> 5.5 Acids and alkalis

In this topic you will:

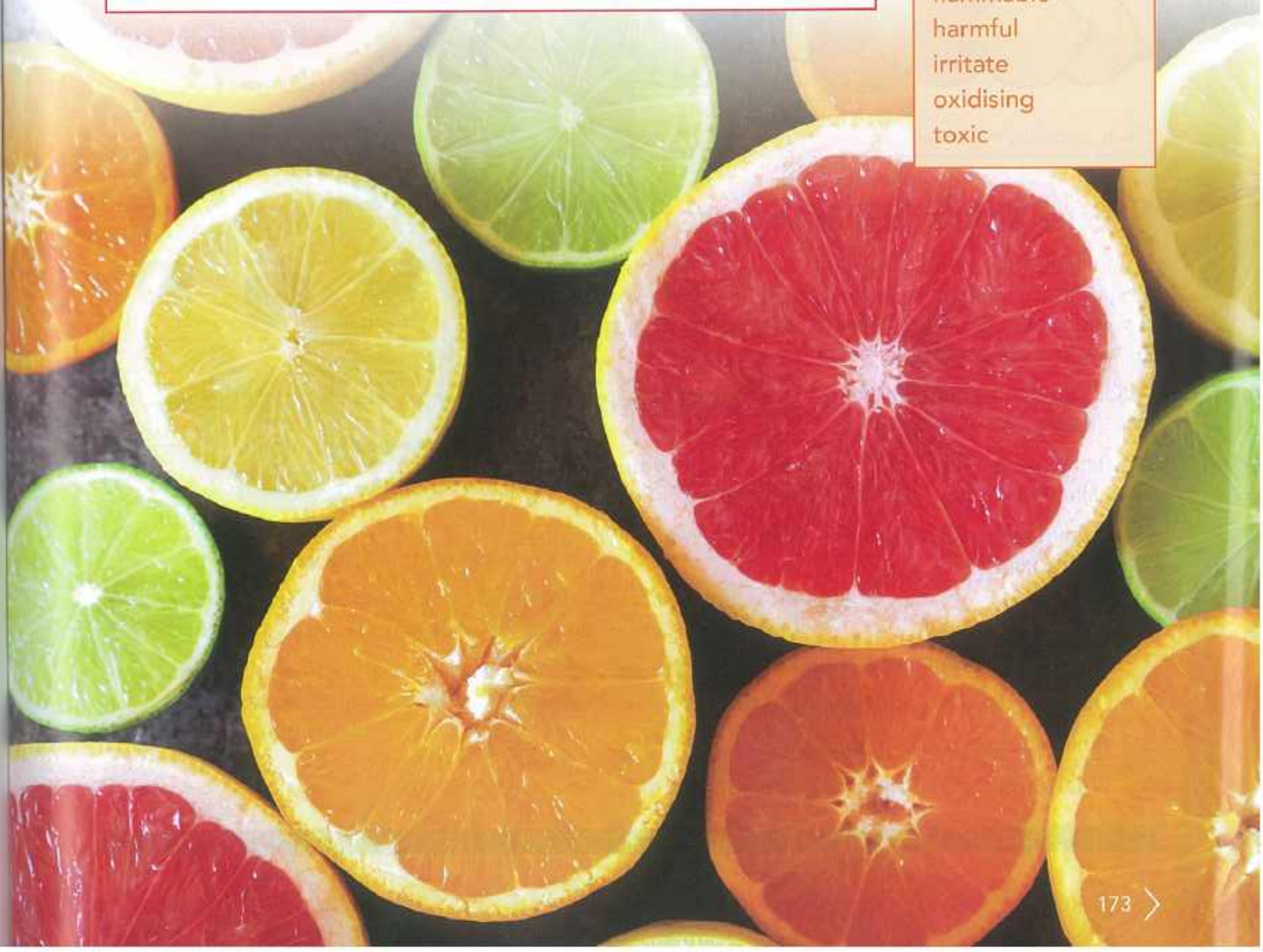
- learn about the properties of acids and alkalis
- learn how to work safely with acids and alkalis
- find out about hazard symbols.

Getting started

What do you think of when you hear the word 'acid'? Write down five words that describe what you think an acid is. Share these with a partner. Did you both come up with same or similar words? Be prepared to share them with the class.

Key words

acid
alkalis
corrosive
flammable
harmful
irritate
oxidising
toxic



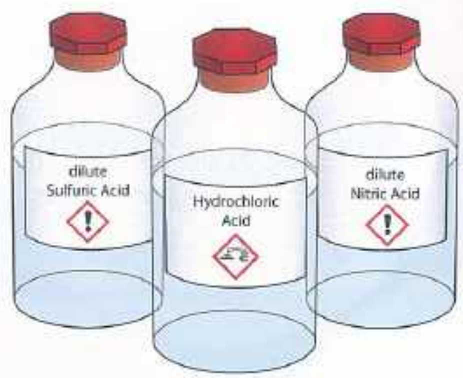
Acids are everywhere

Many things contain **acid**. Some foods contain acid. These foods have a sour, sharp tangy taste. Lemons and limes taste sour. They contain citric acid. This is a weak acid.

Common acids in the laboratory are hydrochloric acid, sulfuric acid and nitric acid.

Foods containing fruits often contain acids.

Some acids are dangerous



Some acids are strong. They are **corrosive**. The bottles have a hazard warning label. If strong acid gets onto your skin, it will dissolve the skin. You will get a chemical burn. Always use eye protection when using acids.

Acids can be diluted with water. This makes them less dangerous.

Dilute acids are still **harmful**, they can **irritate** your skin and eyes. The bottles have hazard warning labels.

If you spill acid, wash the area with lots of water. The water dilutes the acid.

Questions

1. Name a food that contains acid.
2. Describe the taste of lemons and limes.
3. What does corrosive mean?
4. What should you do if you spill acid?

Alkalis are everywhere

Many cleaning products contain **alkalis** such as sodium hydroxide, which is a compound of sodium, hydrogen and oxygen. Sodium hydroxide is a strong alkali. Strong alkalis are dangerous. They are corrosive.

If strong alkali gets on your skin, it dissolves your skin. Your skin feels soapy. You get a chemical burn. Alkalis are harmful if you get them in your eyes. Always wear eye protection when using alkalis.

Alkalis can be diluted with water. This makes them less dangerous.

Common alkalis found in the laboratory are sodium hydroxide, potassium hydroxide and calcium hydroxide.

Acids and alkalis are chemical opposites. They cancel each other out when they are mixed together. The acidity or alkalinity of a substance is a chemical property of that substance.

All of these products contain alkalis.

Strong sodium hydroxide is corrosive.

Working safely with acids and alkalis

When you handle chemicals you should:

- stand up to work, so that if you spill something it does not spill on to you
- wear safety glasses, so nothing gets into your eyes
- take the top of the bottle and place it upside down on the work surface, so that it does not get acid onto the surface or dirt into the acid
- replace the bottle top as soon as you have finished using the bottle. This prevents spills and reduces the risk of replacing the wrong top on the wrong bottle.

Hazard warning labels

Many chemicals are hazardous. Their bottles are clearly labelled with hazard warning symbols so that you know you must handle them carefully. Here is a list of the most common hazard symbols and what they mean.

Explosive		A substance that can explode if it comes into contact with a flame or heat.
Flammable		A substance that can catch fire easily.
Oxidising		A substance that gives off a large amount of heat when in contact with other substances.
Corrosive		A substance that can destroy living tissue. It can cause burns.

Toxic		A substance that can poison you.
Hazardous to the environment		A substance that can kill or damage living things in the environment.
Health hazard		A substance that can cause harm such as irritating your skin and eyes.
Serious health hazard		A substance that can cause a serious problem to your health.

When you use chemicals in the laboratory, make sure you look at the hazard symbols and listen to advice on how to use them safely.

Activity 5.5.1

Learning the hazard warning symbols.

You will need:

- card, scissors

Make three sets of cards:

- one set with the hazard warning symbols on them
- one set with the names of the hazards on them
- one set with the details on them.

You must make up a game with these cards to help you learn the symbols and their meanings.

Play your game with a partner, and then play their game.

Peer-assessment

Was your partner's game useful to help you learn the symbols? How could they improve their game? How did your game compare?

Which methods of learning information like this are the most helpful to you?

Summary checklist

- [ ] I can identify the properties of acids and alkalis.
- [ ] I can explain how to work safely with acids and alkalis.
- [ ] I can identify and understand the hazard warning symbols.

> 5.6 Indicators and the pH scale

In this topic you will:

- learn how to tell an acid from an alkali
- learn how to make and use indicators
- use the pH scale to find out more about acids and alkalis.

Getting started

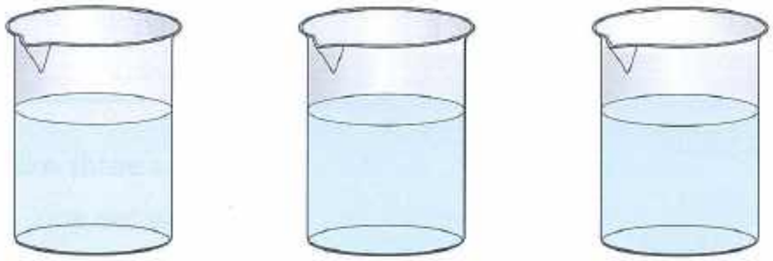
Draw one of the hazard warning symbols. Show it to your partner. Can they identify it? Test each other on as many as you can remember. Check up and see how many you got correct and how many you forgot.

Key words

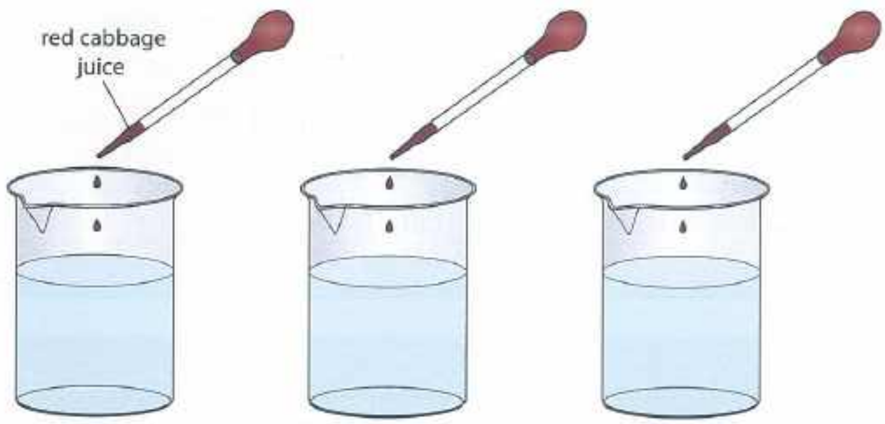
indicator
litmus
neutral
pH scale
universal indicator

Which is which?

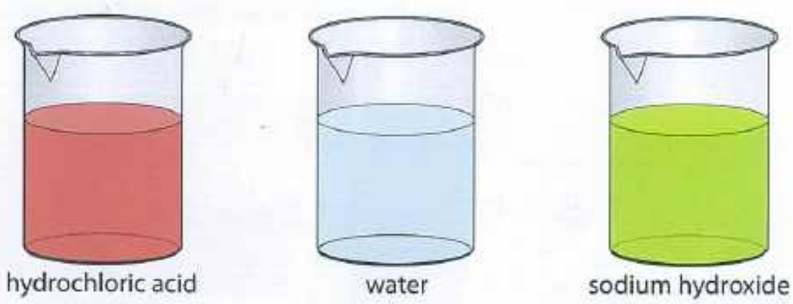
These three containers all look the same. One contains water, one contains acid and one contains alkali.



You can tell them apart when you add a few drops of an **indicator**. An indicator turns one colour in an acid and a different colour in an alkali. Red cabbage juice can be used as an indicator.



Red cabbage indicator turns red in acids, blue in water and yellow in alkalis. So, you now know what was in each beaker.



Indicators can be made from the brightly coloured berries, flowers and other parts of plants. These include:

- red cabbage
- blackcurrant
- beetroot.

Questions

1 How does an indicator show whether a substance is an acid or an alkali?

2 What is the colour change when red cabbage juice is added to lemon juice?

Litmus

Litmus is a very common indicator. It is a dye. You usually use litmus paper, which is made by soaking absorbent paper in litmus solution.

Litmus turns red in acids. Litmus turns blue in alkalis. Litmus turns purple when it is in a **neutral** substance. A neutral substance is one that is neither acid nor alkali.

Litmus turns purple in water. Water is neutral. This means water is neither an acid nor an alkali.

This table shows the colours litmus goes in some substances and what those colours mean.

Substance	Litmus colour	Type of substance
hydrochloric acid	red	acid
sodium hydroxide	blue	alkali
water	purple	neutral
lemon juice	red	acid
calcium hydroxide	blue	alkali

Questions

3 What does litmus do when it is added to sodium hydroxide?

4 What colour does litmus change to in an acid?

5 Is water an acid, an alkali or neutral? Give the reason for your answer.

Think like a scientist

Making and using your own indicator solution

In this task you will make your own indicator solution and use it to test various chemicals in the laboratory.

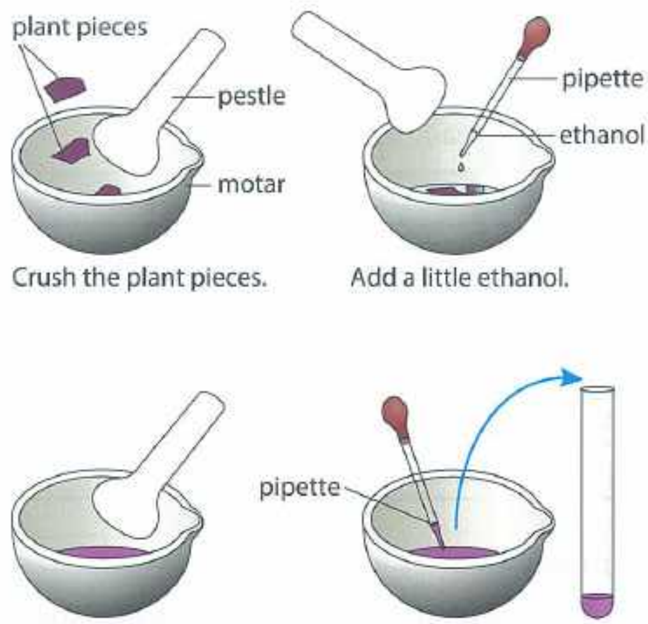
You will need:

- some plant material, such as red cabbage or beetroot, a knife and cutting board, a pestle and mortar, two dropper pipettes, test tubes and a test-tube rack, safety glasses, a range of laboratory chemicals, ethanol

Safety

Make sure you are careful and read all the hazard warning labels. Ethanol is flammable.

1. Cut up the plant material.
2. Place some of the material into a pestle and mortar and crush it.
3. Use a pipette to add a little ethanol.
4. Crush the plant material again.
5. Use a different pipette to transfer some of the liquid from the mortar to a test tube.
6. Use the liquid you collect to test some everyday liquids and laboratory chemicals.
7. Make a table to record the chemicals you test and the colours you see.



Crush the plant pieces. Add a little ethanol.

Keep crushing until the colour comes out. Use a pipette to put the liquid into a test tube.

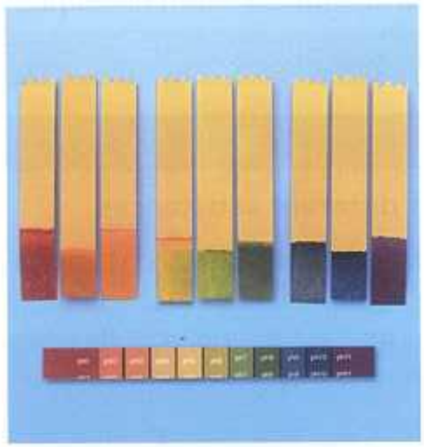
Self-assessment

Compare your indicator with litmus. Does your indicator turn the same colour as litmus? Does it clearly show which is an acid and which is an alkali?

Other indicators

Litmus and other simple indicators just show *if* a substance is an acid or an alkali. **Universal indicator** shows *how* acidic or alkaline a substance is. The acidity or alkalinity of a substance is one of its chemical properties. Universal indicator can change to many different colours. Universal indicator is made up of a mixture of different indicators.

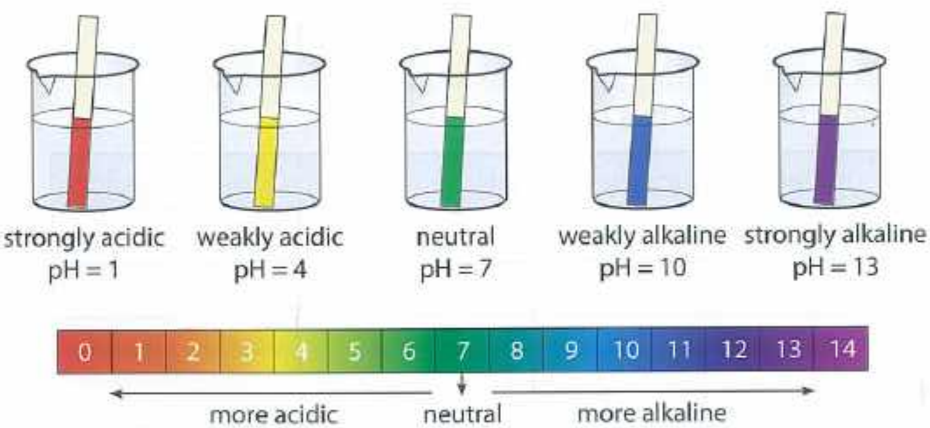
Type of substance	Colour of universal indicator
strongly acid	red
weakly acid	yellow
neutral	green
weakly alkaline	blue
strongly alkaline	purple



These strips of paper were soaked in universal indicator solution and then dried. The papers were then dipped into different liquids.

The strength of acids and alkalis is measured on the **pH scale**.

Universal indicator changes colour and shows the pH of a substance. The pH of a substance is one of the chemical properties of that substance.



A colour chart for universal indicator showing the pH scale.

Questions

6 What does the pH scale measure?

7 What is the pH of a neutral solution?

8 A liquid has a pH of 1. What type of liquid is it?

9 What range of pH do strong alkalis have?

10 What colour does universal indicator turn in a liquid with a pH of 9?

11 Which colours does universal indicator turn in acids?

Think like a scientist

Investigating the pH of different substances

In this task you will test various laboratory chemicals with universal indicator to measure the pH and what type of chemical it is.

You will need:

- universal indicator papers, a range of liquids, test tubes and a test tube rack, safety glasses

Safety

Read any hazard warning labels and take care not to spill substances on your skin. Make sure you know what to do if you do spill anything.

1 Put on your safety glasses.

2 Pour a small amount of liquid from a bottle of liquid into a clean test tube.

3 Test with universal indicator.

4 Record the colour of the indicator and the pH.

5 Record the type of each liquid, such as strongly or weakly acidic, neutral, strongly or weakly alkaline. You could use a table like this one.

Liquid	Colour of universal indicator	pH	Type of liquid
lemon juice		4	weakly acidic
salt water	green		
soap solution		8	weakly alkaline
cola drink	yellow	4	

Continued

Self-assessment

How well were you able to decide on the pH? Were the colours easy to match to the numbers?

What safety considerations did you follow?

Activity 5.6.1

Make your own pH chart

Make your own colour chart to show the colours to which universal indicator changes in liquids of different pH.

You can do this by arranging different coloured pieces of paper in the correct order, starting with the colour that universal indicator turns in a liquid of pH 1. You could also use plain paper and paint or colour it yourself. You could do it on a computer and print it off in colour.

Try to make it interesting. You can cut out different coloured shapes, such as T-shirts on a washing line or racing cars on a track. You can do this on a large sheet of paper so that it can be displayed in your classroom.

On each item, write the pH that the colour represents and state if that pH means strong acid, weak acid, neutral, weak alkali or strong alkali.

Try to add the names and/or pictures of substances next to various pH values.

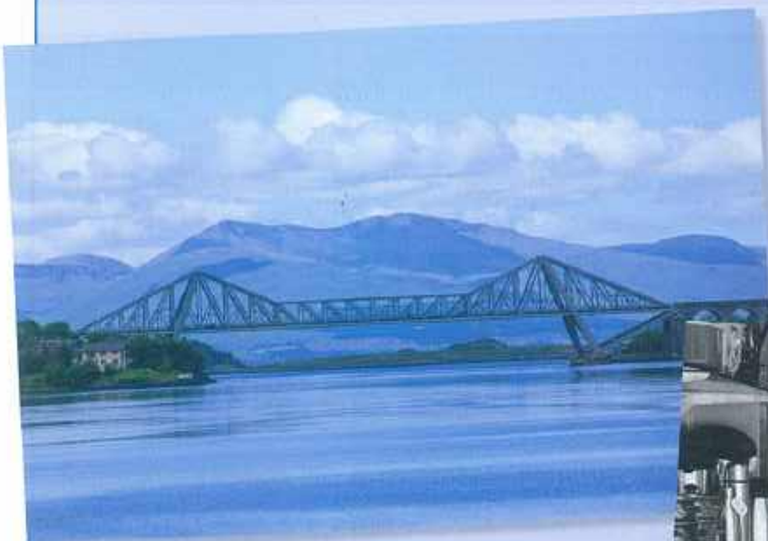
Summary checklist

- [ ] I can identify acids and alkalis by use of indicators.
- [ ] I can make an indicator.
- [ ] I can use the pH scale.

Project: Different steel for different jobs

All over the world people use iron to make many things, such as car bodies and bridges, and to form the structures of buildings. They don't use pure iron because it is not strong enough. Instead, they use an alloy of iron, called steel.

Mixing other substances with iron – such as carbon, chromium and nickel – makes steel. The amount of carbon used, and the amounts and types of other metals used, make different types of steel. Some different types of steel are mild steel, medium steel, high carbon steel and stainless steel.



Find information about the different types of steel.

These questions give you a starting point.

1 What substances and how much are added to iron to form the different types of steel?
2 What are the properties of these different types of steel?
3 What are these different types of steel are used for? You should try to link this with their properties.
4 Where are these different types of steel made?

Continued

5 Where do the iron, carbon and other metals needed to make them come from? Do they have to be extracted or treated in some way before they can be used?

6 What does this mean in terms of the cost of manufacture?

7 Where does the steel get used?

8 What does this mean in terms of transport costs?

9 Can you find out about any other specialist steels?

Present the information to your class.

You could make a poster, a slide presentation, a television interview with a presenter and an 'expert', a newspaper article or you could use any other way to present your information. Ensure that the information you use is relevant and makes your presentation clear.

Check your Progress

5.1 Copy the paragraph and choose words from the list to complete it. Each word may be used once, more than once or not at all.

brittle	conduct	cut	ductile
electricity	malleable	metal	ring

Metals are shiny when freshly ____________ or polished. They are strong and if you tap them they ____________ like a bell. Metals ____________ heat energy and ____________ . Metals are ____________ , which means they can be beaten into shape. They are ____________ , which means they can be drawn out into wires. [6]

5.2 a Why aren't 'silver' coins made of pure silver? [2]

b Explain, using particle theory, why alloys are harder than the metals they are made from. [4]

5.3 a Which property of metals is most useful when:

- **i** copper is used for electrical wiring [1]
- **ii** gold is used for jewellery [1]
- **iii** iron is used to build bridges [1]
- **iv** stainless steel is used for cooking pans? [1]

b State **three** differences between metals and non-metals. [3]

5.4 Marcus has dropped a glass bottle of copper sulfate crystals on the floor and it has broken into small pieces. He has swept the broken glass and crystals into a container. Explain how he can separate the mixture of glass and copper sulfate crystals. Remember to include a list of equipment he needs and to explain how he will stay safe. You could draw diagrams to help explain. [6]

5.5 Litmus is a dye made from a living organism. It is red in acid. It is blue in alkali. It is purple in a neutral solution.

a What is the correct scientific term for a substance that changes colour in this way? **[1]**

b What colour is litmus in a liquid of pH4? **[1]**

c What colour is litmus in water? **[1]**

5.6 This truck is loading acid at a factory.

a The driver has placed an orange warning notice nearby. **[1]**

Explain why this is important.

b Suggest what could be done if there is an accident and some acid is spilt on the ground. Explain your answer. **[2]**

5.7 The table gives information about the melting points and boiling points of some metals and non-metals.

Substance	Melting point in °C	Boiling point in °C
gold	1064	2850
lead	328	1750
copper	1082	2580
helium	−270	−269
oxygen	−219	−183
mercury	−39	357
aluminium	660	2400
nickel	1455	2150
sulfur	119	445
sodium	98	900

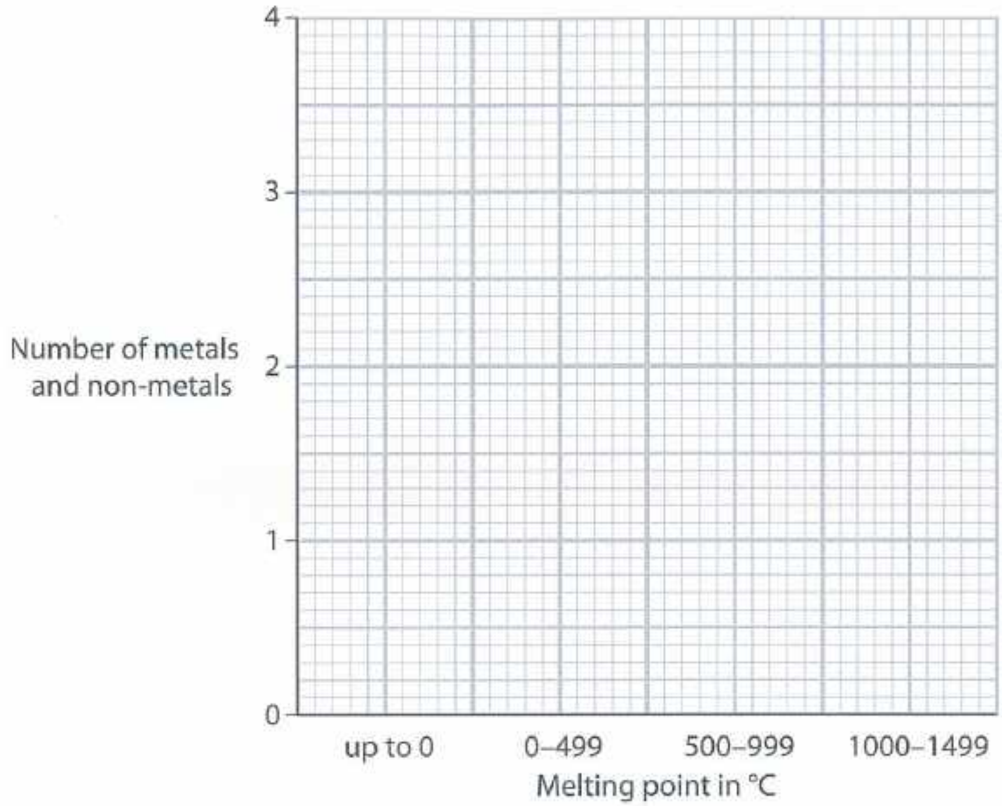
a Copy and complete these tally charts. [2]

Melting point in °C	Tally
up to 0	
0 to 499	
500 to 999	
1000 to 1499	

Boiling point in °C	Tally
up to 0	
0 to 999	
1000 to 1999	
2000 to 2999	

b Plot the tallied figures on two separate frequency diagrams. **[6]**

Use the grid below to help plan your diagram for melting points.



Use the tables and your diagrams to help answer the following questions.

c Which metals and/or non-metals are gases at room temperature of 25 °C? **[1]**

d Which metals and/or non-metals are liquid at room temperature of 25 °C? **[1]**

e Which metals and/or non-metals are solid at room temperature of 25 °C? **[2]**

f Which metal and/or non-metal has the smallest difference between its melting point and its boiling point? **[1]**

g Which metal or non-metal has the largest difference between its melting point and its boiling point? **[1]**

6 Earth physics

6.1 Sound waves

In this topic you will:

- learn how sound comes from vibrations
- discover how particles vibrate in a sound wave
- find out why sound does not travel in a vacuum.

Getting started

Work in groups to discuss the answers to these questions.

1 Give two examples of things that make very loud sounds.
2 Give two examples of things that make very quiet sounds.
3 Give two examples of high-pitched sounds.
4 Give two examples of low-pitched sounds.

Key words

backwards and forwards
loudness
medium
particles
pitch
sound wave
speed of sound

Where does sound come from?

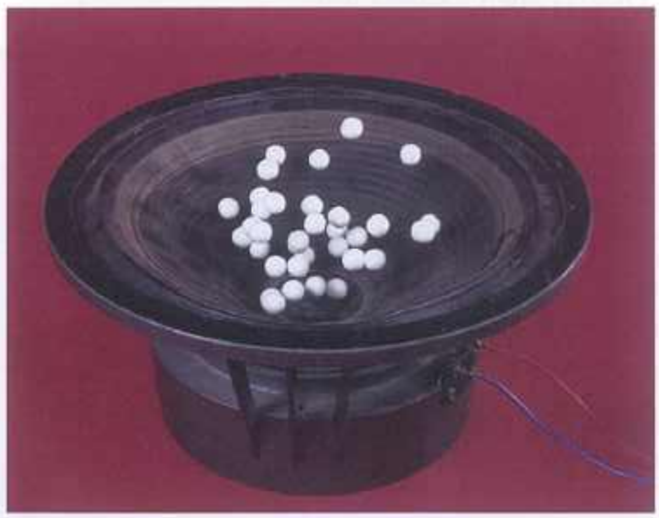
Things that vibrate make sounds. To vibrate means to move **backwards and forwards** very quickly.

The men in the picture are hitting drums to make them vibrate. When the drums vibrate, the drums make a sound.

If you hit a drum with more force, it vibrates more. This makes a louder sound.

If you touch the front of your neck while you are speaking, you can feel a vibration. The vibration comes from your vocal cords, which make the sound when you speak.

Loudspeakers produce sounds from television, radio and music players. If you put small objects into the paper cone of a loudspeaker, the objects will bounce around. This shows that the paper cone in the loudspeaker is vibrating.



Not all sounds are the same.

Sounds can vary in both **loudness** and **pitch**.

Thunder makes a sound with a low pitch.

A baby crying makes a sound with a high pitch.

Questions

1 A guitar is a musical instrument with strings.

Which one of these is needed to make a sound from the guitar?

Write the letter.

A The guitar is made from wood.

B The guitar strings vibrate.

C There is air inside the guitar.

D There are metal parts on the guitar.

2 Zara is playing the guitar by plucking a string.

Which statement describes a way that Zara can make the sound louder?

Write the letter.

A Pluck the string with more force.

B Pluck the string with less force.

C Make the string tighter.

D Make the string looser.

3 Some flying insects make a buzzing sound.

Describe what causes this sound.

Sound waves

Sound travels from a vibrating object to our ears.
This is called a **sound wave**.

What is a sound wave?

When an object vibrates, it moves backwards and forwards.

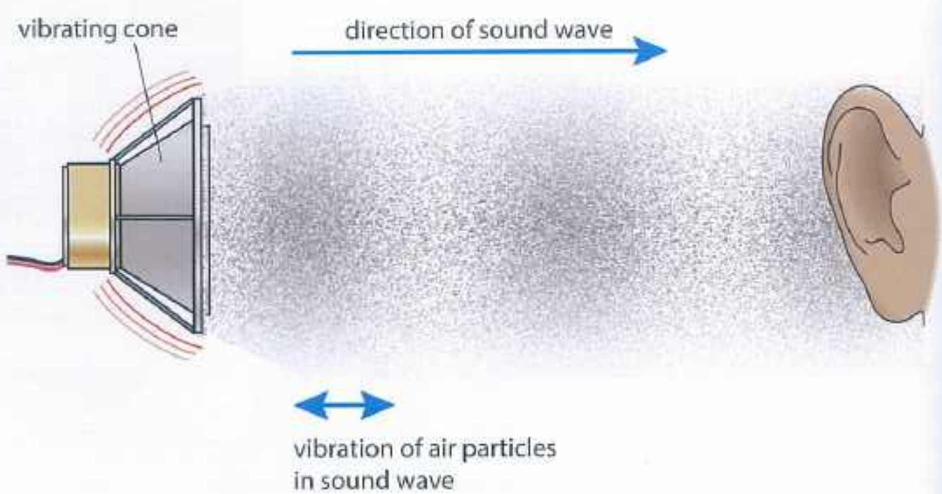
Every time the object vibrates forward, the air in front of the object gets pushed forward.

The **particles** in the air are made to vibrate backwards and forwards in time with the vibrating object.

When the particles in front of the object vibrate, those particles make other particles in front of them vibrate. This makes a sound wave.

The **speed of sound** waves in air is about 343 metres per second.

The picture shows how a vibrating cone in a loudspeaker makes a sound wave.



A sound wave travels to your ear by the vibration of air particles.

The vibrations of the air particles in very loud sounds can cause damage to the ears.

Vibrations from very quiet sounds can be too small for the ears to detect.

Sound at a certain pitch can cause damaging vibrations, even when the sound is not very loud.

You saw in Topic 3.5 that sound is a way of transferring energy. Sound waves transfer sound energy.

The vibration of particles in the air is transferred to other objects. When the vibration is transferred, the other objects will start to vibrate.

The glass in the bottom right picture has broken because of the vibrations of a high-pitch sound.

These people are wearing ear protection while working near an aeroplane.

This boy has thrown some feathers in the air. When they hit the floor there will be a sound but the vibrations will be too small for his ears to detect.

Vibrations from sound can break objects.

Questions

4 Copy the sentence and use the correct word from the list to complete it.

current wind wave stream

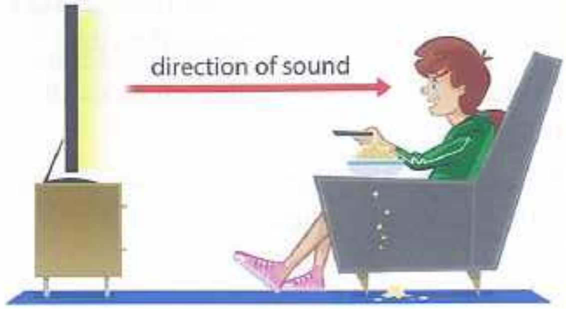
Sound travels through air as a sound..................... .

5 Sofia is watching television.

The sound from the television is travelling across the room, as shown in the diagram.

Which of these arrows shows how the particles in air vibrate?

Write the letter.



6 Thunder can make objects inside a room vibrate.

Explain what causes the objects to vibrate.

7 A fly is walking up a glass window. The fly's feet make vibrations.

Explain why people cannot hear the sound of the fly walking.

Sound waves on the move

Sound waves travel by making particles vibrate. Sound will travel though anything that has particles: gas, liquid or solid.

You can demonstrate this by tapping on a table. Ask another person to listen to the sound. Then ask them to put their ear on the table and listen again.

The first part of this demonstration shows that sound travels through air, which is a gas.

The second part shows that sound travels though the table, which is a solid.

Sound also travels through liquids.

Sound vibrations travel easily through solids.

Animals such as whales and dolphins communicate with sounds.

Sound waves move the same way in gases, liquids and solids. The sound wave makes the particles vibrate backwards and forwards.

The substance that the sound wave moves through is called the **medium**. Therefore, solids, liquids and gases can all be a medium for sound.

These dolphins can use sound to communicate under water.

Vibrations in a vacuum

To hear a sound, there must be:

- a vibration to make the sound
- a medium containing particles through which the sound wave can travel.

You saw in Topic 3.3 that a vacuum is a space where there are no particles.

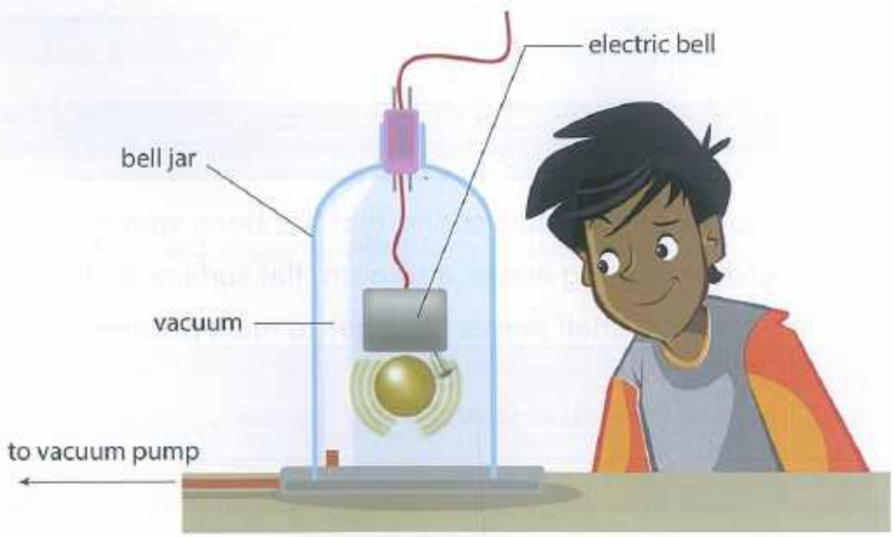
As there are no particles in a vacuum, there is nothing to vibrate to make a sound wave.

Therefore, sound will not travel in a vacuum.

Space is a vacuum. If sound waves could travel through space, we would be able to hear the Sun! Scientists think that the Sun would make a high-pitched humming sound, with louder, low-pitched sounds from time to time.

You can demonstrate that sound does not travel in a vacuum. If you put an electric bell in a glass jar, you can see it vibrate as it makes the sound.

If the air is pumped out of the jar to make a vacuum, you can see the bell vibrating but you cannot hear the sound of the bell.



Sound waves cannot travel in a vacuum as there are no particles to vibrate.

Questions

8 Which of these can sound travel through?

Select all the correct answers. Write the letters.

A **solid**

B **liquid**

C **gas**

D **vacuum**

9 The Moon has no atmosphere. People who went to the Moon wore suits that contained air.

The people who went to the Moon worked close together.

They did work such as hammering and digging.

Explain why the people doing this work could **not** hear it happening.

10 Science fiction films are made in studios on Earth.

These films often show explosions in space.

There is usually a loud bang when the explosion happens.

Explain whether you would really hear an explosion in space.

Activity

Modelling sound waves

Work in groups or as a whole class.

You will need:

- a slinky spring for each group (slinky springs made from metal work better than plastic ones), chalk or small pieces of paper

Do not suddenly release a spring that has been stretched.

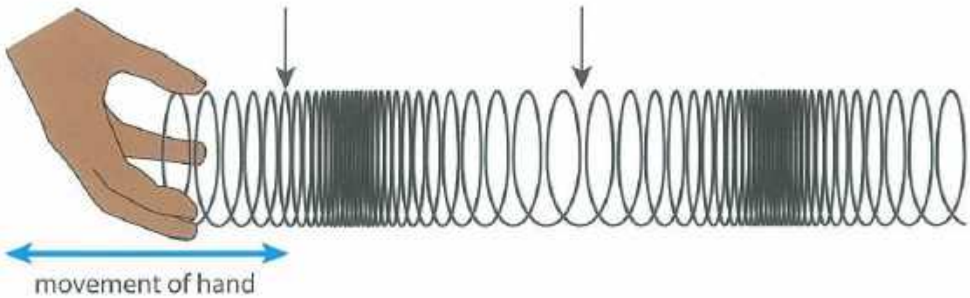
1 Stretch the spring across a smooth, flat surface such as a long bench or the floor.

2 Use chalk or small pieces of paper to mark positions on the spring. These represent particles.

3 One person holds one end of the spring and keeps it still.

Continued

4 Another person holds the opposite end and moves the end of the spring backwards and forwards, as shown in the diagram. This will make a wave in the spring.



Movement of a slinky spring to show movement in a sound wave. The black arrows show possible positions of the chalk marks on the spring.

Questions

In your groups, discuss the answers to these questions.

1 In which direction does the wave in the spring move?
2 Does the whole spring move in that direction?
3 In which direction do the marks that represent particles move?
4 What did the person holding the fixed end of the spring feel from the spring?

- Did you see the representation of movement of particles in the wave?
- Did this help you understand how particles in air move in a sound wave?

Think like a scientist

Sound and vibration

You are going to investigate whether sound requires vibrations to travel.

Work in groups of three.

You will need:

- 2 disposable cups, a sharp object to make a small hole in the bottom of each cup, a string long enough to go across the classroom, scissors to cut the string

Continued

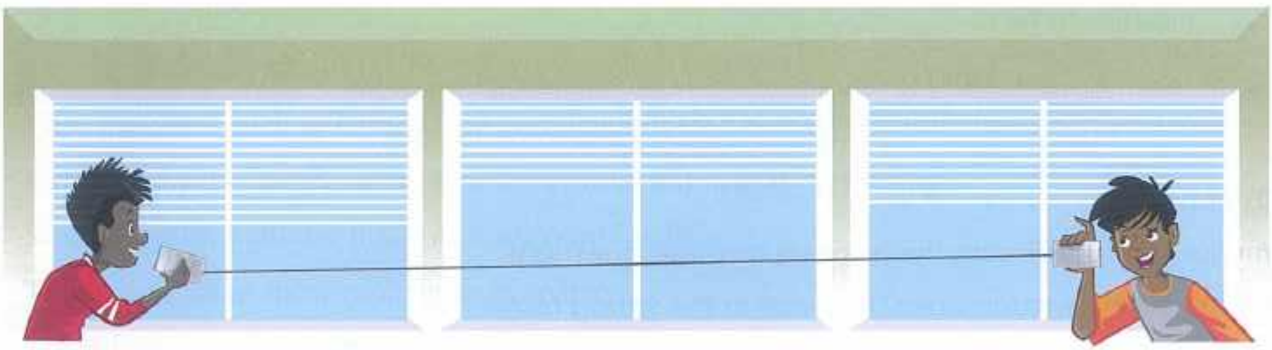
Safety

Take care when using the sharp object to make a hole in the cups.

1 Pass the string through the holes in the cups so that the open ends of the cups face away from each other. Make the string as long as possible.

2 Secure the string inside each cup by tying a knot.

3 Set up the equipment as shown in the diagram. This is sometimes called a string telephone.



4 Pull the string tight between the cups.

5 The person speaking puts the cup over their mouth.

6 The person listening puts the cup over their ear.

7 Speak as quietly as possible, so that the person hears the sound of your voice through the string.

8 Let the string go slack. Say the same thing, with the same loudness, when the string is slack.

9 Pull the string tight again. The third member of the group should grip the string in their hand. Do this around the middle of the string and then in different places.

10 Say the same thing, with the same loudness, when the string is being gripped.

Questions

1 State what the sound wave passes through to travel between the cups.

2 Describe the difference in what you heard when the string was tight and when the string was slack.

3 Describe what happened when the string was gripped in the middle.

4 State whether the position that the string was gripped made any difference to the sound that you heard.

Continued

5 Explain what you can conclude from these observations.

6 It is very difficult to speak with the same loudness each time. Suggest an improvement for this so that the investigation is a fair test.

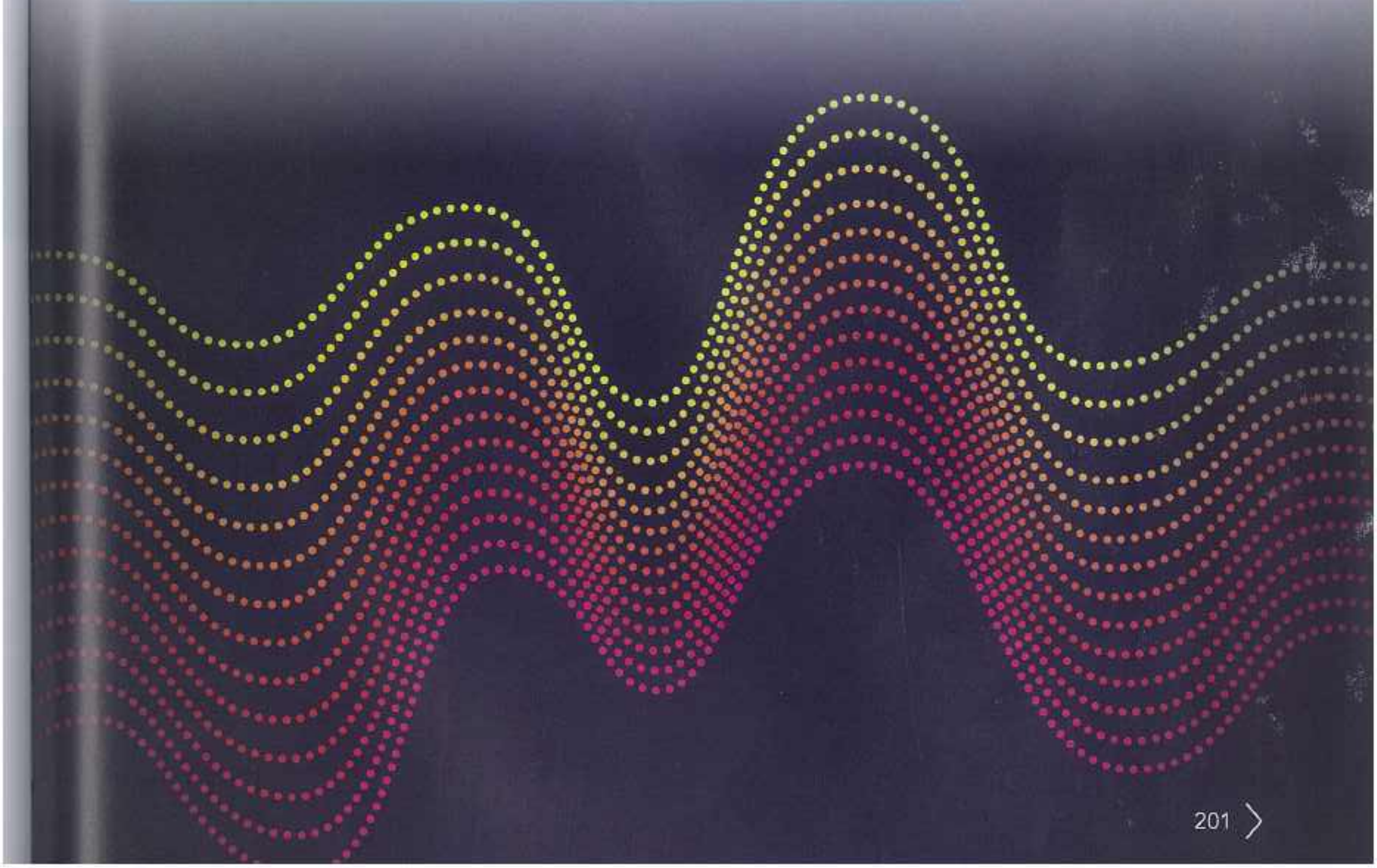
Peer-assessment

Swap your answers with a partner.

- Do your partner's answers agree with your observations in the investigation?
- Do you agree with your partner's conclusion?
- Do you agree with your partner's suggestion for making this a fair test?

Summary checklist

- [ ] I can understand that vibration makes sound.
- [ ] I can understand that sound travels as a wave.
- [ ] I can recall how the particles move in a sound wave.
- [ ] I can recall that sound can travel in solids, liquids and gases.
- [ ] I can understand why sound does not travel in a vacuum.



6.2 Reflections of sound

In this topic you will:

- learn that sound waves can be reflected
- discover what can happen when sound is reflected.

Getting started

Work in groups.

Discuss how you would describe the movement of particles in a sound wave.

For a challenge, try to do this without a diagram and without moving your hands.

Key words

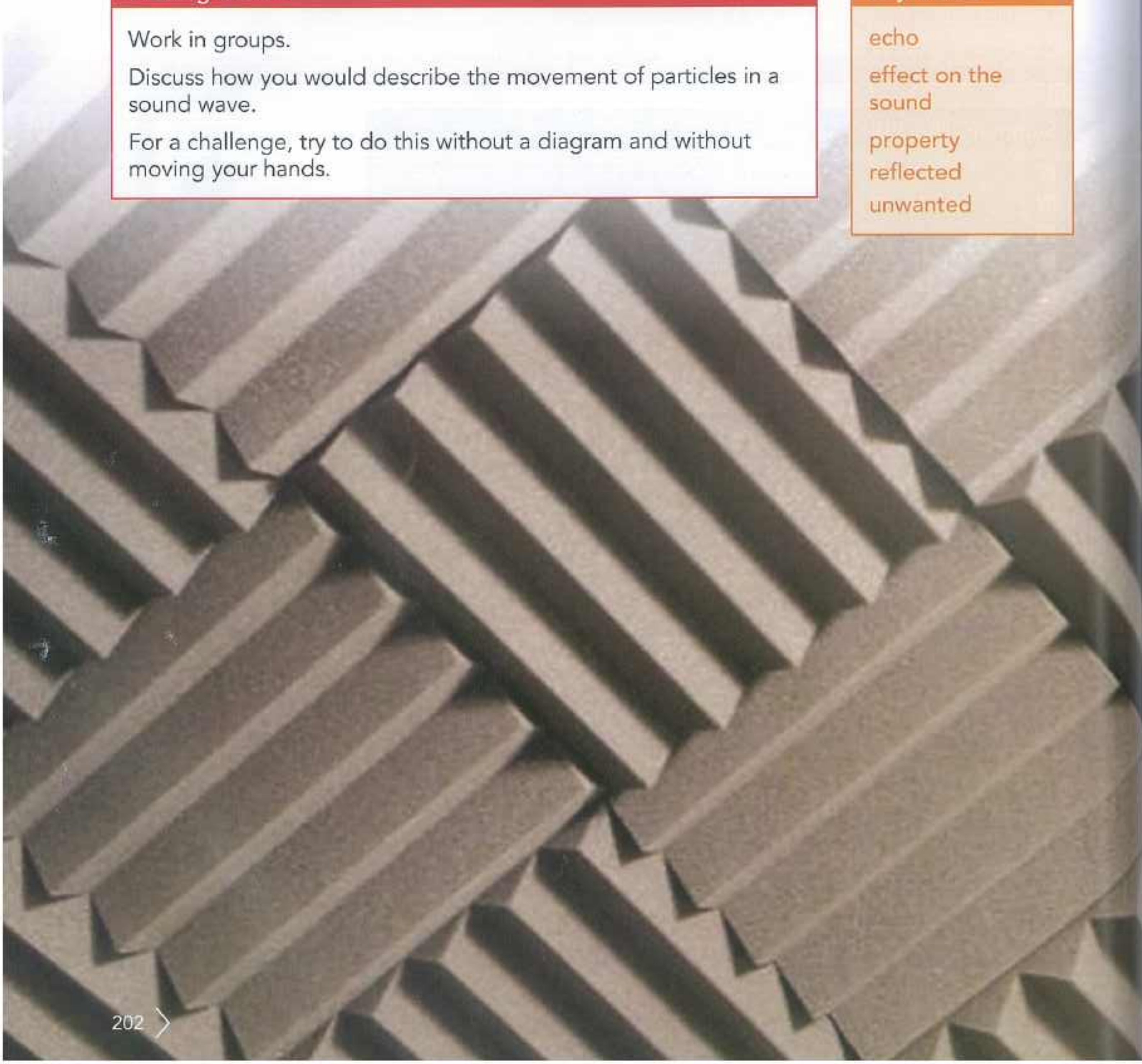
echo

effect on the sound

property

reflected

unwanted



Reflections

One **property** of all waves is that they can be **reflected** from surfaces. Therefore, sound waves can be reflected.

Reflection is like bouncing a ball off a wall. When a wave is reflected, the wave behaves like the ball. The only difference is that a wave is not affected by gravity.

A sound wave travelling towards a wall will hit the wall and come back.

Sound waves reflect best from large, smooth, flat surfaces. Surfaces such as glass, tiles, flat metal and smooth concrete give good reflections of sound.

If you stand between two flat walls you can hear the reflection from sound. You can do this in an empty room.

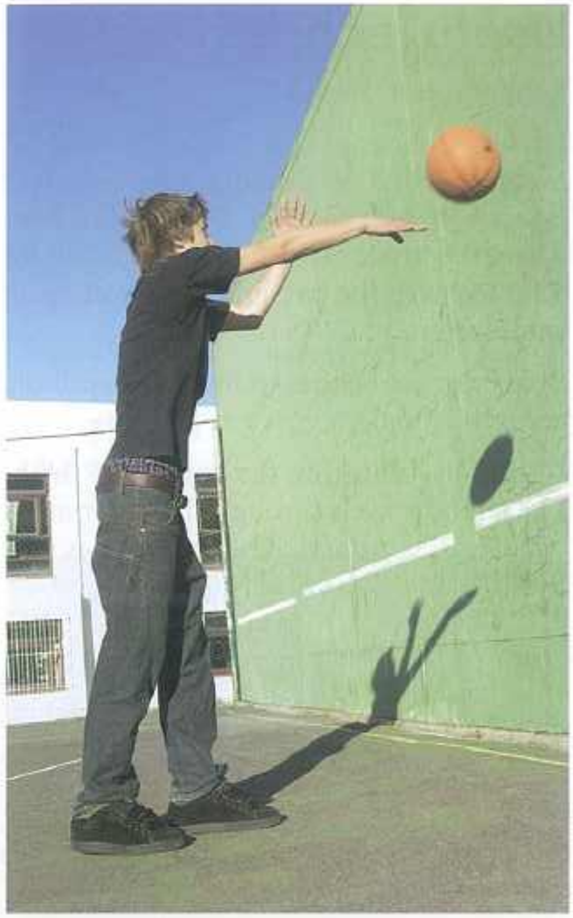
When you clap your hands, you hear a strange **effect on the sound**. An effect on a sound means the sound is changed.

The sound of the clap seems to last longer than usual, then fade away.

Clapping your hands makes a sound wave. The sound wave will travel away from your hands in all directions.

When the sound wave hits a wall, it is reflected back.

The reflection of a sound wave is called an **echo**.



Reflection of a sound wave is like bouncing a ball – the wave comes back off the wall.

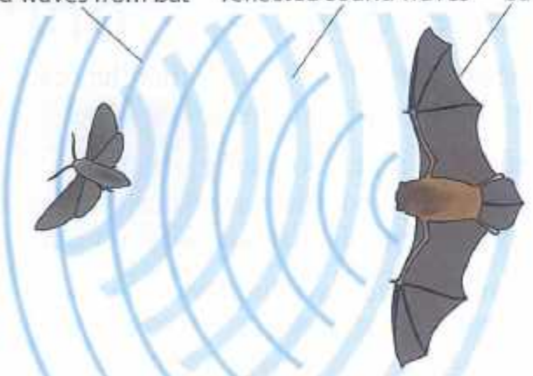
Stand between two flat walls and clap your hands once. What do you hear?

This room would give good reflections of sound.

Useful echoes

Echoes can be useful.

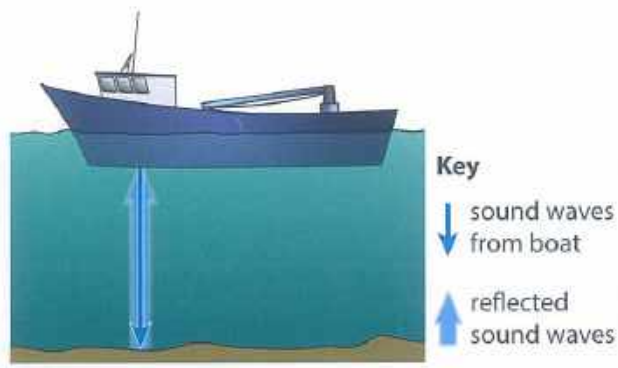
Bats use echoes to find insects for food. The bat makes a sound. The sound wave reflects off the insect – there is an echo. The bat can work out where the insect is from the time taken for the echo to reach the bat, and the direction the echo comes from.



The sound wave from the bat (thin lines) echoes off the insect (wider lines).

Boats can use echoes to find the depth of water under the boat.

A sound is sent from the bottom of the boat. The sound travels through the water and reflects off the solid ground. The echo comes back to the boat. The time taken for the echo to come back can be used to work out the depth.



Notice that the distance travelled by the sound is double the distance from the object making the sound to the reflecting surface. The sound has to travel from the object to the reflecting surface and back again. You can see this in the picture of the bat and insect, and in the picture of the boat.

Echoes can also be used to make images from inside the body. Sounds sent into the mother's body echo back out of her body. This method is used to make the image of the unborn baby.

Unwanted echoes

Sometimes echoes are **unwanted**. For example, when recording music, echoes change the sound. A musical note that is played once will repeat with an echo. This effect will spoil the recording.

A room with large flat walls would give many echoes.

The picture below shows how the walls of a room are changed to stop echoes. This room can now be used to record music without the effect of echoes.

In a theatre, the audience needs to hear the voices of people on the stage. If there were echoes in a theatre, the voices would not be clear. Theatres are designed to stop echoes. Theatres usually have no large flat surfaces that could cause echoes.

The shapes on the walls of this room are made to stop echoes.

The design of this theatre will stop echoes.

Questions

1 Which statement describes what happens to a sound to make an echo?

Write the letter.

A The pitch of the sound increases.

B The pitch of the sound decreases.

C The sound gets reflected.

D The sound gets louder.

2 Which one of these will give the best echo in a room?

All of the materials have the same area.

Write the letter.

A soft curtains

B glass window

C thick carpet

D wool blanket

3 Arun goes to the same music concert in two different theatres, A and B.

The theatres are shown in the pictures.

A

B

Arun says the music sounded better in theatre B.

Use information in the pictures to explain why the music sounded better in theatre B.

4 Zara has an empty room where she can practise playing her drums. Which one of these materials could she put on the walls to stop echoes when she plays?

Write the letter.

A flat wood sheets

B shiny metal sheets

C soft thick curtains

D large flat mirrors

5 **Extension question:**

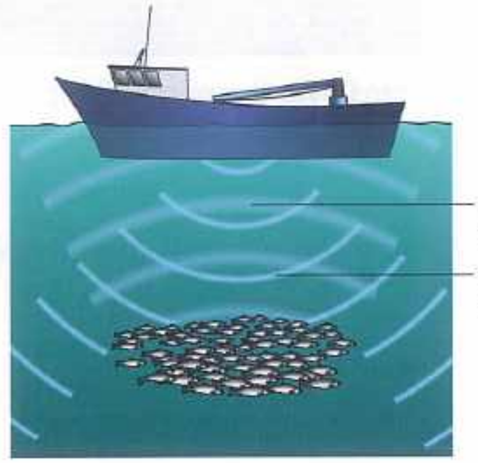
A fishing boat uses an echo to find the distance from the boat to some fish.

A sound is sent from the ship to the fish. The sound reflects back to the ship.

The speed of sound in water is 1500 metres per second.

The time taken for the sound to go from the ship and back to the ship is 0.2 seconds.

Use this equation to calculate the distance from the boat to the fish:
distance = speed × time



Remember that the distance travelled by the sound wave in 0.2 seconds is from the ship to the fish **and back again**.

Activity

Modelling echo location

Some animals, such as bats and dolphins, use echo location to find food. In this activity, you will use light and a mirror to model echo location.

You will need:

- a small plane mirror that can be propped up vertically, a flashlight or ray box, a piece of card or wood that will cover the mirror when placed horizontally, four items to support the piece of card over the mirror

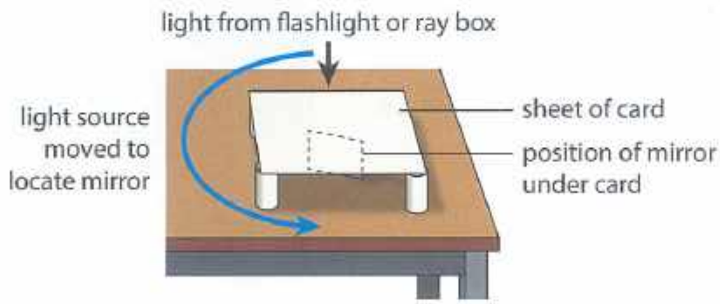
You need to work in pairs, as learner A and learner B. Then swap roles.

Learner A

1 Place the mirror vertically on a desk without letting your partner see.

Continued

2 Place the card over the mirror. Support it so that the mirror cannot be seen, as shown in the diagram.



Learner B

1 Look at the apparatus from above, so that you cannot see where the mirror is.

2 Use the flashlight or ray box to locate the mirror.

3 Attempt to find:

- where the mirror is, as accurately as possible
- what direction the mirror is facing.

Questions

1 In this model, the light represents the sound made by the dolphin or bat. State what the mirror represents.

2 Make a list of:

a strengths of this model in representing echo location

b limitations of this model in representing echo location.

Think like a scientist

How is sound reflected?

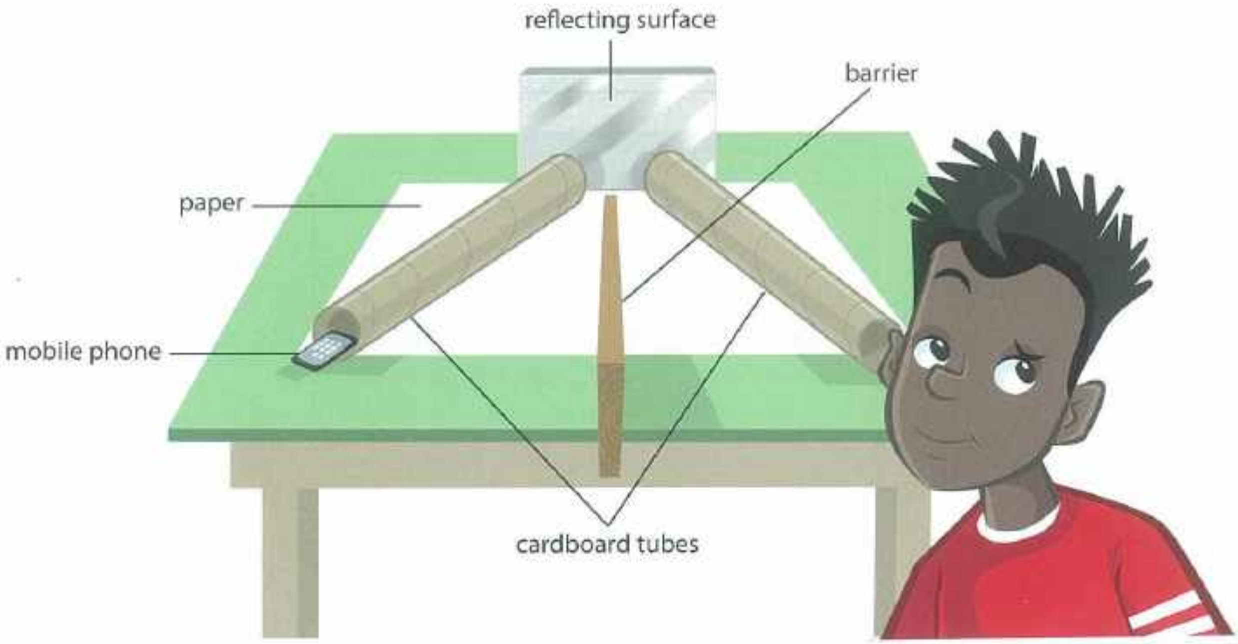
You are going to investigate how sound is reflected.

Work in groups of two or three.

You will need:

- 2 plastic or cardboard tubes and a mobile phone, a large sheet of paper, or 2 A4 sheets taped together, a block or piece of hard plastic, metal or a tile for a reflecting surface, piece of wood for a barrier, a piece of soft material, such as foam or polystyrene as another reflecting surface

1 Set up the apparatus as shown in the diagram.



2 Set the mobile phone to make a quiet sound that you can hear. Place the mobile phone as close as possible to, or inside, one of the tubes. Put the other end of this tube close to the reflecting surface.

3 Mark the position of this tube on the paper.

4 Set the other tube so one open end is close to the reflecting surface and also close to the other tube.

Continued

5 Put your ear to the end of this tube. Turn this tube until the sound from the mobile phone sounds loudest.

6 Mark the position of this tube on the paper.

7 Repeat the investigation with the first tube (containing the mobile phone) in a different position.

8 If you have time, change the reflecting surface.

Questions

1 Describe any trend or pattern you noticed in the positions of the tubes.

2 Describe the observations you made if you changed the reflecting surface.

3 If you did not have time to change the reflecting surface, suggest:

- one surface that would be good for reflecting sound
- one surface that would be bad for reflecting sound.

This investigation can be difficult to do.

Make a list of things you found difficult in this investigation.

Try to suggest improvements that could:

- make the investigation easier
- give better results.

Summary checklist

- [ ] I can understand that sound can be reflected.
- [ ] I can recall what happens when sound is reflected.

6.3 Structure of the Earth

In this topic you will:

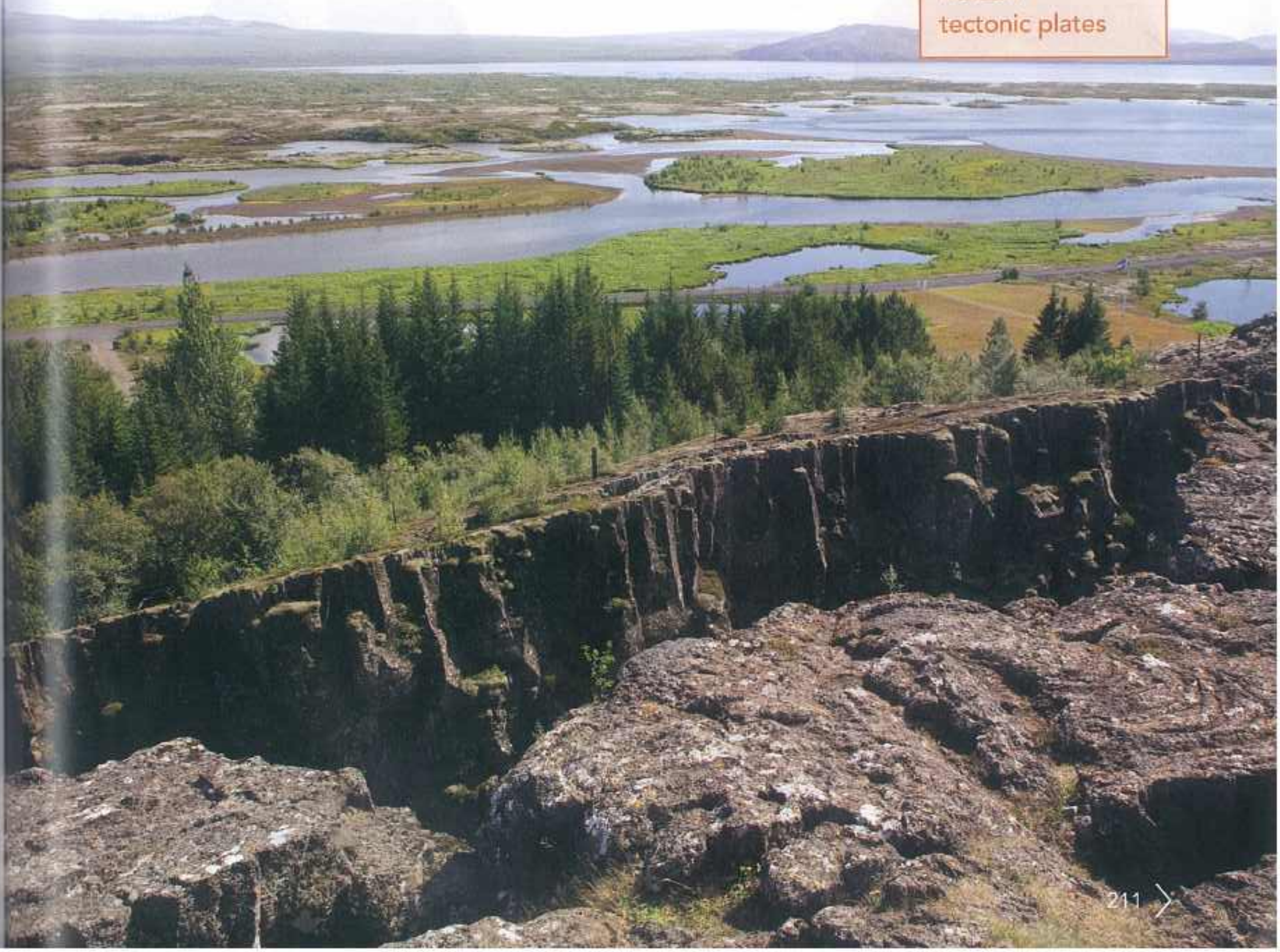
- describe a model of the structure of the Earth
- understand how the continents on Earth have changed.

Getting started

Draw and label a diagram to show what the Earth would look like if it were cut through.

Key words

continental drift
core
crust
magma
mantle
molten
tectonic plates



What do we know about the Earth?

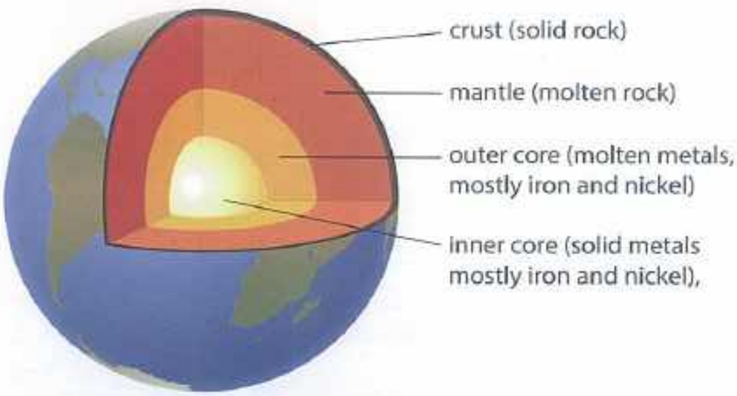
Scientists have worked out that the Earth is about 4500 million years old. They have also worked out what is inside the Earth.

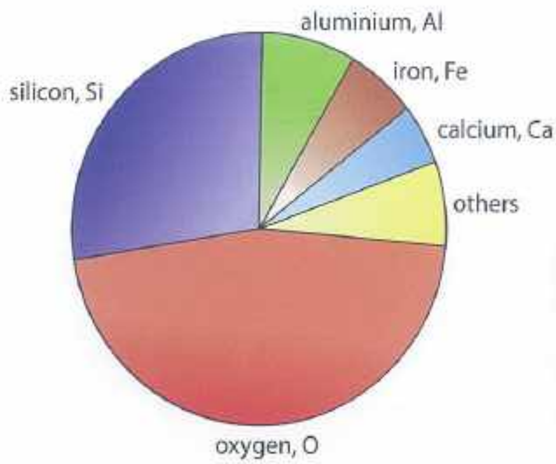
The Earth has a **crust** of solid rock.

Under the crust is the **mantle**, which is **molten** (hot liquid) rock that can flow.

In the centre of the Earth is the **core**. It is made of the metals nickel and iron. The outer part of the core is molten. The inner part of the core is solid.

The rocks found in the crust contain metals and non-metals. The pie chart below on the right shows the approximate proportions of the most common elements in the Earth's crust.





Questions

1 State the name of the part of the Earth that forms the centre.

2 Name the metals found in this part.

3 Name the most common non-metal in the Earth's crust.

4 Name the most common metal in the Earth's crust.

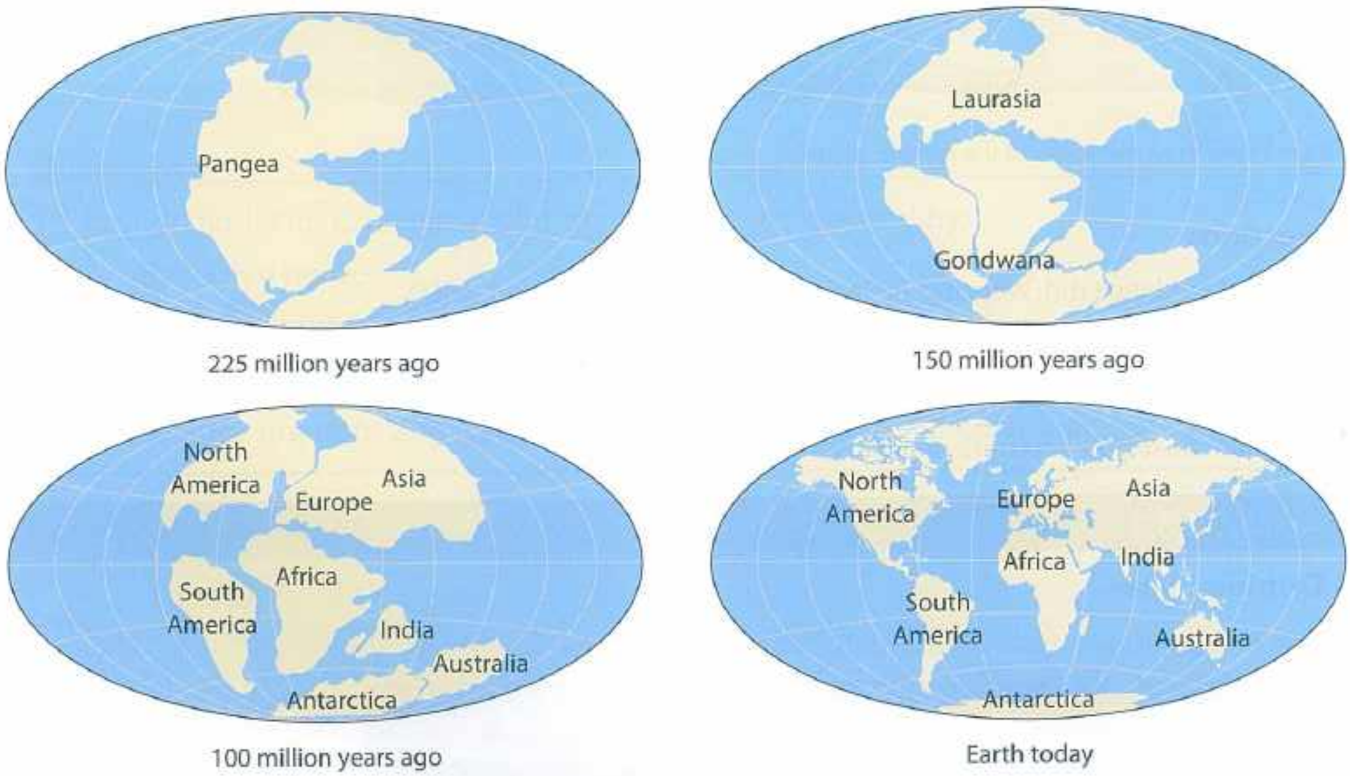
People used to think that the Earth was only a few thousand years old. They thought the Earth had never changed.

In 1912, a German scientist called Alfred Wegener suggested that, millions of years ago, all the land was one large continent. Over millions of years the land broke up and drifted apart. This idea is called **continental drift**.

His evidence for this idea was that:

- the shapes of the continents fit together
- the types of rock on the different continents match up where they fit together
- the fossils on the different continents match up where they fit together.

Wegener could not explain how continental drift happened, so not everyone believed his ideas.

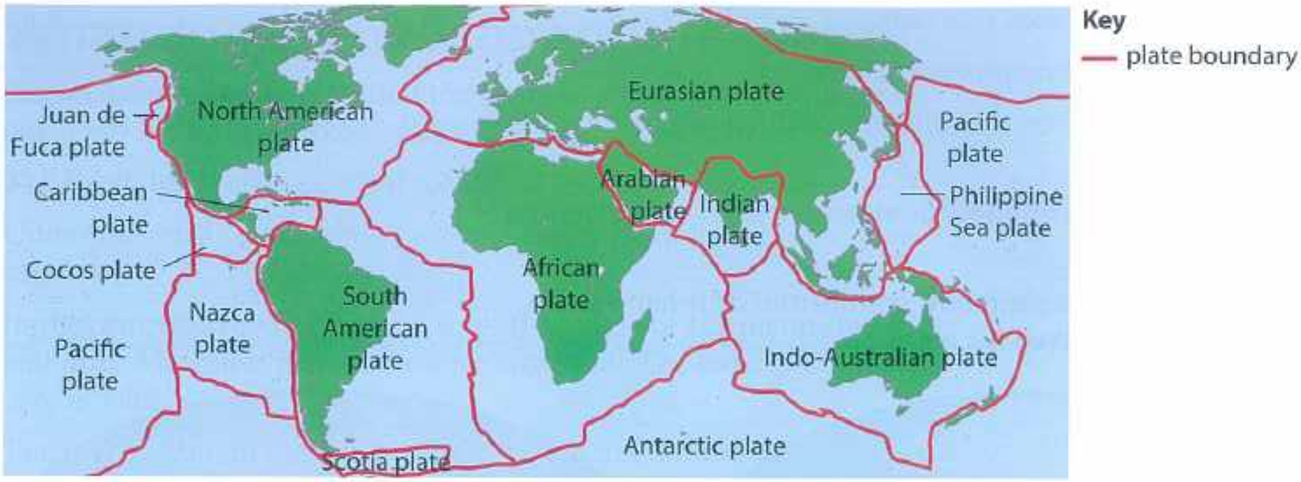


These drawings show how the continents have drifted apart over a very long time.

We now know that the Earth's crust is made up of large **tectonic plates**. Some of the plates are under the oceans: they are called oceanic plates. Some of the plates form the continents: they are called continental plates.

These tectonic plates move slowly on the liquid rock called **magma** beneath them. This is how continental drift occurs.

The plates only move about 4 cm each year, which is about same speed as your fingernails grow.



The red lines show the edges of the tectonic plates.

Questions

5 What evidence did Wegener have for his idea of continental drift?

6 Why did some people reject his idea?

7 Which tectonic plate do you live on?

8 What causes the tectonic plates to move?

Activity 6.3.1

Drifting plates

You are going to model continental drift.

You will need:

- some pieces of polystyrene, water, a large heat-proof dish, something to heat the water, such as a Bunsen burner and safety glasses

Safety

Take care when heating the water, as the dish may get very hot. Wear safety glasses. Do not touch equipment until it has had time to cool.

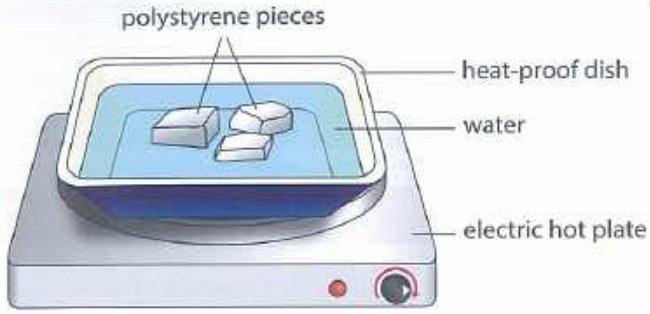
1 Pour some water into the heat-proof dish.

2 Place the pieces of polystyrene on the water. Wait for them to stop moving.

Continued

3 Heat the water gently.

4 Observe what happens.



Questions

1 In your model for continental drift, state what is represented by:

  a the polystyrene

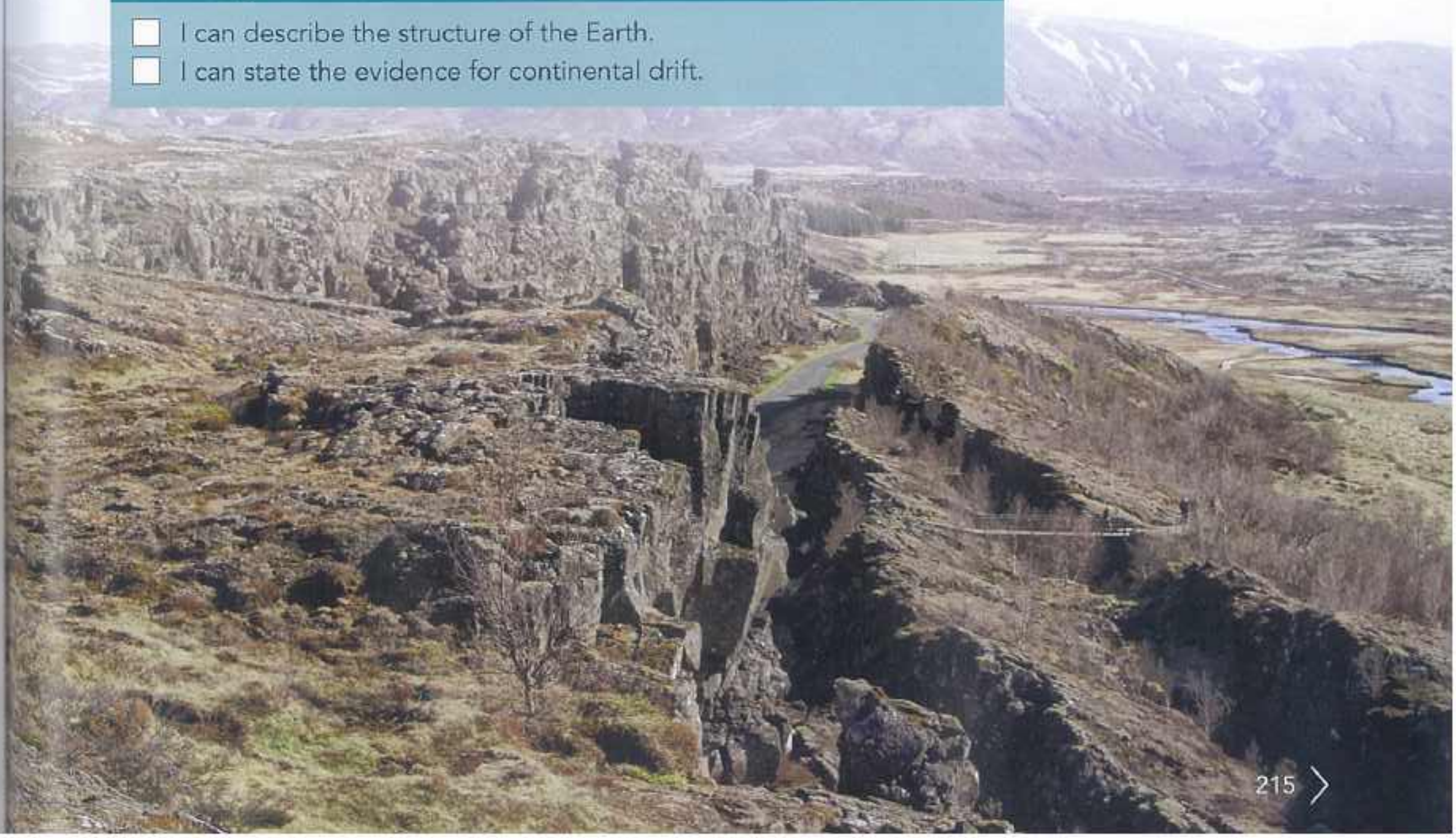
  b the heat source

  c the water.

2 Explain the strengths and weaknesses of this model of continental drift.

Summary checklist

- [ ] I can describe the structure of the Earth.
- [ ] I can state the evidence for continental drift.



6.4 Changes in the Earth

In this topic you will:

- explain how fold mountains and volcanoes are formed
- explain how earthquakes happen.

Getting started

Work with a partner.

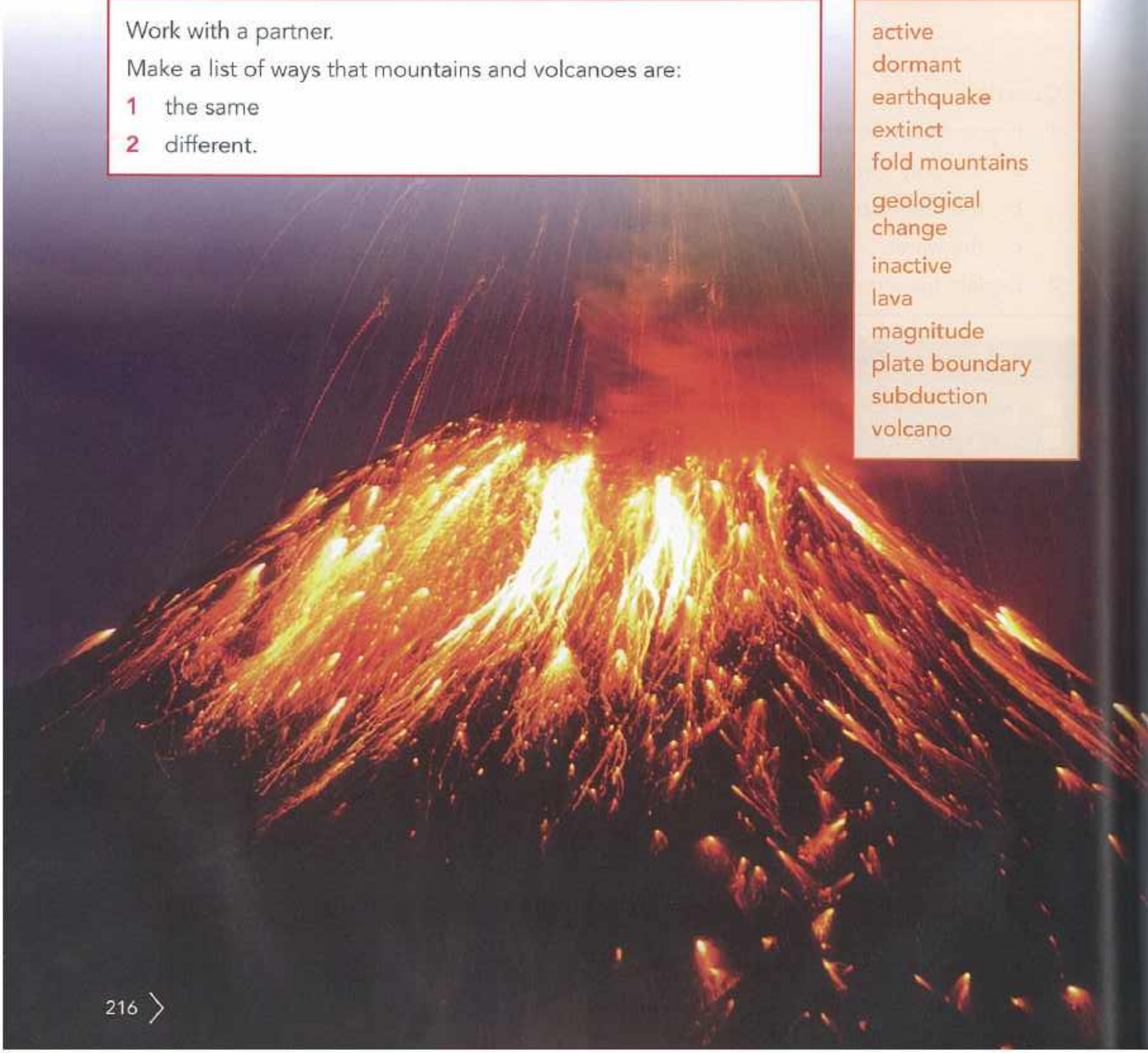
Make a list of ways that mountains and volcanoes are:

1 the same

2 different.

Key words

active
dormant
earthquake
extinct
fold mountains
geological change
inactive
lava
magnitude
plate boundary
subduction
volcano

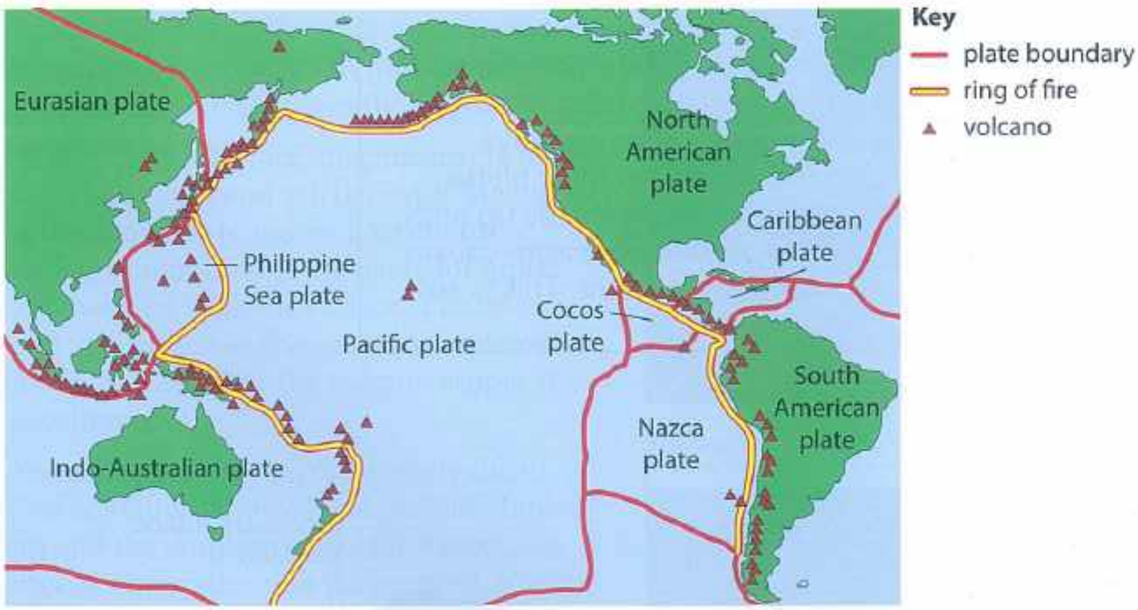


Geological change

The places where tectonic plates meet are called **plate boundaries**.

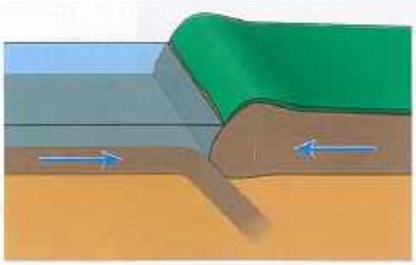
Geological change happens most frequently at plate boundaries. This is because the tectonic plates are always moving. Some of the geological change is very slow – it happens over millions of years. But some of the geological change is very sudden and violent.

This illustration shows the plate boundaries around the edge of the Pacific Ocean. There are many geological changes and events, such as volcanic eruptions and earthquakes, here. This area is often called the Pacific Ring of Fire.



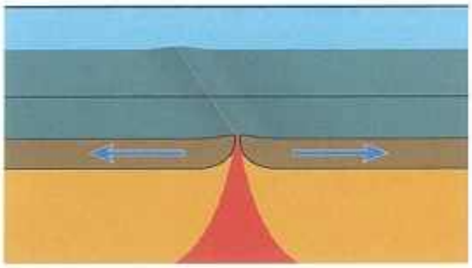
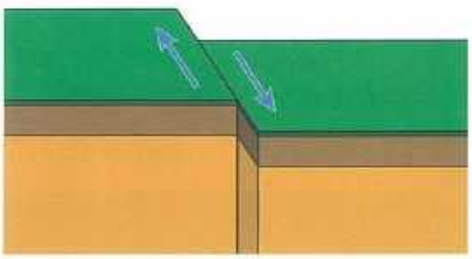
Movement of plates

The movement of tectonic plates creates three types of plate boundaries.



Plates moving together

One plate may slide underneath the other one. This is called **subduction**. The rocks in the Earth's crust melt as they move into the mantle. They become part of the mantle.

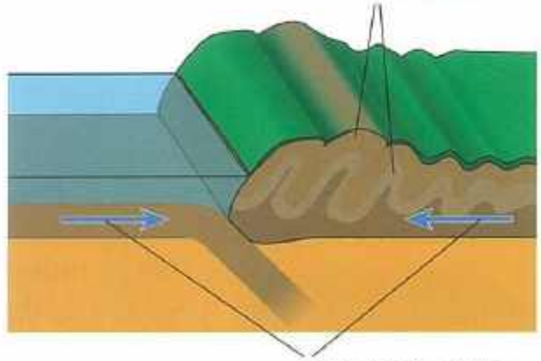
	**Plates moving apart** As tectonic plates drift away from each other, they break and crack when they become too thin. **Lava** (liquid rock) erupts from the mantle and hardens to form new crust with new rocks. This causes a **volcano**.
	**Plates sliding past** Because the plates are very large and heavy, there is a lot of friction between the plates. Over the years, this makes the plates stick together. There is always force on the tectonic plates, so the pressure builds up and eventually the pressure causes violent movement. This is an **earthquake**.

Fold mountains

Sometimes, when tectonic plates move together, the rocks crumple and fold upwards. The mountains that this produces are called **fold mountains**.

This can happen under the ocean or on land.

The newest fold mountains are between 10 and 25 million years old. These include the Himalayas in Asia and the Rocky Mountains in North America. The oldest fold mountains are more than 200 million years old. These include the Ural Mountains in Russia.



The Himalayas, Rocky Mountains and Ural Mountains were all formed when tectonic plates pushed against each other.

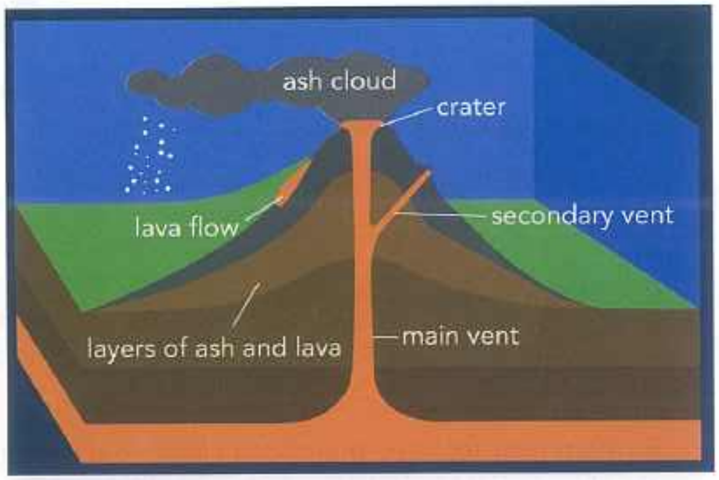
Volcanoes

Volcanoes are usually formed at the plate boundaries when magma from the mantle rises up through cracks in the Earth's crust.

At the Earth's surface, magma erupts to form lava flows and ash deposits. Magma is the name for liquid rock when it is underground. Lava is the name for liquid rock when it is on the surface. The lava and ash harden as they cool to form new rocks. So each time the volcano erupts, it gets bigger.

Sometimes, if the magma is really thick, and contains dissolved gas, pressure builds up and the eruption is violent. Gases and rock shoot up through the opening. Violent eruptions can even cause avalanches and earthquakes – and tsunamis if the volcano is close to the sea.

Some volcanoes are **active** and may erupt at any time. Some volcanoes are **inactive** or **dormant**, which means they have not erupted for a very long time. Other volcanoes are **extinct**, which means they will not erupt again.



The parts of a volcano.

A powerful eruption at Anak Krakatau volcano, Indonesia. Part of the volcano was blown off into the sea, causing a tsunami.

Earthquakes

Some earthquakes are extremely violent and cause a lot of damage. Some are so slight that they only register on scientific instruments.

The size or **magnitude** of the earthquake depends on the size of the faults at the plate boundaries, and how far the rocks move when the earthquake happens. In the largest earthquakes, the rocks can move tens of metres in seconds.

Earthquakes can cause damage to roads and buildings.

Questions

1 Which statement is true about tectonic plates?

Write the letter.

A They never move.

B They move in different ways.

C They always move towards each other.

D They always move away from each other.

2 Explain how tectonic plates can cause fold mountains to form.

3 Which word is used to describe the strength of an earthquake?

Write the letter.

A force

B energy

C magnitude

D destruction

4 Explain what causes an earthquake.

Activity

Model for moving tectonic plates

Try out these models to show what happens where tectonic plates meet.

You will need:

- a large piece of cloth, 2 pieces of paper, modelling clay, 2 chocolate bars with soft centres (not solid chocolate)

Safety

Do not attempt to eat chocolate that has been used in a classroom or laboratory.

Model A

Place a large piece of cloth on the table.

Place your hands flat on the cloth, about 30 cm apart. Push your hands together.

Model B

Place two pieces of paper flat on the table so that they are touching. Push them together. Can you make them slide so that one piece goes over the other one? This is similar to what happens when one tectonic plate slides over another. Can you make the pieces of paper form mountains?

Model C

Use modelling clay and make two flat pieces. Place them on the table and then push them together. What happens?

Model D

Push the two chocolate-covered bars together. What happens?

Questions

For each of the models you used:

1. Describe what happened.
2. Explain what it was modelling.
3. Discuss the strengths and limitations of the model.
4. Could you improve that particular model in any way?
5. Which do you think was the best model? Why?

Summary checklist

- [ ] I can describe how fold mountains are formed.
- [ ] I can explain how earthquakes occur.
- [ ] I can describe how volcanoes are formed.

6.5 Solar and lunar eclipses

In this topic you will:

- find out how solar eclipses happen
- find out how lunar eclipses happen.

Getting started

Discuss the answers to these questions. Work in groups of three or four.

1 Which of these describes how light travels?

in curved paths   in straight lines   in circles
randomly in straight and curved paths

2 Explain how a shadow is formed.

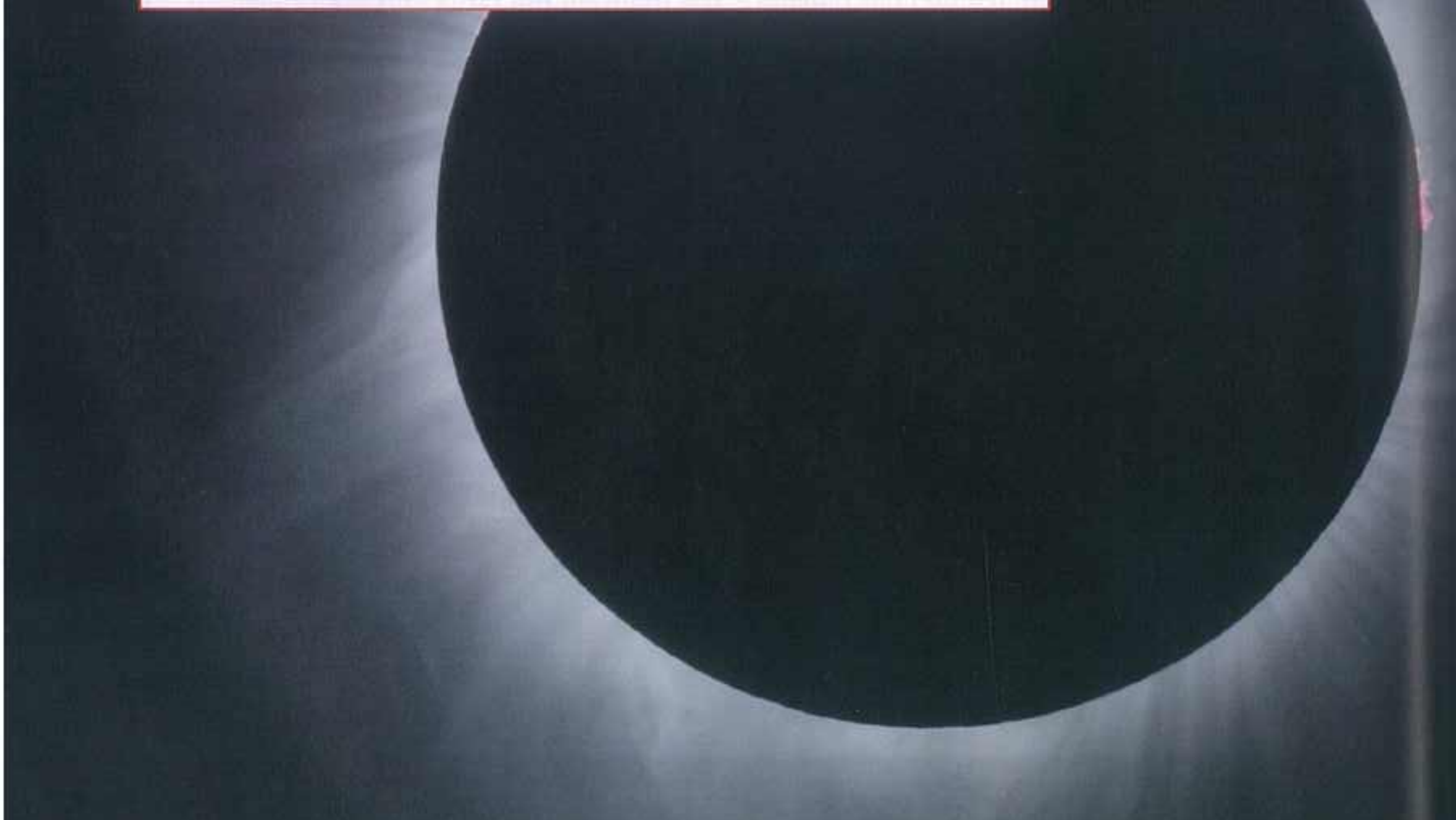
3 Decide whether each of these statements is true or false.

The Moon gives out its own light.

The Sun gives out its own light.

Key words

lunar eclipse
opaque
partial
ray
shadow
solar eclipse
total



Shadows

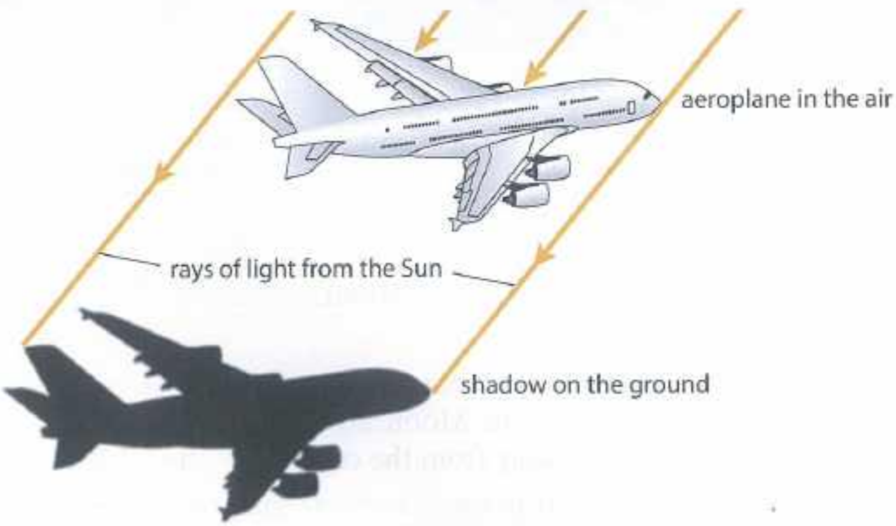
An **opaque** object is an object that will not allow light to pass through.

When an opaque object passes in front of a source of light, a **shadow** will form.

Look at the shadow of the aeroplane in the picture. The shadow looks dark because the light from the Sun has been blocked from reaching the ground. The aeroplane is made from metal which is opaque.

The grass around the shadow looks brighter because light from the Sun is reaching those areas.

The next picture shows how the shadow is formed.



Light travels in straight lines called **rays**. Light rays from the Sun cannot pass through the aeroplane, so light rays that reach the aeroplane cannot reach the ground.

Imagine you were standing on the grass. When the shadow of the aeroplane passes you, it will seem to go dark. When the shadow has gone, it will get brighter again.

Solar eclipse

A **solar eclipse** happens when the Moon comes between the Sun and the Earth.

The Moon is made from rock, so is an opaque object. The Moon blocks the rays of light coming from the Sun.

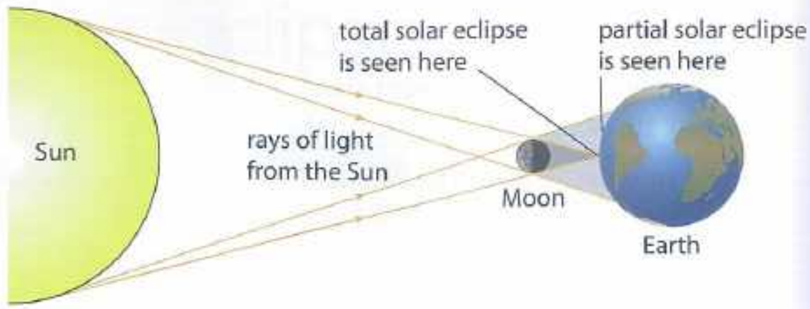
The shadow of the Moon forms on the Earth.

The diagram shows how the shadow of the Moon is formed on the Earth. In the middle of the shadow, all the light rays from the Sun are blocked. People in the middle of the shadow observe a **total** solar eclipse.

The left picture shows what a total solar eclipse looks like.

Away from the middle of the shadow of the Moon, some of the light rays from the Sun can reach the Earth. Away from the middle of the shadow there is a **partial** solar eclipse.

The right picture shows what a partial solar eclipse looks like.



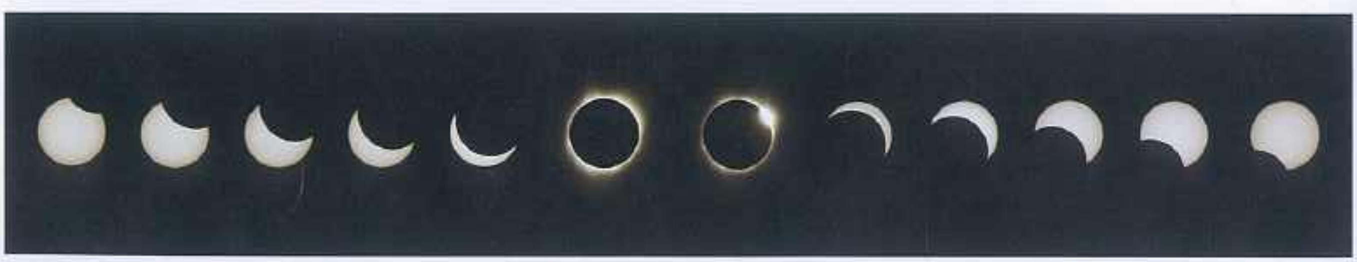
A solar eclipse happens when the Moon comes between the Sun and the Earth.

A total solar eclipse is seen from the middle of the Moon's shadow.

A partial solar eclipse is seen away from the middle of the shadow of the Moon.

The picture below shows a series of photographs taken as the Moon passes between the Earth and the Sun.

The picture on the next page shows what a solar eclipse looks like from space. The dark part of the Earth is in the shadow of the Moon. At the centre of the shadow, there is a total solar eclipse. Away from the centre, there is a partial solar eclipse.



The Moon is passing between the Sun and the Earth in these photographs.

You must **never** look directly at the Sun, even when there is an eclipse. The light from the Sun is very bright and can cause permanent damage to your eyes.

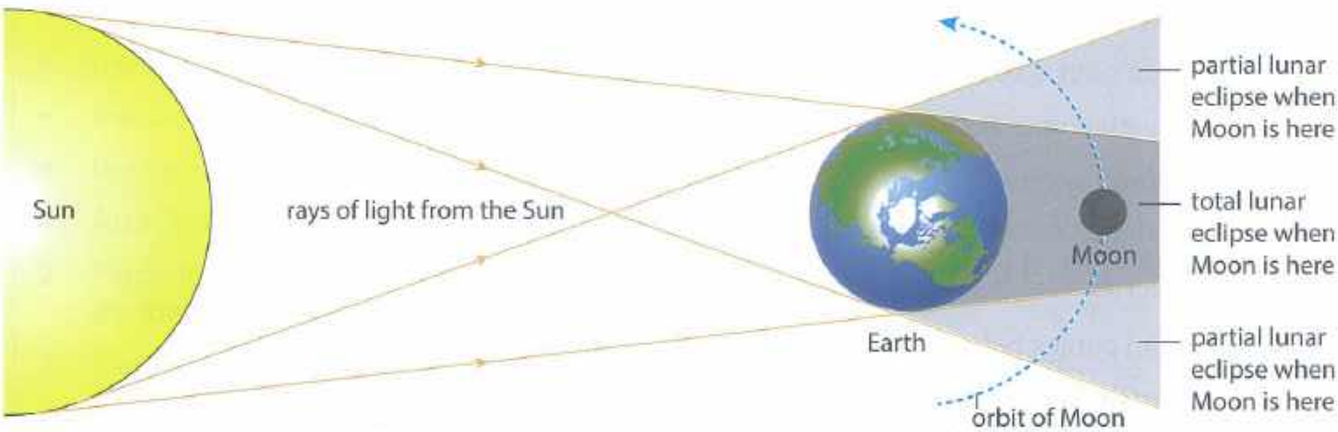
The dark part of the Earth is in the shadow of the Moon. People here see a solar eclipse.

Lunar eclipse

A **lunar eclipse** happens when the Earth comes between the Sun and the Moon.

The Earth is also an opaque object, so the Earth blocks the light from the Sun. The shadow of the Earth is formed on the Moon.

The diagram below shows how the shadow of the Earth forms on the Moon.



A lunar eclipse happens when the Earth comes between the Sun and the Moon.

The picture on the next page shows a series of three photographs of the shadow of the Earth passing across the Moon.

You might think that solar and lunar eclipses should happen every month. The Moon takes 27 days to orbit the Earth, but the orbit of the Moon is tilted slightly. The orbit of the Moon is not exactly in the same plane as the orbit of the Earth around the Sun.

It is only when the Sun, Earth and Moon are in the same straight line that eclipses can happen.

Questions

1 Which of these describes how a solar eclipse happens?

Write the letter.

- **A** The Sun comes between the Moon and the Earth.
- **B** The Earth comes between the Moon and the Sun.
- **C** The Moon comes between the Earth and the Sun.

2 Which of these describes how a lunar eclipse happens?

Write the letter.

- **A** The Sun comes between the Moon and the Earth.
- **B** The Earth comes between the Moon and the Sun.
- **C** The Moon comes between the Earth and the Sun.

3 Explain why a solar eclipse can only ever be seen in the daytime.

4 Write true or false for this statement.

A total lunar eclipse can only ever be seen in the daytime.

Explain your answer.

Activity 6.5.1

Classroom eclipses

In this activity, you will make models to show how eclipses happen.

Work in groups of four or five.

You will need (per group):

- an electric lamp and power supply – 12 V lamps work well, a white soccer ball, a tennis ball, a paper cup, a light string or thread, adhesive tape

Safety

Take care not to touch the lamp because it will be hot. Do not look directly at a bright lamp. Use only a lamp and do not use the Sun for any part of this activity.

You need to work in a shaded position in the room. You should turn the classroom lights off. If your classroom has blinds or curtains, these should be closed.

In your model:

- the electric lamp will be the Sun
- the white soccer ball will be the Earth
- the tennis ball will be the Moon.

1 Attach the string to the tennis ball with the adhesive tape.

2 Place the soccer ball on the plastic cup. This will lift the ball off the desk and also stop the ball from rolling.

3 Place the lamp about 50 cm from the soccer ball. Switch on the lamp.

4 One side of the soccer ball should be lit from the lamp. The other side of the soccer ball should be in the shade.

Questions

1 In your model, which side of the Earth is in the day and which side is in the night?

Hold the string so the tennis ball hangs down.

Move the tennis ball between the lamp and the soccer ball. The shadow of the tennis ball should be seen on the soccer ball.

2 What type of eclipse is the model showing?

3 Point out where there is a total eclipse and where there is a partial eclipse.

Now move the tennis ball to the other side of the soccer ball. Make sure the tennis ball is in the shade of the soccer ball.

4 What type of eclipse is the model showing now?

Continued

Self-assessment

Give each of these statements a number from 1 to 5.

1 means 'strongly disagree' and 5 means 'strongly agree'.

- I understood why a lamp was used to model the Sun.
- I understood why the model of the Earth was bigger than the model for the Moon.
- I understood how the model showed a solar eclipse.
- I understood how the model showed a lunar eclipse.

- How did you decide which type of eclipse happened in your model?
- How well do you think the model showed eclipses?

Think like a scientist

Making predictions about eclipses

In this task, you will think about making observations and using them to make predictions.

Astronomers in the Middle East made the earliest known predictions of when eclipses would happen. The astronomers were working about 3000 years ago.

1 List the facts that need to be given when making a prediction about an eclipse.

2 These astronomers 3000 years ago knew that the pattern of solar eclipses repeats after every 223 lunar months.

  One lunar month is 29.5 days.

  Calculate the number of days in 223 lunar months.

3 Suggest what must happen to the Sun, the Moon and the Earth every 223 lunar months.

4 Explain how a pattern of observations can be used to make future predictions.

5 Scientists working in the present day have predicted eclipses into the future.

  Scientists think these predictions are accurate until 17 April 3009.

  Describe how the accuracy of an eclipse prediction can be tested.

Continued

6 Suggest why the accuracy of eclipse predictions decreases as the time into the future of the prediction increases.

7 Scientists working in the present day have also calculated when eclipses happened in the past.

There was a battle in Greece in the year 585 BCE. People at that time recorded that there was an eclipse during the battle.

Scientists in modern times have worked out that the battle happened on 28 May 585 BCE.

Explain how scientists can use information about the eclipse to work out the exact date of the battle.

8 What type of eclipse is shown in the photograph?

Explain your answer.

Summary checklist

- [ ] I can understand how a solar eclipse happens.
- [ ] I can understand how a lunar eclipse happens.

Project

Volcanoes and earthquakes

The actions of volcanoes and earthquakes change the rocks and the shape of the land on Earth.

You have four tasks to complete in your group.

1 Make a model to show how a volcano erupts or an earthquake takes place.

You may use any materials you choose but you need to label the parts.

2 Explain how the volcano erupts or an earthquake takes place. You can do this by making a poster or writing a statement as if you are an expert who needs to explain to a journalist why a recent volcanic eruption or earthquake has happened.

3 Research a recent volcanic eruption or earthquake. Write a report about:

- the immediate damage it has caused, and how this affects people
- the long-term effects to the lives of people, plants and wildlife in the area.

You will present your model and explanations to the whole class.

4 Research how scientists detect movements in the Earth's crust. Include how this technology:

- has developed over the last 2000 years
- can be used to make predictions about earthquakes and volcanic eruptions.

Check your Progress

6.1 Which of these is needed for a sound to be made? [1]

heat **light** **liquid** **vibration**

6.2 Arun drops his pen on the floor. Sofia hears the pen hit the floor.

Copy the sentences and use words from the list to complete them. [2]

You can use the words once, more than once or not at all.

the pen **sound wave** **Sofia's ears** **air** **particles**

A ………………… travels from ………………… to ………………… .

The ………………… travels through the ………………… .

6.3 Draw an arrow to show the direction of a sound wave. Your arrow can be in any direction.

Now show the direction of movement of the particles in your sound wave. [3]

6.4 A slinky spring can be used to show how particles move in a sound wave.

Which of these describes this use of a slinky spring? [1]

modelling **predicting** **concluding** **observing**

6.5 a Match the parts of the of the Earth's structure, A–D, with the descriptions, W–Z. [2]

Parts of the Earth's structure
A Inner core
B Outer core
C Mantle
D Crust

Descriptions
W molten iron and nickel at the centre
X solid outer layer of the Earth
Y molten rock below the crust
Z solid iron and nickel at the centre of the Earth

b What are tectonic plates? [2]

6.6 State what can happen when tectonic plates rub against each other in opposite directions. **[1]**

6.7 Describe how new fold mountains form. **[2]**

6.8 Copy the sentence and use words from the list to complete it.

Each word can be used once, more than once or not at all. **[2]**

light **the Sun** **the Moon** **shadow**

A solar eclipse happens when the .... of .... forms on the Earth.

6.9 Make two copies of this diagram. Your copies do not have to be accurate.

a Add the Moon to your first diagram to show how a lunar eclipse happens. **[1]**

b Add the Moon to your second diagram to show how a solar eclipse happens. **[1]**

7 Microorganisms in the environment

> 7.1 Microorganisms

In this topic you will:

- learn about the different kinds of microorganism
- grow some microorganisms on agar jelly.

Getting started

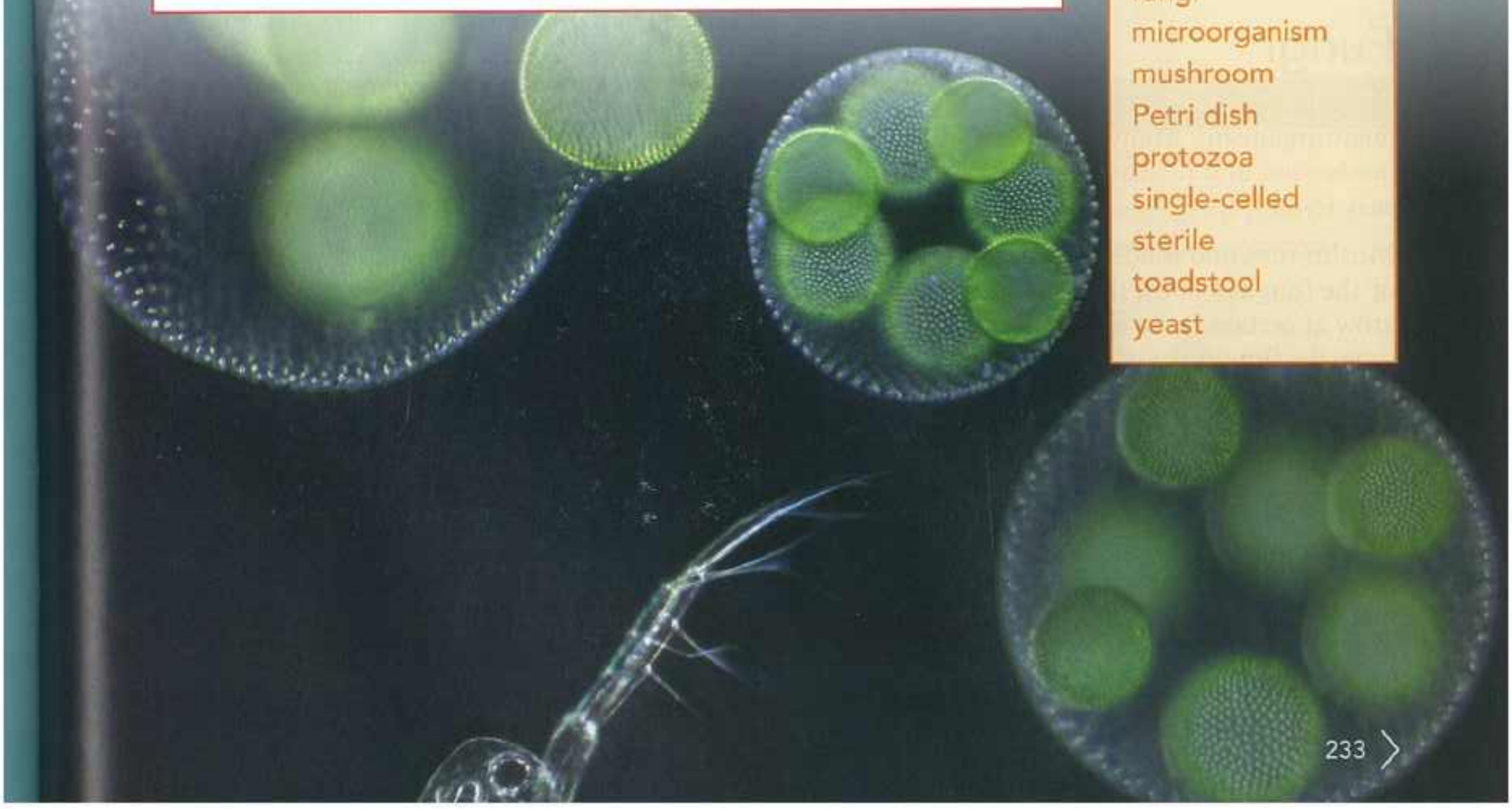
Work individually to answer these questions.

1 Some bacteria can cause diseases in humans.
  Can you name **two** diseases caused by bacteria?

2 What other kinds of organisms can cause disease?

Key words

agar jelly
algae
bacteria
colony
fungi
microorganism
mushroom
Petri dish
protozoa
single-celled
sterile
toadstool
yeast



What is a microorganism?

A **microorganism** is a living organism that is so small that you can only see it clearly by using a microscope.

Like all living organisms, microorganisms are made of cells. Many microorganisms are made of only one cell: they are **single-celled**.

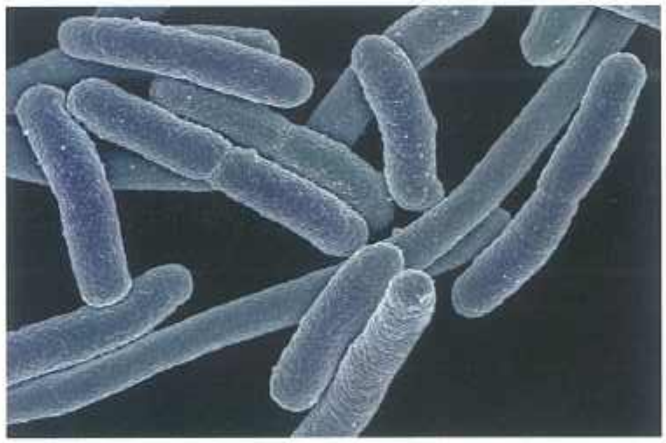
There are several different kinds of microorganism. They include **bacteria**, microscopic **fungi**, **protozoa** and **algae**. Each of these microorganisms is described later in this topic.

Bacteria

Bacteria are everywhere. (Bacteria is a plural word. The singular word, for just one of them, is bacterium.)

Each bacterium is made of a single cell. Cells of bacteria are much smaller than animal cells or plant cells. You could fit 1000 of the bacteria in the photograph, lined up end to end, between two of the millimetre marks on your ruler.

Most bacteria are harmless but there are a few kinds that can make you ill.



These bacteria live in our digestive systems. They are completely harmless.

Fungi

Fungi (singular: fungus) are not always microorganisms. Many fungi, including **mushrooms** and **toadstools**, are large and easy to see.

Mushrooms and toadstools are only part of the fungus's body, though, and they only grow at certain times of year. Most of the time, the fungus is just a tangle of very thin threads. The threads often grow under the ground, or inside a dead log. The threads are so thin that they are difficult to see without a microscope.

There are also some kinds of fungi that do not produce mushrooms or toadstools. They are made of single cells, not threads, so they are

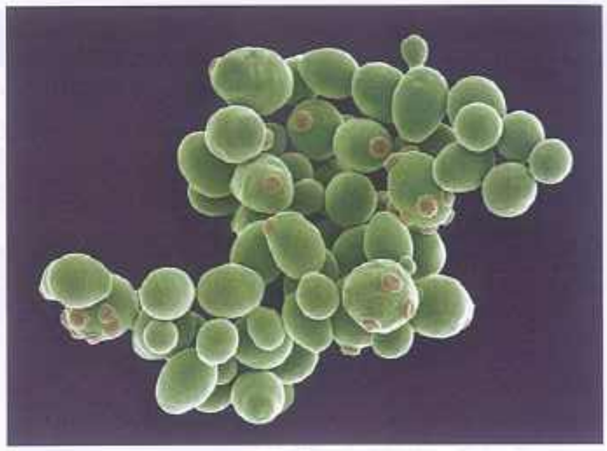
The white 'powder' on these grapes is yeast. The yeast cells feed on sugar in the grapes.

definitely microorganisms. The powdery substance that you sometimes see on the surface of grapes is made up of millions of cells of **yeast**, which is a microscopic fungus.

Questions

1 Viruses are even smaller than bacteria. Suggest why they are not usually said to be microorganisms.

2 We can see yeast on the surface of fruit. Why is yeast classed as a microorganism?



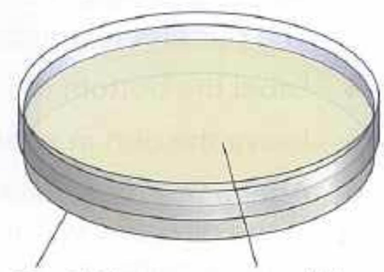
This is a group of yeast cells seen through a microscope. If you look closely, you can see little buds growing out of some of the cells. This is how yeast reproduces. Yeast is a microscopic fungus.

Growing microorganisms

A single microorganism is too small to see without a microscope, but when left to grow, a single cell of a bacterium or fungus divides repeatedly to make a collection of many cells. This collection of cells is called a **colony**. The colonies are big enough for you to see without a microscope.

This can be done safely in the laboratory. Scientists let microorganisms grow in a **Petri dish** containing a special kind of jelly, called **agar jelly**.

The dish and the jelly have to be **sterile**. This means that any living organisms on them have been killed.



Think like a scientist

Growing microorganisms from the air

Microorganisms are so small that they can float around in the air. You cannot see them, but they are there. In this experiment, you will use agar jelly to grow some bacteria and fungi from the air.

You will need:

- a sterile Petri dish containing sterile agar jelly, some sticky tape, a pen that can write on plastic, safety glasses

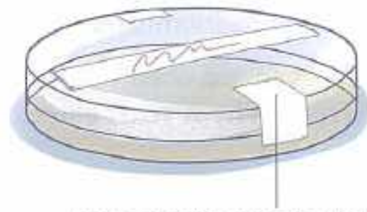
Continued

Safety

Wear safety glasses. Do not breathe or talk over the top of the jelly. You do not want the bacteria in your breath to start growing on the jelly.

It is very unlikely that any of the bacteria or fungi that you grow are harmful. But – just in case – keep the lid on the Petri dish after step 2. That way, you cannot accidentally touch them or breathe them in.

Read the safety notes before you start.



taping the lid onto the dish

1 Take the lid off the dish. Leave the dish open for about 5–10 minutes. This allows microorganisms in the air to get onto the jelly.
2 Put the lid back on the dish. Use sticky tape to fasten the lid onto the dish.
3 Turn the dish upside down. This is so that any droplets of water that form inside the dish do not make puddles on the jelly. The puddles might drown the microorganisms.
4 Label the bottom of the dish with your name and the date.
5 Leave the dish in a safe place for a few days. Do not take the lid off the dish.
6 After a few days, look at the surface of the jelly in the dish. You will see colonies of bacteria and fungi growing on the jelly. Each colony began as a single microorganism.

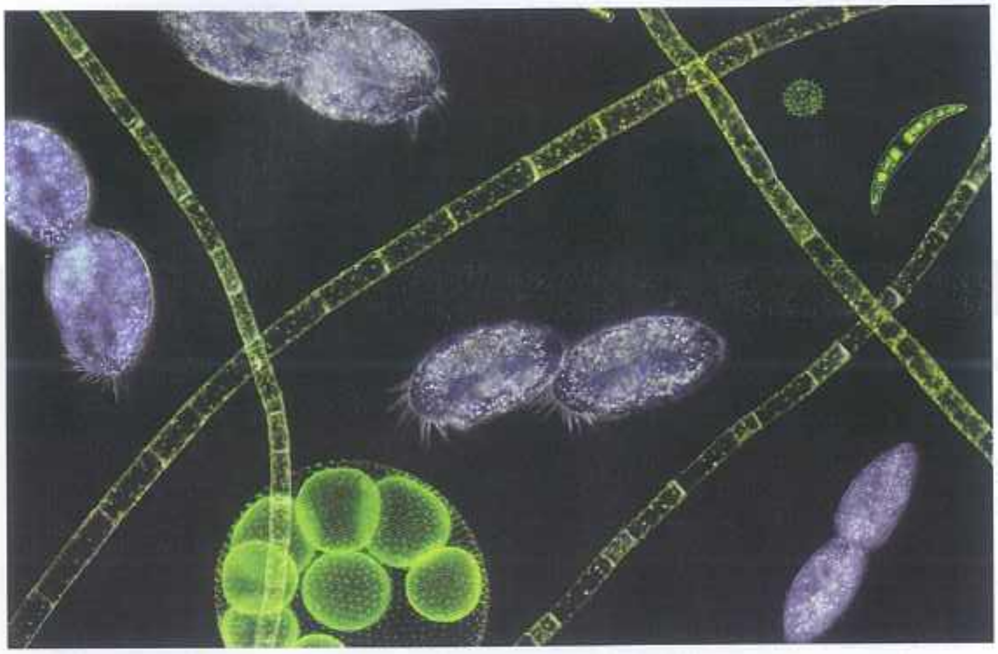
Colonies of bacteria usually have smooth edges. Colonies of fungi are usually furry, or have rough edges.

Questions

1 The jelly contains nutrients for the microorganisms. Can you suggest what the word 'nutrients' means? (You will find out more about nutrients in Topic 7.4.)
2 Suggest why the Petri dish and agar jelly must be sterile.
3 Make a drawing of the colonies of microorganisms on the surface of the jelly. You may have some colonies of bacteria, and some colonies of fungi. Label them.

Microscopic algae and protozoa

If you look at some pond water through a microscope, you will see many tiny living organisms in the water. Some of them are tiny plant-like organisms, called algae. Some of them are animal-like organisms, called protozoa. (The singular forms of these two words are alga and protozoan.)



These microorganisms are in a drop of pond water.

Questions

3 Some of the microorganisms in the photograph are not single-celled. How are their cells arranged?

4 Some of these microorganisms have cells like animal cells, and some have cells like plant cells.

a Make a simple drawing of one of the microorganisms that has cells like animal cells.

b Make another simple drawing of one of the microorganisms that has cells like plant cells.

c Label your drawings to explain the differences between them.

Summary checklist

- [ ] I can explain what a microorganism is.
- [ ] I can name some different kinds of microorganism.
- [ ] I can describe how to grow microorganisms on agar jelly.

7.2 Food chains and webs

In this topic you will:

- practise constructing food chains and food webs, using arrows to indicate energy transfer
- practise using the correct terms to describe the organisms in a food chain or food web
- think about how well food chains and food webs describe feeding relationships.

Getting started

Try to answer these questions on your own.

1. Tigers eat deer. Deer eat grass. Write this as a food chain.
2. Tigers also eat langur monkeys. Deer are also eaten by leopards. Add those animals to your food chain to make a food web.

Key words

carnivore
consumer
ecology
food chain
food web
herbivore
predator
prey
producer

Microorganisms in the environment

The study of organisms in their environment is called **ecology**. All the different organisms that live together affect one another in some way. For example, one species of animal may eat another animal. A plant may provide shelter for an animal.

Microorganisms have important roles to play in the environment. In the rest of this Unit, we will look at how microorganisms affect other organisms in their environment, including their importance in **food chains** and **food webs**.

In this topic, you will look at how food chains and food webs describe how energy, in the form of food, is transferred between animals and plants. In the next topic, you will look at how microorganisms fit into food chains and food webs.

Food chains

Arun has chicken and rice for lunch. It gives him a lot of energy. The food you eat gives you energy.

How did the energy get into the food?

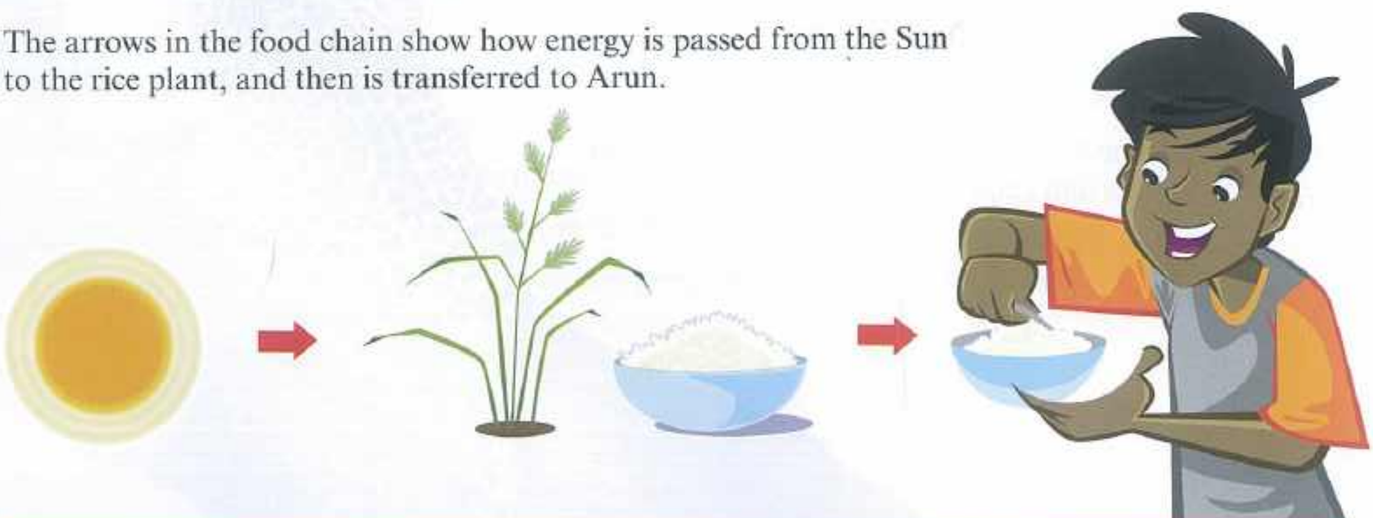
The energy in food begins in the Sun. Energy from the Sun reaches the Earth in sunlight.

Plants use energy from sunlight to make their own food. Some of the energy from the sunlight goes into the food that the plant stores in its roots, stems, fruits and leaves.

When an animal – such as Arun – eats part of the plant, it eats the food the plant made. This is how the animal gets energy. This is called energy transfer.

You can show how the energy passes from the Sun into the rice, and then into Arun's body, by drawing a food chain.

The arrows in the food chain show how energy is passed from the Sun to the rice plant, and then is transferred to Arun.



The first organism in a food chain is a **producer**. Plants use energy from the Sun to produce food.

All the other organisms in a food chain are **consumers**. Animals are always consumers. They have to eat ready-made food to get their energy. They consume (eat) plants or other animals.

Consumers that consume only plants are **herbivores**.

Consumers that consume other animals are **carnivores**.

Animals that catch, kill and eat other animals are **predators**. The animals they eat are their **prey**.

Questions

1 The chicken that Arun ate for lunch ate wheat. Wheat is a plant. Draw a food chain showing how the energy passed from the Sun to Arun when he ate the chicken.

2 Draw a food chain showing how energy from the Sun passed into you when you ate one of the things that you had for breakfast or lunch.

Food webs

Here are two more food chains. These food chains describe part of the feeding network of plants and animals on the African plains.

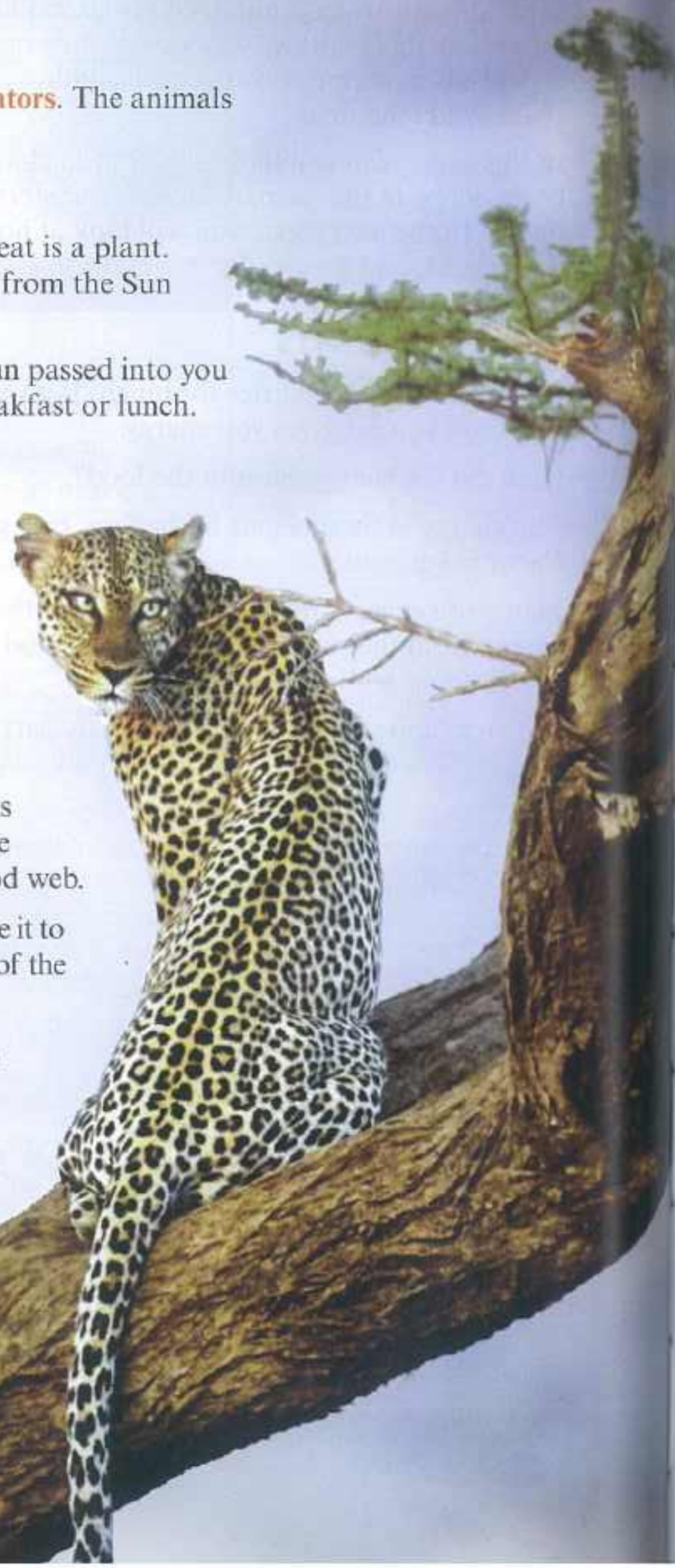
acacia tree → springbok → cheetah

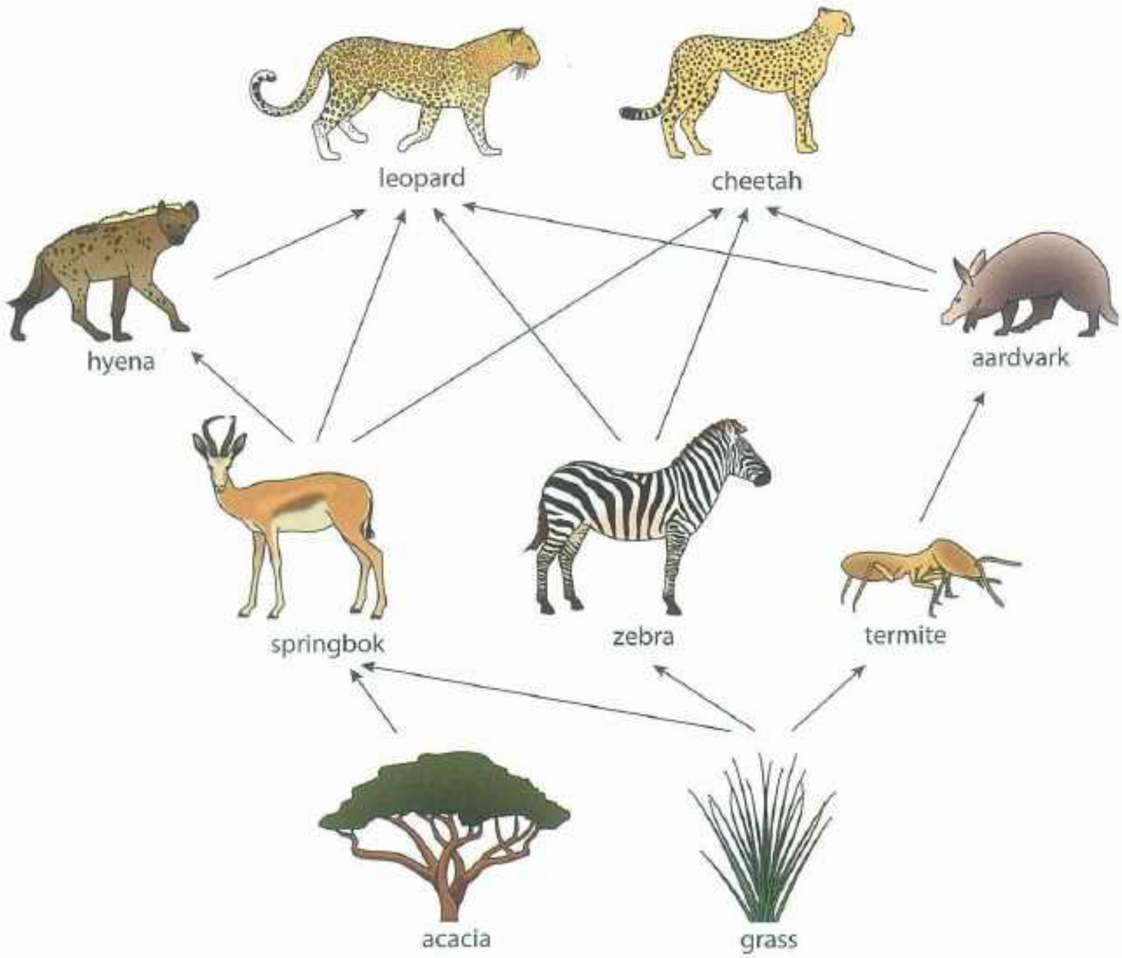
grass → termite → aardvark → leopard

The diagram on the next page shows how the organisms in these two food chains, and some other organisms, are connected by their feeding habits. This diagram is a food web.

Put your finger on the acacia tree in the food web. Then move it to the springbok, then to the cheetah. You are tracing the path of the energy as it transfers along a food chain.

Now do the same for another food chain – the one that begins with grass and ends with a leopard.





A food web on the African plains.

Questions

3 Write down **two** more food chains that you can find in the food web diagram.

4 Write the names of the **two** producers in the food web.

5 How many consumers are there in the food web?

6 How many herbivores are there in the food web?

7 Write the names of **two** carnivores from the food web.

8 Write the names of **two** predators and their prey, from the food web.

Activity

Describing a food web

Work in a group of four or five. Your task is to write a series of descriptions that someone else can use to build a food web using the cards and arrows.

You will need:

- a diagram of a food web (each group needs a different food web to work with)
- some cards that you can write on
- some lined paper
- some arrows cut out of card or paper

1 Write the names of the organisms in the food web on the cards, one name on each card.

2 Write the descriptions on lined paper. For example, for the African food web, some of your descriptions could be:

   Springbok eat acacia trees.

   Termites are eaten by aardvarks.

   Cheetahs and leopards eat zebras.

3 When your group has finished writing the descriptions, take your cards and arrows to another group. Ask this group to use your descriptions to build the food web.

Self-assessment

Could the other group use your descriptions to build the food web?

Did they make the arrows point the correct way?

How do you think you could make your descriptions easier to follow?

Think like a scientist

Using a food web as a model

A food chain or a food web is a model. It tries to show how plants and animals that live in the same place depend on each other for food.

In your group of two or three, discuss how well you think the African food web shows what really happens on the African plains. Here are some ideas you could discuss.

- How complete do you think the food web is?
- Is it possible to draw a totally complete food web?

Question

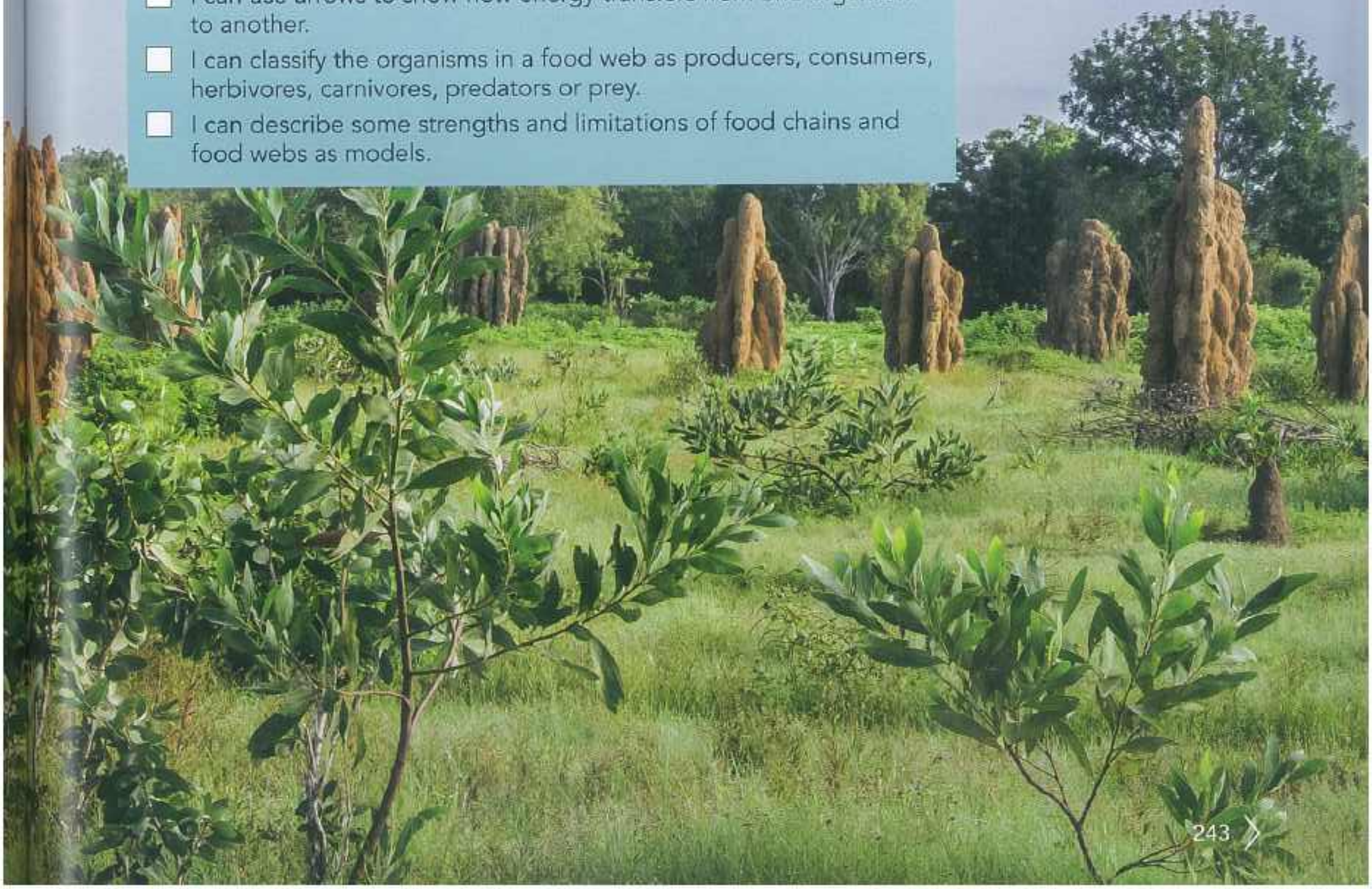
1 When you have finished your discussion, copy and complete these sentences.

I think the food web is a useful model because ....

I think the food web is not a perfect model because ....

Summary checklist

- [ ] I can use descriptions to construct a food chain or a food web.
- [ ] I can use arrows to show how energy transfers from one organism to another.
- [ ] I can classify the organisms in a food web as producers, consumers, herbivores, carnivores, predators or prey.
- [ ] I can describe some strengths and limitations of food chains and food webs as models.



7.3 Microorganisms and decay

In this topic you will:

- learn about microorganisms and decay
- investigate how temperature affects the rate of decay
- plan an experiment to test an hypothesis about decay.

Getting started

In a group of three, think of **three** different ways to complete this sentence:

A microorganism is ....

Be ready to share your ideas with the rest of the class.

Key words

decay
decomposer
mould
organic matter
rot

Decomposers and decay

The food chains and food webs that you looked at in the previous topic did not include microorganisms. But microorganisms are everywhere. They live in the air, in the soil, in water, on our skin and inside our bodies.

The apple in the picture has microorganisms growing on its surface. Each spot on the apple is made up of millions of cells of microscopic fungi. This kind of fungus is sometimes called **mould**. The apple is mouldy.


The spots on the apple are colonies of fungi.

The microorganisms have changed the apple. They have made it **decay**. Organisms that make things decay are called **decomposers**. Many different kinds of microorganisms – including some kinds of bacteria and microscopic fungi – are decomposers.

Apples come from plants, which are living organisms. Any substance that has been made by a living organism is called **organic matter**. So, apples are organic matter.

Some microorganisms can break down organic matter when they feed on it. This is what has caused the apple to decay. The microscopic fungi have broken down the crisp, fresh apple and made it become brown and soft. They have made the apple **rot**.

Activity 7.3.1

What can microorganisms decay?

Here are three questions.

First, think quietly about the answers to the questions on your own.

When your teacher tells you to, turn to your partner and discuss your ideas.

Be ready to share your answers with the rest of the class.

Questions

1 Which of these things are made of organic matter?

bread   water   leather   rock   wood   fruit

2 Think of **two** more things that are made of organic matter, and **two** more things that are not made of organic matter.

3 Which of the things in your answers to Questions 1 and 2 can be broken down by microorganisms?

Questions

1 Some microorganisms are decomposers. Explain what this means.

2 Describe **one** way in which decay by microorganisms is not useful.

3 Suggest **one** way in which decay by microorganisms is useful.

Think like a scientist

Investigating how temperature affects decay by microorganisms

Doing this investigation will give you practice in carefully collecting results and using them to make a conclusion.

You will need:

- 2 similar pieces of bread, 2 paper plates, 2 plastic bags or some transparent food wrap, a dropper pipette, safety glasses

Safety

Wear safety glasses when you look at the bread in step 5. Do not uncover the bread when you look at it.

1 Put two similar pieces of bread onto two paper plates.

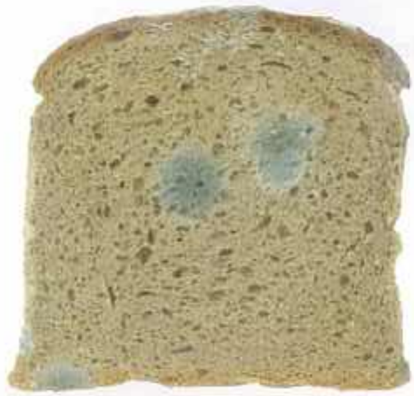
2 Add a little water to both pieces of bread. Take care not to get them too wet.

3 Leave the bread open to the air for about 30 minutes. Then cover each plate with a plastic bag or food wrap.

4 Put one plate in a warm place. Put the other plate in a refrigerator.

5 Record the appearance of each piece of bread each day, for several days. Do not uncover the bread, as you do not want to breathe in any mould spores.

Continued



This bread has several patches of blue mould growing on it.

This is what bread mould looks like through a microscope. You can see the tiny threads that it is made of.

Questions

1 Compare the results for the bread in the warm place and the bread in the cold place.

2 Did other people in your class get similar results? If they were not the same, suggest possible reasons for the differences.

3 Make a conclusion from the results of your investigation.

Self-assessment

1 For each of these statements about your experiment, decide whether you did it very well, fairly well or not at all:

- I was careful to add the same amount of water to each piece of bread.
- I made a careful record of the appearance of each piece of bread each day.
- I wrote down or drew my results clearly, so that someone else could understand them.
- I made my conclusion from my actual results, not from what I thought should happen.

2 Write down **one** thing that you did really well.

3 Choose **one** thing that you think you could do better next time, and explain how you will try to improve it.

Think like a scientist

Investigating how moisture (water) affects decay

You are going to plan your own experiment. You can use ideas from the investigation about how temperature affects decay by microorganisms.

Plan an experiment that you could do to test this hypothesis:

Moist bread decays more quickly than dry bread

Think about:

- the variable you will change, and how you will do this
- the variable you will observe or measure, and how you will do this
- the variables you will keep the same
- the results you predict you will obtain if the hypothesis is correct.

You may be able to do your experiment. If you can, collect results and use them to make a conclusion.

Summary checklist

- [ ] I can explain how microorganisms make things decay.
- [ ] I can explain what a decomposer is.
- [ ] I can use the results of my experiment to make a conclusion.
- [ ] I can decide which variables to change, measure and keep the same in an experiment.

> 7.4 Microorganisms in food webs

In this topic you will:

- draw and interpret food webs that include microorganisms as decomposers
- think about how microorganisms contribute to food webs.

Getting started

With a partner, discuss whether each of these statements is correct.

1 The arrows in a food chain show the direction in which energy flows from one organism to another.

2 All animals are consumers, and all plants are producers.

3 Some consumers are herbivores and some are carnivores.

Key words

dung

nutrients

Roles of decomposers

No-one would want to eat a rotten apple. The microorganisms that make an apple decay have spoiled the food.

But most of the time, decay by microorganisms is useful. Microorganisms break down dead bodies and animal waste. They decompose this material. Almost all decomposers are microorganisms. Fungi and bacteria are the most important decomposers.

If the dead bodies and waste are not broken down by decomposers, they would just build up. There would be heaps of dead plants, dead animals and animal **dung** everywhere.

But there is an even more important reason why decomposers are useful. The dead bodies and waste contain substances that living organisms can use to supply them with energy, or to help them to grow. These substances are called **nutrients**.

When microorganisms decay organic matter, they return the nutrients to the soil. Plants can then use the nutrients to help them to grow. This is really helpful for the plants.

This also helps animals, because there are more plants to eat.

This fungus is a decomposer. It is breaking down the elephant dung.

Activity 7.4.1

Decomposing fruit

You will need:

- a piece of fruit, such as a lemon or strawberry
- a plate or dish to put the fruit onto
- a pen and a sticky note to label the plate or dish
- safety glasses

Safety

Do not touch the mouldy fruit with your hand, and take care not to breathe in any mould spores.

1 Write your name on a dish. Put the fruit onto the dish. Do not cover the fruit.
2 Leave the fruit in the laboratory, or another warm place.
3 Look at the fruit every two or three days. Wear safety glasses when you do this, and do not touch the fruit with your hands. Take digital photographs of the fruit, or make drawings of it.

Questions

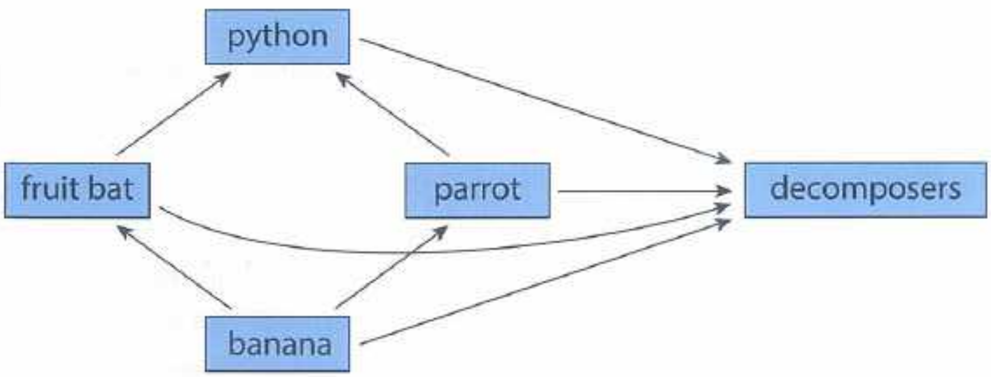
1 What changes can you see in the fruit?
2 Explain what happens to the fruit.

What sort of decomposers are growing on these oranges?

Decomposers in food webs

Decomposers feed on almost every organism after it dies. They also feed on waste from animals. This is how decay microorganisms get their energy. Energy from the dead organisms and their waste is transferred to the decomposers.

You can show this by adding decomposers to food chains or food webs. You do not usually do this because you have to draw an arrow from every organism in the food chain or food web to the decomposers. This makes it look very complicated. The diagram shows a simple food web with decomposers added to it.



Questions

1 Write a food chain of your own. Add decomposers to your food chain.

2 Look at the food web above. Are decomposers producers or consumers? Explain your answer.

Activity 7.4.2

Are all decomposers microorganisms?

In this activity, you will think about how fungi fit into food chains.

Look at the photograph.

The toadstools in the photograph are not microorganisms. You can see them easily, without a microscope.

In the photograph, the part of the fungus that you cannot see is inside the log, breaking it down.

Activity 7.4.3

Questions

In a group of three, discuss these questions about the photograph. Be ready to share your ideas with the rest of the class.

1. Is this fungus a decomposer? Explain your answer.
2. Is this fungus a microorganism? Explain your answer.
3. A slug eats the fungus. Explain where the energy obtained by the slug originally came from.
4. Draw a food chain that describes your answer to question 3.
5. Apart from fungi, what other kinds of microorganisms act as decomposers?

Activity 7.4.4

Making a mind map

On a large sheet of paper, construct a mind map to link ideas about food webs, microorganisms and decay.

Compare your mind map with a partner's mind map. Ask your partner to explain their mind map to you. Then explain your mind map to them.

Are there any similarities between the mind maps? What are the differences? Do you think one is better than the other? If so, why do you think that?

Which is better for helping you to understand what you have learned in this unit – making your own mind map, or looking at someone else's? Why do you think that?

Summary checklist

- [ ] I can draw a food chain or food web including decomposers.
- [ ] I can explain why microorganisms are important in food chains and food webs.

Project: DDT and malaria

Most microorganisms are not harmful. But some microorganisms cause disease. Malaria is a serious disease that is caused by a microscopic protozoan.

The microorganism that causes malaria is spread by mosquitoes. In some countries, a chemical called DDT is used to kill mosquitoes. This reduces the number of cases of malaria.

Unfortunately, DDT harms other animals as well as mosquitoes.

- The World Health Organization, WHO, thinks we need to carry on using DDT until better alternatives are found, to save thousands of human lives.
- The Worldwide Fund for Nature, WWF, thinks we need to stop using DDT as soon as possible, to protect the environment.

Work in a group of three or four. You are going to pretend that you represent the WHO or the WWF. Your task is to put together a case to support your point of view. You will then use your ideas in a debate about the different points of view.

You can use the information on these pages. You may also want to look for other information on the internet. When you do this:

- think carefully about who has produced the web pages you are looking at, and decide whether you can trust the information to be unbiased
- decide how relevant the information is to this task and use only the most relevant information.

DDT and food chains

DDT does not break down completely in an animal's body. When an animal eats another animal that has DDT in its body, it also eats the DDT. If an animal moves from one place to another, it takes the DDT with it.

DDT effects on animals

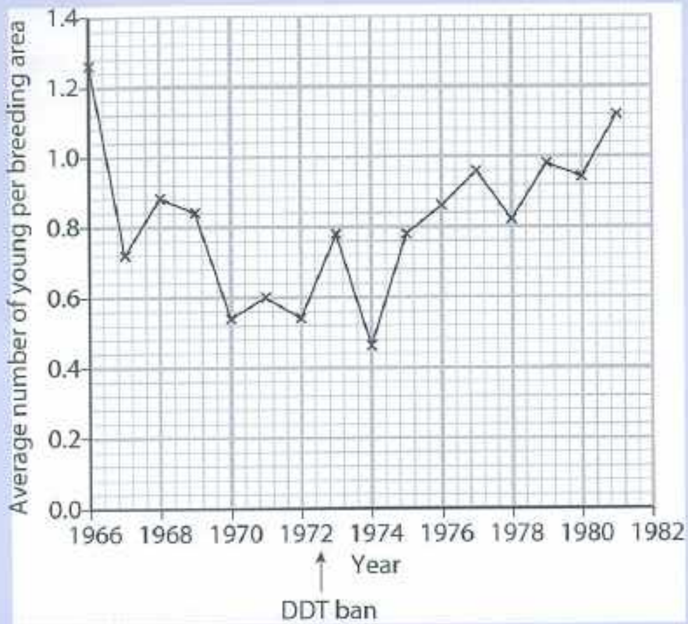
DDT is very poisonous to fish, and quite poisonous for frogs and other amphibians. We are not sure yet how poisonous DDT is to humans.

Midway Atoll, where this black-footed albatross lives, is thousands of miles from any land where DDT is used. But DDT has been found in the albatrosses there.

Continued

DDT and birds of prey

DDT in birds of prey makes the shells of their eggs very thin. The eggs break before the young birds hatch. In the USA, numbers of bald eagles fell when DDT was used. DDT was banned in 1972.



Indoor residual spraying

In many countries where malaria is present, DDT is sprayed inside houses. The DDT sticks to the walls and kills mosquitoes. The DDT continues to work for up to 6 months. This method needs much less DDT to control mosquitoes than spraying it outside.

Deaths from malaria

In 2015, 212 million people had malaria. 429 000 people died from it. In 2016, there were 216 million cases and 445 000 deaths. In 2019, there were 229 million cases and 409 000 deaths.

More than two-thirds of people dying from malaria are children under the age of 5.

Continued

Where is malaria present?

Malaria occurs where the mosquitoes that transmit it live. These mosquitoes only live in tropical or subtropical countries.

Malaria and global warming

The Earth's mean temperature is increasing. This may mean that the mosquitoes that transmit malaria may be able to move into new areas.

Other methods of controlling malaria

Other chemicals can be used to kill mosquitoes. However, most of these are much more expensive than DDT.

Sleeping under a bed net can help to reduce the risk of being bitten by a mosquito.

A malaria vaccine?

Scientists are trying to make a vaccine for malaria. The best one they have found so far needs four injections. It only halves the risk of getting malaria.

DDT persistence

DDT is a persistent chemical. This means that it lasts for a long time. If DDT gets into a lake or river, over half of the DDT will still be there 150 years later.

Where is DDT used?

DDT has been completely banned in 34 countries. Many countries, including India and many African countries, still use DDT.

Check your Progress

7.1 Yeast is a single-celled organism that grows on fruit, such as grapes. Yeast feeds on sugar in the grapes. It breaks down the grapes and makes them rot.

Which sentences about yeast are correct?

- **A** Yeast is a producer.
- **B** Yeast is a decomposer.
- **C** Yeast is a microorganism.
- **D** Yeast is a virus. **[2]**

7.2 Draw a food chain that includes microorganisms as decomposers.

You do not need to draw pictures – just write the names. **[2]**

7.3 A farmer keeps cattle in a field of grass.

The cattle leave dung in the field. Fungi grow on the dung. The farmer notices that the grass looks greener, and grows taller, when it grows next to cow dung.

The farmer measures the length of five grass leaves close to some cow dung, and another five grass leaves where there is no cow dung.

Here are her results.

Next to cow dung: 11 cm, 13 cm, 9 cm, 12 cm, 8 cm

No cow dung: 9 cm, 10 cm, 6 cm, 7 cm, 9 cm

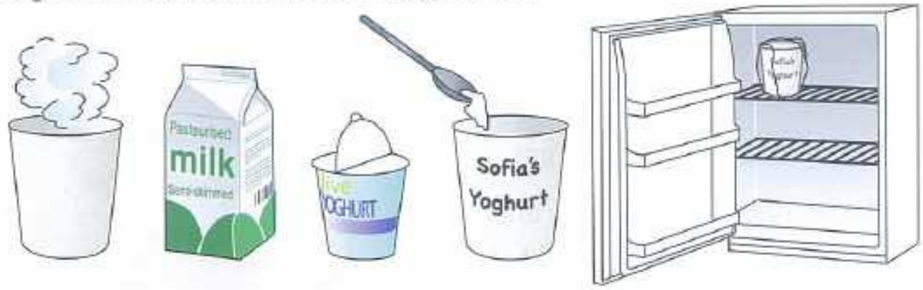
- **a** Record the farmer's results in a suitable results table. **[4]**
- **b** Calculate the mean length of the grass leaves next to cow dung. Then calculate the mean length where there is no cow dung. Write the mean lengths in your results table. **[2]**
- **c** The farmer concludes that grass grows longer next to cow dung. Do you think she has enough evidence to make this conclusion? Explain your answer. **[3]**
- **d** Explain how the fungi and cow dung might help the grass to grow better. **[2]**

7.4 Some bacteria are decomposers. They break down food and change it. Usually this makes the food unpleasant, but sometimes it changes it to something that is good to eat.

One kind of bacterium changes milk to yoghurt. When the bacteria do this, they change sugar in the milk to acid. Many people like the sharp taste that the acid provides.

Sofia makes some yoghurt.

- She washes out a plastic container with boiling water.
- She lets the pot cool down, then puts some fresh milk into the container.
- She adds a small spoonful of yoghurt she bought.
- She covers the container with cling film.
- She puts the container in the refrigerator.



a Explain why it is a good idea to wash the container with boiling water. **[1]**

b Suggest what is in the yoghurt that Sofia bought, that helps to turn her fresh milk into yoghurt. **[1]**

c It takes a long time for Sofia's milk to turn into yoghurt.

Suggest what she can do to make it happen faster.

Explain your answer. **[2]**

d Sofia measures the pH of the milk before she puts it into the pot.

She measures it again after it had been in the pot for four days.

Suggest how the pH changes. Choose from:

becomes higher **becomes lower** **stays the same**

Explain your answer. **[2]**

8 Changes to materials

› 8.1 Simple chemical reactions

In this topic you will:

- learn about the chemical properties of some metals
- learn to recognise that a chemical reaction has taken place.

Getting started

Draw each of these hazard symbols and write down the scientific word for:

- a substance that can poison you
- a substance that catches fire easily
- a substance that can dissolve your skin.

Check your answers with a partner. Be prepared to share them with the class.

Key words

chemical reaction
combine
product
react
reactant

Chemical and physical properties

The physical properties of a substance are features such as:

- what colour it is
- if it is a solid, liquid or a gas
- what its boiling or melting temperature is
- if it is heavy or light.

For example, some of the physical properties of iron are that it is a grey, heavy solid with a melting point of 1538 °C. One of the physical properties of hydrochloric acid is that it is a colourless liquid.

The chemical properties of a substance are features such as:

- how acidic or alkaline it is
- how it **reacts** with water, acids or metals
- how readily it reacts.

Some of the chemical properties of iron are that it **combines** with sulfur when heated to form iron sulfide, and it combines with oxygen to form iron oxide or rust. One of the chemical properties of hydrochloric acid is that it is has a pH of 2.

Chemical changes

Chemical changes are different from physical changes.

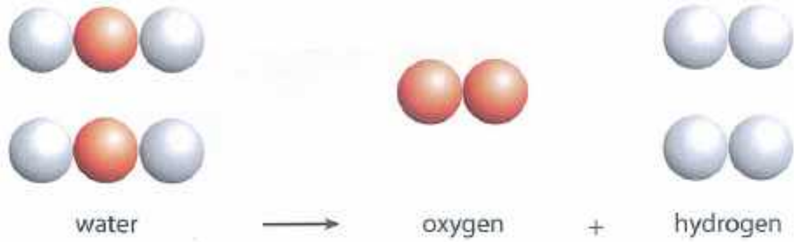
In a physical change, no new substances are formed. For example, when liquid water freezes, the water has changed state but it is still the same substance after the change.

In a chemical change, new substances are formed. For example, when iron and sulfur are heated together, they form a new substance (a compound called iron sulfide).

The iron and the sulfur have reacted together to form a new substance. A **chemical reaction** has taken place. The iron atoms have combined and bonded with the sulfur atoms.

The **reactants** (the substances that react together) are the iron and the sulfur. The **products** are the new substances made in the reaction. In this reaction, there is only one product – iron sulfide.

In some chemical reactions, a substance breaks apart to make new substances. For example, water can be split apart to form oxygen and hydrogen.



Chemical reactions happen everywhere. They happen inside plants when they grow and when they decay. Chemical reactions happen inside your body to keep you alive, for example, when you digest food.

Burning

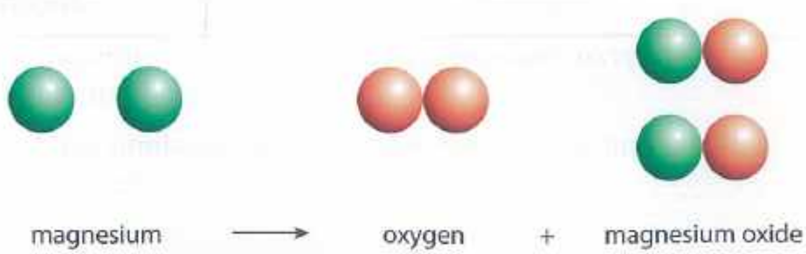
Burning is a chemical reaction. When a substance burns, the substance reacts with the oxygen in the air. Sometimes ashes are formed. The ashes contain new substances. The new substances in the ashes are oxides.

Charcoal is made up of the element carbon. When carbon burns it combines with oxygen in the air to make the gas carbon dioxide.

When charcoal burns, ash is left behind.

When magnesium metal is burnt, a white powder is formed. This powder is magnesium oxide. A new substance has been formed from magnesium and oxygen.

Magnesium and oxygen are the reactants. Magnesium oxide is the product. A chemical property of magnesium is that it burns in air to form magnesium oxide by combining with oxygen.



Think like a scientist

Burning magnesium

In this task you will burn some magnesium and produce a new product.

You will need:

- safety glasses, a Bunsen burner, a heat-proof mat, tongs, a piece of magnesium ribbon

Safety

Wear safety glasses. While the magnesium ribbon is burning, **do not look directly at the flame.** Magnesium burns very brightly and the **bright** light could harm your eyes.

1. Set up the Bunsen burner on the heat-proof mat.
2. Take a small piece of magnesium ribbon and place it in the tongs.
3. Hold the tongs at **arm's length** and place the magnesium ribbon in the Bunsen flame.
4. Once the magnesium ribbon has caught fire, remove it from the flame.

Magnesium ribbon

Burning magnesium ribbon

Magnesium oxide

Continued

Questions

1 Describe what happens to the magnesium ribbon.

2 Describe what has been formed.

3 Name the reactants in this chemical reaction.

4 List all the safety precautions you need to take while carrying out this experiment.

Not all metals have the same chemical properties as magnesium. They may not burn in the same way. You could try holding pieces of other metals, such as copper, zinc or iron, in the Bunsen flame and record what happens.

Properties of reactants and products

This table compares the properties of the reactants and products when you burn magnesium. You can see that the properties of the product are different from those of the reactants.

	Reactants		Product
	magnesium	oxygen	magnesium oxide
Element or compound?	element	element	compound
State at room temperature	solid	gas	solid
Appearance	soft, shiny, malleable	colourless, has no smell	white, powdery
Conducts electricity?	yes	no	no
Melting point in °C	651	−214	2800

Questions

1 Compare the melting points of magnesium, oxygen and magnesium oxide.

2 Find **one** similarity between magnesium oxide and one of the reactants.

3 For each of these photographs, say if it is a physical change or a chemical reaction, and explain why you think so.

		
a Making toast	b Melting chocolate	c Fireworks going off
		
d Ice melting	e Coal burning	f Copper roof turning green

Reactions with water

Some substances react very violently with water. Some substances do not react with water at all.

Potassium (a metal) is very soft and can be cut with a knife. This is a physical property. Potassium is so reactive that it has to be stored under oil to prevent it reacting with the water vapour in the air. This is a chemical property.

When a very small piece of potassium is placed in a large trough of water, hydrogen gas is given off. The reaction produces so much heat that the gas burns.

Potassium reacting with water in a large glass trough

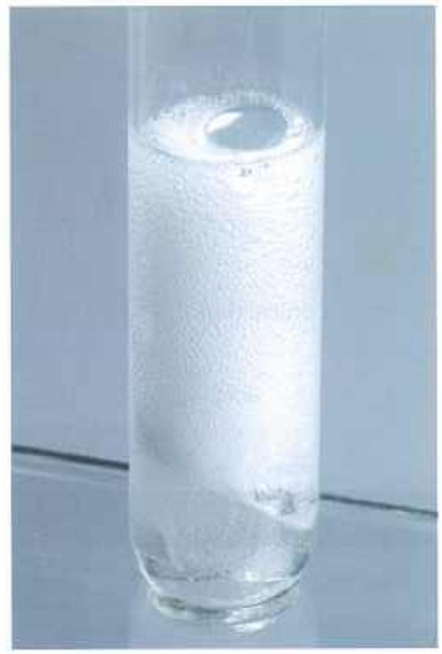
Safety

You cannot carry out the potassium and water reaction yourself. If your teacher shows it to you as a demonstration, you **must** wear safety glasses and there **must** be a safety screen in front of the beaker to protect you.

Reactions with acid

When magnesium is placed in hydrochloric acid, bubbles of gas are given off. The magnesium has reacted with the hydrochloric acid and formed new substances. The gas is hydrogen, and magnesium chloride has been formed. This is a chemical property of magnesium.

magnesium + hydrochloric acid ⟶ magnesium chloride + hydrogen



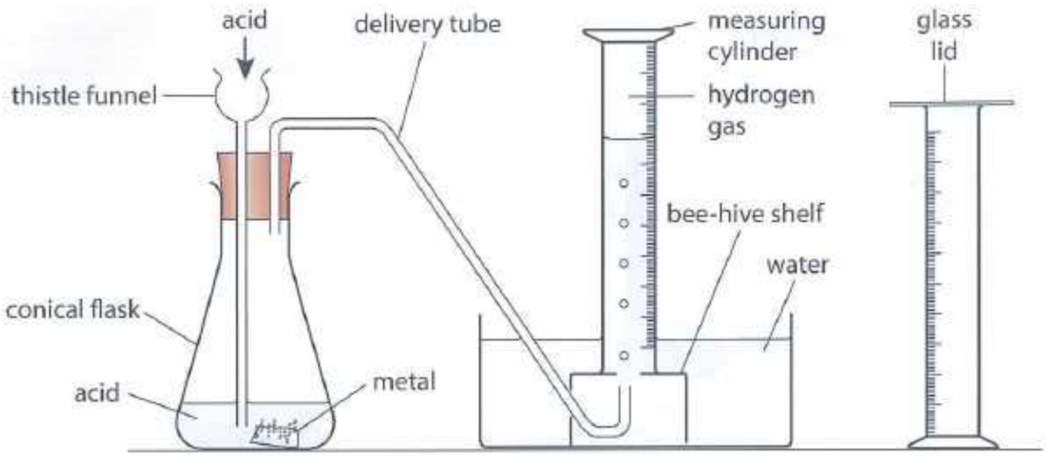
Magnesium in acid

When you see bubbles forming in a reaction, you know that a gas is being produced. But you cannot tell what **type** of gas it is.

The diagrams show you how to test a gas to find out if it is hydrogen. Hydrogen gas burns with a squeaky pop. To carry out the test you light a splint and place it in the mouth of the test tube. You need to keep your finger over the end of the test tube until the last moment or you will have no hydrogen left to test. This is because hydrogen gas is lighter than air.

When the hydrogen pops, it is reacting with oxygen, in the air, to form water.

Hydrogen can be produced on a larger scale by collecting the gas produced in the reaction over water, as shown in the diagram on the next page. You could try this for yourself.



Think like a scientist

Reactions with water and acid

You will need:

- safety glasses, test tubes, a test tube rack, water, hydrochloric acid, small pieces of a selection of metals such as magnesium, iron, copper, zinc

Safety

Wear safety glasses. Remember to pay attention to hazard warning labels when you use chemicals.

Part 1: Reactions with water

1. Place a small piece of each of the metals into a different test tube.
2. Take one tube at a time and add water, so that the test tube is half full.
3. Record your observations and findings in a table.

Part 2: Reactions with acid

1. Place a small piece of each of the metals into a different test tube.
2. Take one tube at a time and add hydrochloric acid, so that the test tube is half full.
3. If you see bubbles given off, test for hydrogen gas.
4. Record your observations and findings in a table.

Questions

1. For each reaction with acid, write down the reactants and the products.
2. What safety precautions did you take?
3. Explain how you tested for hydrogen.

Comment on any difficulties you had testing for hydrogen and how you tried to overcome them. What have you found out about the chemical properties of the metals you tested?

Questions

4 Give **two** of the chemical properties of magnesium.

5 Give **two** of the physical properties of magnesium.

6 What are the products when zinc reacts with hydrochloric acid?

Summary checklist

- [ ] I can describe some of the chemical properties of some metals.
- [ ] I can recognise that a chemical reaction has taken place.
- [ ] I can test a gas to see if it is hydrogen.

8.2 Neutralisation

In this topic you will:

- learn how to make a neutral solution
- learn why neutralisation is important.

Getting started

What does the word 'neutral' mean? Discuss with a partner all you know about the properties of a neutral liquid. How can you tell if the liquid you have is neutral?

Be prepared to share your ideas with the class.

Key words

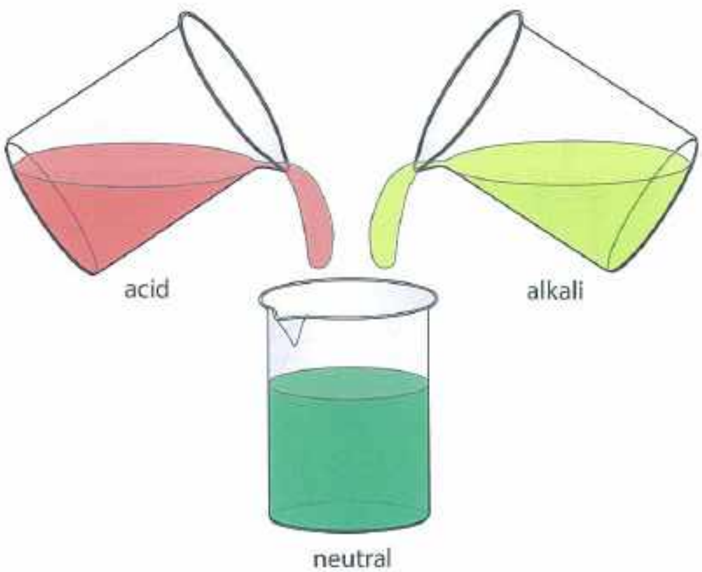
burette
decay
digest
filtrate
indigestion
neutralisation
neutralised

Mixing acids and alkalis

Acids and alkalis can cancel each other out. When you mix them together they react and make a neutral solution. This is called **neutralisation**. This is another chemical change. Neutrality is also a chemical property of a substance.

If you add too much acid to an alkali, it makes an acidic liquid. If you add too little acid to an alkali, it stays as an alkaline liquid.

You can add the acid very slowly, adding a few drops at a time. This makes it easier to judge exactly when it becomes neutral.



Mixing acid and alkali to make a neutral solution.

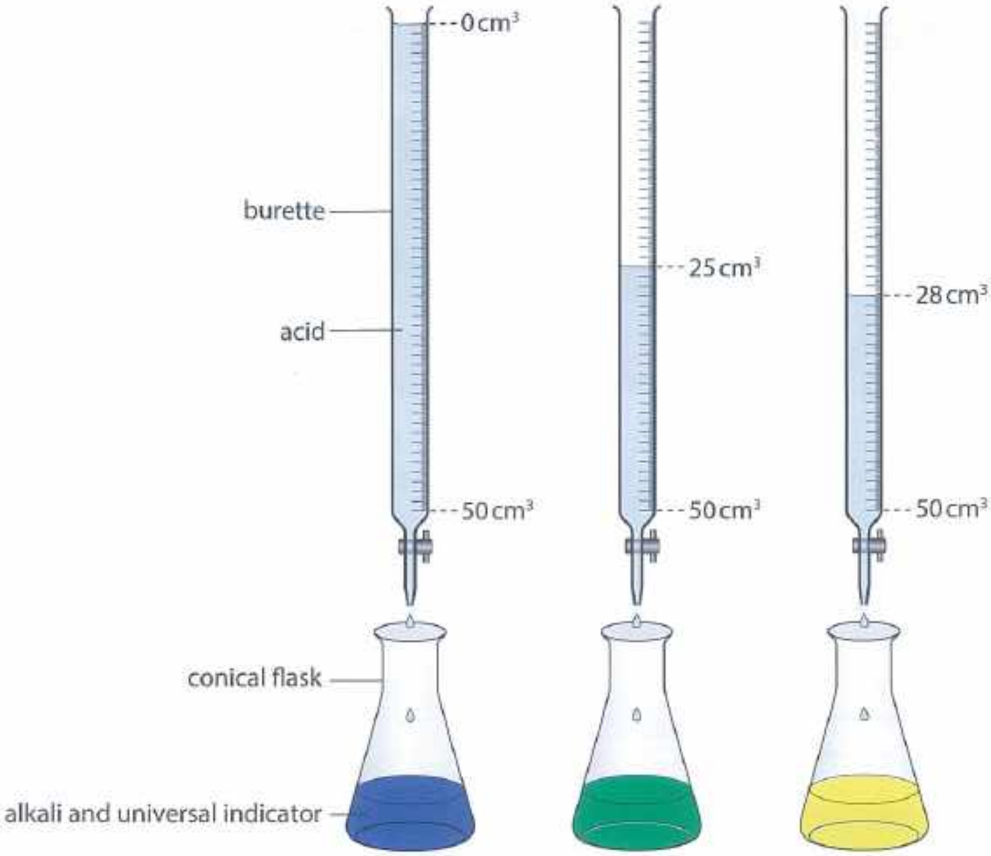
Questions

1 What colour is universal indicator when the solution is neutral?

2 What sort of reaction happens when an acid and an alkali are mixed?

Making a neutral solution

You can use a special piece of equipment called a **burette** to neutralise an alkali very accurately. You add universal indicator to the alkali in the flask. See the diagrams on the next page.



Using a burette to add acid to a flask of alkali.

Look at the three diagrams of a burette.

In the first diagram, the pH in the flask is about 13. As the acid is added, the pH becomes lower. The acid is added slowly. The flask is shaken each time some acid is added.

In the second diagram, 25 cm^3 of acid has been added to the flask. The pH in the flask is now 7. The liquid is now neutral.

The acid has reacted with the alkali and **neutralised** it.

In the third diagram, a little more acid has been added to the flask. The pH in the flask is now about 6. The liquid is weakly acidic.

When this happens there is a chemical reaction and new substances are formed. If you use hydrochloric acid and sodium hydroxide (an alkali), these are the reactants. When they react together, the products that form are sodium chloride and water.

hydrochloric acid + sodium hydroxide ⟶ sodium chloride + water

Activity 8.2.1

Rainbow neutralisation

In this activity you will demonstrate the different colours shown by universal indicator solution.

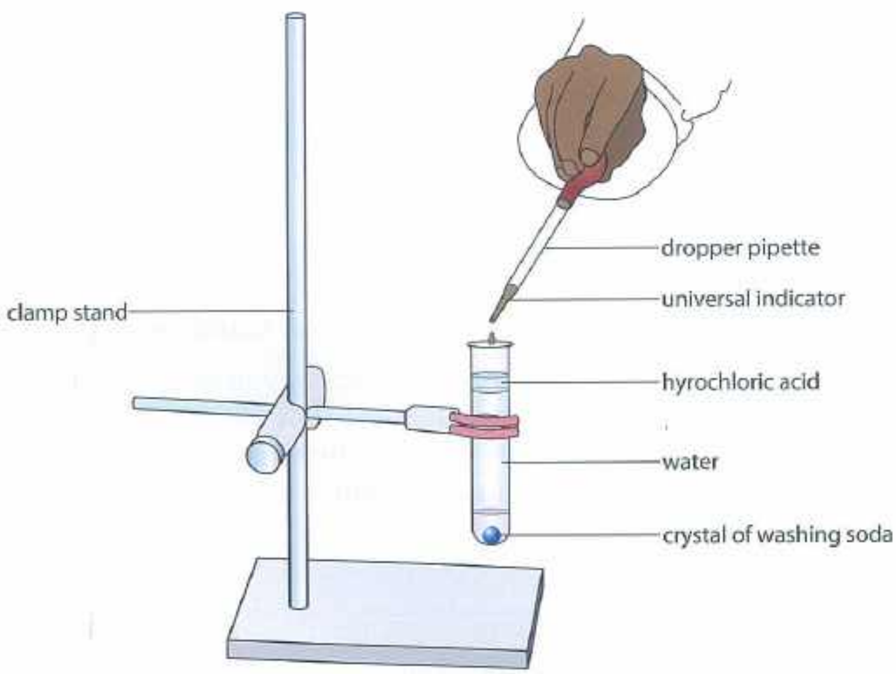
You will need

The apparatus shown in the diagram.

Safety

Wear safety glasses.

1 Fix a test tube into a clamp stand and place it somewhere it will not get moved.
2 Place a crystal of washing soda in the bottom of a test tube.
3 Carefully add some water until the tube is about two-thirds full.
4 Add a few drops of universal indicator.
5 Carefully pour some acid on the top. Do not shake the tube.
6 Leave the tube to stand for a few days.



Questions

1 What is the pH at the top part of the test tube?
2 What is the pH at the bottom of the test tube?

Continued

3 Which is the most alkaline part of the tube?

4 Why did you have to keep the tube still when you left it for a few days?

5 Which hazard symbols are displayed on the equipment you used? What do these mean?

How does the rainbow appear?

At the top of the test tube

The acid has turned the universal indicator red at the top of the tube. This shows it is strongly acidic. The acid particles gradually move down the tube. They mix with more water and the universal indicator turns yellow. This is more weakly acidic.

In the middle of the test tube

The acid and the washing soda solution mix. They react together. The universal indicator is yellow. The washing soda solution and acid have neutralised each other.

At the bottom of the test tube

The washing soda has dissolved in the water around it. The universal indicator is purple or dark blue around the washing soda. The washing soda is a strong alkali. The particles of the washing soda gradually move up the test tube. They mix with more water and the universal indicator turns a lighter blue. This shows it is more weakly alkaline.

The rainbow neutralisation experiment after a few days.

Self-assessment

How successful was your rainbow? Was there anything you could have done to improve the outcome?

Neutralisation in everyday life

Indigestion

Your stomach produces hydrochloric acid. This acid gives the stomach the right conditions to **digest** your food. When your stomach produces too much acid, you have **indigestion**. It can be very uncomfortable. There are many medicines that can help. They are all alkalis and they neutralise the acid. Sometimes these medicines are called antacids.

Antacid medicines for indigestion

Toothpaste

There are millions of **bacteria** in your mouth. These bacteria feed on the pieces of food left on your teeth. The bacteria produce acid when they feed. This acid damages your teeth and makes them **decay**. Toothpaste contains alkali and this helps to neutralise the acid.

Toothpaste helps to neutralise the acid in your mouth.

Neutralising lakes

In some parts of the world there are harmful chemicals in the air that make the rain acidic. This acid rain damages trees and changes the pH of the lakes, rivers and ponds. The plants and animals that live in the lakes cannot live in acid conditions. Some countries drop alkalis into the lakes to neutralise the acid.

Growing crops

In some areas, the soil is very acidic and plants do not grow well. Farmers spread lime on the soil to neutralise the acid so that the plants can grow better.

Lime is added to acidic soils, to neutralise the acid.

Questions

3 Why is toothpaste alkaline?

4 Where does the acid in your mouth come from?

5 Why is an alkaline substance dropped into lakes in some countries?

6 What do farmers spread onto acidic soil? Explain why they do this.

Think like a scientist

Testing the pH of the soil

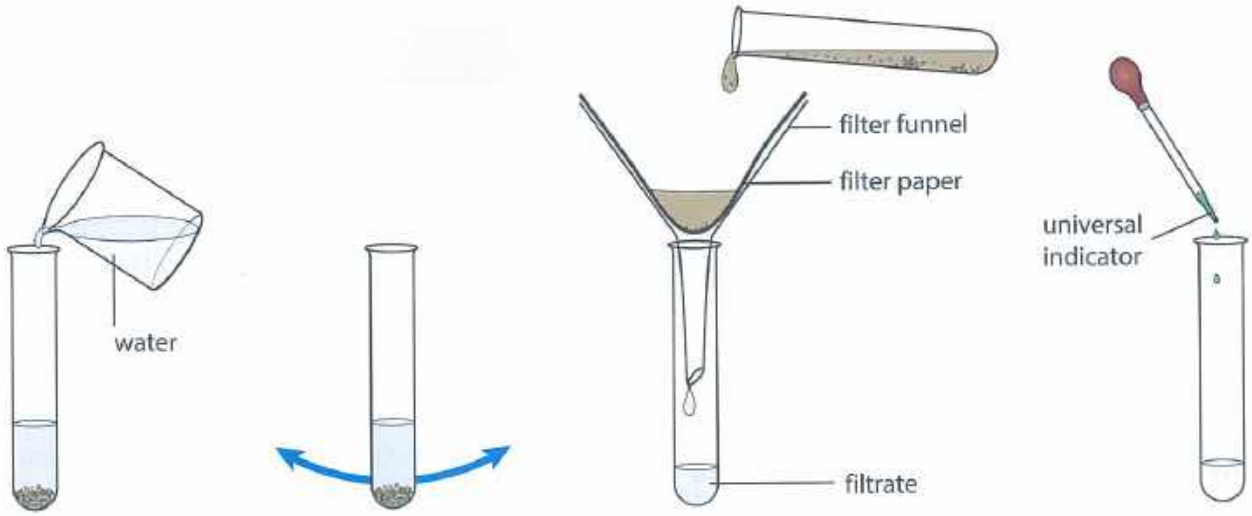
In this task you will test a soil sample to find the pH.

You will need:

- 2 test tubes, a beaker of water, a filter funnel, filter paper, universal indicator, a sample of soil

1. Take a sample of soil in a test tube and add some water.
2. Shake the tube.
3. Filter the mixture in the tube.
4. Add a few drops of universal indicator to the **filtrate**. (The filtrate is the liquid that comes through the filter paper.)
5. Record your results.

Continued



1 Add water. **2** Shake. **3** Filter. **4** Test.

Question

Use books or the internet to find out what sort of plants will grow well in this type of soil.

Summary checklist

- [ ] I can describe neutralisation as a change to a pH of 7.
- [ ] I can explain how to make a neutral solution.
- [ ] I can explain why neutralisation is important.

8.3 Investigating acids and alkalis

In this topic you will:

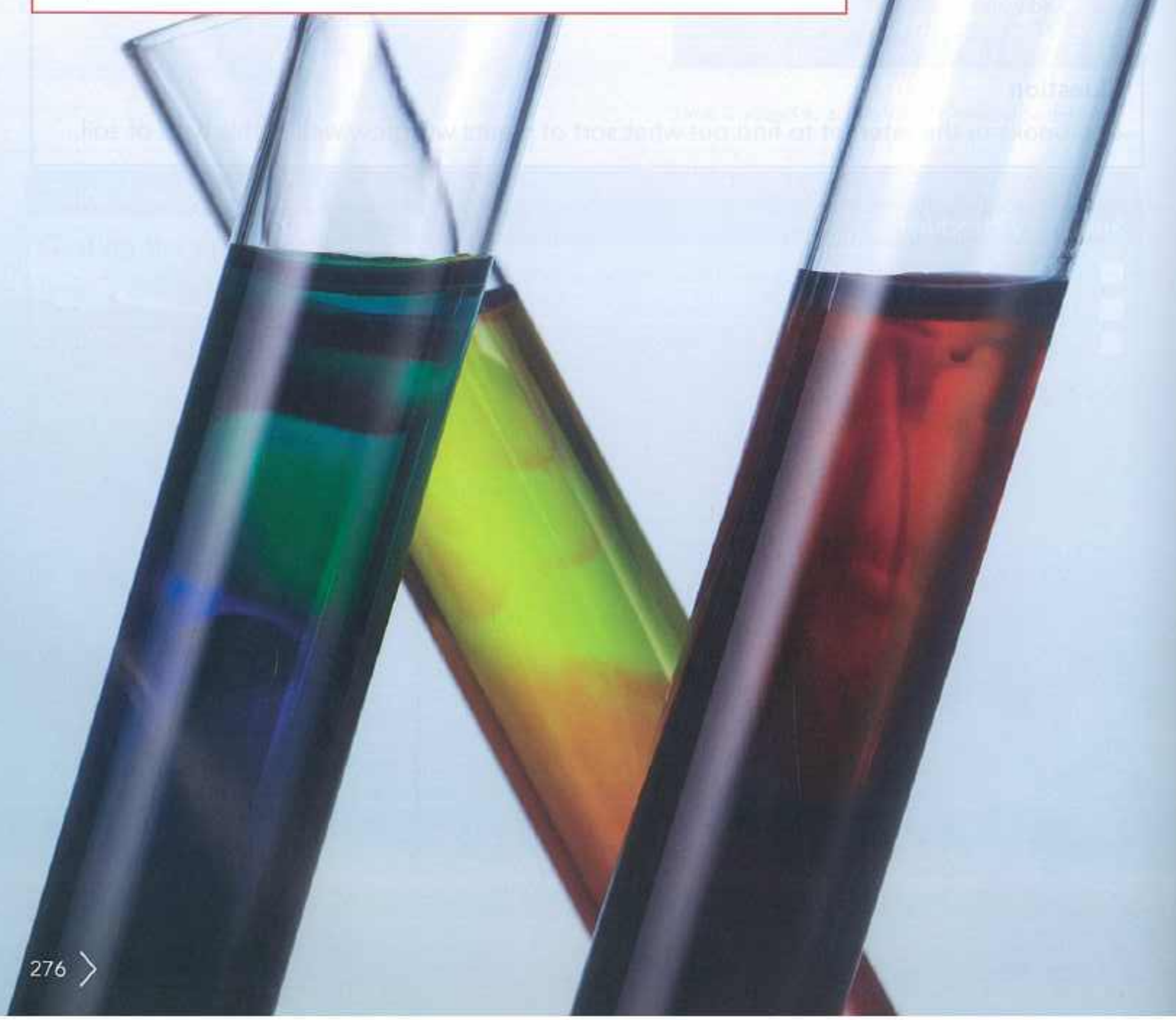
- decide if an hypothesis can be tested
- plan an investigation
- think about what the results of an investigation tell you.

Getting started

With a partner, write down the different colours of universal indicator when it is added to solutions with different pH.
How good were you at remembering the colours and what they mean?

Key words

remedy
variable



Asking questions

Scientists ask questions. These are some questions about neutralisation that scientists might try to answer.

- How much lime should be added to an acid lake to neutralise it?
- Which is the best indigestion **remedy** (treatment for an illness or injury)?
- How much toothpaste is needed to neutralise the acid in your mouth?

Let's look at the second question: 'Which is the best indigestion remedy?'

How could you decide which indigestion remedy is the best? What information do you have? Is it based on facts or opinions? In a pharmacy there are many different types of indigestion remedy. All the manufacturers make claims that theirs is the best, but their opinions may be biased because they want us to buy their product.

Scientists want evidence that is based on facts, not opinion. They need to look carefully at the question: *Which is the best indigestion remedy*?

It is not a very precise question. What does 'best' mean? Does 'best' mean the most pleasant tasting, the cheapest, the most effective or the most cost-effective?

Scientists need to write their question in a way that they can test. They need to be able to have a factual answer, not an opinion. So, instead of asking: 'Which is the best indigestion remedy?', a scientist might ask:

- 'Which indigestion powder neutralises the acid, using the least amount of powder?'

Think like a scientist

Asking questions

In a group of three or four, discuss and write down **four** questions about acids and alkalis that you could investigate.

Share your ideas with the rest of the class.

Could each of your questions be investigated? Would each of your questions produce factual answers rather than opinions?

Planning an investigation

When you plan to do an investigation, you have to design an experiment. If you are investigating the effect of indigestion powders on stomach acid, you cannot use your own stomach acid. You have to use a model instead, such as a beaker of acid.

There is a lot to think about.

The things that change are called **variables**.

- How will you know when the powder has neutralised the acid?
- What will you see happen?
- How will you carry out the investigation?
- How will you record the results?

Think like a scientist

Planning an investigation

Working in the same group as before, choose one of the questions from *Think like a scientist: Asking questions.*

In your group, plan how you could carry out the investigation.

When you have discussed it in your group, divide up the tasks. These might include 'equipment list', 'method', 'safety', 'results table' and so on.

Each group member should produce something to put onto a large piece of paper and share with the class.

You may be able to carry out your investigation, once it has been checked for safety.

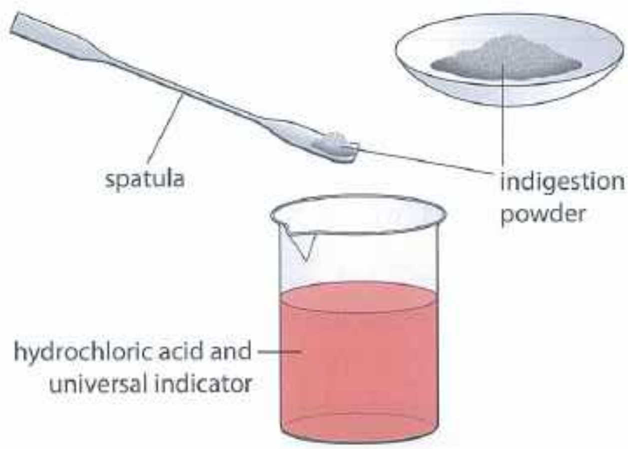
Self-assessment

How well did your group do? Was your plan safe? Would your plan work? Was the test fair?

Which powder is best at neutralising acid?

Marcus and Arun put 20 cm^3 of hydrochloric acid into each of three beakers. The acid has a pH of 1. This is like the strong acid in your stomach. They also put a few drops of universal indicator in each beaker.

They add the indigestion powder, spatula by spatula, until the acid is neutralised and the universal indicator is green. They do this with each of the three powders A, B and C. They record the number of spatulas they used.



Here are Marcus and Arun's results.

Powder	Number of spatulas used to neutralise the acid
A	10
B	6
C	24

Questions

1 Marcus and Arun are using acid that is pH 1. What should they do to stay safe?

2 Which variables are they keeping the same in this investigation?

3 Which variable is being changed?

4 What is being measured?

5 Which is the most effective powder?

6 Which is the least effective powder?

7 Do you think there is enough evidence to be certain of your answers to questions **5** and **6**?

Marcus and Arun repeat their investigation twice more. The table shows all their results.

Powder	Number of spatulas used to neutralise the acid			
	First try	Second try	Third try	Mean
A	10	9	11	10
B	6	17	16	13
C	24	23	25	24

8 Now which powder do you think is the most effective?

9 Which result looks 'wrong'?

10 Suggest why Marcus and Arun might have got this 'wrong' result.

11 What should they have done about it?

12 Should they have included the 'wrong' result when working out the mean?

What do the three sets of results tell you about carrying out an investigation? When you see evidence from someone else's investigation, what do you need to ask?

Summary checklist

- [ ] I can recognise when a question can be investigated scientifically.
- [ ] I can plan an investigation.
- [ ] I can look critically at what the results of an investigation tell me.

8.4 Detecting chemical reactions

In this topic you will:

- learn about different ways of telling if a chemical reaction has happened
- test gases given off in reactions so that you can identify them
- carry out practical tasks safely.

Getting started

What is the difference between:

- reactants and products
- chemical and physical changes
- acids and alkalis?

Think about these three questions for a minute, then spend one minute writing your answers. Compare your answers with a partner. Take two minutes to improve your answers. Be prepared to share your answers with the class.

Key words

cloudy
glowing
precipitate

What happens in a chemical reaction

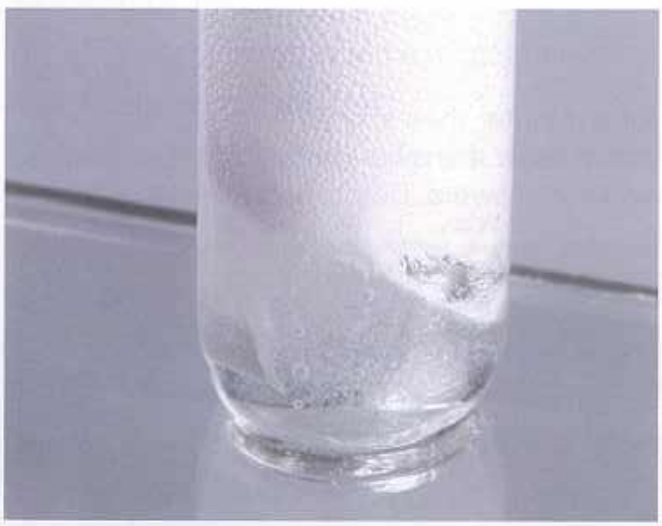
In a chemical reaction, new products are formed from the reactants. How can you tell this has happened? There are some clues you can look out for that might mean a reaction has taken place.

A gas is given off

One of the most useful clues to help decide if a chemical reaction has taken place is whether a gas is given off. Consider these three reactions.

Reaction 1

You have seen the reaction of magnesium with acid and seen bubbles of the gas hydrogen given off in Topic 8.1. You learnt how to test for hydrogen.



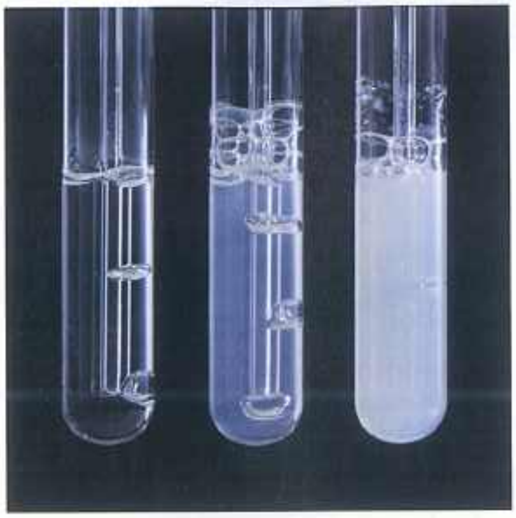
Magnesium reacting with hydrochloric acid

magnesium + hydrochloric acid ⟶ magnesium chloride + hydrogen

Reaction 2

When baking powder and vinegar react, a gas is also given off. This gas is carbon dioxide. You can test for carbon dioxide by using limewater.

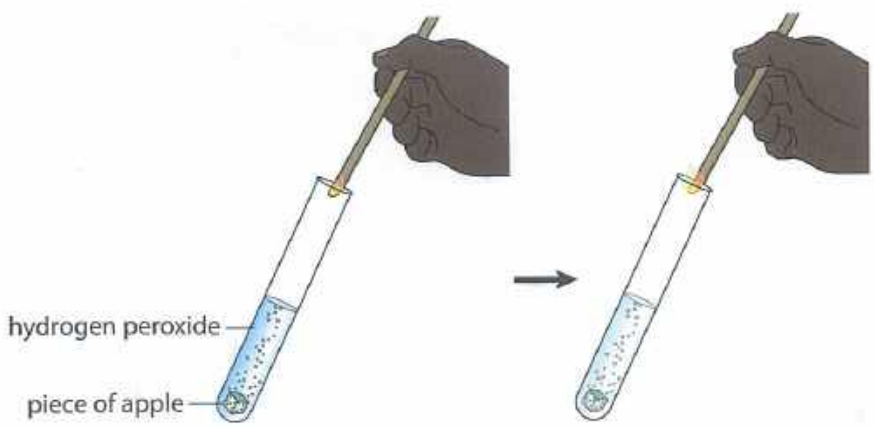
When limewater mixes with the carbon dioxide, the limewater turns **cloudy**.



Limewater turns cloudy when carbon dioxide is bubbled through it.

Reaction 3

When a piece of apple is placed in hydrogen peroxide it bubbles. A gas is given off. This gas is oxygen. To test for oxygen you use a **glowing** splint. When the glowing splint is placed in the mouth of the test tube, it will relight if the gas is oxygen.



When hydrogen peroxide and the chemicals in the apple react, oxygen is given off. Oxygen will relight a glowing splint.

Activity 8.4.1

Testing gases

Try these reactions and test the gas that is given off.

You will need:

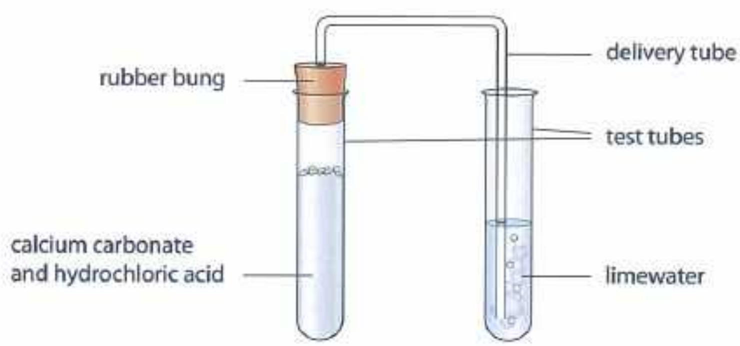
The apparatus shown in the diagrams

Safety

Wear safety glasses.

Testing for carbon dioxide

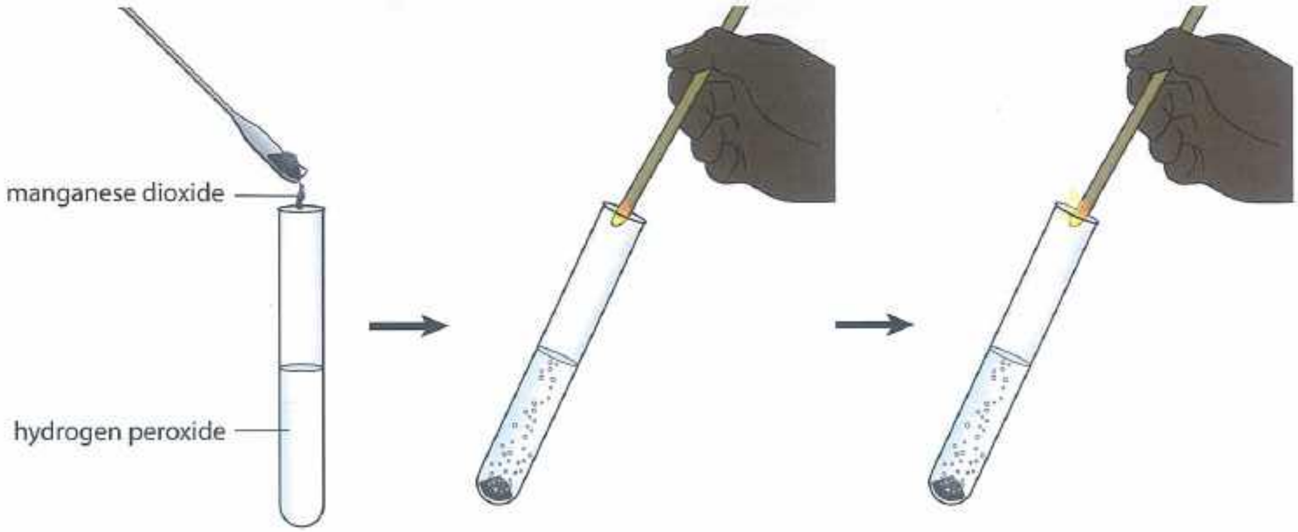
1. Pour limewater into a test tube until it is about half full.
2. Place a small amount of calcium carbonate into another test tube.
3. Add some hydrochloric acid to the calcium carbonate in the test tube.
4. Quickly fit the rubber bung and delivery tube.
5. Ensure the delivery tube reaches into the limewater.



Testing for oxygen

1. Pour hydrogen peroxide into a test tube until it is about half full.
2. Add a spatula of manganese dioxide.
3. Place a glowing splint into the neck of the test tube.

Continued



Questions

1 Describe the changes to the limewater when you tested for carbon dioxide.
2 Describe what happened to the glowing splint when you tested for oxygen.

How easy was it to carry out the tests for gases? What difficulties did you have? How did you attempt to overcome them?

Other chemical reaction clues

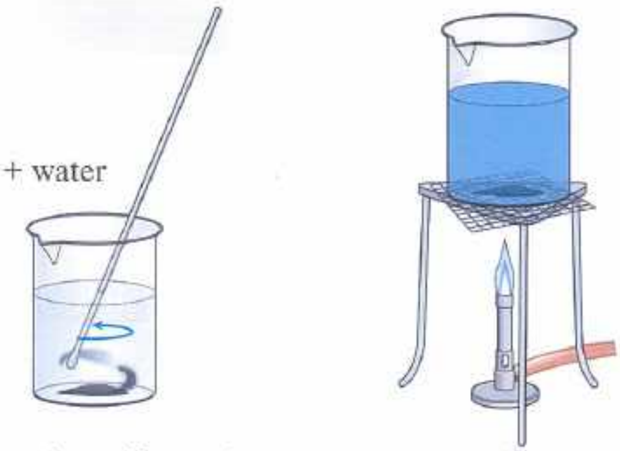
Reactant 'disappears'

When magnesium ribbon reacts with acid, hydrogen is produced and the magnesium ribbon 'disappears'. The magnesium is used up in the reaction; it combines with the chlorine from the hydrochloric acid to form magnesium chloride.

Colour change

Gently heating black copper oxide with sulfuric acid produces a blue solution of copper sulfate.

copper oxide (black) + sulfuric acid → copper sulfate + water



Safety

If you try this in the laboratory, make sure you do not boil the blue liquid, as harmful fumes will be given off.

Heat is produced

When potassium is placed in water, hydrogen gas is given off. The reaction produces so much heat the hydrogen burns.

Safety

This reaction should only be done by a teacher.

When you added zinc to hydrochloric acid, hydrogen gas was given off and the test tube felt hot.

Change in pH

When you neutralise an alkali, there is a change in pH. It is called a neutralisation reaction.

sodium hydroxide + hydrochloric acid → sodium chloride + water

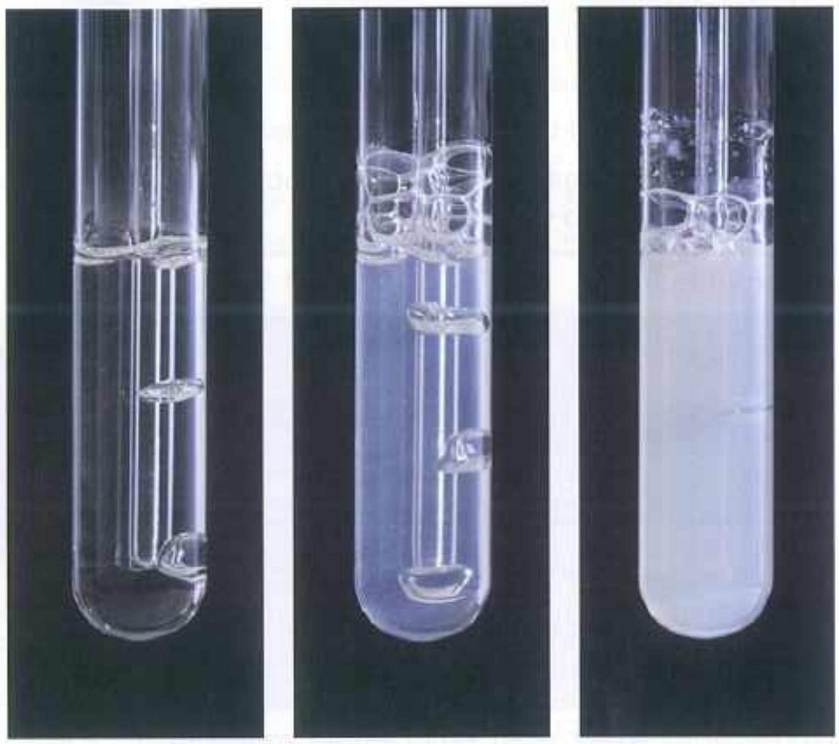
In this reaction, sodium chloride and water are produced.

A precipitate is formed

If you mix solutions of silver nitrate and calcium chloride, a chemical reaction takes place. When the two solutions (liquids) are mixed, a solid is formed. This solid is called a **precipitate**. In the example shown in the first photograph below, the solid is silver chloride.

silver nitrate + calcium chloride → silver chloride + calcium nitrate

When silver nitrate and calcium chloride react, a precipitate is formed.



As carbon dioxide is bubbled into limewater, a precipitate is formed.

When you tested for carbon dioxide gas, you used limewater. Limewater is a solution of calcium hydroxide. You saw that the limewater turned cloudy when carbon dioxide was bubbled into it, as in the series of three photographs above. This is because a precipitate of calcium carbonate formed. You added a gas to a liquid, and a solid was formed.

calcium hydroxide + carbon dioxide → calcium carbonate + water

Think like a scientist

Chemical reactions or not?

A series of experiments will be set up in the laboratory. You will be told which ones to carry out.

Safety

Before trying any of these reactions, you must carry out a risk assessment. Think about how you will stay safe.

Try some or all of these activities and decide if a chemical reaction has taken place. Share them with the class.

You do not need to carry out these investigations in any particular order.

For each investigation, state what you did and mention any safety considerations. What clues help you to decide?

Experiment A

You will need:

- safety glasses, black copper oxide powder, dilute sulfuric acid, a beaker and a stirring rod

Add some black copper oxide powder to about 150 cm^3 dilute sulfuric acid in a beaker. Stir gently.

What do you observe? Has a chemical reaction taken place? What evidence do you have?

Experiment B

You will need:

- safety glasses, a test tube, a test tube rack, a small piece of zinc, dilute hydrochloric acid, a beaker and a stirring rod

Half-fill a test tube with dilute hydrochloric acid. Add a small piece of zinc.

What do you observe? Has a chemical reaction taken place? What evidence do you have?

When you hold the test tube in your hands, do you notice anything?

Experiment C

You will need:

- safety glasses, limewater, a test tube, test tube rack, a straw

Half-fill a test tube with limewater. Use the straw and blow gently into it.

What do you observe? Has a chemical reaction taken place? What evidence do you have?

Experiment D

You will need:

- safety glasses, a piece of chocolate, test tube, test tube rack, a beaker, access to hot water

Fill a beaker with hot water. Place a small piece of chocolate in a test tube. Stand the test tube in the beaker of hot water.

What do you observe? Has a chemical reaction taken place? What evidence do you have?

Continued

Experiment E	*Experiment F*
You will need: • safety glasses, copper sulfate solution, evaporating dish, pipe-clay triangle, tripod, Bunsen burner, tongs Place a solution of copper sulfate in an evaporating dish. Heat gently until the solution starts to spit. Turn off the heat and leave the evaporating basin to cool. What do you observe? Has a chemical reaction taken place? What evidence do you have?	**You will need:** • safety glasses, sodium hydroxide, conical flask, measuring cylinder, universal indicator, hydrochloric acid, burette Place of sodium hydroxide in a conical flask and add a few drops of universal indicator solution. Add acid slowly from a burette until the universal indicator changes to green. What do you observe? Has a chemical reaction taken place? What evidence do you have?
Experiment G	*Experiment H*
You will need: • safety glasses, baking powder, spatula, vinegar, test tube, test tube rack Put a few spatulas of baking powder in a test tube. Add vinegar. What do you observe? Has a chemical reaction taken place? What evidence do you have?	**You will need:** • safety glasses, test tube, test tube rack, solution of silver nitrate, solution of calcium chloride Place silver nitrate in the test tube, about half full. Add calcium chloride solution slowly. What do you observe? Has a chemical reaction taken place? What evidence do you have?

What clues helped you to decide if a chemical reaction had taken place?

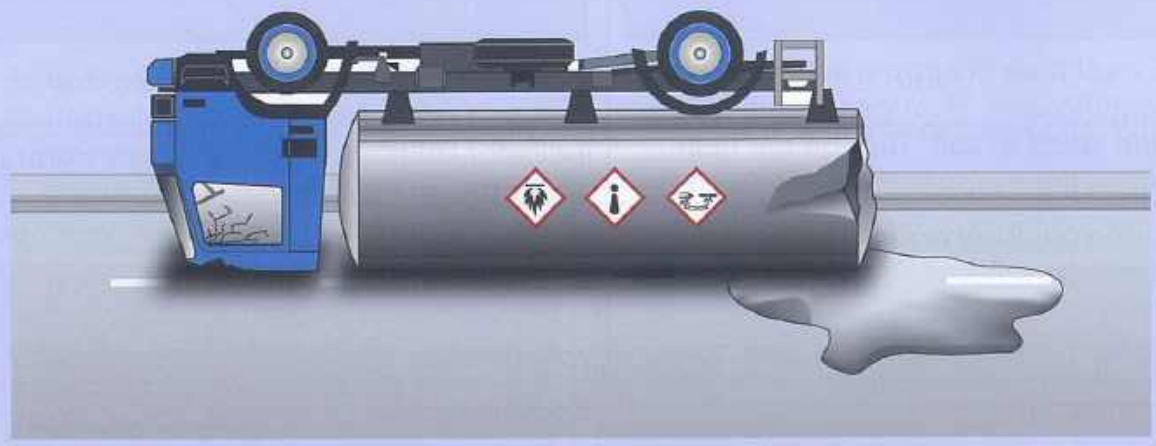
Summary checklist

- [ ] I can list different ways of identifying that a chemical reaction has taken place.
- [ ] I can test gases for hydrogen, oxygen and carbon dioxide.
- [ ] I can carry out practical work safely.

Project: Moving dangerous chemicals

Acids and alkalis need to be moved from where they are produced to where they are used. This can be very dangerous if there are spills and accidents.

Work in a group of three. You are a team of reporters who are going to write a report about a serious accident that has happened on a major road. The accident involved a truck carrying concentrated acid. The emergency services attended the accident and dealt with the spill of acid.



Here is a list of some things you could consider.

- Why is an acid spill so dangerous?
- What would happen if people drove their cars through the acid spill?
- How do the emergency services know which chemical they are dealing with?
- What must the emergency services do to the spilt acid?
- How will they know when the task is complete?
- What safety measures must be taken by the emergency services to deal with the spill?
- What would be the effect of the acid reaching the soil alongside the road?
- What regulations are in place in your area about the transportation of dangerous materials?
- What considerations are there for moving dangerous chemicals by sea or air?

Decide which of you will research each of the suggestions above. Set a time limit and then meet to share your findings. You may need to do further research or discover other areas you want to find out about.

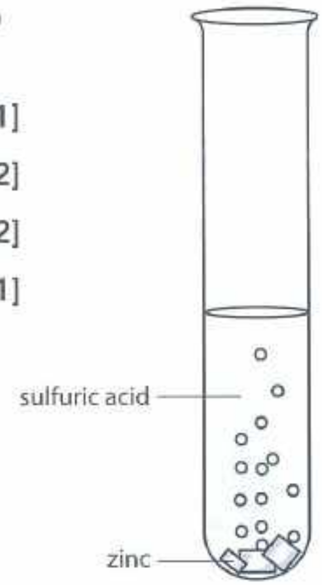
Your report could be written as if it is for a newspaper or magazine. It could be in the form of a radio or television interview or a presentation to the class. Choose a form that you have not used in another science project.

Check your Progress

8.1 Draw a table to sort the following list into either **physical change** or **chemical reaction**. [5]

- burning a piece of wood
- melting chocolate
- cooking an egg
- heating glass and bending it
- baking a cake

8.2 The diagram shows an experiment where zinc metal is added to sulfuric acid.



a What is the name of the gas given off in this reaction? [1]

b How do you test for this gas? [2]

c What products are formed in this reaction? [2]

d How do you know when all the acid has reacted? [1]

8.3 Magnesium ribbon burns in air.

a Write the chemical symbol for magnesium. [1]

b Name the element in the air that reacts with magnesium when it burns. [1]

c Name the compound formed when this element reacts with magnesium. [1]

d Magnesium also reacts with chlorine. Suggest the name of the product of this reaction. [1]

8.4 Look at these reactions.

A Carbon combines with oxygen to form carbon dioxide.

B Sodium hydroxide reacts with hydrochloric acid to produce sodium chloride and water.

C Potassium and water react to form potassium hydroxide and hydrogen.

D Copper carbonate reacts to produce copper oxide and carbon dioxide.

Write the letter of the reaction that:

a produces a metal oxide **[1]**

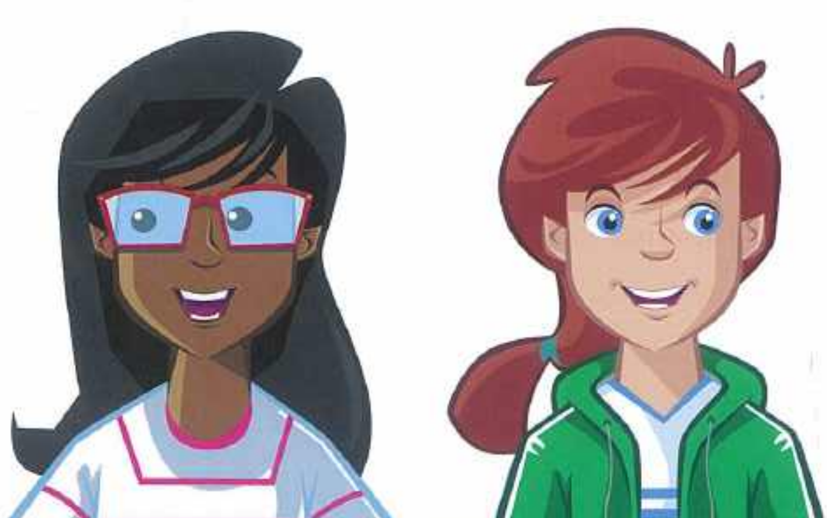
b is a neutralisation reaction **[1]**

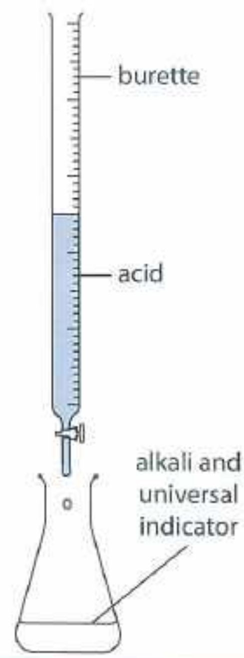
c is a burning reaction. **[1]**

8.5 Zara and Sofia put 50 cm^3 of alkali into a conical flask. They added a few drops of universal indicator to the alkali. They used a burette to add acid to the alkali. Zara added the acid 10 cm^3 at a time. Sofia stirred the contents of the conical flask each time acid was added. They recorded the pH after each addition of acid.

The table shows their results.

Volume of acid added in cm^3	0	10	20	30	40	50
pH of solution	12	11	10	9	8	7





a What colour was the alkali and universal indicator solution at the start? **[1]**

b What colour was the solution in the flask at the end? **[1]**

c Which one of the statements is correct? **[1]**

- The acid was stronger than the alkali.
- The alkali was stronger then the acid.
- The acid and the alkali were equal in strength.

Explain your answer.

d Draw a line graph of Zara and Sofia's results on graph paper.
Place the pH on the vertical axis. **[4]**

9 Electricity

> 9.1 Flow of electricity

In this topic you will:

- understand how electricity flows around a circuit
- learn about the electrons that flow to make electric current.

Getting started

Work in groups to discuss answers to these questions.

1 Which of these must be present in a complete circuit for current to flow?

lamp cell switch wire

2 Which of these flows around a complete circuit?

voltage wires current heat

Key words

attract
battery
cell
components
current
electrons
free to move
negative charge
repel
terminals

Current

Look at the circuit in the picture.

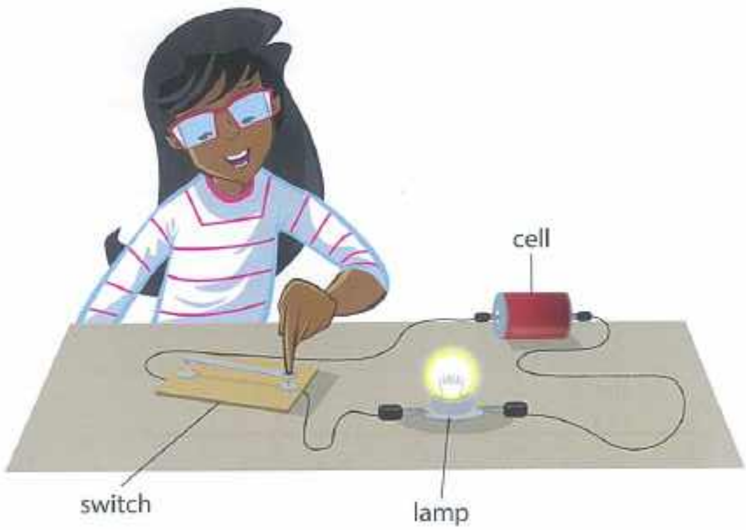
When you close the switch, the lamp lights.

A **cell** stores chemical energy that can be changed to electrical energy in a circuit. A **battery** contains two or more cells joined together.

The cell in the circuit has two connections, called **terminals**.

All cells, batteries, power supplies and many other **components** have two terminals.

The terminals are labelled with + and − symbols, meaning positive (+) and negative (−).



What happens to make the lamp light?

You can see these symbols in the photograph of these three cells.

The photograph below shows one of the batteries from an electric car. You can see that the battery is made from many cells.

When connected into a circuit, the negative terminal of a cell, battery or power supply pushes **electrons** around in the wires. All materials contain atoms. Atoms contain smaller particles. An electron is one type of smaller particle in an atom.

The flow of electrons in the circuit is called **current**.

This is one battery pack from an electric car. Many of these are connected together to give hundreds of cells.

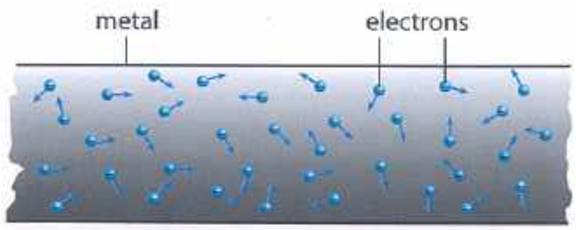
The flow of current in a circuit is the movement of electrons around the circuit.

More about electrons

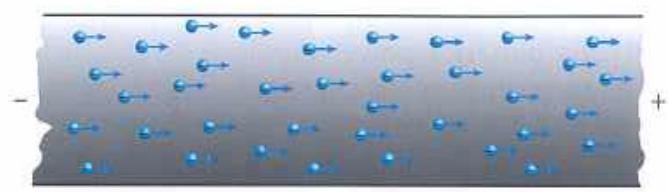
Some of the electrons in a metal are **free to move**. That means they can move through the metal.

In a metal, these electrons move randomly, as shown in the diagram. Electrons are very small and this diagram is not to scale.

When the metal is placed into a circuit, all the electrons move in the same direction.



Electrons in a metal move randomly.



Electrons are negatively charged so they move toward the positive terminal in a circuit.

Electrons have a **negative charge**.

Opposite charges **attract**, and like charges **repel**. To attract means to pull together and repel means to push apart. That means:

- positive and negative attract
- positive and positive repel
- negative and negative repel.

Therefore, electrons will be attracted towards the positive terminal of the power supply and be repelled from the negative terminal.

If there is a break in the circuit, all the electrons stop flowing. Electrons can only flow in a complete circuit.

Questions

1 Name the particles that move around a circuit when current flows.

2 Copy the sentences and use words from the list to complete them.

Each word may be used once, more than once or not at all.

attracted repelled positive negative electrons atoms

Current in a circuit is the movement of ....

These particles have a .... charge.

These particles are .... by the positive terminal of a battery and .... by the negative terminal of a battery.

Activity 9.1.1

Modelling electron flow

In this activity, you will use a model to show how current flows in a circuit.

Work in groups of four to six.

You will need:

- a ball of string, scissors, coloured tape or coloured marker pen

Safety

Do not pull string quickly through your hands as it can cause burns.

1. Tie the ends of the string together to form a large loop. The loop must be long enough to be held by all the people in the group. Attach coloured tape or make coloured marks on the string at equally spaced intervals. The intervals should be about 10 cm long.
2. In your group, stand in a circle facing toward the centre of the circle.
3. Each person should hold the loop of string in front of them in both hands, so the string forms a circle. Hold the string so that it is quite tight but can move.
4. The people in the group are the components in the circuit. One person is the cell. The person who is the cell must pull the string around through the hands of the other group members. The other group members can be components such as lamps or buzzers.
5. Watch how the string moves. Use the coloured marks to see the movement of the string.

Questions

Discuss these questions in your group.

1. What part of the circuit made the string move?
2. When the string started to move, was the speed the same all the way around the circuit or different?
3. Was it possible for the string to be moving in one part of the circuit and not moving in another part?
4. Name the particles represented by the coloured marks.
5. In what ways does this model:
   a. correctly represent what happens in a circuit
   b. not correctly represent what happens in a circuit?

Think like a scientist

Making predictions about current

In this task, you will make and test predictions about the flow of current in a circuit.

Work as a whole class.

You will need:

- a power supply or battery, wires longer than 2 metres, or many short wires that can be connected end to end, 4 identical lamps that can operate in series from the power supply

1 Make a circuit with one lamp close to the negative terminal of the power supply.

2 Place the next lamp several metres away from the first lamp, and another lamp a similar distance from this lamp.

3 Place the fourth lamp close to the positive terminal of the power supply.

Do not switch on the lamps yet.

Questions

Discuss these questions as a whole class.

1 What will happen when the power supply is switched on?

Will all the lamps come on at the same time?

If not, in what order will they light?

2 a Is this prediction testable?

b What name is given to a testable prediction?

Now switch on and see what happens.

3 Describe what you observed.

4 Try to explain what happened in terms of the flow of electrons.

Self-assessment

What did you learn about current in a circuit? List as many things as possible.

Is there anything you're still unsure about current in a circuit?

Summary checklist

- [ ] I can describe how electrons move in circuits.
- [ ] I can understand how to work out the direction that electrons move.

9.2 Electrical circuits

In this topic you will:

- learn how to draw and compare circuit diagrams
- learn the circuit symbols for cells, switches, lamps, buzzers and ammeters.

Getting started

Work in pairs.

Discuss with your partner the role of each of these components in a circuit:

a cell

b switch

c lamp

d buzzer

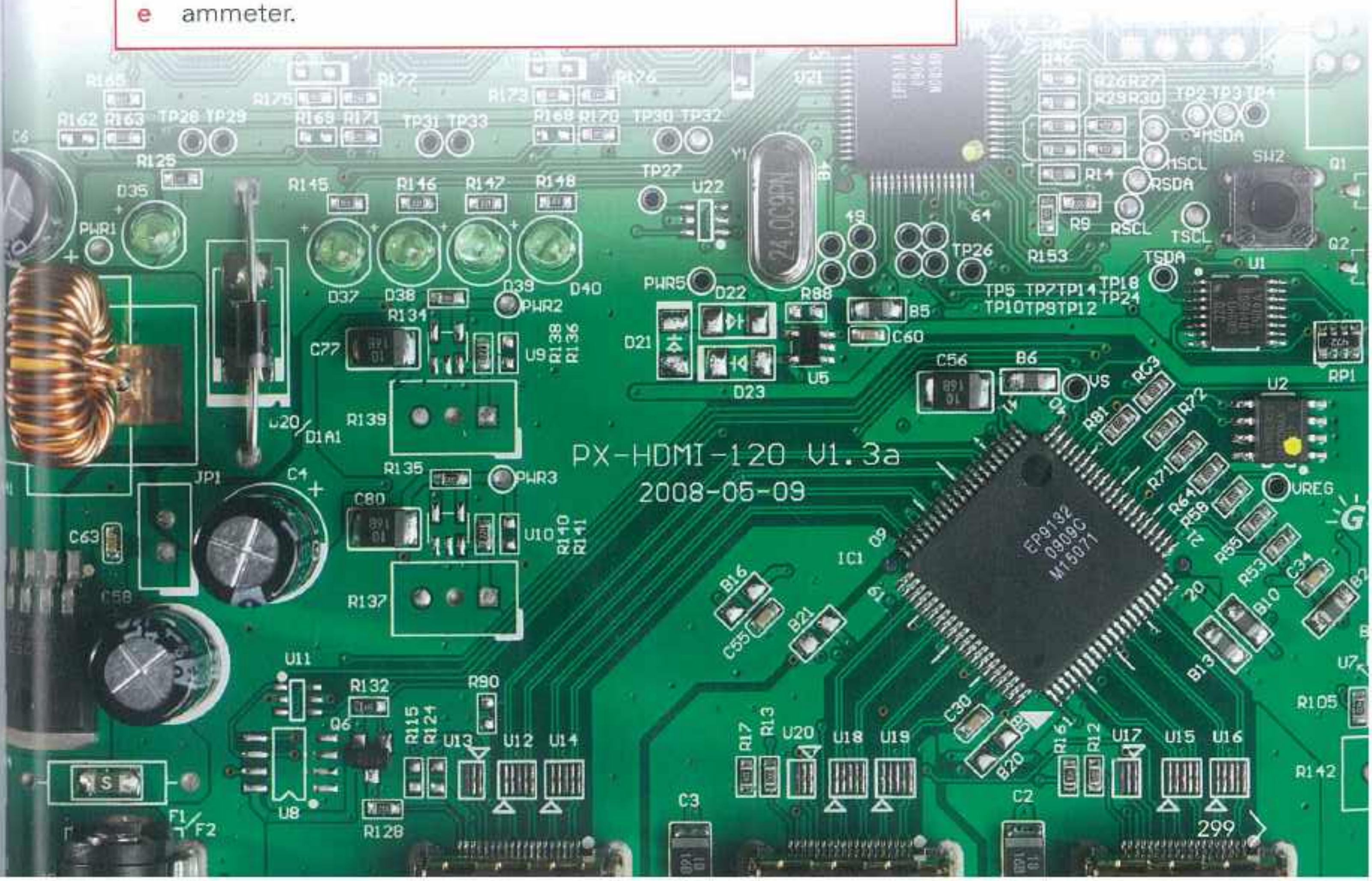
e ammeter.

Key words

ammeter

circuit diagram

circuit symbols

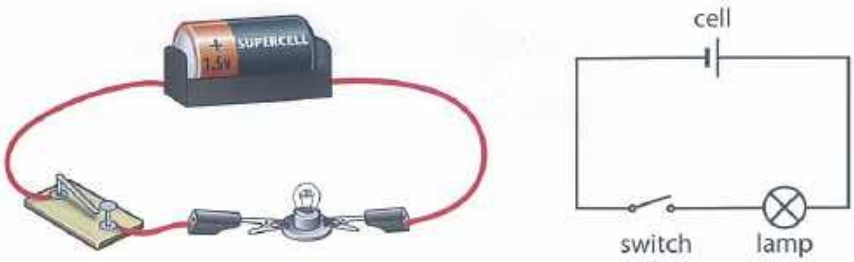


Circuit diagrams

Circuits can be shown in a drawing or a **circuit diagram**.

Advantages of circuit diagrams compared with pictures

- Circuit diagrams are easier to draw.
- The components have standard symbols.
- Wires are drawn with straight lines, which is easy to interpret.



This is a drawing of a simple circuit and the circuit diagram for the same circuit.

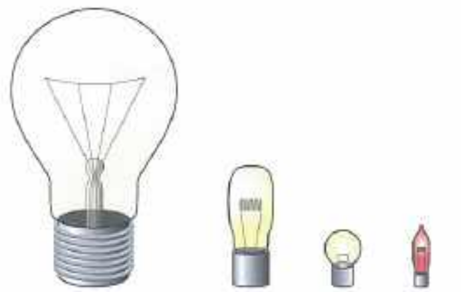
Circuit symbols

Components in circuits can look very different.

The picture shows how different some lamps can look.

Standard **circuit symbols** are used in circuit diagrams so there is no confusion. The same symbols are used in all countries.

The table shows the names, symbols and functions of some components.



These are all different types of lamp but they all have the same circuit symbol.

Name	Symbol	Function
Ammeter		measures current in the circuit
Cell		provides energy to make current flow
Lamp		gives out light
Switch (open)		stops the flow of current when opened
Switch (closed)		starts the flow of current when closed
Buzzer		makes a buzzing sound

Common circuit symbols

In the circuit symbol for a cell, the positive is the longer of the two lines. The negative is the shorter line.

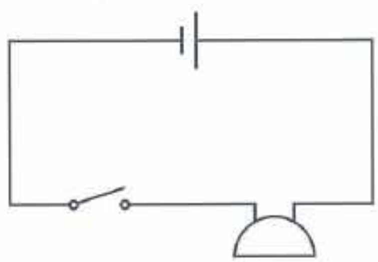
Take care when drawing circuit diagrams. Make sure:

- there are no gaps in the lines, especially at the corners and where wires meet components
- wires are not drawn through components.

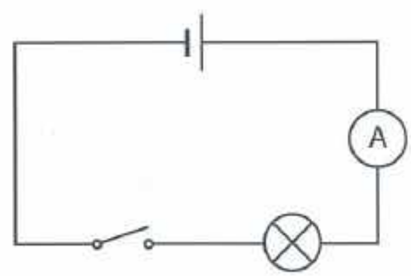
Comparing circuit diagrams

Different circuits are used to do different jobs.

This circuit contains a cell, a switch and a buzzer. The circuit could be used in a doorbell. If the switch is pushed outside a door, it makes the buzzer sound and attracts attention inside.



This circuit contains a cell, a switch, a lamp and an **ammeter**. The ammeter measures the electric current. This circuit could be used to light a room and measure the current flowing though the circuit. By measuring the current, you could tell if the cell needs to be replaced – a smaller current means the cell is low on stored energy. The lamp would also become less bright, but you might not notice until too late and you find yourself sitting in the dark!



Questions

1 Draw the circuit symbol for:

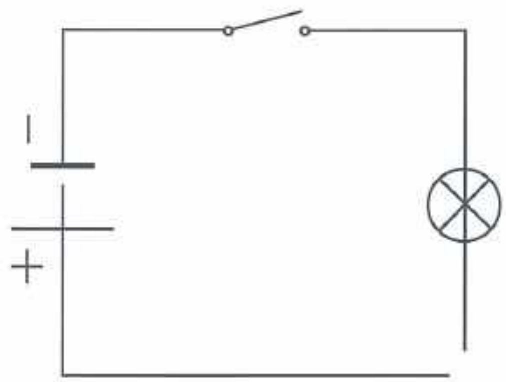
  a a lamp

  b a cell

  c a buzzer

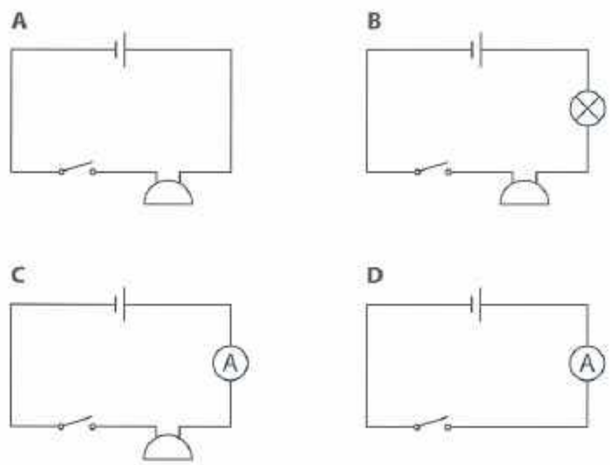
  d a closed switch.

2 Arun draws a circuit diagram with a cell, a switch and a lamp. He makes three mistakes.



Describe the **three** mistakes in the diagram.

3 Which of these circuits could be used to measure the current in a buzzer?



Think like a scientist

Drawing circuit diagrams

Work individually.

Draw circuit diagrams for each of these jobs.

A Two lamps that can be switched on and off together in a car.

B A buzzer on a front door with a lamp that comes on at the same time as the buzzer.

C Three lamps that operate all the time, with a way to measure current in the lamps.

Questions

1 Now swap your circuit diagrams with someone else. Are they the same?

2 Can two circuit diagrams be different and both correct? Explain your answer.

Continued

Self-assessment

Write a number from 1 to 5 for each of these statements.

The number represents how confident you are.

Use 1 for 'not confident'.

Use 5 for 'very confident'.

- I can remember all the circuit symbols in the table.
- I can draw circuit diagrams correctly and accurately.
- I can tell what the circuits in different circuit diagrams could be used for.

Activity 9.2.1

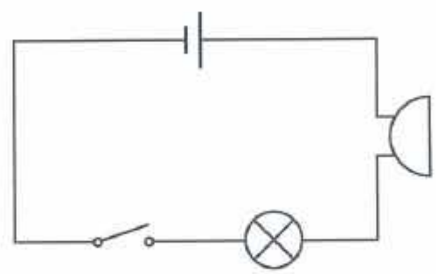
Circuit uses

Work in groups of three or four.

Look at this circuit diagram.

Discuss what this circuit could be used for.

Make a list of as many possible uses as you can.



Summary checklist

- [ ] I can recognise the circuit symbols for a cell, a switch, a lamp, a buzzer and an ammeter.
- [ ] I can draw the circuit symbols for a cell, a switch, a lamp, a buzzer and an ammeter.
- [ ] I can draw a circuit diagram containing any of these components.
- [ ] I can recognise and compare the jobs of different circuits from their circuit diagrams.

9.3 Measuring the flow of current

In this topic you will:

- learn the unit for measuring current
- learn how to measure current
- learn a rule about current in series circuits.

Getting started

1 Name the particles that move in wires when current flows.

2 a Name the component that is used in a circuit to measure current.

b Draw the circuit symbol for this component.

Key words

amps

in series

Measuring current

In Topic 9.1 you saw that electrons move when current flows.

When electrons move more quickly, the current increases.

When electrons move more slowly, the current decreases.

In Topic 9.2 you saw that you can use an ammeter to measure current.

Current is measured in units called **amps**. Amps have the symbol A.

There are different types of ammeter but they all do the same job.

The picture shows two different ammeters.

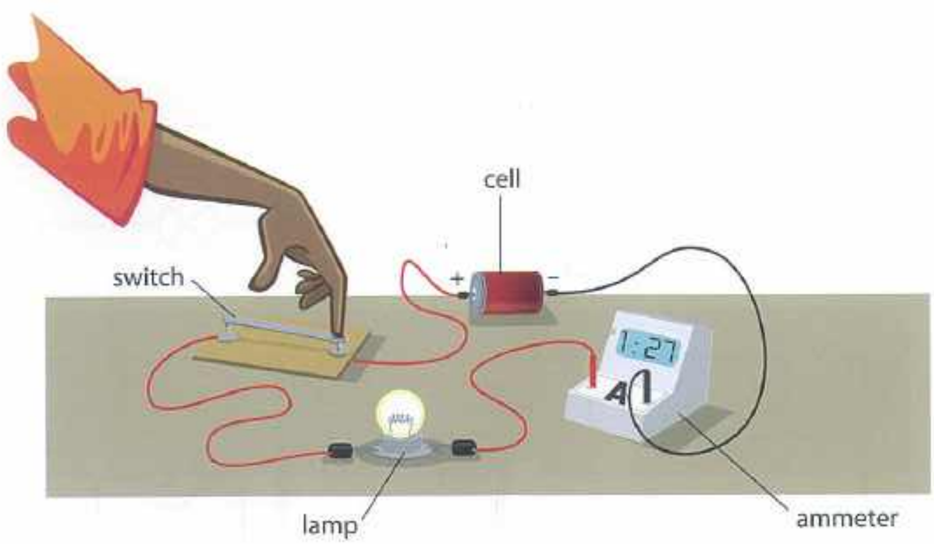
Look carefully at the ammeters in the picture. They both have two terminals, for wires to be attached. One terminal is red and the other terminal is black.

In a circuit, the red terminal of the ammeter must be connected to the positive terminal of the power supply. The red terminal may be connected directly, or through other components, to the positive terminal of the power supply.

Both ends of the ammeter are the same in a circuit diagram. You do not need to show the red and black terminals on the circuit symbol for an ammeter.

Ammeters are always connected **in series** with other components in a circuit. If the components are connected in series they are all connected end-to-end, one after another, and there are no branches in the circuit.

The drawing shows an ammeter connected in series with a battery, a switch and a lamp. The circuit diagram shows the same circuit.

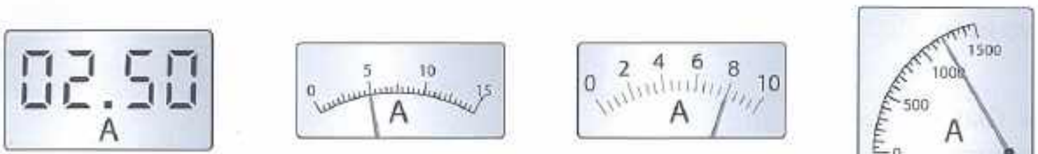


Questions

1 Name the unit used to measure current.

2 The diagram shows four different ammeters in four different circuits.

Write down the current shown on each ammeter. Include the unit in your answer.



A B C D

3 Copy the sentence and use words from the list to complete it.

Each word may be used once, more than once or not at all.

slower **faster** **electrons** **atoms**

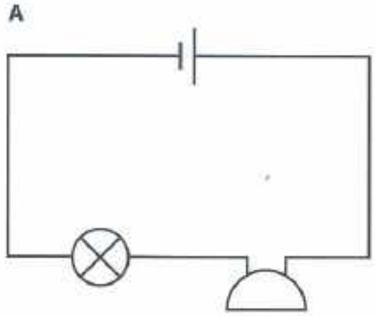
The greater the current in a circuit, the .... the flow of ....

4 Marcus has a circuit with a cell, a lamp and a buzzer.

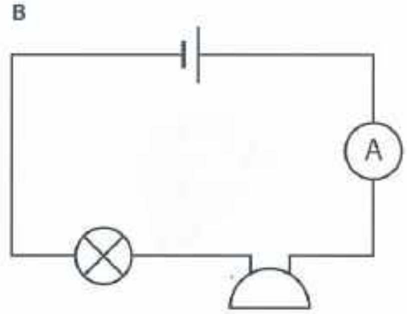
He wants to measure the current in the circuit.

Which is the correct way to connect the ammeter in this circuit?

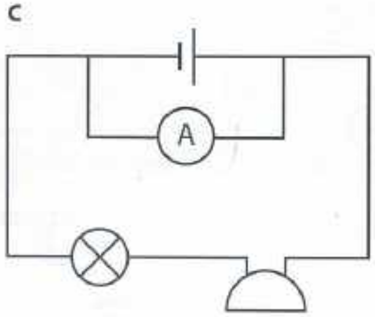
A



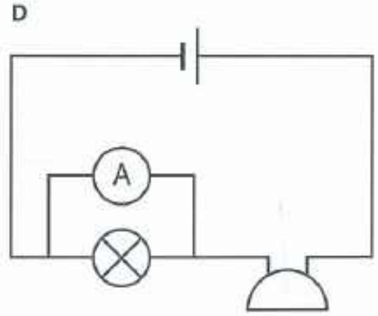
B



C



D



Activity 9.3.1

Drawing ammeter scales

In this activity, you will draw the scale for ammeters.

Work in pairs.

Draw an ammeter scale and mark the scale with numbers and divisions. The scale should look like one of those in question **2**.

Do not add the pointer to the scale.

Write a current beside your ammeter scale. Make sure the current you write is within the scale you have drawn.

Start with a whole number of amps, such as 4 A or 2.0 A.

Swap your drawing with your partner. Your partner will add the pointer to the drawing. The pointer should be in the correct place to match your current.

Swap your drawings back again. Is the pointer in the correct place?

You can progress to decimal numbers, such as 1.7 A. Make sure your drawing has the correct number of divisions between whole numbers.

Swap drawings again and check them as before.

Self-assessment

Which was more difficult:

- drawing the scale correctly
- putting the pointer in the correct place?

Think like a scientist

Making predictions about current

In this task, you will make and test predictions about current in a circuit.

Work in groups.

You will need (for each group):

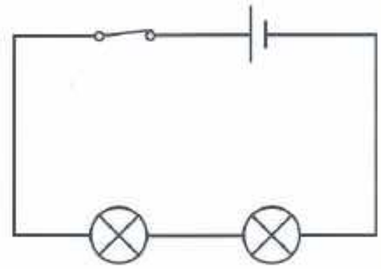
- a cell (or cells) that can operate two lamps in series, a switch, lamps, an ammeter, wires and connectors

Safety

Never connect an ammeter directly across the terminals of a cell, battery or other power supply.

Continued

Part 1



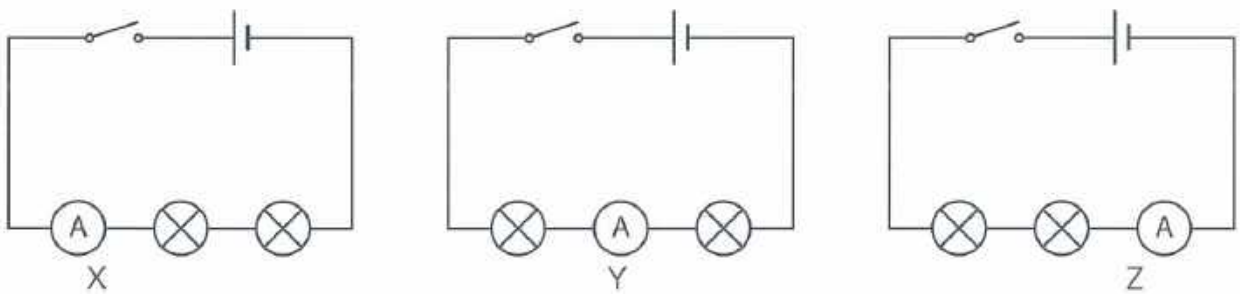
1 Connect the circuit so that the lamps and the switch are in series with the cell (or cells), as shown. Do not include the ammeter yet.

2 Copy the circuit diagram.

3 Add arrows to your circuit diagram to show the direction that electrons flow through the circuit.

Question

1 You are going to measure the current at different positions in the circuit. You will do this by placing the ammeter in the positions X, Y and Z, as shown.



a Predict what will happen to current going around the circuit.

Choose one statement.

A Current will stay the same all the way around the circuit.

B Current will decrease as it goes around the circuit.

C Current will increase as it goes around the circuit.

b Explain your prediction.

Part 2

4 Connect the ammeter into your circuit. Connect it at position X.

5 Close the switch and record the ammeter reading.

6 Do this two more times, once with the ammeter in position Y, and once with the ammeter in position Z. Remember to open the switch before you make changes.

7 Copy the three circuit diagrams.

8 Write your ammeter readings next to each circuit diagram.

Questions

2 Describe the trend in your results.

3 Was your prediction from question 1 correct?

4 Explain your results. Use ideas about how electrons move in wires.

Answer the questions that apply to you.

If your prediction was not correct:

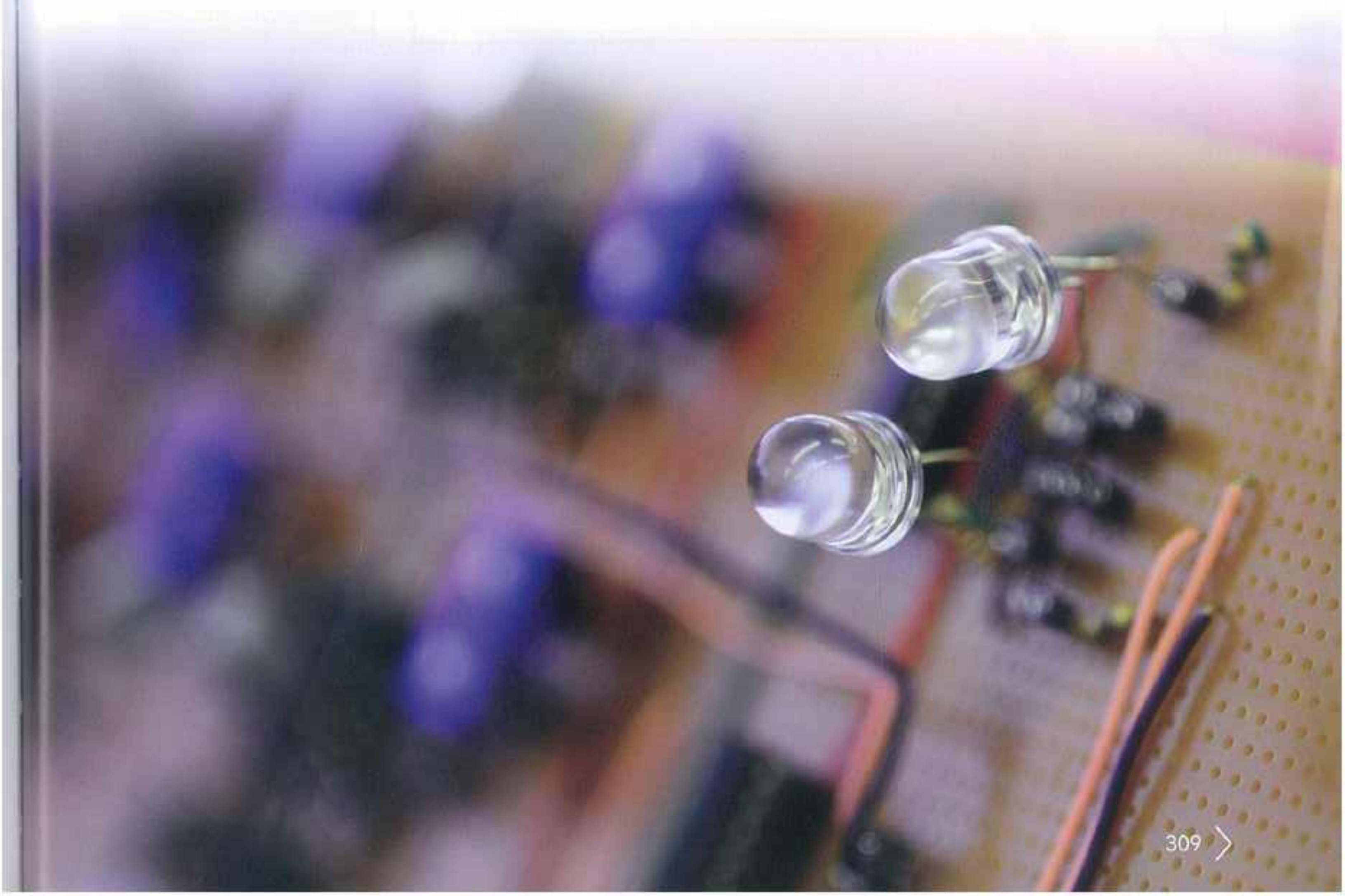
- Did the result surprise you?
- How will you remember this result?

If your prediction was correct:

- How did you work out what would happen?
- How will you remember this result when you use other series circuits?

Summary checklist

- [ ] I can recall the unit of current and its symbol.
- [ ] I can take accurate readings from an ammeter.
- [ ] I can draw a circuit diagram with an ammeter connected correctly.
- [ ] I can explain how to connect an ammeter in a circuit.



9.4 Conductors and insulators

In this topic you will:

- discover the difference between electrical conductors and insulators
- learn about uses for conductors and insulators
- test some materials for electrical conduction or insulation.

Getting started

Work in pairs.

Complete the sentences. Use words from the list.

The words may be used once, more than once or not at all.

are free to move **cannot move** electrons **atoms** **wires**

When current flows, particles called .... move.

In metals, these particles ....

Key words

allow current to flow

conduct electricity

conductor

inhibit

insulator

Conductors

Conductors are materials that **conduct electricity**.

That means conductors **allow current to flow**. Electric current can flow through a conductor.

You saw in Topic 9.1 that electrons move when current flows.

Therefore, a **conductor** is a material in which electrons are free to move. Conductors allow electrons to flow.

All metals are conductors.

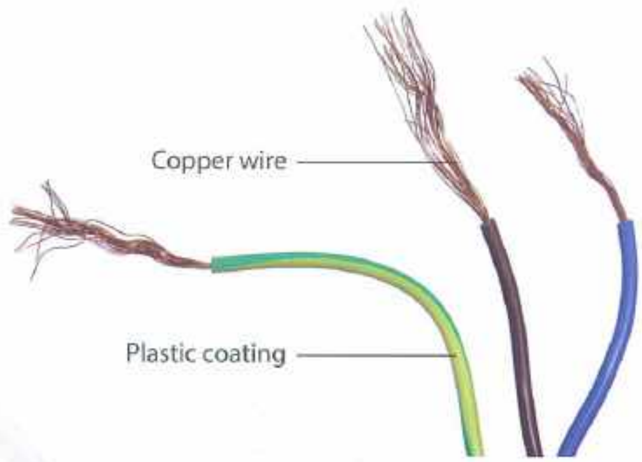
Wires that carry electric current are made from metal.

Most wires in houses and schools are made from copper, with a plastic coating.

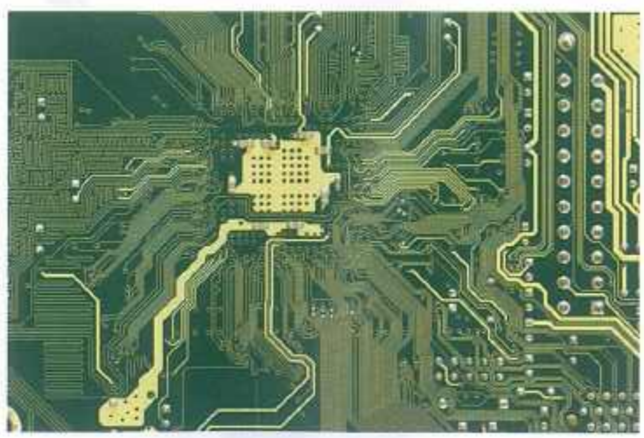
Wires that cover long distances are usually made from aluminium or steel. These metals are cheaper than copper.

Some circuits, such as those in phones and laptops, do not use wires. The printed circuit board in the bottom right picture has copper tracks instead of wires. The tracks are green because the copper is coated with another material.

Metals conduct electricity because electrons in metals are free to move.



Some wires are hundreds of km long.



This printed circuit uses copper tracks instead of wires.

Insulators

Electrical **insulators** are materials that do **not** allow current to flow through.

Most non-metals, such as plastic, wood, air and cotton, are insulators.

In an insulator, the electrons are **not** free to move.

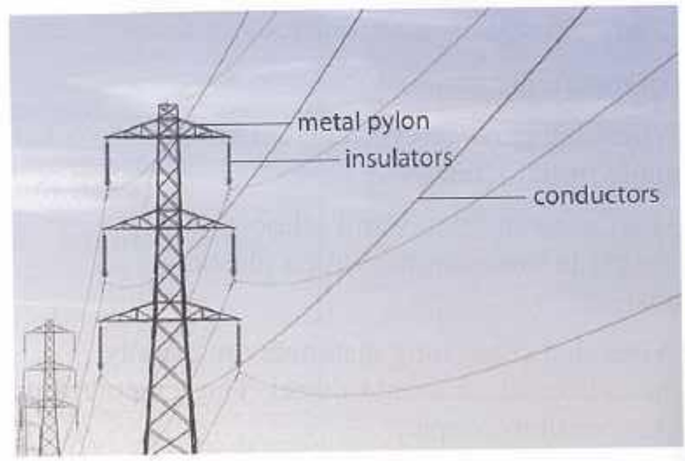
Because the electrons are **not** free to move, current cannot flow. Insulators **inhibit** electron flow.

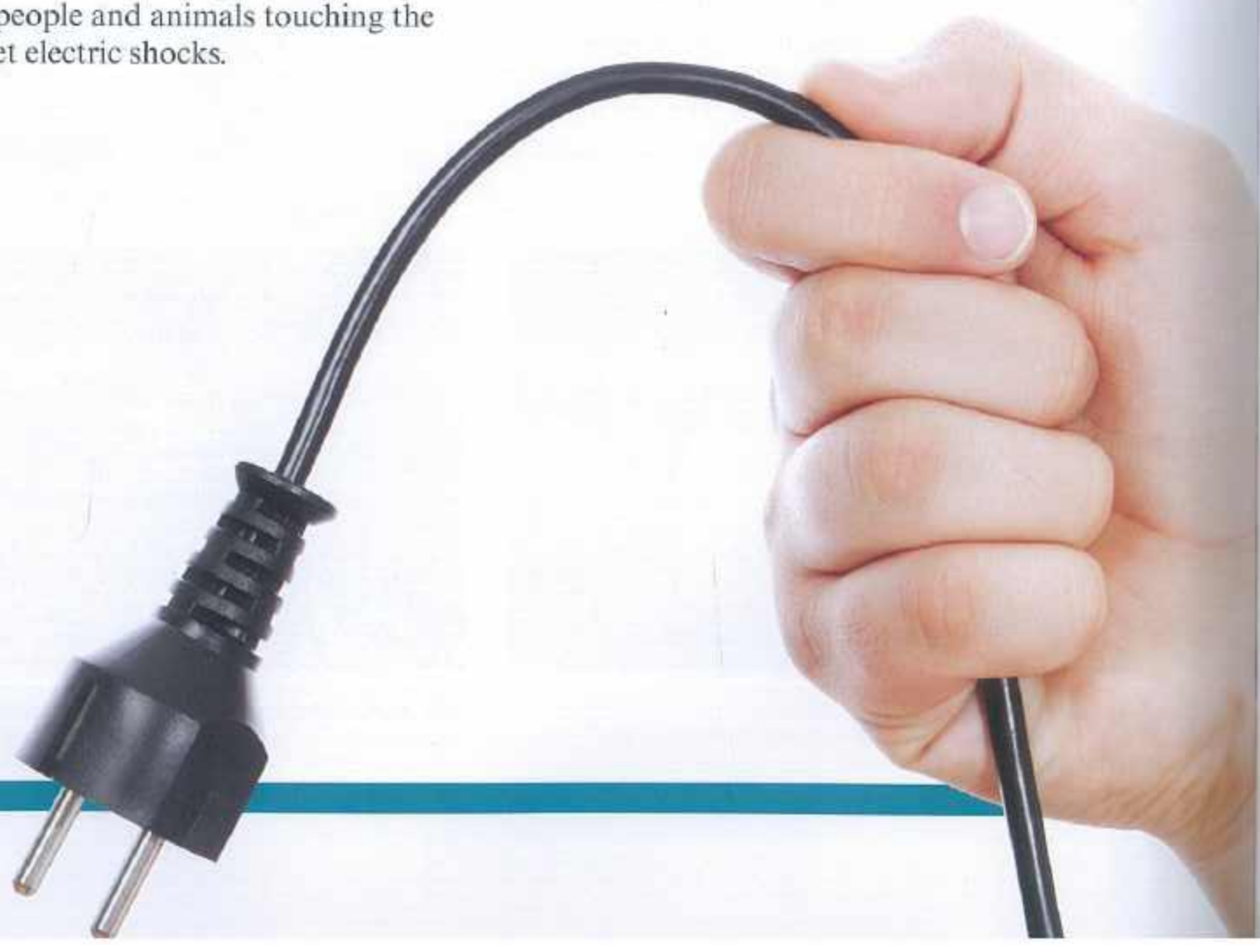
Insulators are used to keep people safe from electricity.

The plug in the picture below is made from plastic so people can touch the plug. The wire coming from the plug is also coated in plastic to protect people from electric shocks.

Plastic insulation on wires is also useful because the plastic can be coloured differently to identify each wire.

The insulators on these power lines stop the current from flowing from the wires into the metal pylon. If the current flowed to the pylon, electrical energy would be dissipated into the ground. Also, people and animals touching the pylon would get electric shocks.





Questions

1 Copy the sentences and use words from the list to complete them.

plastic **steel** **aluminium** **wood**

Examples of electrical conductors include .... and ....

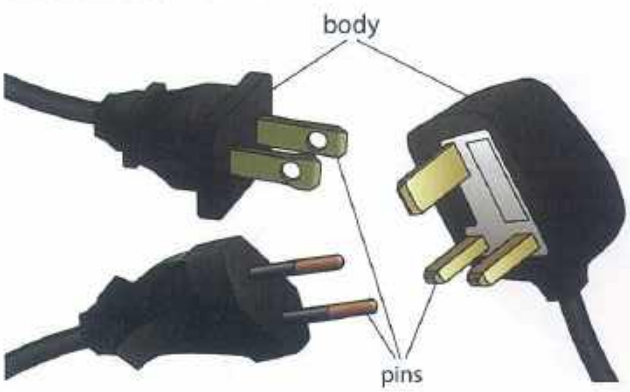
Examples of electrical insulators include .... and ....

2 Copper is used to make wires for home use. Copper is a good conductor of electricity.

Silver is a better conductor of electricity than copper.

Suggest why wires for home use are **not** made from silver.

3 The drawing shows some types of plugs that are used in different countries.



Explain why:

a the bodies of the plugs are made from plastic

b the pins on the plugs are made from metal.

4 Explain, in terms of particles, the difference between conductors and insulators.

Activity 9.4.1

Conduct or insulate?

Work in groups.

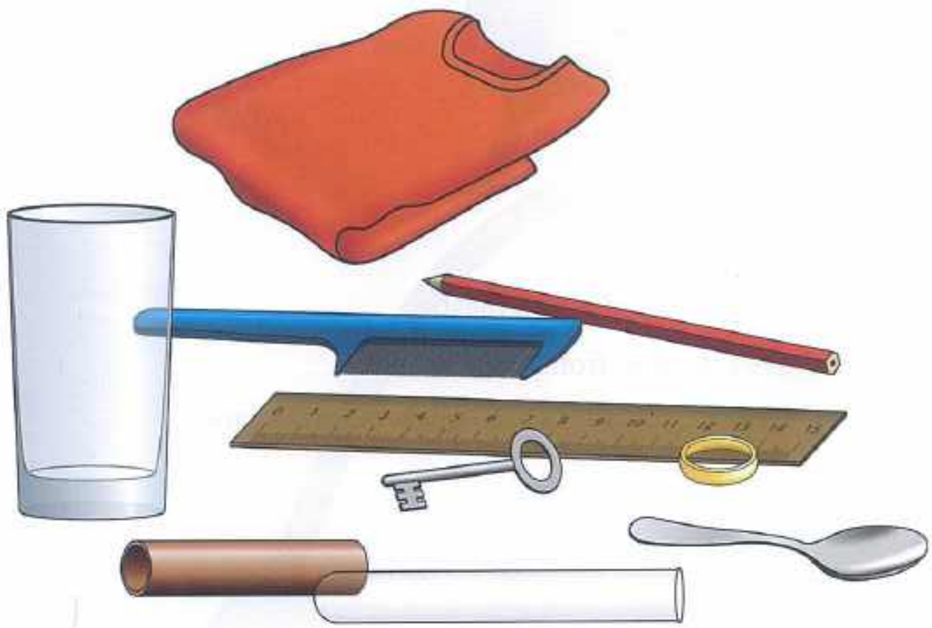
You will need:

- a piece of paper, a pen, a pencil, a ruler

Use the ruler to make a large table on a sheet of paper, with these headings.

Object	Conductor or insulator	Reason

Put the names of each of these objects into the table and complete the other columns.



Self-assessment

How many of the objects did you classify correctly as conductors or insulators?

Did you get the reasons correct?

Think like a scientist

Conductor or insulator?

In this task, you will test some materials to find out whether they are conductors or insulators.

Work in pairs or groups of three.

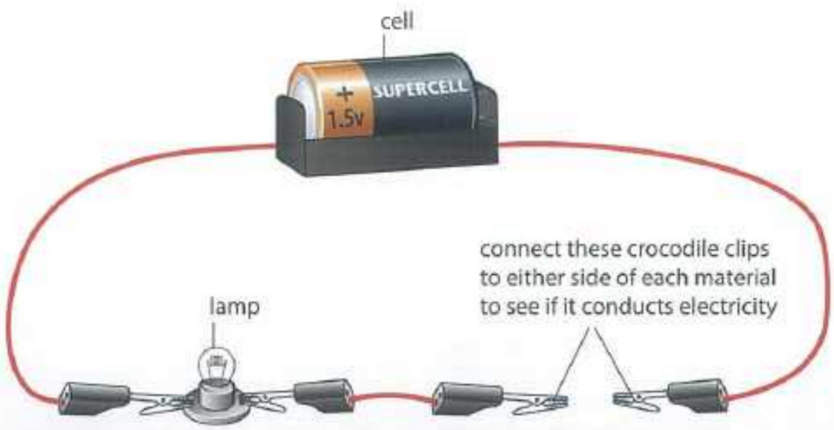
You will need (for each group):

- a battery or cell, a lamp, crocodile clips, wires, a selection of materials to test, such as items found in the classroom

Safety

Never connect a conductor directly across the terminals of a cell, battery or other power supply without the lamp in the circuit.

1 Set up a circuit as shown in the drawing.



2 Touch the crocodile clips together and watch what happens to the lamp.

3 Test some materials by connecting the materials between the crocodile clips.

Questions

1 Explain why you touched the crocodile clips together before you started.

2 Explain how the test works.

3 Present your results in a suitable way.

4 Describe any trends or patterns in your results.

5 Some objects that are made from metal may appear to be insulators in this test.

   a Explain why.

   b Describe how you could show that these metals are actually conductors.

Summary checklist

- [ ] I can describe what is meant by 'electrical conductor' and 'insulator'.
- [ ] I can understand how conduction and insulation work, in terms of electrons.
- [ ] I can recall some examples of conductors and insulators.
- [ ] I can describe some uses of conductors and insulators.

9.5 Adding or removing components

In this topic you will:

- find out what happens to current when you add more cells in a circuit
- find out what happens to current when you add more lamps in a circuit.

Getting started

Work in pairs to answer these questions.

1 a Name the unit for measuring current.

  b Give the symbol for this unit.

2 Complete the sentences.

  a Current in a circuit is the flow of particles called …………………… .

  b As current increases, the flow of these particles gets …………………… .

Key words

adding components

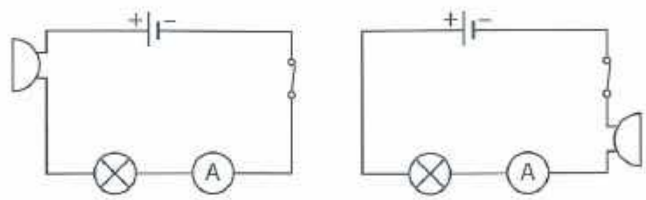
dimmer

position

removing components

Current in a series circuit

If you did *Think like a scientist: Making predictions about current* in Topic 9.3, you may remember that current is the same all the way around a series circuit.



The ammeter will give the same reading in both these circuits if the components are identical.

You can think of the electrons in a series circuit like a train. All parts of the train move at the same speed on the track. The back of the train cannot go faster than the front of the train. As soon as one part of the train moves, all of the train will move.

Electrons flow at the same speed in the wires of a series circuit. When electrons start to flow in one part of the circuit, they all start to flow.

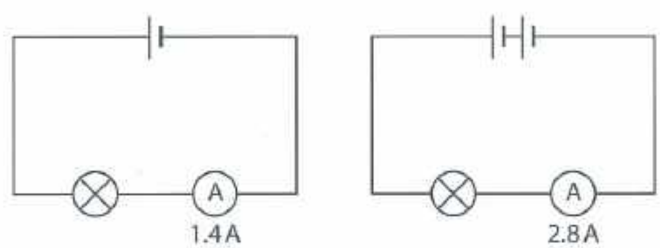
That means you can put an ammeter at any **position** in a series circuit and it will give the same result.

It also means that you can put the same components of a series circuit in a different order and the current will be the same.

Adding components or **removing components** will affect the current. The effect depends on what components are changed.

Adding or removing cells

You saw in Topic 3.5 that cells and batteries are stores of chemical energy. In a complete circuit, the chemical energy gets changed to electrical energy.



That means if you add more cells to a circuit, you have more chemical energy to change into electrical energy in the circuit.

Look at the two circuits. Each component is identical in both circuits.

The circuit with two cells has double the electrical energy of the circuit with one cell.

The lamp will be brighter.

The ammeter in the circuit with two cells shows that the current is doubled.

You need to be careful adding more cells to a circuit. The lamps can be damaged and the wires can get hot.

Adding more cells increases the current when the other components are kept the same.

Removing cells decreases the current when the other components are kept the same.

Adding or removing lamps

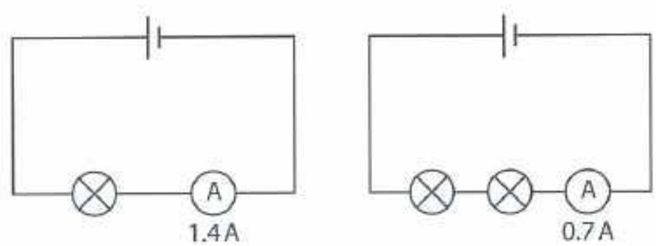
You saw in Topic 3.5 that lamps change electrical energy to light energy and thermal energy.

Electrons carry electrical energy around a circuit. When the electrons pass through a lamp, the electrons transfer some of their electrical energy to the lamp. The lamp changes the electrical energy into light energy and thermal energy.

Remember that the current is the same at all positions in a series circuit. Putting a lamp in a circuit will make the electrons move more slowly, but they move more slowly the whole way around the circuit.

The circuit with two lamps transfers twice as much energy as the circuit with one lamp. The lamps will be **dimmer**. That means they do not shine as brightly.

This makes the electrons move at half the speed, so the reading on the ammeter is halved.



Adding more lamps decreases the current when the other components are kept the same.

Removing lamps increases the current when the other components are kept the same.

Questions

1 Which statement is true about current in **any** series circuit?

Write the letter.

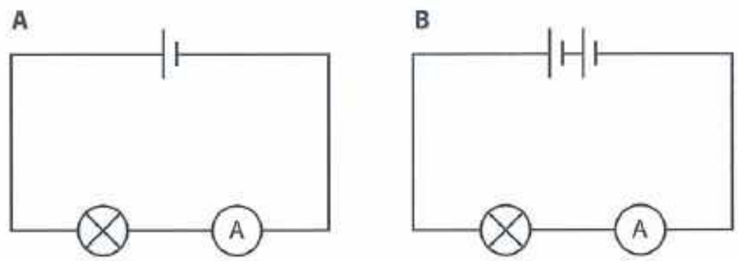
A Current decreases around the circuit.

B Current increases around the circuit.

C Current stays the same around the circuit.

D Current increases and decreases around the circuit.

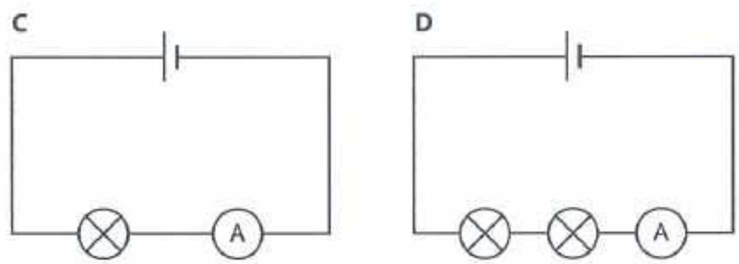
2 Look at these two circuit diagrams. Each component is identical in both circuits.



a Which of these circuits has a larger current? Write the letter.

b Explain your answer.

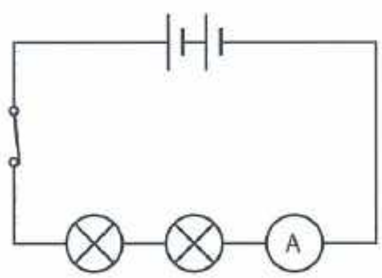
3 Look at these two circuit diagrams. Each component is identical in both circuits.



a Which of these circuits has a larger current? Write the letter.

b Explain your answer.

4 Look at the circuit diagram.



a Describe **two** ways to **increase** the current in this circuit.

b Describe **two** ways to **decrease** the current in this circuit.

Activity 9.5.1

Model circuits

In this activity, you will make models of circuits from cards.

Work in groups.

You will need:

- paper or card, scissors, a pen or pencil

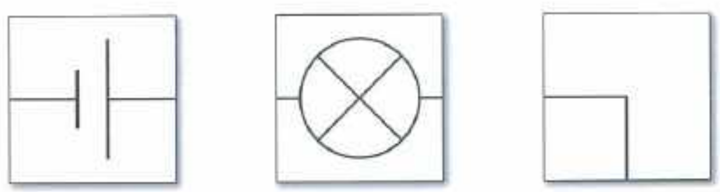
Start by cutting out 10 equal-sized squares of paper or card. The squares should be about 4–5 cm wide.

Draw circuit symbols on each card with wires that go to the end of the card. The cards will need to fit together to make circuits.

You should have:

- three cards with a cell
- three cards with a lamp
- four cards with circuit corners.

The cards should look something like this.



Work on a large sheet of paper, where you can draw extra lengths of wire if needed.

Questions

1 Build a series circuit with three cells and three lamps.

2 a Make **one** change that would **increase** the current in your circuit.

b Discuss in your group why this change would increase the current.

Put the circuit back together with three cells and three lamps.

3 a Make **one** change that would **decrease** the current in your circuit.

b Discuss in your group why this change would decrease the current.

4 Make another, **different** series circuit.

Discuss whether the current will be different from the first circuit and why.

Continued

Peer assessment

- Did everyone in the group agree with the changes?
- Did everyone in the group agree with the explanations?

Think like a scientist

Measuring current

In this task, you will measure current in circuits when components are added and removed.

Work in groups.

You will need (for each group):

- 3 cells, 3 lamps, an ammeter, wires, a switch

Safety

You must avoid damage to components where possible.

Follow these rules.

- Do not remove all the lamps from a circuit, leaving only the cells.
- Do not connect an ammeter directly to cells without lamps.
- If a lamp appears too bright, switch off immediately.

Part 1

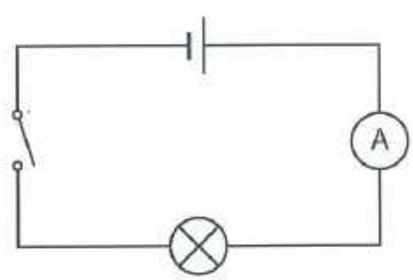
1 Build this circuit.

2 Close the switch and record the current.

3 Add another lamp.

4 Record the current with two lamps.

5 Repeat with three lamps.



Questions

1 Discuss in your group the best way to display these results.

2 Display the results in the way your group decided.

Continued

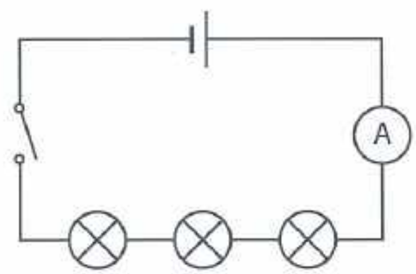
Part 2

6 Build this circuit.

7 Close the switch and record the current.

8 Repeat with two and then three cells.

9 Display your results in an appropriate way.



Questions

3 a Make conclusions about your results.

b Suggest any limitations of the conclusions.

- How do you build a circuit from a circuit diagram?
- Is it easy or difficult to build circuits from circuit diagrams? Rate your answer from 1 (very easy) to 5 (very difficult).
- If you find building a circuit from a circuit diagram difficult, what could make it easier?

Summary checklist

- [ ] I can understand that the current is the same all around a series circuit.
- [ ] I can predict what will happen to current in the same series circuit when more cells are added.
- [ ] I can predict what will happen to current in the same series circuit when more lamps are added.

Project: Paying for electricity

Many homes and schools are connected to electricity supplies.

People who use the electricity pay for how much they use.

Task 1

Work individually for this task.

Find out how much current some electrical items use. Do **not** include items that work only on batteries.

For example, most phone chargers use about 1.5 A.

When searching for this information, you may find a number with the unit W. This is **not** the current. You can find the current by dividing this number by the voltage. In most countries, the voltage is about 230 V. In some countries, the voltage is 110 V or 120 V. For example, if you find something with 500 W, and your voltage is 230 V, the current used is $\frac{500}{230} = 2.2$ A.

Display your results in a bar chart.

Questions

1 Which electrical item in your list uses the most current?

2 Which electrical item in your list uses the least current?

3 Explain why a bar chart is better than a line graph for showing these results.

Task 2

Work in groups for this task.

Around the year 1870, some cities had the first electricity supplies.

People in 1870 also had to pay for electricity. The amount they had to pay depended on the number of electric lamps they had.

Someone who had four lamps would pay double what someone who had two lamps paid.

This method of payment was called the pay-per-lamp method.

In 1870, there was no technology to measure the quantity of electricity that was actually used.

Today, the amount people pay depends on the current they use and the time the current is flowing.

Continued

Questions

In your groups, discuss answers to these questions.

1 Suggest reasons why the pay-per-lamp method was fair for 1870.

2 Suggest reasons why the pay-per-lamp method was **not** fair for 1870.

3 Would a pay-per-lamp method be fair today? Explain your answer.

An electric lamp from 1870

Check your Progress

9.1 a Name the particles that flow inside a wire when current flows. [1]

b State the charge on these particles. [1]

c Explain, with reference to the cell, what direction these particles flow in a circuit. [2]

9.2 a Draw the circuit symbols for:

i a cell [1]

ii an open switch [1]

iii a lamp [1]

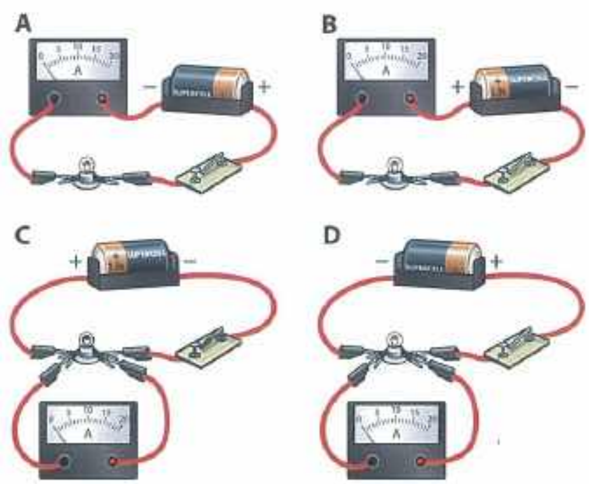
iv an ammeter [1]

v a buzzer. [1]

b Draw a series circuit with a cell, a lamp and a switch. [3]

9.3 Which of these ammeters will give a correct result for the current in the lamp?

Write the letter. [1]



9.4 Which of these can be measured in amps? [1]

Write all the correct letters.

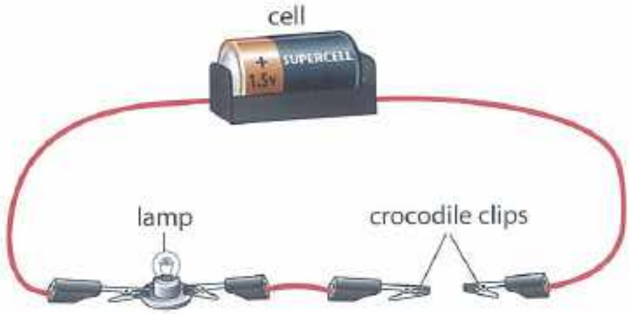
A brightness of a lamp

B loudness of a buzzer

C current in a circuit

D speed of electron flow

9.5 Arun has a circuit for testing whether an object is a conductor or an insulator.



a Explain why the lamp will light if Arun connects a conductor into the circuit. [2]

b Arun puts a different object into the circuit. [2]

The lamp does **not** light.

Suggest **two** possible reasons for this result.

c Copy the sentences and use the words from the list to complete them. [1]

inhibits **free to move** **allows** **not free to move**

A conductor … electron flow.

In a conductor, electrons are … .

An insulator … electron flow.

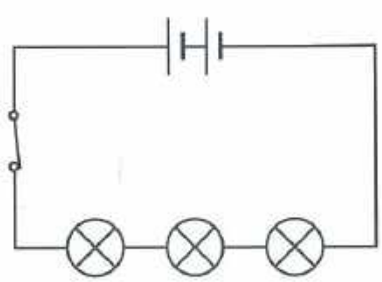
In an insulator, electrons are … .

9.6 Look at the circuit diagram.

Draw another circuit that would have:

a a **larger** current flowing than the one in this diagram [2]

b a **smaller** current flowing than the one in this diagram. [2]



Science Skills

Laboratory apparatus

Units

We use different units for measuring different things.

For example, we use metres to measure length.

- If we want to measure very long things, we can use kilometres. A kilometre is 1000 metres.
- If we want to measure small things, we can use centimetres. There are 100 centimetres in 1 metre.
- If we want to measure very small objects, we can use millimetres. There are 1000 millimetres in 1 metre.

Quantity	Unit	Abbreviation
length	metre	m
	centimetre	cm
	millimetre	mm
	kilometre	km
mass	gram	g
	kilogram	kg
force	newton	N
energy	joule	J
	kilojoule	kJ
volume	centimetres cubed	cm^3
temperature	degrees Celsius	°C
time	seconds	s
current	amperes (amps)	A

Place the 0 mark on the ruler exactly at one end of the object you are measuring.

Make sure you know the units the ruler is marked in.

This ruler is marked in millimetres (mm). There are 10 mm in 1 cm.

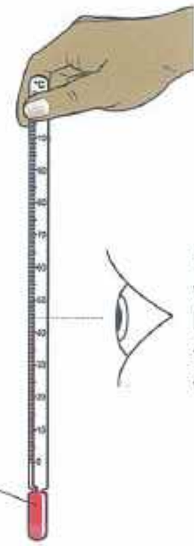
This drinking straw measures 11.4 cm in length. We could also write this as 114 mm.

Read the scale at the other end of the object you are measuring.

How to measure temperature

Safety! Never put a laboratory thermometer into your mouth.

Measuring the temperature of the air

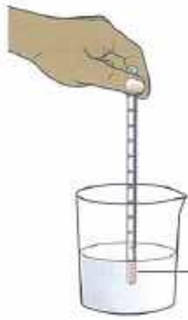


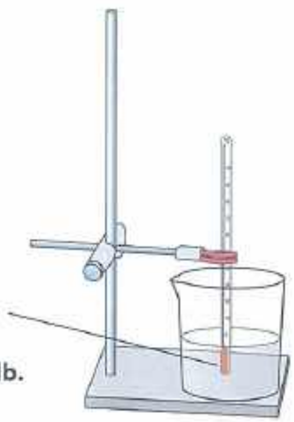
Measuring the temperature of a liquid

Hold the thermometer at the top.

Stir the liquid using a glass rod, to make sure the liquid is mixed up and all at the same temperature. Then place the thermometer bulb in the liquid.

Do not let the bulb touch the glass, or the thermometer will measure the temperature of the glass.





How to measure a volume of liquid

The scale on apparatus for measuring a volume is shown in ml or cm^3. ml stands for millilitres.

cm^3 stands for cubic centimetres.

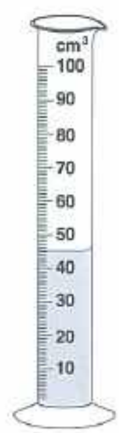
1 ml is exactly the same as 1 cm^3.

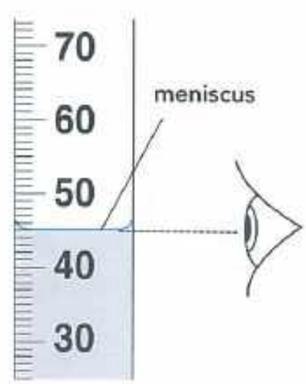
Reading the scale

The top of a liquid forms a curve. The curve is called a meniscus.

Put your eye exactly level with the meniscus.

Note the point on the scale that the bottom of the meniscus comes to.





How to make a results table

You use a results table to record the results that you collect when you do an experiment.

The purpose of a results table is:

- to show other people your results
- to organise your results clearly, so that you can use them to draw a graph, to do a calculation or to make a conclusion.

Imagine that you are doing an experiment to measure how the temperature of some hot water changes as it cools. You measure the temperature of the water every five minutes for 30 minutes. Here is what your results table could look like

Make sure that each column has a heading saying exactly what the numbers mean. (Sometimes, it might be better to have headings for the rows, rather than the columns.)

Always use a ruler to draw neat lines for the rows and columns of your table.

Always include the units of your measurements in the headings.

Time in minutes	Temperature in °C
0	76
5	64
10	54
15	46
20	41
25	36
30	34

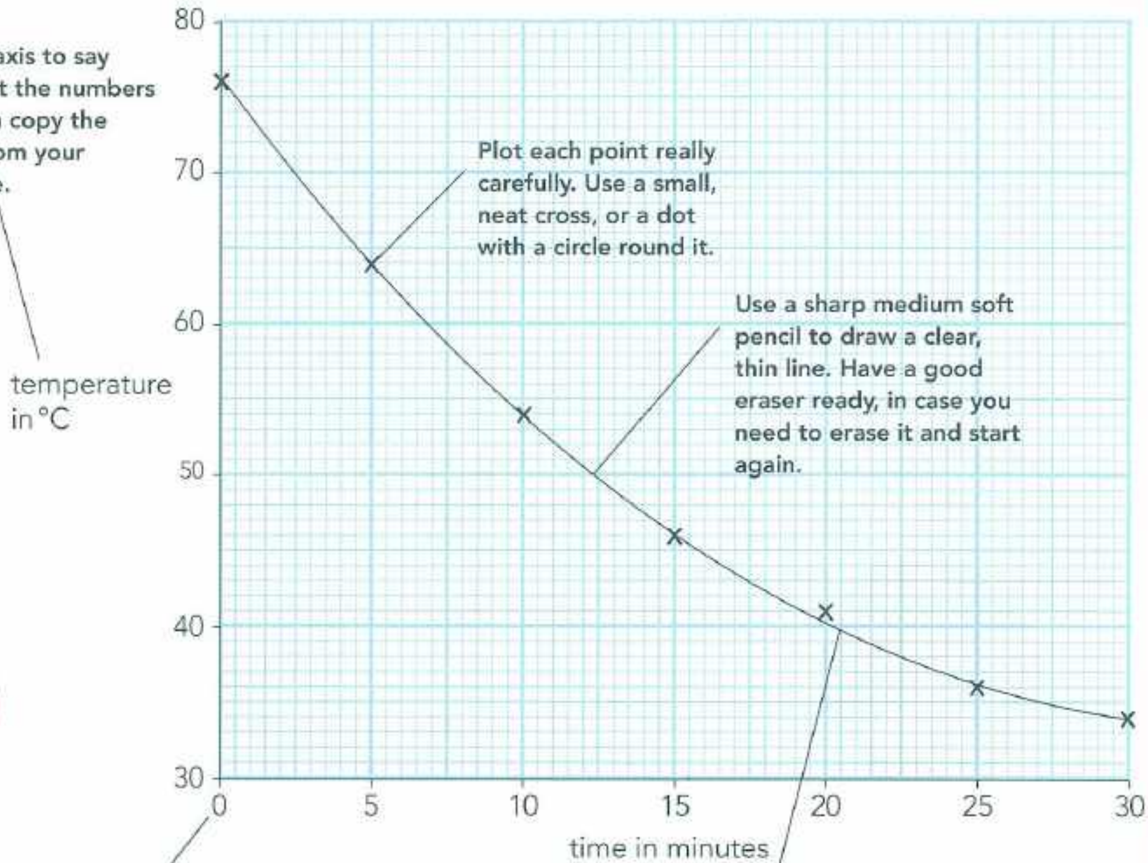
Do not write units with your results.

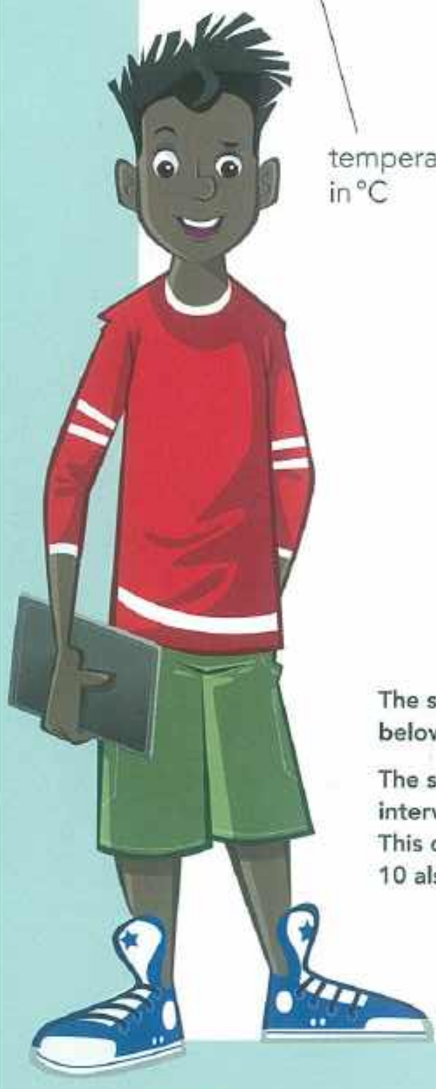
How to draw a line graph

If your results are a series of numbers, like the ones in the results table on the previous page, it's often a good idea to draw a line graph to display them. This makes it easy to see trends and patterns in the results.

- The independent variable goes along the bottom of your graph. In this case, this is the time at which you took your readings.
- The dependent variable goes up the side of your graph. In this case, this is the temperature of the water.

Label each axis to say exactly what the numbers are. You can copy the headings from your results table.





The scale runs from your lowest value (or just below it) to your highest value (or just above it).

The scale goes up in equal intervals. Choose intervals that make it easy to plot your graph. This one goes up in steps of 5. Steps of 1, 2 and 10 also work well.

These points are making a curve shape. So we can draw a smooth best fit curve like this. It does not go exactly through every point. There are the same number of points above and below the line.

Glossary and Index

absorb	Soak up.	13
accurate	Close to the true value.	32
acid	A substance which contains hydrogen particles and has a pH lower than 7; the chemical opposite of an alkali.	168
active	Of a volcano, one that has erupted in the recent past and that may erupt again at any time.	213
acts towards the centre	Of gravity, the direction of the force towards an object, such as the Earth or the Sun is directed towards the middle of that object.	70
adapted	Having features that help it carry out its function.	12
adding components	Putting more cells or lamps into a circuit.	312
agar jelly	A thick, clear substance made from seaweed, used for growing microorganisms.	229
air resistance	The force on a moving object caused by pushing against particles in the air.	87
algae	Small, plant-like organisms that grow in or near water (singular: alga).	228
alkali	A substance that contains hydroxide particles and has a pH higher than 7; the chemical opposite of an acid.	169
allow current to flow	Property of an electrical conductor.	305
alloy	A mixture of metals.	156
ammeter	A component that measures current in the circuit.	295
amps	The unit of measure for current.	299
atmosphere	The mixture of gases around the Earth.	41
atom	The smallest piece of matter.	46
attract	To pull something towards something else.	290
attractive forces	Forces that hold particles together.	36
axis	An imaginary straight line going through the centre of a spinning object.	80
axis (graph)	A reference line drawn on a graph that you can measure from to find values. The x-axis goes along the horizontal and the y-axis up the vertical on the graph.	34
axon	Very long strand of cytoplasm along which electrical signals travel.	12

backwards and forwards	To move first in one direction and then in the opposite direction, again and again.	187
bacteria	Organisms made of a very small single cell, with a cell wall but no nucleus (singular: bacterium).	228
battery	A component that changes chemical to electrical energy in a circuit; made from two or more cells in series.	289
boil	To heat something strongly so that it begins to change from a liquid to a gas.	30
boiling point	The temperature at which a liquid changes to a gas.	30
bonding	The term for joining two or more atoms together chemically.	52
brittle	Something that breaks easily with a snap.	149
bronze	An alloy made by mixing copper and tin.	156
burette	A piece of laboratory glassware used for measuring the volume of a liquid accurately.	263
capillary	The smallest type of blood vessel, which delivers blood close to every cell in the body.	12
carnivore	Consumers that eat other animals.	234
cell (in biology)	One of the small structures that make up living organisms.	3
cell (in physics)	Component that changes chemical energy to electrical energy in a circuit.	289
cell membrane	A thin, flexible 'skin' on the outside of every cell, which controls what enters and leaves the cell.	3
cell wall	The strong, stiff outer covering of plant cells and bacterial cells.	3
cellulose	The substance that makes up cell walls in plants.	3
change	To become different.	106
changes of state	The changes between different states of matter.	30
chemical (energy)	Energy stored in food, batteries and fuels.	100
chemical reaction	A reaction between two or more substances that forms a new substance or substances.	254
chlorophyll	The green substance in plants that allows them to use energy from the Sun.	3
chloroplast	One of many structures inside some plant cells, which contain the green pigment chlorophyll; where photosynthesis takes place.	3
cilia	Tiny, hair-like structures that extend from the surface of some cells.	12
ciliated cell	A cell with tiny threads called cilia along its edge which can move in a wave-like motion.	12
ciliated epithelium	Tissue that lines the tubes leading down to lungs.	17
circuit diagram	A plan of an electrical circuit.	294
circuit symbols	Symbols used in circuit diagrams to represent components.	294

circular	In the shape of a circle.	86
cloudy	A substance that is not transparent.	277
coastal	Parts of the land which are close to the seas or the oceans.	94
colony	A group of bacteria or fungi, such as the ones growing on the surface of agar jelly.	229
combine	To join together.	254
components	Parts that combine with other parts to form something bigger, such as an electric circuit.	289
composition	The parts or substances that something is made up of.	61
compound	A substance made up of two or more different types of atom bonded together.	52
compressed	Squashed.	23
condensation	The process of changing from a gas to a liquid, for example water vapour cooling and changing to liquid water.	30
condenser	A piece of laboratory glassware that can be used to separate mixtures of two liquids.	164
condense	The process by which a gas cools and changes state to become a liquid.	30
conduct	To allow electricity or heat to pass through.	147
conduct electricity	Allow current to flow.	305
conductor	A material that allows electricity or heat to pass through.	305
conical flask	A piece of laboratory glassware.	165
consumer	An organism that cannot make its own food, and therefore relies on food made by plants; all animals and fungi are consumers.	234
contact	Two things touch each other.	153
contact force	The force that acts from a surface in a direction opposite to weight from a surface to support an object.	71
continental drift	The idea that the continents on Earth are slowly moving relative to one another.	206
contradict	Disagree with.	82
core	The most central part of the Earth's structure.	206
corrosive	A substance that is able to dissolve or eat away other materials such as your skin.	168
crust	A hard outer covering.	206
current	The flow of electrons in a circuit.	289
cytoplasm	The 'background' substance that fills a cell, in which many chemical reactions happen.	3
decay	Rot; organic substances can be decayed by microorganisms.	239
decomposer	An organism that decays dead plant and animal matter.	239

dendrite	A short strand of cytoplasm on a neurone which collects electrical signals from other neurones.	12
depth	The distance from the surface of the water to the bottom.	92
dichotomous	Branching into two.	133
digest	Change food in the digestive system into substances that can be absorbed into the blood.	267
dimmer	Does not shine as brightly.	313
disrupt	Upset the pattern.	157
dissipated	Energy that spreads out and cannot be recovered.	112
distinguish	To tell the difference between things.	153
ductile	A substance that can be drawn out into wires.	146
dung	Solid animal waste.	244
Earth	The planet on which we live.	70
earth tide	Slight rise and fall of the land caused by tidal forces.	92
earthquake	A sudden violent movement of the Earth's crust.	94
echo	The reflection of a sound wave.	197
ecology	The study of organisms in their environment.	233
effect on the sound	The changes that happen to sound.	197
elastic potential	Energy stored when things are pulled or squeezed to change their shape.	101
electrical	The energy transferred by current in a circuit.	101
electron microscope	A very powerful microscope that allows scientists to see viruses and other very small things.	125
electron	One type of smaller particle in an atom.	289
element	A substance made of just one kind of atom.	46
energy	A quantity that must be changed or transferred to make something happen.	100
evaporating basin	A piece of laboratory equipment that can be heated to evaporate liquid contained in it.	63
evaporation	The process of changing from a liquid to a gas at a temperature below boiling point.	30
event	A thing that happens.	107
evidence	Facts from observation or experiments.	80
examine	To look at something closely in order to discover something about it.	153
excretion	Getting rid of waste materials, such as carbon dioxide.	122
expand	To get bigger or spread out.	36
extinct	Of a volcano, one that will not erupt again.	213
fertile	Being able to produce offspring.	130

filings	Small pieces of metal.	60
filter funnel	A piece of laboratory equipment into which filter paper is placed.	165
filter paper	A special type of paper that can be used in a filter funnel to separate solid particles from those in a liquid.	165
filtrate	The liquid that is filtered through a filter paper.	268
flammable	A substance that can catch fire easily.	170
flow	To pour, move smoothly.	23
fold mountain	A mountain that is formed when two tectonic plates move towards each other, causing the rocks to crumple and fold upwards.	212
food chain	A diagram that shows how energy is transferred from one organism to another, in the form of food.	233
food web	A diagram showing many interconnecting food chains.	233
force of gravity	The force that makes objects fall toward a large object, such as the Earth, called weight.	70
formed	Began to exist; made.	80
formula	Uses chemical symbols to show how many atoms of different elements are present in a particle of an element or compound (plural: formulae).	55
formula triangle	A method to find the rearrangement of an equation.	73
free to move	Property of electrons in a conductor that enables the conductor to carry current.	290
freeze	The process by which a liquid changes to a solid.	30
fuel	A substance that provides heat, usually by being burned.	100
function	The job that something does or the role it plays.	12
fungi	Organisms such as mushrooms, toadstools and yeast; they get their energy by decaying organic material (singular: fungus).	228
geological change	Changes that occur in rocks and at plate boundaries, such as volcanoes and earthquakes.	211
glowing	Something that is burning very slowly.	277
gravitational potential	Energy stored when an object moves higher.	101
gravity	The force that pulls masses towards one another.	70
groundwater	Water from precipitation that has soaked into the soil and rocks on the ground.	43
groups	The columns on the Periodic Table.	48
growth	A permanent increase in size.	122
haemoglobin	A red pigment inside red blood cells, which carries oxygen around the body.	12

harbour	An area of water next to the coast where ships and boats can shelter.	94
harmful	Something that causes damage.	168
heat energy	The energy put into a substance that causes it to get hotter.	36
herbivore	An organism that gets its energy by eating plants.	234
hypothesis	A testable theory.	24
identical	Exactly the same.	129
in series	Components of a circuit that are all connected end-to-end, one after another, with no branches.	299
inactive (dormant)	Of a volcano, one that has not erupted for a very long time.	213
indicator	A substance that turns different colours in acid and alkali.	174
indigestion	Discomfort that occurs in the stomach when too much acid is produced.	267
infertile	Unable to produce offspring.	130
influenza	Flu; a common viral illness that causes fever and headache.	126
inhibit	To prevent something from happening.	306
insulator	A substance that does not conduct heat or electricity.	149
irritate	To cause itching or sores on your body.	168
joule	The unit of energy.	100
key	A set of questions about an organism that helps with identification.	133
kilogram	The unit of mass.	73
kinetic	The energy in movement.	100
lava	Liquid rock on the surface of the Earth.	212
light	Visible energy from luminous objects.	101
limitations	Weaknesses.	4
litmus	A dye that is used as an indicator.	175
loudness	The strength or weakness of a sound; shouting has more loudness than whispering.	187
lower epidermis	The tissue that covers the lower surface of leaves.	18
luminous	Objects that give out their own light.	101
lunar eclipse	The shadow of the Earth on the Moon caused when the Earth comes between the Sun and the Moon.	219
magma	Liquid rock below the surface of the Earth.	207
magnetic	Attracted to a magnet.	147
magnify	Make things look bigger than they really are.	3
magnitude	The strength of an earthquake.	214
malleable	A substance that can be bent or hammered into shape.	146
mantle	The part of the Earth between the outer core and the crust.	206

mass	The quantity of matter in an object.	70
materials	Substances from which objects are made.	146
matter	Everything that you can see, feel and smell.	23
measuring cylinder	A tall, narrow piece of glassware used for measuring the volume of liquids.	31
medium	The substance that waves move through.	191
melting point	The temperature at which a solid melts.	30
melt	When a solid turns into a liquid.	30
meniscus	The slight curve in the surface of a liquid where it meets the side of the container.	31
metal	An element that is generally hard and shiny, that allows electricity and heat to travel through it.	49
microorganism	A living organism so small that it can only be seen with a microscope.	228
minerals	Substances that make up rock; each mineral is made of one type of chemical.	62
mitochondrion	A small structure inside a cell, where energy is released from food (plural: mitochondria).	3
mixture	Something that contains two or more substances (elements or compounds) that are not combined chemically.	60
model	A way of representing something that is difficult to observe directly.	81
molten	In a liquid state.	206
mould	Microscopic fungi that are growing on organic matter.	239
movement	The ability of organisms to change position.	122
mucus	Sticky substance made by cells lining the tubes from the mouth to the lungs. Mucus traps dust and bacteria.	12
mushroom	A fungus with a round top and short stem.	228
nanotubes	Very small tubes made of carbon atoms.	46
nebula	A cloud of dust and gas in space.	81
negative charge	The type of electrical charge carried by electrons.	290
neurone	A cell that carries electrical signals from one part of the body to another.	12
neutral	A substance that is neither acid nor alkali and is at pH 7.	175
neutralisation	Changing an acid or an alkali into a solution at pH7.	263
newtons	The unit of force.	71
nucleus	A structure found in animal cells and plant cells, which controls the activity of the cell.	3
nutrients	Substances that living organisms can use to supply them with energy, or to help them to grow.	244

nutrition	Feeding; taking in substances that are needed for growth or to provide energy.	122
observe	To take notice of something by using your eyes, ears and other senses.	80
offspring	The 'children' of a living organism.	130
onion epidermis	The tissue on the surface of the layers of an onion bulb.	17
opaque	The property of a substance that will not allow light to pass through.	217
orbit	The path that a smaller object follows around a larger one in space.	80
organ	A structure made up of many different tissues, which work together to perform a particular function.	18
organ system	A set of organs that all work together to carry out the same function.	18
organic matter	Any substance that has been made by a living organism.	239
organism	A living thing.	17
oxidising	A substance that gives off a large amount of heat when in contact with other substances.	170
palisade cell	A cell found inside the leaf of a plant; this is where most photosynthesis happens.	14
palisade layer	The tissue made up of many palisade cells arranged side by side in a leaf.	18
partial	Not complete; for example, a partial solar eclipse blocks most rays from the Sun, but not all.	218
particles	Very small pieces of matter that make up everything.	24
Periodic Table	An arrangement of all the elements in rows and columns, according to a pattern.	47
periods	The rows on the Periodic Table.	48
Petri dish	A small, clear, round dish with a lid, used for growing microorganisms.	229
pH scale	A scale that measures the strength of acids and alkalis.	177
pigment	A coloured substance; chlorophyll and haemoglobin are pigments.	12
pitch	The highness or lowness of a sound on a musical scale.	187
plane	A flat surface that continues in all directions, and can be imaginary.	81
plate boundary	The places where tectonic plates meet.	211
position	The place where something is in relation to other things.	312
pour	To flow from a container.	23
precipitate	A solid that is formed when two solutions are mixed.	281

precipitation	The process of water in the atmosphere condensing and falling to earth. This can result in a fall of rain, snow or hail.	42
predator	An animal that catches, kills and eats other animals.	234
prey	An animal that is killed and eaten by a predator.	234
process	A series of changes that happen, such as burning.	107
producer	The first organism in a food chain.	234
product	The substance created in a chemical reaction.	254
property	A quality of a substance or material.	23
protein	A chemical that is a necessary part of the cells of all living things.	125
protozoa	Very small, single-celled, animal-like organisms (singular: protozoan).	228
pure	Something that only contains a single substance.	61
quantity	The amount or number of something.	73
rays	The straight lines in which light travels.	217
react	A change that happens when two or more substances change to form new products.	254
reactant	The substances that react together in a chemical reaction; the chemicals you start with in a reaction.	254
recovered	To get back something back again.	112
red blood cell	A very small cell with no nucleus that delivers oxygen to every part of the body.	12
reflected	When heat, energy or sound comes back from a surface.	197
remedy	A substance or action that can be used to put something right.	271
removing components	Taking cells or lamps out of a circuit.	312
repel	To push something away from something else.	290
reproduction	The ability of organisms to produce young.	122
respiration	The process of breaking down food to provide an organism with energy.	122
RNA	A substance inside a virus containing a set of coded instructions for making more viruses.	125
root hair cell	A cell that is found on the outside of plant roots, and is specialised to absorb water.	13
rot	Decay.	239
sap vacuole	The space inside a plant cell containing liquid (sap).	3
sensitivity	The ability of an organism to notice and respond to changes happening around them.	122

shadow	An area of darkness caused by light being blocked by an opaque object.	217
shatter	To break into many pieces.	149
shiny	A surface that reflects light, such as polished metal.	146
single-celled	Made of only one cell.	228
sodium chloride	A compound that is a salt, formed when one atom of sodium is bonded with one atom of chlorine.	52
solar eclipse	The shadow of the Moon on the Earth that is caused when the Moon comes between the Sun and the Earth.	218
sonorous	A substance that makes a ringing sound when hit.	147
sound	Energy transferred from vibrating objects.	101
sound wave	The movements that transfer sound through air or water.	188
specialised	Built to do its job really well.	12
species	A group of organisms that can reproduce with others in the same species, but not with members of a different species.	129
specimen	A sample.	131
speed	Distance moved in a certain time.	87
speed of sound	The speed of sound waves through the air, around 340 m/s.	188
spin	To turn around an axis.	80
spongy layer	The tissue made of many rounded cells containing chloroplasts, found beneath the palisade layer inside a leaf.	18
stain	To colour to something, making it easier to see.	8
states of matter	Three groups of matter: liquids, solids and gases.	23
steam	The hot gas produced when water boils.	30
steel	An alloy made of a mixture of iron and carbon and/or other metals; steel is much harder than iron.	156
sterile	Completely clean; free from bacteria and other microorganisms.	229
stored	Kept for future use.	100
subduction	The process of one tectonic plate sliding underneath another.	211
support	To agree with.	82
surface run-off	Rain water that reaches the surface of the land and flows into rivers, lakes and oceans.	43
symbol	A shorthand way to represent the elements.	48
tectonic plates	Areas of the Earth's crust that can move relative to one another.	207
terminals	The two connection points of batteries, cells, power supplies and ammeters that connect to a circuit.	289
theory	The ideas that scientists have.	24

thermal	Heat energy stored in hot objects and transferred to colder objects.	101
thermometer	A piece of apparatus used to measure temperature.	31
tidal force	The pull from the Moon's gravity and, to a smaller extent, the Sun's gravity.	93
tidal range	The difference in depth of water between high and low tides.	92
tide	The rise and fall of the sea that happens twice every day.	92
tissue	A group of similar cells that work together for a particular function.	17
toadstool	A fungus with a round top and narrow stem.	228
total	Of an eclipse, one that blocks all the rays from the Sun in a particular area.	218
toxic	Poisonous.	171
transferred	To move from one place to another.	36
transpiration	The loss of water vapour from a plant's leaves.	42
universal indicator	An indicator, made up from a range of other indicators, which shows how acidic or alkaline a substance is.	177
unwanted	Something that is not intended so is wasted.	199
upper epidermis	A tissue made up of cells with no chloroplasts, which covers the top surface of a leaf.	18
useful	Able to be used; wanted	112
vacuum	A space where there are no particles.	27
variable	A quantity that changes in an investigation.	272
variation	Differences between individuals that belong to the same species.	129
vibrate	To shake backwards and forwards with repeating movement.	25
virus	An extremely small structure made of a protein coat surrounding RNA (or DNA); viruses can invade cells and cause them to produce new viruses.	125
volcano	An opening in the Earth's crust, through which lava, gases, steam and dust erupt.	212
volume	The amount of space something occupies.	23
wasted energy	Energy that is not usefully transferred.	212
water cycle	The processes by which water on Earth is recycled around the environment from rivers and oceans to clouds and back again.	41
water vapour	A gas formed by the little droplets of water that exist in the air at the temperature of the air.	30
weight	The force of gravity on an object.	71
yeast	A microscopic fungus.	229

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