of how fast snails can move.

- 1** Which unit would you use for the following measurements? Choose your answers from table C.
 - a| The distance across the playground.
 - b| The amount of ground that a football pitch covers.
 - c| How long it takes you to eat a chocolate.
- 2** Which unit would you use for the following measurements? Give the best prefix as well as the unit.
 - a| The thickness of a leaf.
 - b| The energy stored in your food.
 - c| The distance between London and Birmingham.
- 3**
 - a| Explain why it is important that all scientists use the same set of units.
 - b| People in different countries use different units of mass or length when buying food or other goods. Explain why this does not usually cause problems.

I can ...

- explain why scientists use SI units
- record numbers using suitable units.

7Ke BALANCED AND UNBALANCED

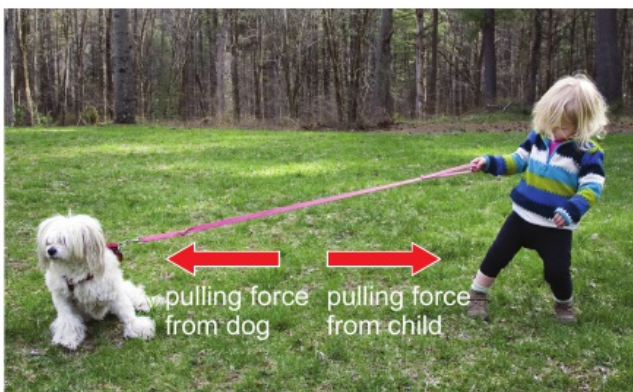
WHAT HAPPENS WHEN FORCES ARE BALANCED?

Forces can add together. It is difficult for one person to push a broken-down car. If another person helps, it is easier to push the car because their forces are added together.

Two forces acting on an object can also work against each other if they are in opposite directions. If the two forces are the same size, nothing will change. The forces are **balanced**.

If one of the forces is stronger than the other, something will start to move. The forces are **unbalanced**. If the unbalanced forces are acting on a moving object, the object will *change* its speed.

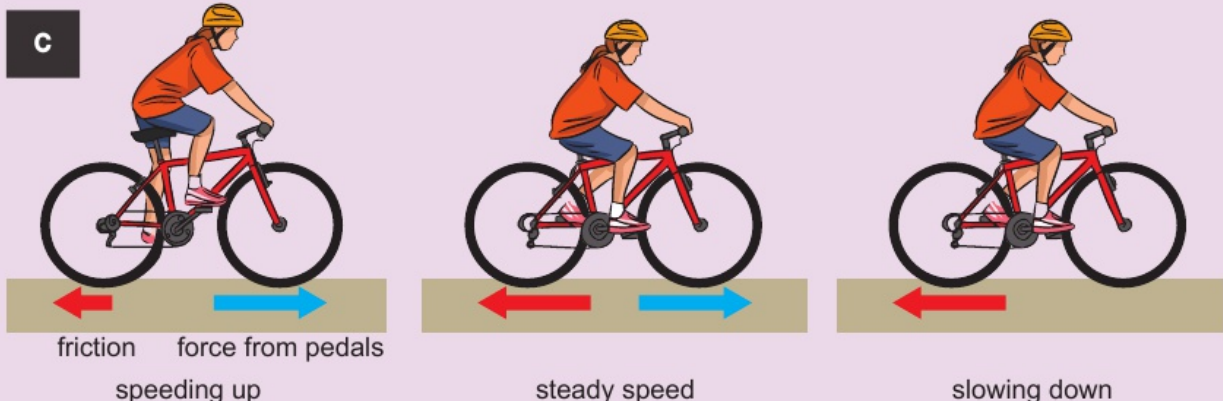
- 1 Look at photo A.
 - a| Why isn't the dog's lead moving?
 - b| What will happen if the dog pulls harder?



A | The dog's lead is not moving. This is because the pulling forces from the child and from the dog are equal and opposite; they are balanced.



B | The pulling forces of all the dogs add together. When the sled is moving at a steady speed, the pulling force from all the dogs is balanced by friction forces trying to slow the sled down.



- 1| The forwards force is bigger than the backwards force. The bike speeds up.
- 2| The forces are equal. Because the bike is already moving, it continues to move at the same speed.
- 3| The girl has stopped pedalling so there is no forwards force. The bike will slow down until it stops.

All **stationary** (still) objects have balanced forces acting on them. Moving objects can also have balanced forces acting on them. If the forces are balanced, the object carries on moving at the same speed. The speed only changes when the forces are unbalanced.

2

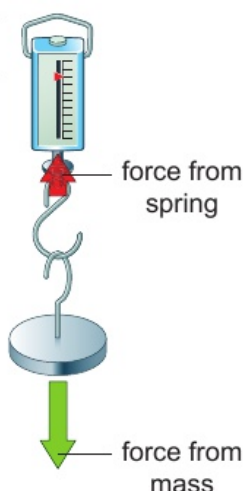
Look at cartoon C.

- How could the girl increase the size of the friction forces on the bike?
- How would increasing the size of this force affect her speed?

3

Look at photo B. What will happen when the dogs get tired and cannot pull as strongly?

D



When you first hang something on a force meter, the forces are not balanced, so the spring begins to stretch.



As the spring stretches, it produces a bigger force.



Eventually the forces are balanced. The force meter is showing the weight of the object.

You can use the idea of balanced forces to explain how a force meter works. When you stretch a spring it gets harder and harder to pull it because the spring 'pulls back'.

There is a similar explanation for why you don't fall through a chair when you sit down. Every object changes shape when a force acts on it but in most cases the movement is too small to see. When you sit on a chair, you squash it slightly and, just as with a spring, the chair pushes back.

E | The beam bends slightly when the gymnast stands on it. The beam pushes back and provides a force that balances the weight of the gymnast.

4

Look at figure D. Explain what will happen if a larger mass is put on the force meter.

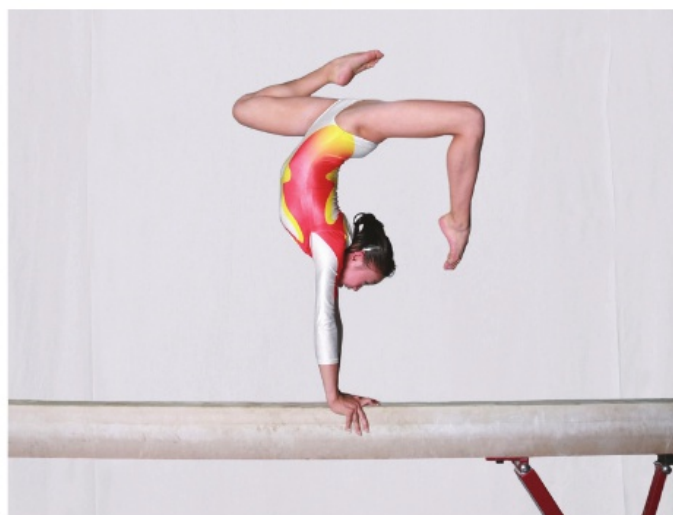
5

Look at photo E.

- Why isn't the gymnast moving?
- How will the forces be different if a lighter gymnast uses the beam?

6

To investigate the friction between different surfaces, you measure the force needed to pull an object at a steady speed. Explain why you need to use a steady speed to find out the size of the friction force.



I can ...

- identify balanced and unbalanced forces
- explain the effects of balanced and unbalanced forces.

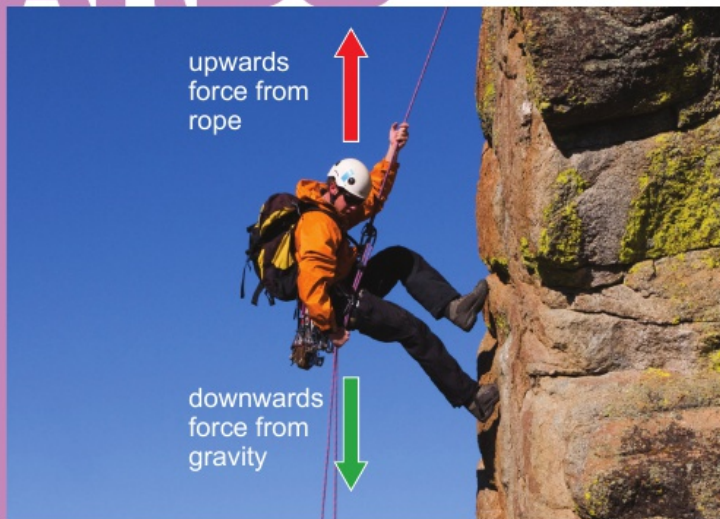
7Ke SAFETY STANDARDS

HOW DO WE KNOW THAT SPORTS EQUIPMENT IS SAFE TO USE?

In many sports, people rely on ropes or other equipment to keep them safe. All this equipment must meet certain standards. These standards make sure that the equipment is strong enough for its purpose and is safe to use.

In climbing, the ropes are tested for strength and for stretchiness. The more stretchy the rope, the smaller the impact force on the climber when the rope stops them falling.

There are no set standards for how much friction the outside of a rope must provide. Most manufacturers will test their equipment for friction as well as for stretch, to make sure that people buying the rope will be happy to use it and continue to buy from them.



A | The outside of the rope has to provide enough friction for the climber to be able to hold onto it, and for the knots to stay done up. But it must be smooth enough to slide through things when necessary.



B | This climber's rope is strong enough to stop her hitting the ground. The rope is also stretchy so that it reduces the impact force on the climber when it stops her fall.

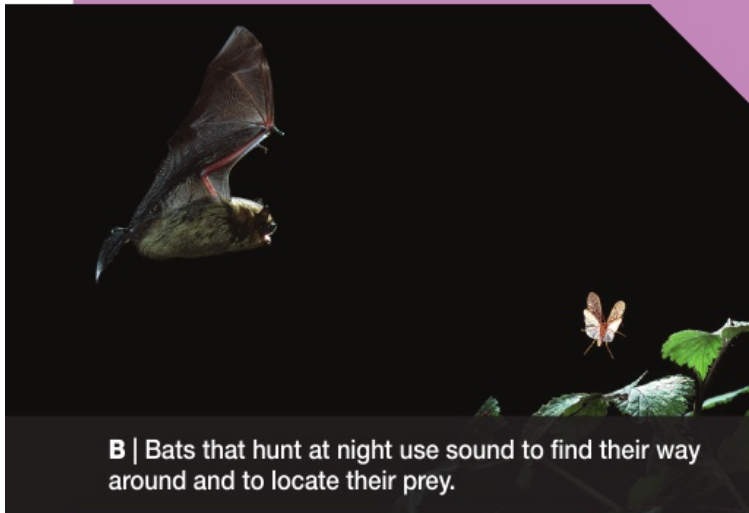
- 1 a | How will a very stretchy rope help a falling climber?
b | Suggest a disadvantage of having a very stretchy climbing rope.
- 2 a | Skiers wax their skis to reduce the friction beneath them. Explain in as much detail as you can why skiers want to reduce the friction.
b | Describe three examples of where high friction is useful in sports.
- 3 Why are there international safety standards for things like climbing ropes but not for ski wax?
- 4 a | Skis are available in different sizes. Explain why a person might want to buy a bigger pair of skis. Use ideas about pressure in your answer.
b | Describe a situation where high pressure is useful in sports.
- 5 a | Describe the forces acting on the climber in photo A.
b | Look at photo B. Describe what happens to the climber as the rope takes her weight as she falls, and how the forces on her change.

HAVE YOUR SAY

Manufacturers have to spend money to test their products against safety standards, and this makes the items more expensive. Do you think there should be standards for adventure sport equipment?

7La ANIMAL SOUNDS

Sounds are all around us. We use sound to communicate, to warn others of danger and for enjoyment. Animals also use sounds to communicate, to warn others of danger, to try to stop others entering their territory, to win a mate and to hunt. Some animals even use sound to help them to find their way around or to find **prey** when they cannot see. Other animal sounds do not seem to have a purpose.



B | Bats that hunt at night use sound to find their way around and to locate their prey.



C | Hummingbirds 'hum' because their wings flap very fast while they are hovering.



A | This stag is roaring to attract the attention of female deer and to warn other males to keep away.

Sounds are made by something **vibrating** (moving backwards and forwards).

- 1** Write down two ways that humans use sounds:
a| for communication
b| for warning.
- 2** How is the sound made by the hummingbird different from the sounds made by the bat and the stag? Give as many differences as you can.
- 3** Write down two different ways that you can make sounds with your body.
- 4** A guitar can be used to make different notes.
a| How do you make a guitar produce sounds?
b| How can you make high and low notes on a guitar?
c| How can you make loud or quiet notes on a guitar?
- 5** Would you expect an elephant or a mouse to be able to make the lowest notes? Explain your answer.

7La MAKING SOUNDS

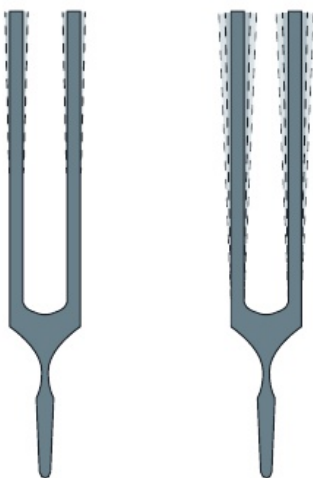
HOW ARE DIFFERENT SOUNDS MADE?

Some sounds are loud and some are soft. This is the **intensity** of the sound. Sounds with a high intensity are often said to have a high **volume**.

Sounds can also be high or low. This is the **pitch** of the sound. The pitch and volume of the sound depend on the way an object vibrates to make the sound.

Generally, smaller objects vibrate faster and make notes with higher pitches. The number of vibrations each second is called the **frequency**. The units for frequency are **hertz (Hz)**. A bell that vibrates 400 times per second has a frequency of 400 Hz.

The volume of a note depends on the size of the vibrations. The size of a vibration is its **amplitude**. The bigger the amplitude, the louder the note.



B | The tuning fork on the right was tapped harder than the one on the left. It is making a louder sound.



A | This robin sings using a series of high-pitched notes.



C | These tubular bells vibrate when they are hit. The short bells vibrate faster than the longer ones, so they make higher notes.

- 1** List four animals that make loud sounds.
- 2** What are vibrations?
- 3** A tuning fork vibrates 500 times per second.
 - a| What is its frequency?
 - b| How will it sound different from a tuning fork that vibrates 300 times per second?

FACT

Whales make many different noises, and some whale calls are louder than jet engines and can be heard over 800 km away. The photo shows a hydrophone suspended beneath a boat. It is being used to record the song of a humpback whale



D

You make sounds using your voice. You have two flaps (called **vocal folds**) across your **windpipe** and these can vibrate when air moves across them. Most animals make noises in a similar way to this but there are also other ways in which animals can make sounds.

Male grasshoppers chirp by rubbing one leg against a wing. Their hind legs have teeth on them and when these are scraped against a wing it makes a sound (a bit like scraping a stick quickly along a fence).

Animals can also make sounds by hitting things. Male gorillas thump their chests or thump the ground to threaten other males.



E



F

- 4 A giant hummingbird flaps its wings about 12 times per second and bee hummingbirds can flap at over 80 times per second. Explain how the noise made by the wings of each species will sound different.
- 5 Two male gorillas are beating their chests.
 - a| One makes a lower sound than the other. Suggest what this could tell you about the two gorillas. Explain your answer.
 - b| Explain how one of them can make a louder sound than the other.
- 6 Henna says: 'Large animals always make lower sounds than small animals.' Explain how you could find out if she is right.

I can ...

- explain what causes sounds and how to make louder sounds
- explain the link between frequency and pitch.

7Lb MOVING SOUNDS

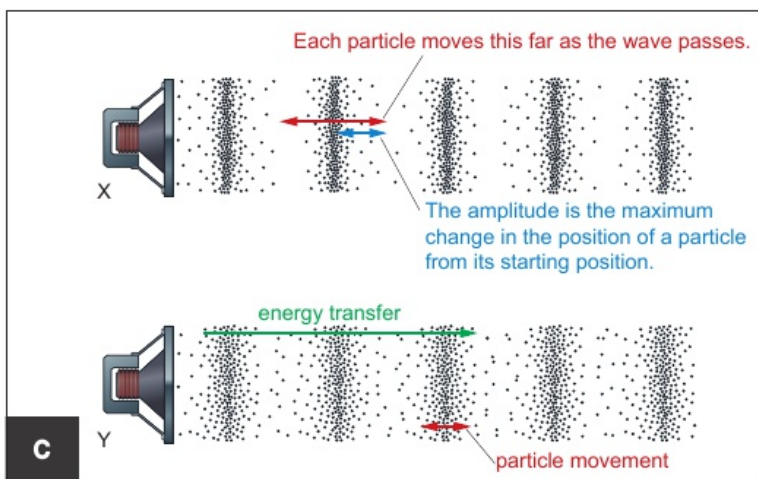
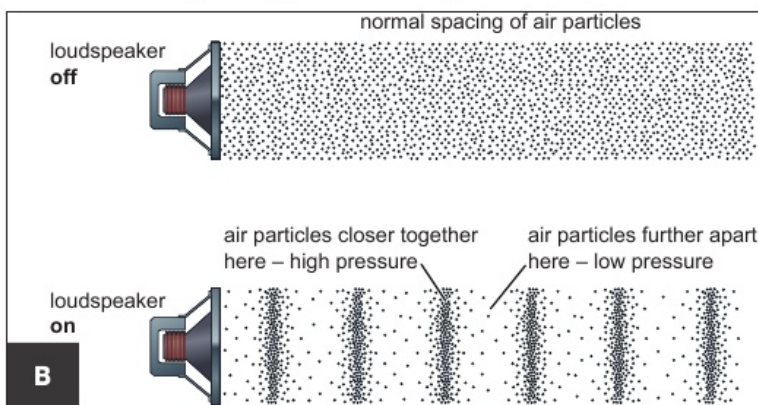
HOW DOES SOUND TRAVEL?

The astronauts in photo A have to talk to each other using a radio system because sound cannot travel through the empty space between them. Sound can only travel through a **medium** (a **solid**, **liquid** or **gas**). It cannot travel through a **vacuum** (a completely empty space).

All substances are made from **particles**. A vibrating loudspeaker makes the air particles close to it move backwards and forwards. These moving particles make neighbouring particles move, and so the vibrations spread out through the air. The moving vibrations form a **sound wave**. The air particles are squashed together in some places – these places have higher **pressure**. The particles are spread out in other places – these places have lower pressure. These waves are called **pressure waves** because there is a repeating pattern of high and low pressure areas.



A | These astronauts are working on the International Space Station.



- 1** How are the particles arranged in solids, liquids and gases? (You may need to look back at page 110.)
- 2** The astronauts in photo A can talk to each other without a radio system if they touch their helmets together. Explain why this works.

The frequency of a sound wave is the number of waves passing per second.

The amplitude of the wave is the distance moved by the air particles as the sound wave passes. The greater the amplitude, the louder the sound.

Pressure waves, such as sound waves, **transfer energy** from one place to another. They do not transfer particles. The louder the sound, the more energy it is transferring.

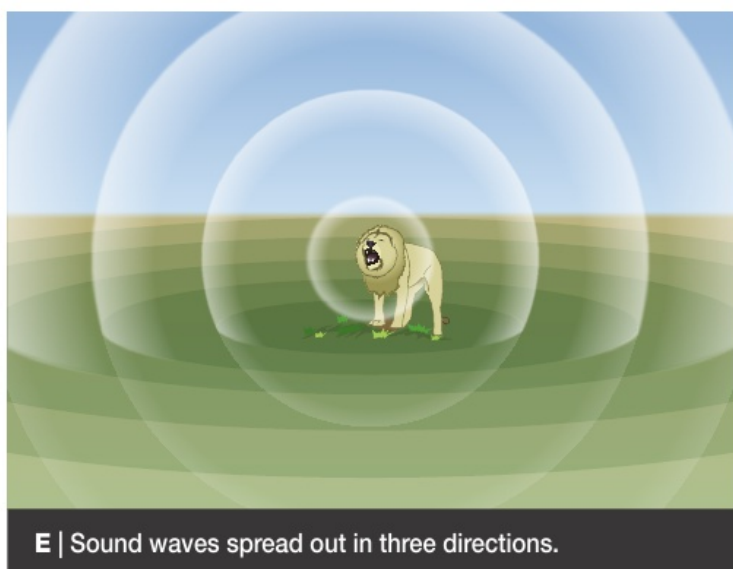
- 3** Look at the sound waves in diagram C. Which shows the loudest sound? Explain your answer.

Speed of sound

Sound travels at different speeds in different materials. The vibrations are passed on more easily when the particles in a material are closer together, so sounds travel faster in solids than in liquids. Sound also travels faster in liquids than in gases.

D	Material	Speed of sound (m/s)
	air (20 °C)	343
	water (10 °C)	1450
	wood	3600
	glass	3950
	steel	6100

- 4 Why does sound travel faster in steel than it does in air? Use ideas about particles in your answer.
- 5 Look at table D. Paul says: 'The table shows that sound travels faster in metals than in other solids.'
- a| Explain why this is not a good conclusion to draw from the data in the table.
- b| How could you find out if sound does travel faster in metals than in other solids?



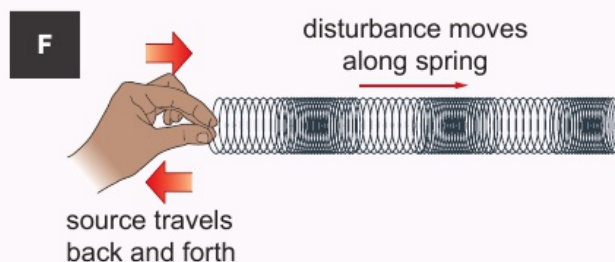
E | Sound waves spread out in three directions.

Sound waves spread out from a **source**. As you get further from the source, the energy carried by the sound wave has spread out further. There is less energy for your ear to detect when you are further from the source.

FACT

You can work out how far away a thunderstorm is by counting the number of seconds between the lightning flash and hearing the thunder. Divide the number of seconds by three and that is the distance in kilometres. This works because light travels at 300 000 km/s and so reaches you very quickly but sound travels at about a third of a kilometre every second and so takes three seconds to travel each kilometre.

- 6 You can make your voice carry further by cupping your hands around your mouth or by shouting through a paper cone. Explain why this works.
- 7 The slinky in diagram F is a model representing a sound wave.
- a| How does the model represent sound waves?
- b| In what ways is this not a good model for sound waves?



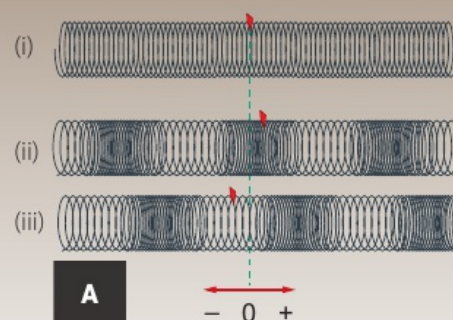
I can ...

- describe how sound moves through materials
- explain why sounds get fainter further from their source.

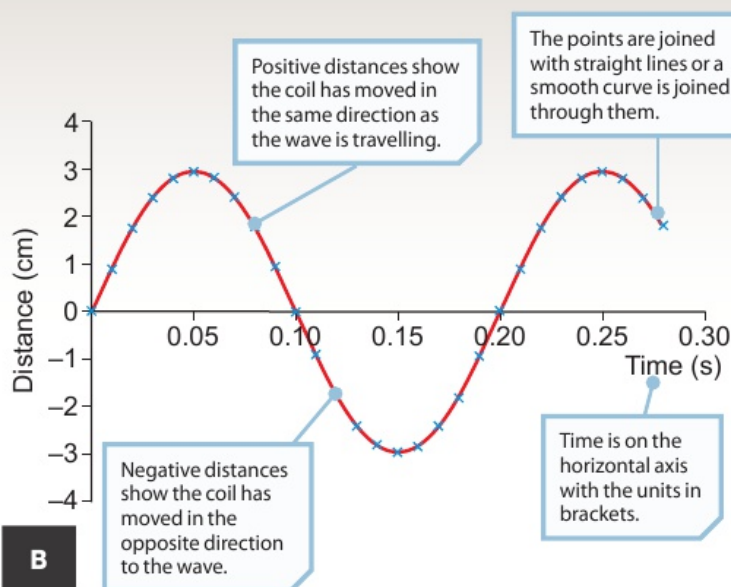
HOW CAN GRAPHS HELP US TO DRAW CONCLUSIONS?

A sound wave is vibrations being passed on by solids, liquids or gases. As the sound wave passes, particles in the medium move backwards and forwards. The particles that make up materials are very small, so it helps to use a model to help us to think about what is happening.

The slinky spring is a model for a sound wave. We can use a **line graph** to show how the marked point on the spring moves as the wave passes. Line graphs are used to show how one **variable** changes as another variable changes (usually time).



- 1** Look at graph B.
 - a| What does zero distance represent?
 - b| What is the amplitude of the wave in the spring?
- 2** The same spring is used to model a quieter sound. Describe how the graph would be different.



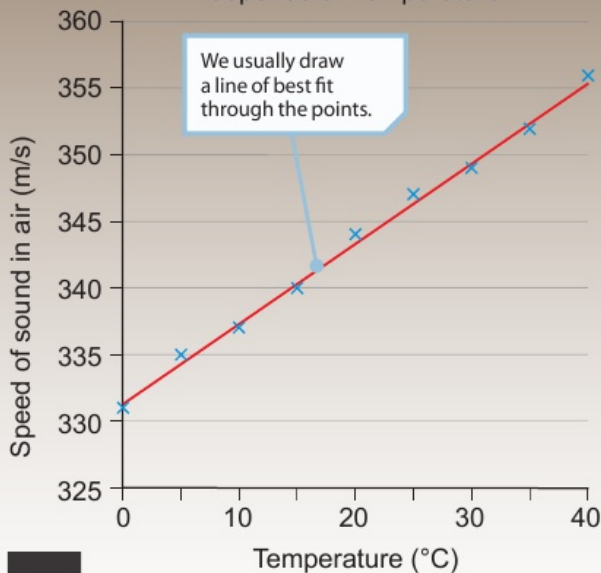
An **oscilloscope** can be connected to a **microphone** to show sound waves. The oscilloscope **trace** is like a line graph.

Graphs can also be used to look for a **relationship** (link) between two **quantitative** variables. Graph D is a **scatter graph** that shows how the speed of sound in air changes when the temperature changes. The **line of best fit** is the best straight line that can be drawn through the points. Lines (or curves) of best fit should only be drawn when the graph shows a clear pattern.

C | The trace on this oscilloscope represents the sound waves that the trumpet is making.

WORKING SCIENTIFICALLY

How speed of sound depends on temperature



D

We often describe in words what the line on a graph tells us. In graph D, as you follow the horizontal axis from left to right, the temperature increases. As the temperature increases, the line on the graph goes up and this tells us that the speed of sound in air is also increasing. The description of a straight line on a graph is often written in the form: As [variable on horizontal axis] increases, [variable on vertical axis] [increases/decreases].

Graph D shows a relationship between the two variables. Relationships like this are known as a positive **correlation**. When a line of best fit on a scatter graph gets lower as you move along the horizontal axis, this is called a negative correlation.

3

Describe what graph D tells us about the speed of sound in air.

4

Draw labelled sketches to show positive and negative correlations.

5

Solid materials have different properties. The **density** is the mass of a certain volume of material. For example, iron has a higher density than wood because a piece of iron has more mass than the same sized piece of wood. Some materials are also stiffer than others.

Table E shows the density and stiffness of some different metals. For stiffness, the higher the number, the stiffer the material. Carrie says that sound travels faster in denser materials. Dave says that sound travels fast if the material is stiffer. You can find out whose hypothesis is correct by plotting scatter graphs.

Plot a scatter graph with stiffness on the horizontal axis and speed on the vertical axis. Then plot another graph with density on the horizontal axis and speed on the vertical axis.

- What conclusion can you draw from your two graphs?
- Whose hypothesis was correct? Explain your answer.
- How did drawing the scatter graphs help you to decide whose hypothesis was correct?

E | The properties of some metals. (You don't need to remember the units for stiffness!)

Metal	Stiffness (GPa)	Density (g/cm ³)	Speed of sound (m/s)
aluminium	76	2.7	5100
copper	140	8.9	3570
iron	170	7.9	4910
magnesium	45	1.7	4602
mercury	25	13.5	1407
nickel	180	8.9	4970
silver	100	10.5	2600
titanium	110	4.5	4140
zinc	70	7.1	3700

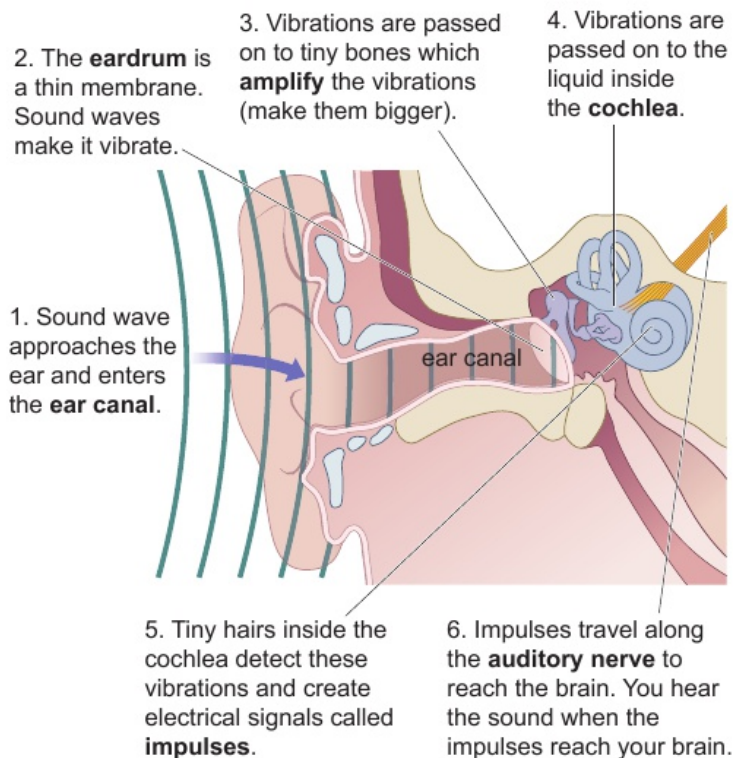
I can ...

- present information as scatter graphs
- describe what line graphs and scatter graphs show
- identify relationships using scatter graphs.

7Lc DETECTING SOUNDS

HOW CAN WE DETECT SOUNDS?

Most animals use ears to detect sound waves. The part of your ears that you can see helps to channel the sound waves into the ear. 'Hearing' happens inside your head.



B | the human ear

Loud sounds can damage our ears, including sounds from MP3 players or noisy clubs. People who work in noisy surroundings often need to wear **ear protection**. Loud noises can also be annoying. We can use certain materials to **absorb** some of the energy transferred by sound waves. In our homes, soft materials like carpets and curtains help to absorb sounds.



A | Owls are nocturnal. They can hunt at night because they have very sensitive hearing. They can hear much quieter sounds than humans can.

FACT

The tufts on the head of a long-eared owl are not ears at all. Some scientists think they may help to camouflage the owl so it can hide from predators. The ear openings in owls are much further down.

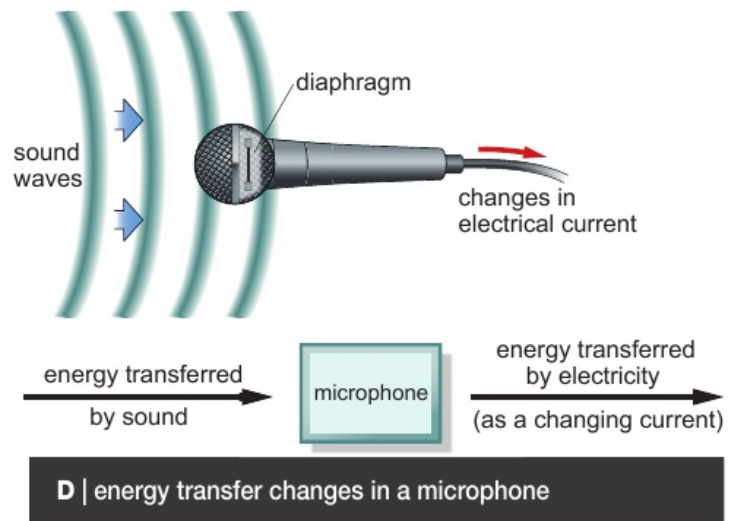


- 1 Write down these parts of the ear in order, starting with the one that vibrates first when a sound wave arrives: bones, cochlea, eardrum.
- 2
 - a | What are impulses?
 - b | Which part of the ear sends impulses to the brain?

Microphones

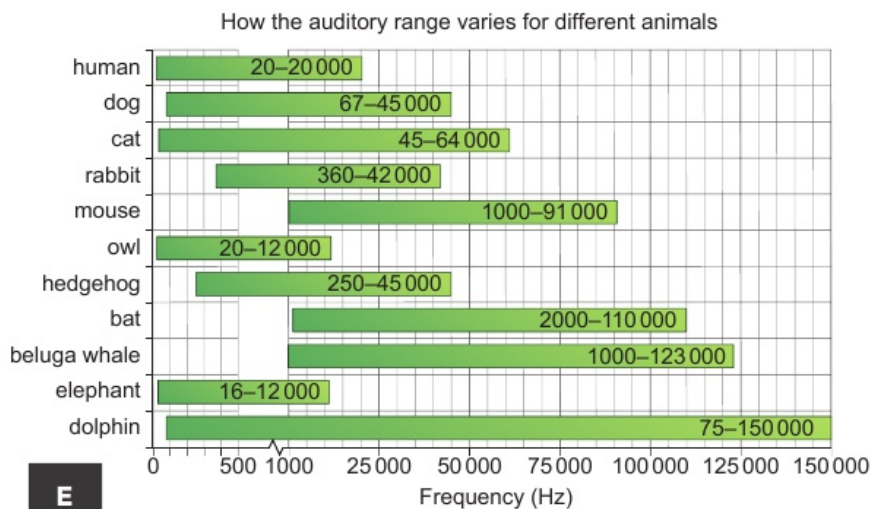
Microphones work in a similar way to ears. Sound waves make a **diaphragm** (a thin sheet of material) vibrate. Electrical circuits in the microphone detect the vibrations and convert them into changes in electrical current. Ears and microphones both change the way in which energy is being transferred.

Sound intensity meters use a microphone to measure the loudness of a sound in **decibels (dB)**. The quietest sound that humans can hear is 0 dB, normal conversation is about 60 dB and sounds are painful at above about 130 dB.



Hearing ranges

Most humans can hear sounds with frequencies from 20 Hz to 20 000 Hz. This is known as the **auditory range**. Sounds with lower frequencies than we can hear are called **infrasound** and sounds at higher frequencies than we can hear are called **ultrasound**. Other animals have different auditory ranges.



- 3** Draw a flow chart similar to the one in diagram D to show how the way in which energy is transferred changes in the ear.
- 4** Employers must provide hearing protection if the noise level is above 85 dB. Why is this necessary?
- 5** How could you find out which materials are the best sound insulators? Write a plan for an investigation.

- 6** Look at diagram E. Which animal(s) can:
 - a| hear infrasounds
 - b| hear ultrasounds?
- 7** Describe two differences between the hearing of owls and humans.
- 8**
 - a| Dogs have similar structures in their ears to humans. Describe how a dog hears.
 - b| Dogs can hear the sound made by dog whistles but humans cannot. Suggest a frequency that a dog whistle might produce.

I can ...

- describe the parts of the ear and their functions
- describe how microphones convert sound into electrical signals
- recall that different animals have different hearing ranges.

7Ld USING SOUND

HOW DO HUMANS AND ANIMALS USE SOUND?

We make use of sound in many different ways, including for **communication**. Sometimes the sound waves are converted to electrical signals and then back to sound waves, such as when we use a telephone. Animals also use sound to transfer information, such as warning calls.

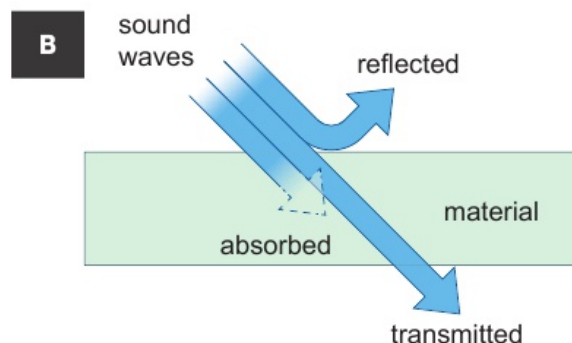
- 1 Write down three ways in which you have used sound to communicate today.
- 2 Write down three different types of communication made by animal sounds.

Transferring energy

Sound waves transfer energy from one place to another. The energy transferred by sound waves is **transmitted** through some materials, or it can be absorbed or **reflected**.

The energy transferred by high frequency sound waves can be used to treat injuries. It can also be used to clean delicate objects such as jewellery or surgical instruments. The object being cleaned is put into a liquid. Ultrasound waves sent through the liquid make lots of tiny bubbles in the liquid, which help to loosen the dirt when they burst.

- 3 Energy transferred by ultrasound is used to clean a watch. What does the energy do?



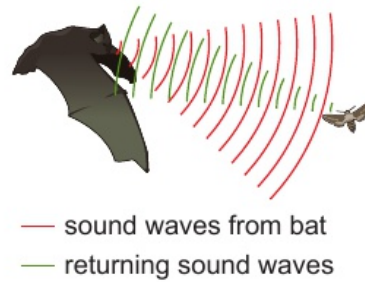
C | Ultrasound being used by a physiotherapist to relieve pain in a sprained wrist. One of the ways it works is to soften scar tissue.



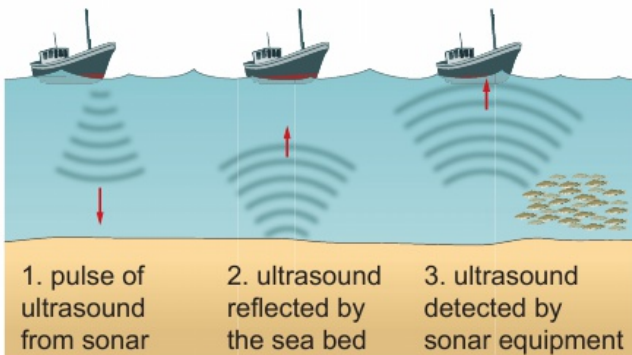
Using echoes

A reflected sound is called an **echo**. Animals such as dolphins and bats use **echolocation** to find their way around and to find their prey. These animals produce bursts of ultrasound and listen for the sound waves reflected by objects or prey. They can detect how far away the object is from the time it takes for the echo to return and they can also sense the direction of the object.

Bats use echolocation to help them to find food at night, when there is not enough light to see. Dolphins and some other sea creatures use echolocation because sound travels through water much better than light. Humans also use a form of echolocation called **sonar** to find fish in the sea and to investigate the depth of the sea.



D | Some species of bat use echolocation to detect prey such as insects.



E | Humans use sonar to find fish in the sea and to investigate the depth of the sea. Warships can use it for finding enemy submarines.

- 4** Each bat can produce different frequencies of ultrasound. Explain why this is useful if there are many bats hunting together.
- 5** The ship in diagram E detects two echoes from a sonar pulse, one 0.05 seconds after the other. Explain what has caused these two echoes and what information the sonar equipment can work out from them.
- 6** Tiger moths do not use echolocation but they can detect and produce ultrasounds.
 - a) Suggest how this helps them to survive.
 - b) How could you check whether or not tiger moths do detect and produce ultrasounds?

FACT

Some blind humans have learned to use echolocation to help them to find their way about and avoid bumping into things. They make clicks with their mouths and listen for the echoes.



F | Lucas Murray is blind and uses clicks to help him to play basketball as well as to find his way around.

I can ...

- describe some uses of ultrasound
- explain how sonar and echolocation work.

7Ld REMEMBERING

HOW CAN WE REMEMBER WHAT WE HAVE LEARNT?

The World Memory Championships take place every year. Competitors have to do things such as memorising strings of numbers or lists of random words. Some people can remember numbers with over 1000 digits in them, or lists of 300 words.

The people who enter these competitions have different ways of remembering things. Some of these techniques are also useful for remembering facts for tests and exams.

Mnemonics (*nem-on-icks*) are words or phrases that can help you to remember lists of things, especially things that have to be in a particular order. For example, you can remember the life processes:

MRS GREN

*Movement Reproduction Sensitivity Growth
Respiration Excretion Nutrition*

You can also write out phrases with some parts underlined or in colour, or draw flow charts to show the order in which things happen.



A | These people are taking part in the World Memory Championships! Ben Pridmore can learn the sequence of a shuffled pack of playing cards in just 30 seconds.

High pitched notes have high frequencies.

Loud notes have large amplitudes.



Diagrams and concept maps

Many of the facts in science are linked together and you usually find it easier to remember the facts if you understand the links. Concept maps can help you to do this.



C | the beginning of a concept map for sound

If you are making a concept map to help you to revise, you can decorate it with pictures that will help you to remember it or use colour coding for different parts.

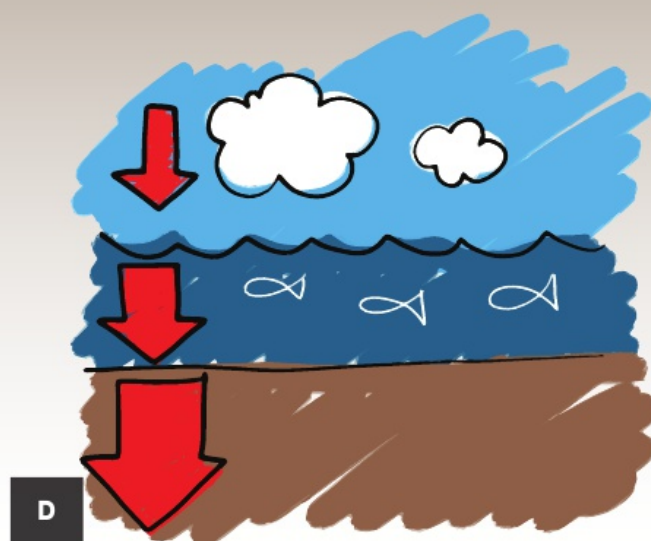
Making notes and summarising

Sitting and reading through a textbook is not a very good way of trying to remember things. It is better to make your own notes and summaries of the work. To do this you need to think about what are the most important parts; this helps you to remember. There is more about making notes and summarising on pages 32–33, 144–145, 172–173.

Linking things together

Some people remember lists of things by linking them with places they know well, such as rooms in a house. They may invent a story that they can repeat to themselves in order to remember the list in order.

You can also link new **facts** with things that you already know. For example, you probably already know that if you drop something it gets faster and faster until it hits the ground. Thinking about something falling through the air, then falling faster through the sea, and then going even faster into the ground can help you to remember how the speed of sound changes in different materials.



- 1 Look at diagram B.
 - a| Why do you think the second 'vibrations' has been written in larger letters than the first one? (You may need to look back at page 190.)
 - b| Why is this a good way of summarising what the ear bones do?
- 2
 - a| Look at diagram B and make up a mnemonic to help you to remember the order in which vibrations pass through the parts of the ear.
 - b| Is the mnemonic or the flow chart the better way of helping you to remember? Explain your answer.
- 3 Copy the concept map in diagram C and add other branches to it. You can choose how you label the branches but if you are stuck for ideas you could add 'pitch', 'loudness', 'hearing' and 'uses' as the beginnings of your branches.
- 4 Draw a flow chart to show how a dolphin uses ultrasound to detect a shark. (You may need to look back at page 193.)
- 5 Write or draw a memory aid to help you to remember how to use different types of graphs and charts. You can include information from pages 58–59, 97, 120–121, 188–189.

I can ...

- use different methods to help me to remember facts.

7Le COMPARING WAVES

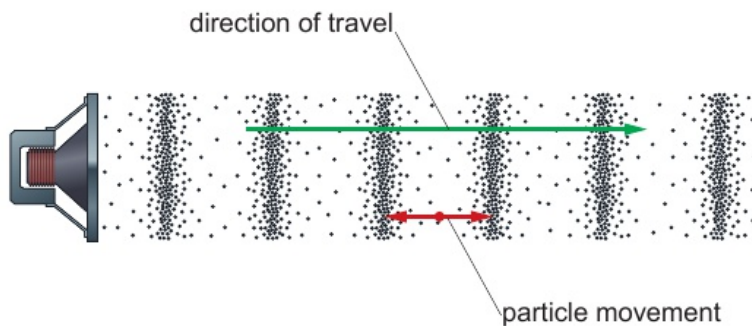
HOW ARE SOUND WAVES LIKE WAVES IN WATER?

The ripples in the pond in photo A are small waves on the surface of the water. They are spreading out across the surface of the water from the duck at the centre. They are transferring energy from this diving duck.

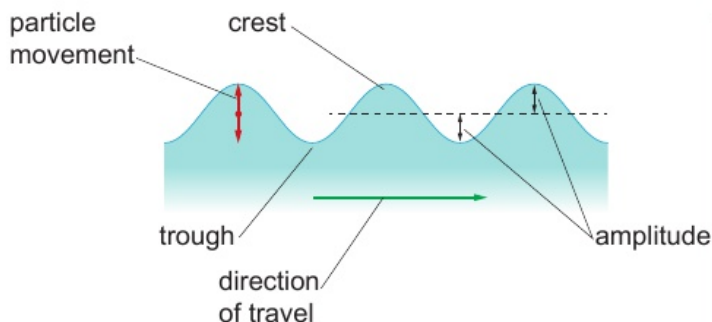
Water particles move up and down as the waves pass but the water as a whole does not move. The other ducks on the pond will not be moved outwards by the waves.

A sound wave is a **longitudinal wave** because the particles vibrate in the same direction as the wave is travelling.

Waves on the surface of water are **transverse waves**. The particles in water are moving at right angles to the direction the wave is travelling. The amplitude of a transverse wave is the maximum distance the particles move up or down from their original position.



B | Sound is a longitudinal wave.



C | Waves on water are transverse waves.

FACT

Waves on the sea are made by the wind blowing over the oceans or by earthquakes in the sea bed. The largest wave ever recorded was over 500 metres high and occurred in Alaska in 1958.

- 1** What is the difference between a transverse wave and a longitudinal wave?
- 2** Which way will ducks on a pond move as waves pass them?
- 3** You drop a stone into a pond.
 - a| What happens to some of the energy that was stored in the falling stone?
 - b| How could you make waves on the pond with a larger amplitude?

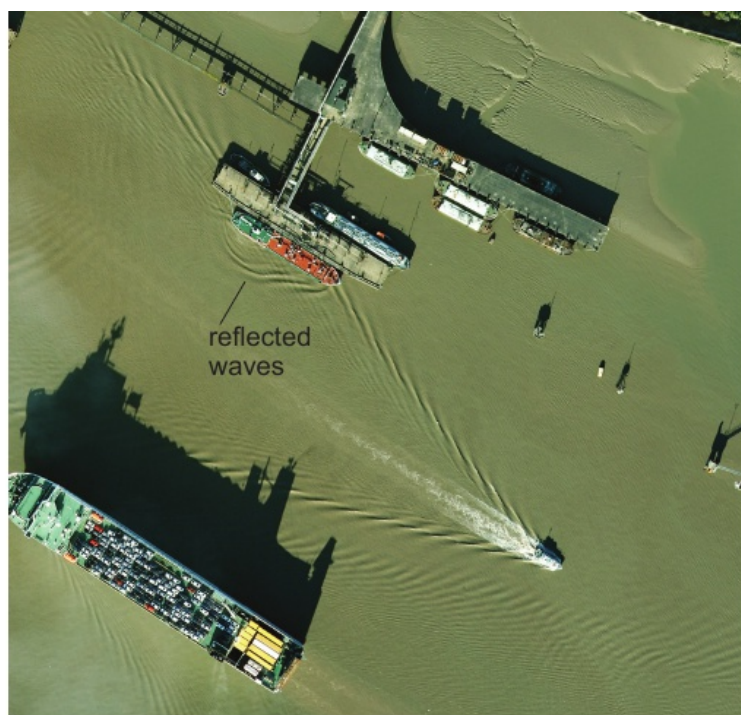
The amplitude of waves on water gets smaller as the waves get further from their source because the energy transferred by the waves gets more spread out.

Waves on water can be reflected. This happens if the waves reach a solid barrier, such as the edge of a canal or a harbour wall.

Waves going in different directions can pass through each other. As the waves pass their effects can add together or cancel out. This is called **superposition**, because one wave is 'on top of' another.

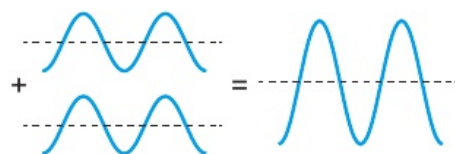


E | The waves affect each other when they cross.

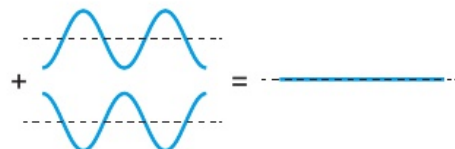


D | The waves made by the small boat are being reflected by the ship in the dock.

When two crests or two troughs meet they add together to make a bigger wave.



When a crest meets a trough they cancel each other out.



F | Superposition of waves can make them add together or cancel out.

- 4** Look at photo A. Which duck will bob up and down the least as the waves pass it? Explain your answer.
- 5** You can think of waves on the surface of water as a model for sound waves. Are water waves or waves in a slinky spring (as shown in figure F on page 187) the best model to help you to think about sound waves? Explain your answer.
- 6** People in small boats need to be careful if they are sailing near cliffs, because the waves can be bigger than in the open sea, and may be coming from more than one direction. Explain why this is.
- 7** Look at photo E above, and diagram E on page 187. Do sound waves or water waves get smaller fastest as they spread out from their source? Explain your answer.

I can ...

- compare longitudinal and transverse waves
- recall that all waves can be reflected
- explain what superposition means.

7Le ANIMALS AND NOISE

HOW DO HUMAN NOISES AFFECT ANIMALS?

Sounds are all around us and we get used to most of them. If sounds are too loud, we can install soundproofing in our houses or cars, or make laws to limit the amount of noise factories or airports are allowed to make.

Animals cannot control the noise around them. We can help our pets by keeping them indoors on bonfire night or other noisy occasions, but it is a bit more difficult to protect wild or zoo animals.



A | Sometimes whales or dolphins become stranded on beaches or rocky shores. This may happen because of human-made noises underwater, such as explosions or sonar 'pings'.

- 1** Explain how noise made by humans can affect the number of baby birds born in a year.
- 2** Some species of bat find it difficult to hunt in noisy areas.
 - a| How can noise affect bats' hunting?
 - b| How will this affect the bats' survival?
- 3** Naval ships use sonar to look for enemy submarines.
 - a| Explain how the sonar sounds produced by the naval ships reach dolphins and divers swimming underwater.
 - b| Why can the dolphins but not the divers hear the sounds?
 - c| Explain how sonar noises might affect dolphins or whales.

In some places, songbirds sing much earlier in the morning, to try to attract mates before traffic noise gets too loud. Some birds sing at different frequencies, or more loudly, in areas where there is a lot of noise. But not all animals that use sounds can adapt in this way.



B | Tourists in Africa go on helicopter safaris. The noise of the low-flying helicopter can frighten the animals.

HAVE YOUR SAY

Some people think that a noisy environment does not matter, as sounds do not usually harm animals directly.

GLOSSARY

Pronunciation note: A capital 'O' is said as in 'so'

absorb	To 'soak up' or 'take in'.
abstract	A summary at the start of a scientific paper.
abstract model	A model that only exists in your thoughts or as a computer program.
acid (<i>ass-id</i>)	A substance that turns litmus red. It has a pH of less than 7.
acid rain	Rainwater that is more acidic than usual due to air pollution.
acne (<i>ack-nee</i>)	Spots on the skin.
across (physics)	When one component is connected in parallel to another.
adaptation (<i>add-app-tay-shun</i>)	The features that something has to enable it do a certain job or survive in a particular place.
adapted	If something has adaptations for a certain job or for survival in a particular place, it is said to be adapted for that job or place.
addictive	If something makes you feel that you need to have more of it, it is said to be addictive.
adolescence (<i>add-ol-less-sense</i>)	A time when physical and emotional changes occur in teenagers.
afterbirth	When the placenta is pushed out through the vagina after the baby has been born.
aim	What you are trying to find out or do.
air pressure	The force on a certain area caused by air molecules hitting it.
air resistance	A force on objects moving through air.
alkali (<i>alk-al-lie</i>)	A substance that turns litmus blue. It has a pH of more than 7.
ammeter	A piece of equipment that measures how much electricity is flowing around a circuit.
amnion (<i>am-nee-on</i>)	A bag containing amniotic fluid.
amniotic fluid (<i>am-nee-ot-ick floo-id</i>)	The liquid surrounding the growing embryo and protecting it.
ampere (A) (<i>am-peir</i>)	The unit for measuring current.
amplify	To make bigger.
amplitude	The size of vibrations or the distance a particle vibrates when a wave passes.
analogy (<i>an-al-O-jee</i>)	A model that compares something complicated to something that is easier to understand.
antacid (<i>ant-ass-id</i>)	An indigestion remedy that contains a base to neutralise the excess acid in the stomach.
antagonistic pair (<i>an-tag-on-is-tic</i>)	Two muscles that work a hinged joint by pulling a bone in opposite directions.
antibody	A substance produced by white blood cells that helps to fight microorganisms that might cause diseases.
apparatus	Pieces of equipment.
artery	A blood vessel that carries blood away from the heart.
atom	Atoms are small particles from which all substances are made.
atomic energy	A name used to describe energy when it is stored inside materials. Another name for nuclear energy.
auditory nerve (<i>ord-it-orry</i>)	The nerve that carries impulses from an ear to the brain.
auditory range (<i>ord-it-orry</i>)	The range of frequencies that an animal can hear.

backbone	A series of small bones (vertebrae) that form a chain to support the main part of some animals' bodies.
balanced diet	Eating a variety of foods to provide all the things the body needs.
balanced forces	When two forces on an object are the same strength but in opposite directions.
bar chart	A chart where the lengths or heights of bars (rectangles) represent the values of the variables.
base	Any substance, soluble or insoluble, that neutralises an acid forming a salt and water only.
biceps	A muscle in the upper arm, used to help pull up the lower arm.
biofuel	A fuel made from plants or animal droppings.
biomechanics	The study of how muscles and bones work together.
bladder	The organ that stores urine.
blood vessel	A tube that carries blood around the body.
boiling	When there is liquid turning into a gas in all parts of a liquid, creating bubbles of gas in the liquid.
boiling point	The temperature at which a liquid boils.
bond	A force that holds some atoms tightly together.
bone marrow	The tissue inside bones in which blood cells are made.
brain	The organ that controls the body. It is part of the nervous system.
breathing	The movement of muscles that make the lungs expand and contract.
breathing rate	The number of times you inhale and exhale in one minute.
breathing system (<i>bree-thing</i>)	The organ system that allows an exchange of gases between the blood and the lungs. Also known as the gas exchange system.
brittle (<i>britt-el</i>)	Not easily bent, not flexible, breaks under force.
Brownian motion (<i>mO-shun</i>)	An erratic movement of small specks of matter caused by being hit by the moving particles that make up liquids or gases.
bulb (biology)	An underground plant organ. Some plants only have leaves at certain times of the year and remain as bulbs at other times.
caffeine (<i>caff-een</i>)	A stimulant that increases the speed at which nerves carry impulses. Found in coffee, tea and cola drinks.
cannabis	A drug that can cause memory loss with long-term misuse.
capillary	A thin-walled blood vessel that carries blood from arteries to veins.
carbon dioxide	A waste gas produced by respiration.
carbonate (<i>car-bon-ayt</i>)	A compound containing an element bonded with carbon and oxygen.
cartilage	A slippery substance that is found on the ends of some bones and is used to help form some body parts (e.g. ear, nose).
caution (<i>cor-shun</i>)	A warning to 'take care'. Some substances need to be used with caution (e.g. they may cause skin irritation).
cell (biology)	The basic unit of all life. All organisms are made of cells.
cell (physics)	A source of electricity with a low 'energy' (low voltage). Cells push electrons round a circuit.
cell surface membrane	The membrane that controls what goes into and out of a cell.
cell wall	The tough wall around plant cells. Helps to support the cell.
cellulose	A strong plant material used to make cell walls.

cervix (<i>sir-vicks</i>)	The ring of muscle at the bottom of the uterus in females.
chamber	A space inside the heart that blood moves through as the heart pumps.
charges	Tiny particles that flow around a circuit.
chemical energy	A name used to describe energy when it is stored in chemicals. Food, fuel and batteries all store chemical energy.
chemical reaction	A change in which one or more new substances are formed.
chlorophyll (<i>klor-O-fill</i>)	The green substance found inside chloroplasts.
chloroplast (<i>klor-O-plast</i>)	A green disc containing chlorophyll. Found in plant cells. Where the plant makes food, using photosynthesis.
chromatogram (<i>kro-ma-t-o-gram</i>)	The results of chromatography (e.g. a dried piece of paper for paper chromatography), when the dissolved solids have been separated.
chromatography (<i>krome-a-tog-ra-fee</i>)	A method that separates out dissolved substances in a mixture, using a liquid or gas solvent.
cilia (<i>sil-lee-ah</i>)	Small hairs on the surface of some cells. Singular = cilium.
circuit breaker	A safety device that switches off the electricity supply if the current is too big.
circulatory system (<i>sir-cu-late-or-ee</i>)	An organ system that carries oxygen and food around the body.
circumcision (<i>sir-cum-siz-shun</i>)	Removal of the foreskin.
clause (<i>clors</i>)	Part of a sentence that contains a subject and a verb.
coal	A fossil fuel made from the remains of plants.
coarse focusing wheel	The wheel on a microscope that moves parts of the microscope a large amount to get the image into focus.
cocaine	A very powerful and harmful stimulant that can cause blocked arteries and mental problems with long-term misuse.
cochlea (<i>cok-lee-a</i>)	The part of the ear that changes vibrations into electrical impulses.
colloid	A mixture of a solid, liquid or gas in a solid, liquid or gas, where the substances do not settle out if left to stand.
communication	The transfer of information.
community	All the organisms that live in a habitat.
competition (<i>com-pet-ish-un</i>)	There is competition between organisms that need the same things as each other. We say that they compete for those things.
complex sentence	A sentence that contains a main clause and one or more subordinate clauses.
component (<i>com-po-nent</i>)	Something in a circuit, such as a bulb, switch or motor.
compound	A substance that can be split up into simpler substances, since it contains the atoms of two or more elements joined together.
compound sentence	A sentence that contains two main clauses.
compress	To squeeze into a smaller volume.
concentrated (<i>con-cen-tray-ted</i>)	A solution that contains a large amount of solute dissolved in a small amount of liquid (solvent).
conclusion (<i>con-cloo-shun</i>)	An explanation of how or why something happens, which is backed up by evidence. You use evidence to 'draw' a conclusion.
condense	When a substance changes from its gas state into its liquid state.
conductor	A substance that allows something to pass through it (e.g. heat, electricity).
conservation of mass	In a chemical reaction the total mass of the reactants is the same as the total mass of the products. Mass is conserved, that is, it is kept the same.
contact force	A force where there needs to be contact between objects before the force can have an effect (e.g. friction).
continuous	Data values that can change gradually and can have any value (between two limits) are continuous (e.g. human height).
continuous variation	When the value of a variable changes in a continuous way, it shows 'continuous variation'.
contract	To get smaller. When a muscle contracts it uses energy to get shorter and fatter.

contraction (<i>con-track-shun</i>)	The uterus muscles squeezing.
convention	A standard way of doing something or representing something, so that everyone understands what is meant.
correlation	A relationship between two variables. If an increase in one appears to cause an increase in the other it is 'positive'. An increase in one linked with a decrease in the other is 'negative'.
corrosive (<i>cor-row-sive</i>)	Substances that attack metals, stonework and skin are said to be corrosive.
coverslip	A thin piece of glass used to hold a specimen in place on a slide. It also keeps the specimen flat and stops it drying out.
criteria (<i>cry-teer-ee-a</i>)	A set of standards by which to judge things.
cubic centimetre (cm³)	A unit used for measuring volume.
current	The flow of electricity around a circuit.
cytoplasm (<i>site-O-plaz-m</i>)	The watery jelly inside a cell where the cell's activities take place.
daily changes	Changes in the physical environmental factors that happen during a day (e.g. it gets dark at night).
data	Observations or measurements collected in investigations.
decibel (dB) (<i>dess-i-bell</i>)	A unit for measuring the loudness of a sound.
deciduous (<i>des-sid-yoo-us</i>)	Plants that lose their leaves in winter.
density	A measure of a substance's mass per unit volume measured in grams per cubic centimetre (g/cm ³).
dependent variable (<i>dee-pend-ent var-ee-able</i>)	The variable that is measured in an investigation. The values of the dependent variable depend on those of the independent variable.
depressant	A drug that decreases the speed at which nerves carry impulses.
desalination (<i>dee-sal-in-ay-shun</i>)	To produce fresh drinking water by separating the water from the salts in salty water.
diagnosis (<i>dye-agg-nO-sis</i>)	A conclusion made by a doctor about what is wrong with someone who is ill.
diaphragm (<i>dye-a-ram</i>) ((biology))	An organ containing a lot of muscle tissue, which contracts and moves downwards to increase the volume of the lungs when inhaling.
diaphragm (<i>dye-a-ram</i>) ((physics))	A thin sheet of flexible material.
diet	The food that you eat.
diffusion (<i>diff-you-zshun</i>)	When particles spread and mix with each other without anything moving them.
digestive system (<i>die-jest-iv</i>)	An organ system that breaks down food.
diluted (<i>die-loot-ed</i>)	A substance that has had water added to it to make it less concentrated.
discontinuous	Data values that can only have one of a set number of options are discontinuous (e.g. shoe sizes and days of the week).
discontinuous variation	When the value of a variable changes in a discontinuous way it shows 'discontinuous variation'.
discrete (<i>dis-kreet</i>)	Data that involves a limited number of values (numbers).
disperse ((chemistry))	To spread without settling out, such as the bits in a colloid.
dissolve	When a substance breaks up into such tiny pieces in a liquid that it can no longer be seen and forms a solution.
distillation (<i>dis-till-ay-shun</i>)	The process of separating a liquid from a mixture by evaporating the liquid and then condensing it (so that it can be collected).
drug	A substance that affects the way your body works.
ear canal	The tube in the head that leads to the eardrum.
ear protection	Ear plugs or covers that prevent damage from loud sounds.
eardrum	A thin membrane inside the ear that vibrates when sound reaches it.

earth wire	The green and yellow wire in a cable or plug. It is there for safety.
Earth's crust	The solid layer of rocks on the surface of the Earth.
echo (<i>ek-O</i>)	We hear a sound again when it reflects off a surface. The reflected sound is called an echo.
echolocation (<i>ek-O-low-kay-shun</i>)	Finding prey or obstacles by emitting sounds and listening for the echoes.
ecosystem	All the physical environmental factors and all the organisms that are found in a habitat.
ecstasy	A stimulant that can cause depression, mental illness and even death with long-term misuse.
efficiency (<i>e-fish-en-see</i>)	A way of saying how much energy something wastes.
egg cell	The female sex cell (gamete).
ejaculation	When semen is pumped out of a man's penis.
elastic	An elastic material changes shape when there is a force on it but returns to its original shape when the force is removed.
elastic limit	If you stretch a spring beyond its elastic limit it will be permanently stretched. It is no longer elastic.
elastic potential energy (<i>po-ten-shall</i>)	A name used to describe energy when it is stored in stretched or squashed things that can change back to their original shapes. Another name for strain energy.
electricity	A way of transferring energy through wires.
element	A simple substance, made up of only one type of atom.
embryo (<i>em-bree-O</i>)	The tiny new life that grows by cell division from a fertilised egg cell.
endangered	When a type of organism is in danger of ceasing to exist.
energy	Something that is needed to make things happen or change.
environment	The conditions in a habitat caused by physical environmental factors.
environmental variation	Differences between organisms caused by environmental factors.
erection	When the penis becomes stiff.
ethical questions	Questions about what people think is fair or right and wrong.
evaluation	Thinking about how you can improve your experiment.
evaporation	When a liquid changes into a gas.
evergreen	Plants that do not lose their leaves in winter.
evidence	Data used to support an idea or show that it is wrong.
excrete (<i>ex-creet</i>)	To get rid of waste. All organisms excrete.
exhale (<i>ex-hay-el</i>)	To breathe out.
expert opinion	An opinion given by someone who is an expert in a particular subject.
explosive (<i>ex-plosive</i>)	An explosive substance reacts very fast, giving out a lot of energy and making a lot of noise and gas. Heating may cause an explosion.
extension (<i>ex-ten-shun</i>)	The amount by which a spring or other stretchy material has stretched. It is the stretched length minus the original length.
external fertilisation	When fertilisation happens outside the bodies of the parents.
extinct	Something that no longer exists is extinct.
eyepiece lens	The part of the microscope you look down.
fact	Something that has been shown to be correct over and over again is often called a 'fact'.
Fallopian tube	Another term for an oviduct.
fat tissue (<i>tiss-you</i>)	Tissue that stores fat. It is made of fat cells.
fertilisation	Fusing of a male gamete with a female gamete.
fertilised egg cell	What is produced when two gametes fuse.
filament	The thin piece of wire inside a light bulb that glows when the bulb is on.
filter	Anything, such as cloth, paper or a layer of sand, through which a liquid is passed to remove suspended pieces of solid.

fine focusing wheel	The wheel on a microscope that moves parts of the microscope a small amount to bring the image into focus.
fixed joint	A place where two or more bones meet but cannot move.
flammable	A flammable substance catches fire easily.
flexible	Able to bend without breaking.
flexible joint	A place where two or more bones meet and can be moved (by muscles).
flow	To move and change shape smoothly.
foetus (<i>fee-tus</i>)	An embryo is known as a foetus once it has developed a full set of organs.
food chain	A way of showing what eats what in a habitat.
food web	Many food chains linked together.
foodpipe	An organ in the shape of a tube that takes food from your mouth to your stomach. Also called the 'gullet' or 'oesophagus'.
force	A push, pull or twist.
force meter	A piece of equipment containing a spring, used to measure forces.
foreskin	A covering of skin protecting the head of the penis.
fossil fuel	A fuel formed from the dead remains of organisms over millions of years (e.g. coal, oil or natural gas).
fracture	Break.
frequency (<i>free-kwen-see</i>)	The number of vibrations (or the number of waves) per second.
frequency diagram	Any chart or graph that shows a frequency (the number of things) on the y-axis.
friction	A force between two objects that are touching. It usually acts to slow things down or prevent movement.
fuel	A substance that contains a store of chemical or nuclear energy that can easily be transferred.
function (<i>funk-shun</i>)	The job or role something has.
fuse (<i>fewz</i>) (biology)	When two things join together to become one.
fuse (<i>fewz</i>) (physics)	A piece of wire that melts if too much electricity flows through it.
gamete	A cell used for sexual reproduction.
gas	One of the states of matter. Does not have a fixed shape or a fixed volume and is easy to squash.
gas exchange	When one gas is swapped for another. In the lungs, oxygen leaves the air and goes into the blood. At the same time, carbon dioxide leaves the blood and goes into the air in the lungs.
gas exchange system	The organ system that allows the exchange of gases in the lungs. Also known as the breathing system.
generate	To produce electricity.
geothermal power (<i>jee-O-therm-al</i>)	Electricity generated using heat from rocks underground.
gestation period (<i>jess-tay-shun</i>)	The length of time from fertilisation to birth.
gland	Tissue that makes and releases substances. The glands in the male reproductive system add liquids to sperm cells to make semen.
gram (g)	A unit for measuring mass.
gravitational potential energy (<i>grav-it-ay-shon-al po-ten-shall</i>)	A name used to describe energy when it is stored in objects in high places that can fall down.
gravity	The force of attraction between any two objects. The Earth is very big and so has strong gravity that pulls everything down towards it.
grow	To increase in size. All organisms grow.
gullet (<i>gull-ett</i>)	A more scientific name for the 'foodpipe'. Also called the 'oesophagus'.
habitat	The place where an organism lives (e.g. woodland).
haemoglobin (<i>hee-mow-glow-bin</i>)	The substance that carries oxygen in red blood cells.

hazard	Something that could cause harm.
heart (<i>hart</i>)	The organ that pumps blood.
heroin	A powerful depressant drug, which can have dangerous side-effects.
hertz (Hz) (<i>hurts</i>)	The unit for measuring frequency.
hibernation (<i>hy-ber-nay-shun</i>)	When animals hide away during the winter and become very inactive.
Hooke's Law	The law that says that the extension of a spring is proportional to the force on it.
hybrid	An organism produced when members of two different species reproduce with each other.
hydroelectric power (<i>hy-drO-el-eck-trick</i>)	Electricity generated by moving water (usually falling from a reservoir) turning turbines and generators.
hydrogen	A gas that burns. It is an element.
hypothesis (<i>hy-poth-uh-sis</i>)	An idea about how something works that can be tested using experiments. Plural = hypotheses.
image	A picture that forms in a mirror or on a screen, or is made by a lens. You see an image when looking down a microscope.
implantation (<i>im-plant-ay-shun</i>)	When an embryo sinks into the lining of the uterus.
impulse	An electrical signal that travels in the nervous system.
independent variable	The variable that you chose the values of in an investigation.
indicator	A substance that changes colour in solutions of different acidity and alkalinity.
infrasound	Sound waves with frequencies below 20 Hz, the lower limit of human hearing.
inhale	To breathe in.
inherited	A feature that an organism gets from a parent is inherited.
inherited variation	Differences between organisms passed on to offspring by their parents in reproduction.
insoluble	Describes a substance that cannot be dissolved in a liquid.
insulating	A material that does not allow something to pass through it is an insulator or insulating material.
insulator	A material that does not allow something to pass through it (e.g. heat, electricity).
intensity	The loudness or volume of a sound.
interdependent	Organisms that depend on one another are said to be interdependent.
internal fertilisation	When fertilisation happens inside the body of a parent.
irritant (<i>irr-it-ant</i>)	An irritant substance causes skin and eyes to be sore or sting.
IVF	A procedure in which egg cells are taken from a woman and fertilised in a dish outside her body. The embryo develops and is then placed inside her.
joule (J) (<i>jool</i>)	A unit for measuring energy.
journal	A scientific magazine in which scientists publish their findings by writing articles called scientific papers.
kidney	An organ used to clean the blood and make urine.
kilogram (kg)	A unit for measuring mass. There are 1000 grams (g) in 1 kg.
kilojoule (kJ)	A unit for measuring energy. There are 1000 joules (J) in 1 kJ.
kinetic energy (<i>kin-et-tick</i>)	A name used to describe energy when it is stored in moving things.
labour	Labour starts when contractions begin in the uterus and ends when the afterbirth has come out.
large intestine	An organ that removes water from unwanted food.
law of conservation of energy	The idea that energy can never be created or destroyed, only transferred from one store to another.
leaf	A plant organ used to make food by photosynthesis.
life cycle	The series of changes in an organism during its life.

life process	A process that something does in order for it to be alive. The life processes that happen in all living things are movement, reproduction, sensitivity, growth, respiration, excretion and a need for nutrition.
ligament	A band of tissue that connects bones together.
limit of proportionality (<i>prO-por-shun-al-it-ee</i>)	The extension of a spring is proportional to the force on it, up to a certain point called the limit of proportionality. If you apply more force the extension is no longer proportional to the force.
line graph	A graph that shows how one variable changes when another changes (usually time). The points are joined with straight lines.
line of best fit	A line drawn on a scatter graph that goes through the middle of the points, so that about half the points are above the line and about half of them are below the line.
liquid (<i>li-kwid</i>)	One of the states of matter. Has a fixed volume but not a fixed shape.
live wire	The brown wire in a cable or plug.
liver	An organ used to make and destroy substances in your body. It also stores some substances.
locomotor system (<i>low-cO-mow-ter</i>)	An organ system that contains all your muscles and bones and allows you to move.
longitudinal wave (<i>long-it-tyood-in-al</i>)	A wave in which the vibrations (e.g. of particles) are in the same direction as the direction of the wave.
lubricant (<i>loo-brick-ant</i>)	A substance (usually a liquid) used to reduce friction.
lubrication (<i>loo-brick-ay-shun</i>)	Adding a lubricant to something.
lung	An organ used to take oxygen out of the air and into the blood. Lungs also put waste carbon dioxide into the air.
magnetic	A material, such as iron, that is attracted to a magnet.
magnetism	A force that attracts objects made of iron or other magnetic materials.
magnification (<i>mag-nif-ick-ay-shun</i>)	How much bigger something appears compared with its actual size.
malleable	Able to be beaten and bent into shape.
mammary gland	A gland that produces milk. Mammary glands are contained in the breasts and in women produce milk after giving birth.
mass	The amount of matter that something is made from. Mass is measured in grams (g) and kilograms (kg).
medicine (<i>med-iss-in</i>)	A drug that helps the body to ease the symptoms of a disease or cure the disease.
medium	Any substance through which something travels.
menopause (<i>men-O-pors</i>)	When the ovaries in women stop releasing egg cells.
menstrual cycle (<i>men-strew-al</i>)	A series of events lasting about a month, happening in the female reproductive system. The cycle causes ovulation and the lining of the uterus is replaced.
menstruation (<i>men-strew-ay-shun</i>)	When the lining of the uterus and a little blood pass out of the vagina as part of the menstrual cycle.
metal ore	A rock containing a compound of a metal, which can be used as a source of the metal.
metal	An element that is shiny when polished, conducts heat and electricity well, is malleable and flexible and often has a high melting point.
method	A description of how an experiment is carried out, written in simple, well-organised steps.
microphone	A machine for converting sound waves into changes in electrical current or voltage.
migration (<i>my-gray-shun</i>)	When animals move to different areas depending on the season.
mitochondria (<i>my-tow-kon-dree-a</i>)	Small structures in the cytoplasm of all cells, where respiration occurs.
mixture	Two or more substances jumbled together but not joined to each other. The substances in mixtures can often be separated from each other.

mnemonic (nem-on-ick)	A pattern of letters or words that helps you to remember something.
model	A way of showing or representing something that helps you to think about it or to find out about it.
molecule	Two or more atoms joined together in a group of a set size.
move	To go from place to place. All organisms can move themselves or parts of themselves.
muscle tissue (muss-ell tiss-you)	Tissue that can change shape and move things. There is muscle tissue in the heart.
natural gas	A fossil fuel formed from the remains of microscopic dead plants and animals that lived in the sea.
navel (nave-ell)	The scar left by the umbilical cord. Often called the 'belly button'.
nerve	An organ that is made of nerve cells (neurons) and carries impulses.
nervous system (nerve-us)	An organ system that contains your brain, spinal cord and all your nerves and carries signals around the body.
neutral (new-tral)	A substance that is neither an acid nor an alkali. It has a pH of 7.
neutral wire	The blue wire in a cable or plug.
neutralisation (new-tral-ise-ay-shun)	A reaction in which an acid reacts with an alkali or a base to produce a salt and water only.
newton (N)	The unit for measuring force.
nicotine	An addictive drug found in tobacco smoke.
nocturnal (nock-ter-nal)	Organisms that are active at night are nocturnal.
non-contact force	A force that can affect something from a distance (e.g. gravity).
non-metal	Any element that is not shiny, and does not conduct heat and electricity well.
non-renewable	Any energy resource that will run out because we cannot renew our supplies of it (e.g. oil).
normal distribution	When many things have a middle value with fewer things having greater or lesser values. This sort of data forms a bell shape on charts and graphs.
nuclear energy	A name used to describe energy when it is stored inside materials.
nuclear fuel	A radioactive metal such as uranium. Nuclear fuels are used in nuclear power stations to generate electricity.
nucleus (new-clee-us)	The 'control centre' of a cell. Plural = nuclei.
nutrient (new-tree-ent)	A substance needed in the diet.
nutrition (new-trish-un)	Substances that help organisms respire and grow. All organisms need nutrition.
objective lens	The part of the microscope that is closest to the specimen.
observation	Something that you see happening.
oesophagus	A more scientific name for the 'foodpipe'. Also called the 'gullet'.
offspring	The new organisms produced by reproduction.
oil	A fossil fuel formed from the remains of microscopic dead plants and animals that lived in the sea.
opaque (o-payk)	A substance that is opaque is not possible to see through.
opinion	An opinion is a view or judgement without evidence to show that it is true.
organ	A large part of a plant or animal that does an important job. Organs are made of different tissues working together.
organ system	A collection of organs working together to do an important job.
organ transplant	Taking an organ from one person to put it into another.
organism	A living thing.
oscilloscope (oss-ill-O-skope)	An instrument that shows a picture of a sound wave on a screen.
ovary (O-very)	A female reproductive organ. Produces egg cells.
oviduct	A tube that carries egg cells from the ovaries to the uterus in females. Fertilisation happens here.
ovulation	Release of an egg cell from an ovary.

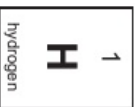
oxygen	A gas that makes up about 21 per cent of the air.
paper chromatography (krome-a-tog-ra-fee)	Chromatography where the solvent moves through paper, carrying the dissolved solids.
parallel circuit	A circuit with branches that split apart and join up again.
parent	An organism that has produced offspring.
particle model	Another term for particle theory.
particle theory	A theory used to explain the different properties and observations of solids, liquids and gases.
particles (part-ick-als)	The tiny pieces of matter that everything is made out of.
pascal (Pa) (pas-kal)	A unit for measuring pressure. 1 Pa = 1 newton per square metre (N/m ²).
periodic table	An ordered list of all known elements.
persistent	A chemical substance that does not get broken down in nature very quickly is persistent. It stays around for a long time.
pest	An organism that damages things that humans want to use.
pesticide (pess-ti-side)	A chemical substance that kills pests.
pH scale	A numerical scale from 1 to 14 showing how acidic or alkaline a substance is. Acids have a pH below 7, neutral substances have a pH of 7 and alkalis have a pH greater than 7.
photosynthesis (fo-tow-sinth-e-sis)	A process that plants use to make their own food. It needs light to work.
physical change (fi-zi-kal)	A change in which no new substances are formed (e.g. changes of state).
physical environmental factors	Physical (non-living) features of an environment (e.g. amount of rain; amount of light).
physical model (fi-zi-kal)	A model that you can touch or a model that you could build.
pie chart	A type of chart in which a circle is divided into sectors to represent the proportions of a total made up by different items.
pitch	How high or low a note sounds.
placenta (plas-en-ta)	This is attached to the uterus wall. It transfers oxygen and food out of the mother's blood into the foetus and transfers waste materials from the foetus into the mother's blood.
plasma	The liquid part of the blood.
plastic	A plastic material changes shape when there is a force on it but does not return to its original shape when the force is removed.
population	The number of a certain organism found in a certain area.
power pack	A source of electricity with a low voltage, which is safe to use.
precaution (pre-cor-tion)	An action taken to reduce the risk of a hazard causing harm (e.g. wearing eye protection when handling an acid to prevent it splashing in your eyes).
predator (pred-att-er)	An animal that catches and eats other animals.
prediction	What you think will happen in an experiment.
prefix (pree-fix)	Something added to the beginning of a word to change its meaning. In 'kilometre', 'kilo' is the prefix.
pregnant	When a female animal has an embryo growing inside her uterus.
premature	When an baby is born much earlier than expected, it is premature.
prescription (press-krip-shun)	An order for some medicines that a doctor writes.
pressure	The amount of force pushing on a certain area. A way of saying how spread out a force is.
pressure wave	Waves like sound waves, where the vibration of particles transfers energy.
prey (pray)	An animal that is caught and eaten by another animal.
product (prod-uct)	A new substance made in a chemical reaction. Products are written on the right side, after the arrow, in a word equation.
property	A description of how a material behaves and what it is like.

proportional (<i>prO-por-shun-al</i>)	A relationship between two variables where one doubles if the other doubles. A graph of the two variables would be a straight line through the origin.
puberty (<i>pew-bert-ty</i>)	A time during which big physical changes happen in the body.
pulse	A feeling of the heart beating that can be felt in arteries.
pulse rate	The number of times a pulse is felt in a minute.
pure	A single substance that does not have anything else in it.
pyramid of numbers	A way of showing the numbers of the organisms in a food chain.
qualitative	Data that is described in words.
quantitative	Data that is described in numbers.
rating (fuse)	The largest current a fuse can conduct without melting.
ratio	A way of comparing two different quantities. Two numbers separated with a colon (:).
reactant (<i>ree-act-ant</i>)	A substance that takes part in a chemical reaction. Reactants are written on the left side, before the arrow, in a word equation.
reaction time	The time it takes you to respond to things happening around you.
recreational drug (<i>reck-ree-ay-shun-al</i>)	A drug used for its mind-altering effect and not as a medicine.
rectum	An organ that stores faeces.
recycling	Using a material again, often by melting it and using it to make new objects.
red blood cell	A blood cell that carries oxygen.
reflect	To bounce off a surface instead of passing through it or being absorbed.
relationship	A link between two variables, so that when one thing changes so does the other. Best seen by using a scatter graph. Also called a correlation.
relax	When a muscle relaxes it stops exerting a force and becomes thinner and longer.
renewable	An energy resource that will never run out (e.g. solar power).
reproduce	When organisms reproduce, they make more organisms like themselves.
reproductive organ	An organ used in sexual reproduction.
reproductive system	All the reproductive organs.
resistance	A way of saying how difficult it is for electricity to flow through something.
resistor	A component that makes it difficult for electricity to flow. Resistors are used to reduce the size of the current in a circuit.
resource (<i>rez-ors</i>)	Something needed by an organism. For example, plants need light as a resource and animals need food as a resource.
respiration (<i>res-per-ay-shun</i>)	A process in which energy is released from substances so it can be used by an organism. All organisms respire.
result	A measurement or observation from an experiment.
ring main	A type of parallel circuit used in house wiring.
risk	The chance that a hazard will cause harm.
root	A plant organ used to take water out of the soil.
root hair tissue (<i>tiss-yoo</i>)	Tissue that helps roots get water out of the ground quickly. This tissue is made out of root hair cells.
salt	The substance (other than water) that is formed when an acid reacts with an alkali or a base.
saturated	A solution that contains so much dissolved solute that no more solute can dissolve in it.
scatter graph	A graph in which data for two variables is plotted as points. This allows you to see whether there is a relationship between the two variables. Lines (or curves) of best fit are often drawn through the points.
scientific method	Any way of testing that involves collecting information in order to show whether an idea is right or wrong. This is often done by developing a hypothesis that is tested by using it to make a prediction. The prediction is then tested using experiments.

scientific paper	An article written by scientists and published in a science magazine called a journal.
scrotum (<i>scrow-tum</i>)	The bag of skin containing the testes in males.
seasonal change	Change in the physical environmental factors of an environment that happens during the course of a year (e.g. it gets colder in winter).
seed	A small part of a plant formed by sexual reproduction that can grow into a new plant.
semen (<i>see-men</i>)	The mixture of sperm and special fluids released by males during ejaculation.
sense	To detect things in the surroundings. All organisms can sense certain changes in their surroundings.
series circuit	A circuit in which there is only one loop of wire.
sex cell	Another word for a gamete.
sex hormones (<i>hor-moans</i>)	Natural chemicals released in the body that control the menstrual cycle and puberty.
sexual intercourse	Or 'making love', 'having sex', during which semen is ejaculated into the end of the vagina.
sexual reproduction (<i>ree-prod-uck-shun</i>)	Reproduction that needs two individuals to produce a new organism of the same type.
SI unit	A standard international unit used by scientists. 'SI' stands for 'Système International d'Unités'.
side-effect	A harmful or unpleasant effect caused by a drug.
skeleton	The structure that supports an organism and gives it its shape. It is made of 206 bones in an adult human.
skin	The organ that covers the body. It is used for protection and to detect changes in the environment (e.g. temperature).
skull	A collection of bones that protects the brain.
slide	A glass sheet that a specimen is put on.
small intestine	An organ used to break up food and get it into the blood.
sodium chloride	The chemical name for table salt.
solar cell	Flat panels that use energy transferred by light to produce electricity.
solar panel	Flat plates that use energy from the Sun to heat water.
solar power	Generating electricity using energy from the Sun.
solar power station	A large power station that uses the Sun to heat water to make steam. The steam is used to make electricity in a similar way to fossil fuel or nuclear power stations.
solid	One of the states of matter. Has a fixed shape and fixed volume.
solubility	The amount of substance that dissolves in a particular solvent at a particular temperature to make a saturated solution.
soluble	Describes a substance that can dissolve in a liquid.
solute	The substance that has dissolved in a liquid to make a solution.
solution (<i>sol-oo-shun</i>)	When a substance has dissolved in a liquid. Solutions are transparent.
solvent	The liquid in which a substance dissolves to make a solution.
sonar (<i>so-nar</i>)	A machine for finding the depth of the sea or finding fish by sending sound waves and listening for the echoes.
sound intensity meter	A meter that measures the loudness of a sound.
sound wave	A wave is a way of transferring energy. A sound wave is vibrations in the particles of a solid, liquid or gas, which are detected by our ears and 'heard' as sounds.
source	Where a sound or other wave begins.
specialised	If something has features that allow it to do a particular job it is said to be specialised.
species (<i>spee-shees</i> or <i>spee-sees</i>)	A group of organisms that can reproduce with each other to produce offspring that will also be able to reproduce.
specimen (<i>spess-im-men</i>)	The object you look at using a microscope.
sperm cell	The male sex cell (gamete).
sperm count	The number of sperm cells in a certain volume of semen.

sperm duct	The tube that carries sperm cells from the testes to the urethra.
spinal cord (<i>spy-nal kord</i>)	The large bundle of nerves that runs through the vertebrae (backbone).
spring	A coil of wire that can be stretched or compressed.
stage	Part of a microscope. You put a slide on it.
stain	A dye used to colour parts of a cell to make them easier to see.
state of matter	There are three different forms that a substance can be in: solid, liquid or gas. These are the three states of matter.
static electricity	A force that can attract or repel things. It is caused when certain materials rub together.
stationary (<i>stay-shun-ary</i>)	Not moving.
steam	Water as a gas. May also be called water vapour.
stem	A plant organ used to take water to and support the leaves.
stimulant (<i>stim-you-lant</i>)	A drug that increases the speed at which nerves carry messages (e.g. caffeine).
stomach (<i>stum-ack</i>)	An organ used to break up food.
storage organ	An organ used by plants to store materials.
strain energy	A name used to describe energy when it is stored in stretched or squashed things that can change back to their original shapes. Another name for elastic potential energy.
stretch	To pull something to make it longer.
subject	The person, place, thing or idea that is doing or being something in a clause.
substance misuse	Taking any substance in a way that causes harm to the body.
superposition (<i>soup-er-poz-ish-un</i>)	When two waves meet and their effects add up or cancel out.
surface area	The area that the surface of something has.
surrogate mother	A human or animal in whose uterus an embryo grows but when the embryo is not made using one of her egg cells.
suspension (<i>sus-pen-shun</i>)	A mixture of a solid and liquid, where the solid bits are heavy enough to settle out if the mixture is left to stand.
symbol (chemistry)	The letter or letters that represent an element.
symptom (<i>simp-tom</i>)	Changes in the way the body works, which help a doctor to work out what is wrong with you.
table	An organisation of data into rows and columns.
tendon	A cord of tissue that connects a muscle to a bone.
testis	A male reproductive organ. Produces sperm cells. Plural = testes.
test-tube baby	A baby born using IVF.
theory (<i>thear-ree</i>)	A hypothesis (or set of hypotheses) that explains how and why something happens. The predictions made using a theory should have been tested on several occasions and always found to work.
thermal decomposition	Breaking down a compound into simpler substances using heat.
thermal energy	A name used to describe energy when it is stored in hot objects. The hotter something is the more thermal energy it has.
tissue (<i>tish-you</i>)	A part of an organ that does an important job. Each tissue is made up of a group of the same type of cells all doing the same job.
topic sentence	The main sentence in a paragraph, which contains the main point of the paragraph.
toxic (<i>tox-ic</i>)	A toxic substance is poisonous.
trace	The line on an oscilloscope screen that represents a sound wave.
trachea (<i>track-ee-a</i>)	A more scientific name for the 'windpipe'.
transfer	When energy is moved from one store into another or from one place to another we say it is transferred.
transmit	To pass through a substance.
transparent	Clear, can be seen through. (Note: transparent substances may be coloured or colourless.)

transverse wave	A wave in which the vibrations (e.g. of particles) are at right angles to the direction the wave is travelling.
triceps	A muscle in the upper arm, used to help push down the lower arm.
ultrasound	Sound waves with frequencies above 20 000 Hz, the upper limit of human hearing.
ultrasound scan	A picture of what is inside someone's body, created by an ultrasound scanner, using sound.
umbilical cord (<i>um-bill-ick-al</i>)	The tissue that carries food, oxygen and waste between the placenta and the growing embryo or foetus.
unbalanced forces	When two forces working in opposite directions on an object are not the same strength. Unbalanced forces change the motion of objects.
upthrust	A force that pushes things up in liquids and gases.
uranium (<i>you-rain-ee-um</i>)	A radioactive metal that can be used as a nuclear fuel.
urethra (<i>you-ree-thra</i>)	The tube that carries sperm cells from the testes and urine from the bladder.
urinary system (<i>your-in-air-ee</i>)	An organ system that cleans the blood and removes wastes in urine.
uterus (<i>you-ter-ous</i>)	The organ in females in which a baby develops.
vacuole (<i>vack-you-oll</i>)	Storage space in cells.
vacuum (<i>vak-yoom</i>)	A completely empty space, containing no particles.
vagina (<i>vaj-eye-na</i>)	The tube in females leading from the cervix to the outside. The penis is placed here during sexual intercourse.
variable (<i>vair-ee-ab-el</i>)	Anything that can change and be measured.
variable resistor	A resistor whose resistance can be changed.
variation (<i>vair-ee-ay-shun</i>)	The differences between things.
vein	A blood vessel that carries blood towards the heart.
ventilation (<i>vent-ill-ay-shun</i>)	The movement of air in and out of your lungs.
vertebra (<i>vert-teb-bra</i>)	A small bone that forms part of the 'backbone'. Plural = vertebrae.
vibrate (<i>vibe-rayt</i>)	To move backwards and forwards.
vocal folds (<i>vo-kal</i>)	Flaps of skin in our throats that vibrate to make the sound when we speak.
volt (V)	The unit for measuring voltage.
voltage	A way of saying how much energy is transferred by electricity.
voltmeter	A piece of equipment that measures how much energy is being transferred by a current.
volume (<i>vol-yoom</i>) (sound)	The loudness of a sound.
volume (<i>vol-yoom</i>) (matter)	The amount of room something takes up. Often measured in cubic centimetres (cm ³).
water resistance	A force on objects moving through water.
weight	The amount of force with which gravity pulls things. It is measured in newtons (N). Your weight would change if you went into space or to another planet.
white blood cell	A blood cell that fights microorganisms.
wind turbine	A kind of windmill that generates electricity using energy transferred by the wind.
windpipe	An organ in the shape of a tube that takes air to and from your lungs. Also called the 'trachea'.
word equation (<i>word eck-way-shun</i>)	An equation in which the names of the reactant(s) are written on the left side, there is an arrow pointing from left to right and the names of the product(s) are written on the right side.
xylem tissue (<i>zy-lem tiss-you</i>)	Tissue that carries water in plants. It is found in stems and roots and is made of xylem cells.



- metal
- semi-metal
- non-metal

3	4		5	6	7	8	9	10
Li	Be		B	C	N	O	F	Ne
lithium	beryllium		boron	carbon	nitrogen	oxygen	fluorine	neon
11	12		13	14	15	16	17	18
Na	Mg		Al	Si	P	S	Cl	Ar
sodium	magnesium		aluminium	silicon	phosphorus	sulfur	chlorine	argon

19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
potassium	calcium	scandium	titanium	vanadium	chromium	manganese	iron	cobalt	nickel	copper	zinc	gallium	germanium	arsenic	selenium	bromine	krypton
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
rubidium	strontium	yttrium	zirconium	niobium	molybdenum	technetium	ruthenium	rhodium	palladium	silver	cadmium	indium	tin	antimony	tellurium	iodine	xenon
55	56	57	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
caesium	barium	lanthanum	hafnium	tantalum	tungsten	rhenium	osmium	iridium	platinum	gold	mercury	thallium	lead	bismuth	polonium	astatine	radon
87	88	89	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Uut	Ff	Uup	Lv	Uus	Uuo
francium	radium	actinium	rutherfordium	dubnium	seaborgium	bohrium	hassium	meitnerium	darmstadtium	roentgenium	copernicium	ununtrium	flerovium	ununpentium	livermorium	ununseptium	ununoctium

58	59	60	61	62	63	64	65	66	67	68	69	70	71
Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
cerium	praseodymium	neodymium	promethium	samarium	europium	gadolinium	terbium	dysprosium	holmium	erbium	thulium	ytterbium	lutetium
90	91	92	93	94	95	96	97	98	99	100	101	102	103
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr
thorium	protactinium	uranium	neptunium	plutonium	americium	curium	berkelium	californium	einsteinium	fermium	mendelevium	nobelium	lawrencium

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