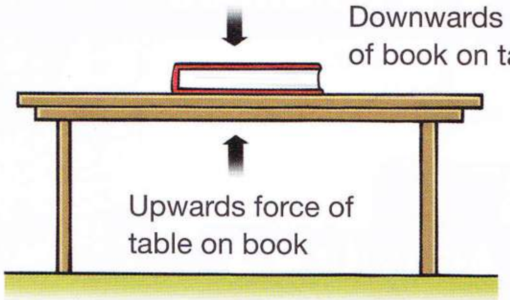
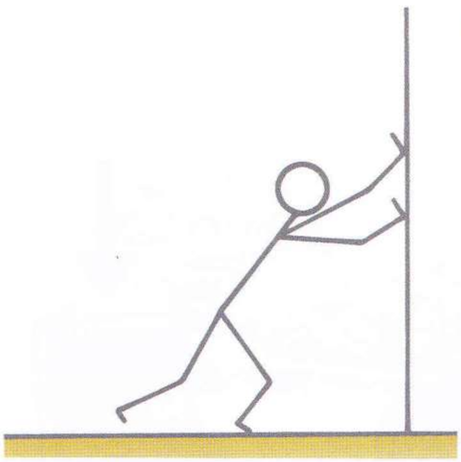
Force diagrams

We can show the direction of forces on an object in a drawing called a **force diagram**. Each force is shown as a force arrow. When the forces are equal, the force arrows are the same length



Forces always act in pairs. In the picture, the book exerts a downward force on the table and the table exerts an upward force on the book. The two forces act in opposite directions.



Questions

1 a Copy the drawing and add arrows to show the direction in which each of the forces act.

b Is one force bigger than the other? Say why or why not.

2 When you stand still, why don't you sink into the ground? Draw a force diagram to explain your answer.

What you have learnt

- Forces act in different directions.
- Forces act in pairs. Each force in a force pair acts in the opposite direction to the other.
- Force diagrams show the direction and size of forces.

Talk about it!

Why does a boat float on the water?

A Vietnamese coracle.

4.3 Balanced and unbalanced forces

Words to learn

balanced

unbalanced

net

Activity 4.3

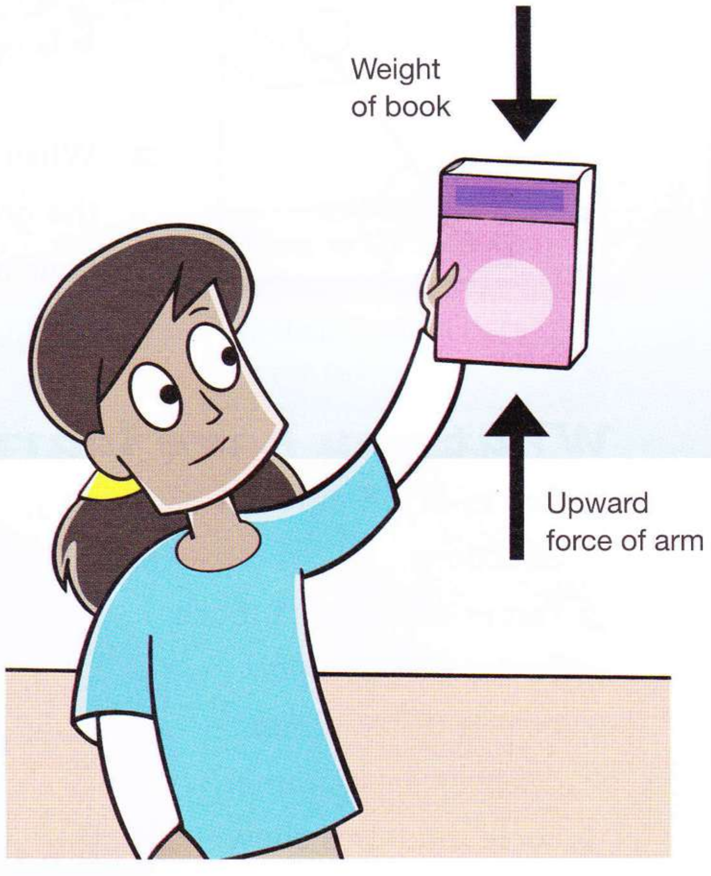
You will need:
a heavy book • a watch

Which force is bigger?

Stretch out your arm and hold up the book.
Does the book move?
What happens if you hold the book for two minutes?

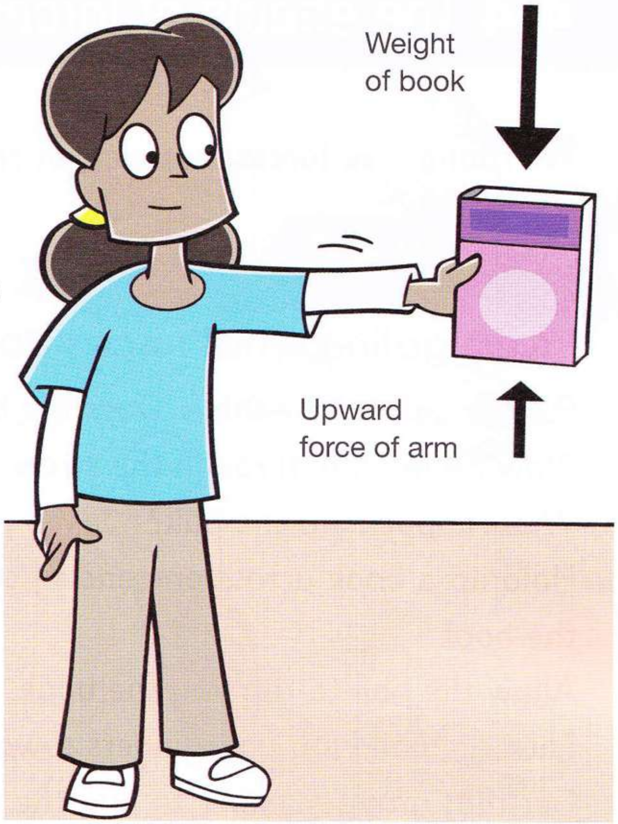
Questions

1. a What force is acting on the book?
   b What force is acting on your arm?
   c When you first hold up the book, is one force bigger than the other? Say why or why not.
2. After holding the book for two minutes, is one force bigger than the other? Say why or why not.



Remember that forces act in pairs. When you are holding a book, you use an upward force to hold up the book. The book exerts a downward force, caused by gravity pulling the book downwards. The forces are the same size but in opposite directions. When both forces are the same size the object does not move. We say the forces are **balanced**.

As your arm gets tired, you exert less upward force. The book exerts a bigger force than your arm, so your arm drops a bit. If one force is bigger than the other, an object moves in the direction of the force. The two forces are **unbalanced**. The arrows in the picture show the size of the forces: the longer the arrow, the bigger the force.



When forces are unbalanced and one force is greater than the other, we say there is a **net** force. When forces are balanced we say there is no net force.

Neither side is winning. Are the forces balanced?

What you have learnt

- When both forces on an object are the same size, the forces are balanced.
- When one force on an object is bigger than the opposite force, the forces are unbalanced.
- When two opposite forces are not balanced, there is a net force.

Talk about it!

Why can a flying golf ball break a window but a ping pong ball can't?

4.4 The effects of forces

We cannot see forces, but we can see or feel what they can do.

Activity 4.4

Investigating what forces do

You will need:
a ping pong ball • a straw
a table • a book

Put the ball on the table. Does the ball move?
Blow on the ball through the straw.
What happens to the ball?
Hold up a book across one end of the table. Roll the ball gently towards the book.
Allow the ball to roll into the book. What happens to the ball?
Flick the ball with your fingers towards someone in your group.
Get that group member to flick the ball to someone else.
What happens to the direction of the ball each time you flick it?
Squeeze the ball gently.
What happens to the shape of the ball?
Are the forces in each case balanced or unbalanced?

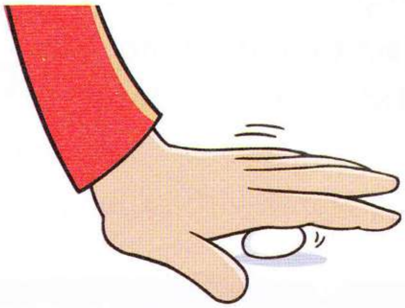
What can forces do?

Forces can make things move.
When you exert a force on a ball by blowing or rolling it, you make the ball move. Forces can also speed up moving objects.

Forces can also slow down moving objects or make them stop. When the ball rolls into the book it stops moving. The book exerts a force on the ball to stop it moving.

Forces can change the direction in which an object moves. When you flick the ball from person to person, it changes direction each time. Each person exerts a force on the ball that changes the direction of the ball's movement.

Forces can change the shape of an object. When you squeeze a ball you exert a force on it. The force makes the ball change shape.



Forces that change the movement or shape of an object are unbalanced forces.

Questions

1. We cannot see forces. Name four ways we know that forces exist.
2. a How do forces act to break a glass when it falls on the ground?
   b How do forces act to make a rubber ball bounce when you drop it?

What you have learnt

- Forces change the movement of an object by speeding it up or slowing it down.
- Forces change an object's direction of movement.
- Forces change the shape of an object.

Talk about it!

Why does the front of a car crumple if it drives into a tree?

Modern cars have crumple zones which protect passengers in an accident.

4.5 Forces and energy

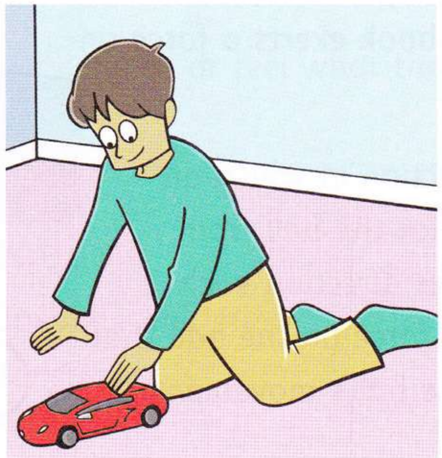
Words to learn

energy

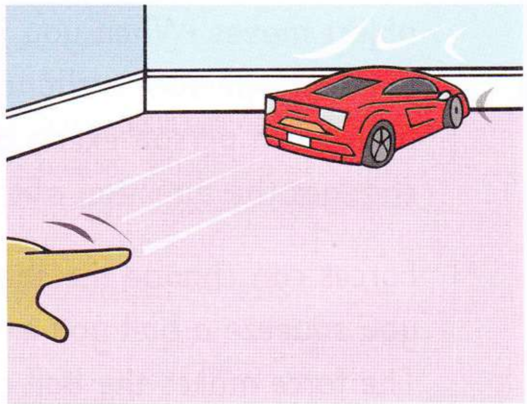
work

A force is needed to make objects move or to stop them moving.

When we exert a force on an object to make it move, we give the object **energy**. The amount of energy transferred to an object to make it move is called **work**.



A force is needed to make the toy car move.



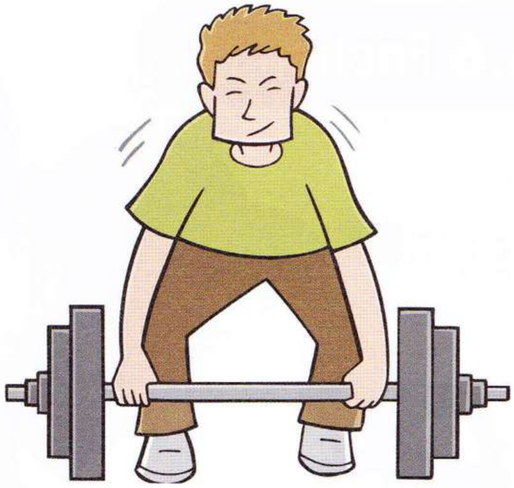
A force is needed stop the toy car moving.

How much work is done?

The amount of work done depends on how far the force makes the object move. The further the object moves, the more work is done as more energy is transferred.

The force from the boy's foot transfers energy to the ball. The ball moves and work is done.

If no force is applied to a ball it cannot move and no work is done.



If there is a force on an object but the object doesn't move, no work is done.

Questions

1 Can an object move by itself? Explain your answer.

2 When you open a door:

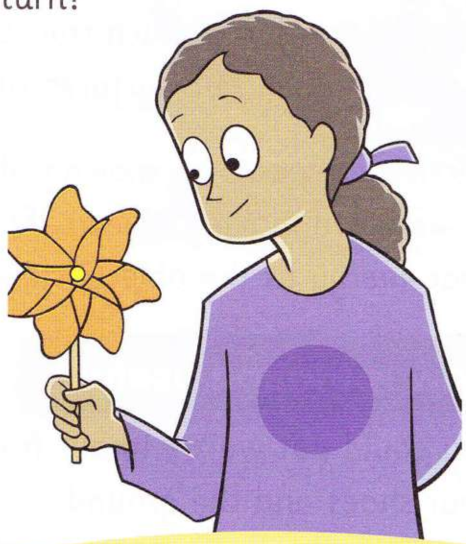
a What force do you exert on it?

b Is any work done? Say why or why not.

3 How can you increase the amount of work done when you lift a book? Explain your answer.

Challenge

Where does the energy come from to make this windmill turn?



What you have learnt

- A force is needed to make objects move or to stop them moving.
- Moving objects have energy.
- Work is the amount of energy transferred to an object to make it move.

Talk about it!

Where do you get energy from to make objects move?

4.6 Friction

Words to learn
friction
lubricate

Activity 4.6

What is friction?

Rub your hands together for 30 seconds.
How do your hands feel? Are they warmer?

You will need:
a watch

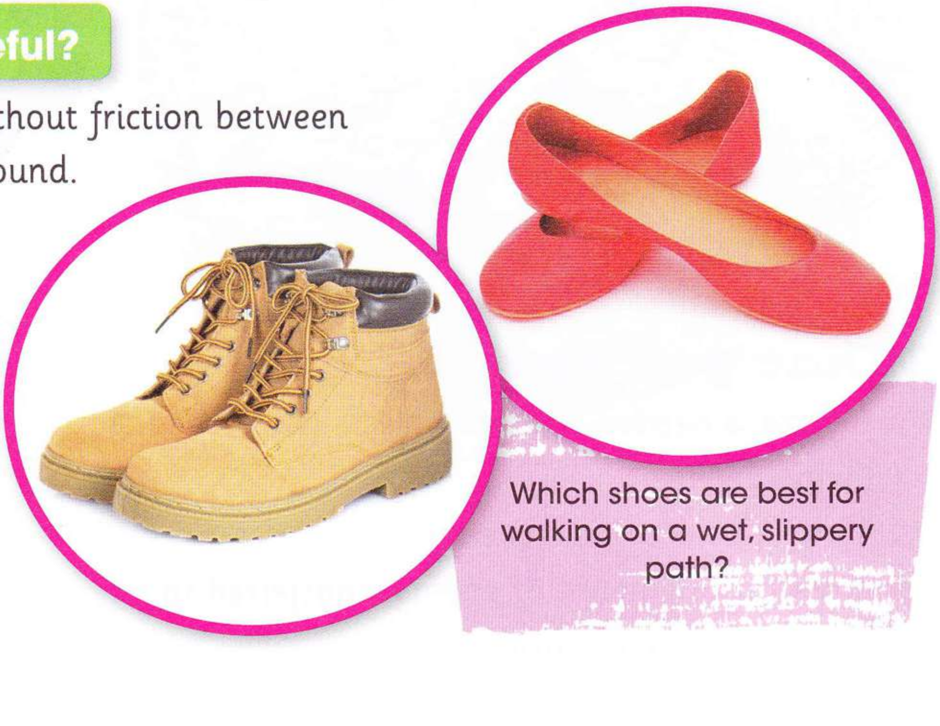
Friction is a force which tries to stop things sliding past one another. Friction is caused when two surfaces rub together.

Friction only acts on moving objects and it cannot make objects move. Friction slows down moving objects. Friction changes the energy of moving objects into heat energy as the objects slow down.

How is friction useful?

You could not walk without friction between your shoes and the ground.

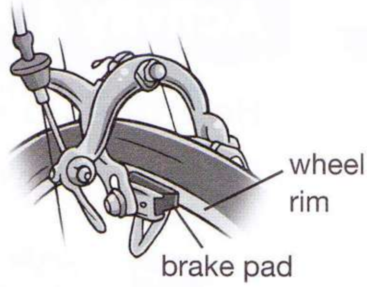
Friction holds your shoe to the ground, allowing you to walk. Think how difficult it is to walk on ice or a wet, slippery floor, where there is little friction.



Which shoes are best for walking on a wet, slippery path?

You could not hold a pencil in your hand without friction. It would slip out when you tried to hold it to write. The pencil lead would not make a mark on the paper without friction.

The brakes in cars, bicycles and other vehicles use friction to slow down and stop. When you pull the brake lever of a bicycle, the brake pads of the bicycle push on the rim of the wheel. This creates friction which makes the wheel turn more slowly.



How is friction a problem?

Friction makes things wear out.

Friction between a car's tyres and the road make the tyres wear out.

Because friction causes heat, moving parts in machines get hot when they rub together. Oil is needed to **lubricate** the machines and allow their parts to move easily. The oil forms a thin layer on the surface of the parts so they don't rub together as much.

Questions

1. How do we use friction to clean our clothes?
2. Think of **two** examples of friction making things we use everyday wear out.
3. How is friction different from other forces?
4. How can we reduce friction?

Challenge

Is there any friction in space? Why or why not?

What you have learnt

- Friction is a force that stops things sliding past each other.
- Friction slows down moving objects.
- Friction can be useful as it helps objects to grip on surfaces.
- Friction can be a problem as it makes objects wear out and get hot.

Talk about it!

How does a pencil eraser work?

4.7 Investigating friction

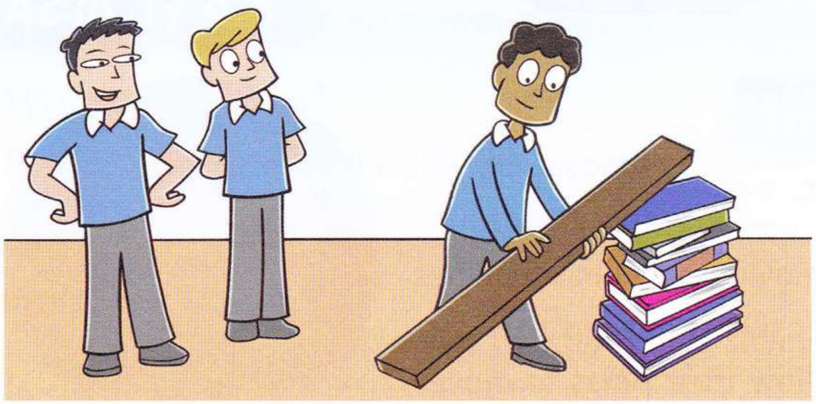
Some surfaces are more slippery than others. Why?

Activity 4.7

How does a surface affect friction?

You will need:
a plank of wood
a pile of books • liquid soap
sand • water
a matchbox filled with sand
a shoebox • a stop watch

Set up the plank so that it makes a slope.



Put the matchbox at the top of the slope.
Measure how fast in seconds the matchbox moves down the slope.
Repeat the measurements another three times.
Record your results in a table like this one.

Time taken for matchbox to reach ground in seconds	Wood	Wood covered in soap
reading 1		

Cover the plank with liquid soap.
Put the matchbox at the top of the slope.
Measure how fast the matchbox moves down the slope. Repeat the measurements another three times.
Pour sand from the matchbox into a shoebox. Predict whether the shoebox will move faster down the plank than the matchbox.
Test your prediction on the dry wood and the soapy wood surfaces.

Questions

1 Compare the results for the two surfaces. On which surface did the matchbox move faster?
2 Which surface exerted the bigger frictional force? How do you know this?
3 How did the soap change the surface of the wood?
4 Why is it good to repeat measurements?
5 a Suggest a reason for your prediction. Think about which box has the bigger surface area.
  b Why did you pour the sand from the matchbox into the shoebox?
  c Suggest a reason for the results you obtained when you tested your prediction on the dry wood and soapy surfaces. Was your prediction correct?
6 Name **two** factors that affect frictional forces between two surfaces.

Ball bearings.

What you have learnt

- Frictional force is greater between rough surfaces than between smooth surfaces.
- Frictional force is bigger over large surfaces than small surfaces.

Talk about it!
How do ball bearings in machines reduce friction?

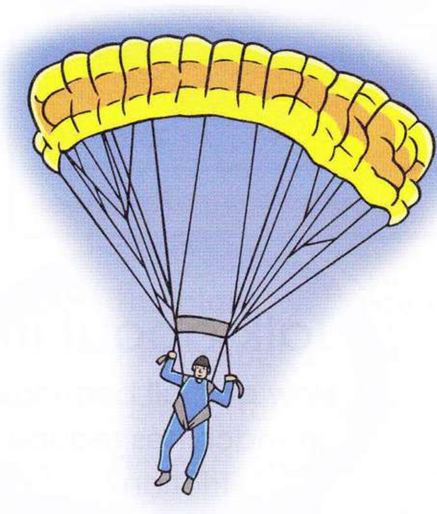
4.8 Air resistance and drag

Words to learn
air resistance
drag
surface area

Have you ever held your hand out of a car window? What did you feel?

Air is a mixture of gases. The particles of gas push against things which are moving and create a force. This force is called **air resistance**. Another name for it is **drag**. Air resistance pushes against a moving object such as a car and slows it down. The larger the **surface area** of the moving object, the more air resistance there is.

Air resistance also pushes against falling objects and slows them down. A parachute uses air resistance to work. It is very light in weight and has a very big surface area. It catches lots of air in it as it falls down so it creates a lot of air resistance or drag.



Which has the greater air resistance, the pick-up or the lorry?

Activity 4.8

Making a parachute

You will need:
string • plastic bag
sticky tape • weights
scissors • watch

Cut out a square from the plastic bag.
Trim the edges so it looks like an octagon (an eight-sided shape).
Cut a small hole near the edge of each side.
Thread a piece of string through each of the holes. The strings should be of the same length.
With sticky tape join the strings to the object you are using as a weight.
Stand on a chair to drop your parachute. Remember that you want it to drop as slowly as possible.
Record the time for the parachute to reach the ground.
Check your results by dropping the parachute another three times. Record these results in a table.

Questions

1. a Name **two** forces that acted on your parachute.
   b Draw a force diagram to show the forces acting on the parachute.
2. a Calculate the average time it took your parachute to fall.
   b Suggest a way you could change your parachute to make it fall more slowly.
3. Would your parachute fall faster or slower if you tested it outside on a windy day? Give a reason for your answer.

The space shuttle lands with a parachute attached.

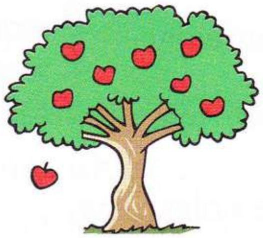
What you have learnt

- Air resistance is a force caused by air pushing against moving objects.
- Air resistance is bigger over large surfaces.

Talk about it!
Why does a space shuttle have a parachute attached to it when it lands?

4 Check your progress

1 Name the type of force acting in each of these pictures.

2 When an astronaut stands on a weighing scales on Earth, they read 60 kg. The astronaut travels to planet X which has half the gravitational force of the Earth.

a What is the astronaut's mass on Earth?
b What is her weight on Earth?
c What is her mass on planet X?
d What is her weight on planet X?

3 Describe **four** ways in which the picture shows the effects of forces on objects.

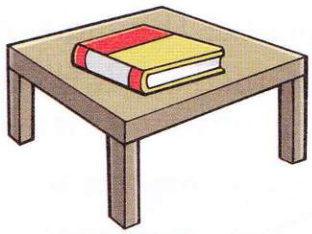
4 a Draw a force diagram to show the forces acting in this picture.

b Are the forces balanced or unbalanced? Say why.

5 Explain the reason for each the following:

a Racing cars have smooth tyres.
b The tyres of trucks have lots of grooves.
c Racing cars are low, flat cars.

6 For each picture say if work is being done, or not, and why.



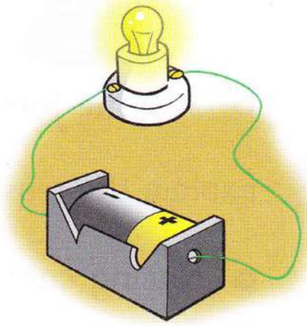
5 Electrical conductors and insulators

5.1 Which materials conduct electricity?

Words to learn
battery
conductor
insulator

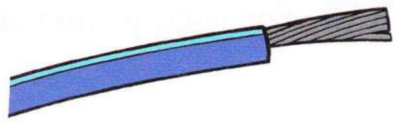
In Stage 4, you learnt about electric current. An electric current needs a continuous path. This path is called an electric circuit.

So far you have used the word 'cells' for the energy storage units like the ones in a torch. Each cell stores 1.5 V of electricity. When we have two or more of these cells connected together we call it a **battery**. Cells and batteries push electricity round a circuit.



What are conductors and insulators?

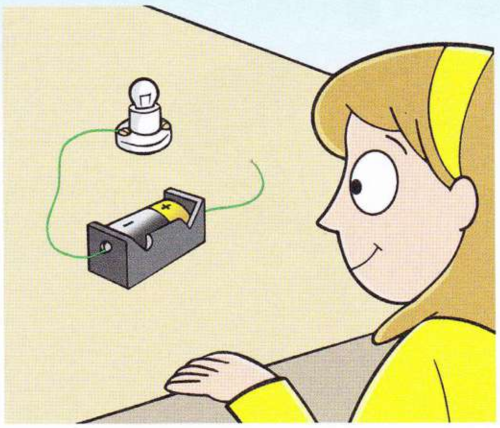
The metal wire is made of copper and it carries the electricity. Materials like metals allow electricity to pass through them. A material that allows electricity to pass through it is called a **conductor**.



The copper wire is covered with plastic. This material does not allow electricity to pass through it. It is called an **insulator**.

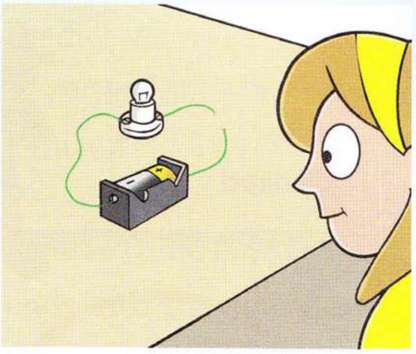
Activity 5.1

Test materials to see if they conduct electricity

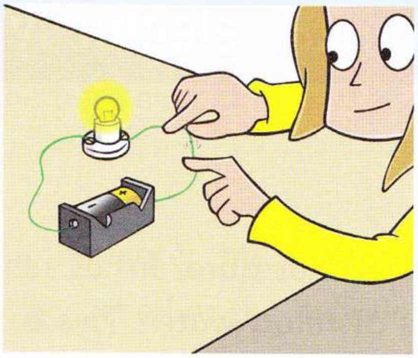


Attach wires to the cell and bulb holder

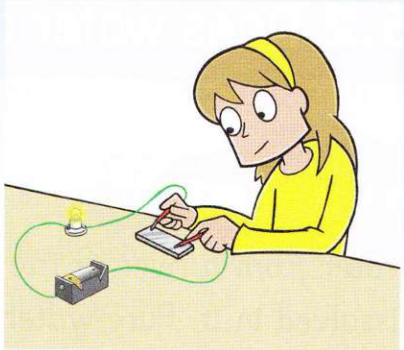
You will need:
three wires • sticky tape
a screwdriver • a 1.5V cell
a 1.5V bulb in a bulb holder
• objects made of different materials



Connect the third wire to the bulb holder and leave the other end free.



Check that your circuit works. Hold the bare ends of the wires together. If the bulb lights up the circuit works. Separate the ends and the bulb goes out.



Test each material. Hold the bare end of one wire at one end of the object. Hold the second bare wire at the other end.

This is your testing equipment. You will use this to see which materials allow electricity to pass though. Before you begin, predict which materials will allow electricity to pass through and which will not. Record your predictions in a table.

If the bulb does not light up, then you can try again to make sure.

Record your results in the last column of your table.

Safety

Do not touch any bare electric wires. Always hold the plastic-covered wire.

Questions

1 How well did your results support your predictions?

2 Identify which types of material are conductors and which are insulators.

3 Did any materials not fit this pattern? If so, identify the material.

4 What conclusion can you make from your results?

Talk about it!

What would happen if the wires in a circuit were not covered in plastic?

What you have learnt

- Metals conduct electricity and are called conductors.
- Other materials do not conduct electricity and are called insulators.

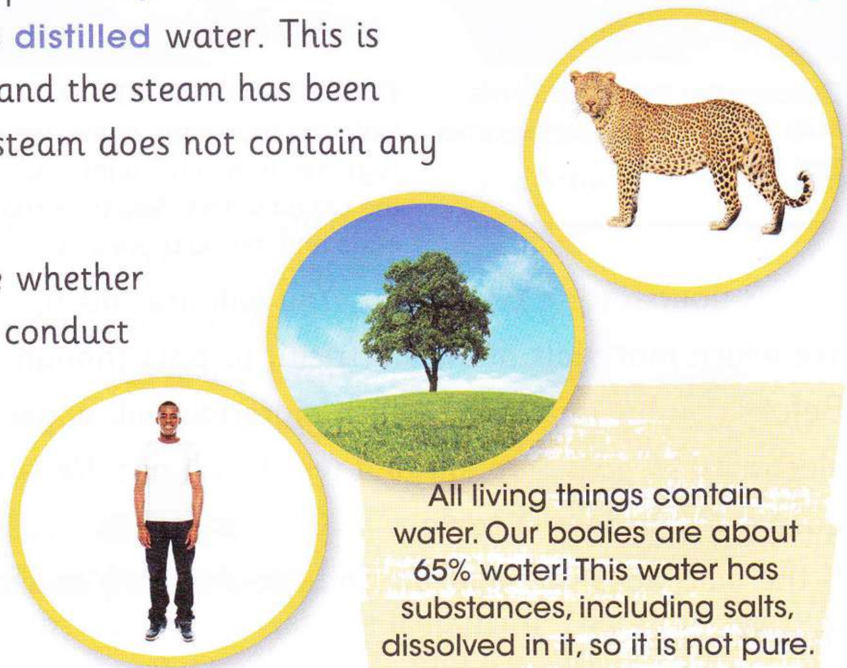
5.2 Does water conduct electricity?

Words to learn
pure
distilled

Is water pure?

Water from a river or the tap is not **pure**. It has salts dissolved in it. Pure water is **distilled** water. This is water that has been boiled and the steam has been condensed. The condensed steam does not contain any dissolved salts.

You are going to investigate whether pure water and salty water conduct electricity.

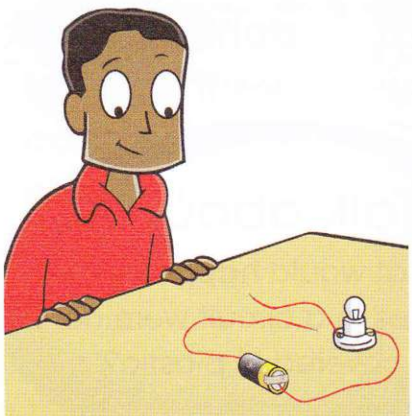


All living things contain water. Our bodies are about 65% water! This water has substances, including salts, dissolved in it, so it is not pure.

Activity 5.2

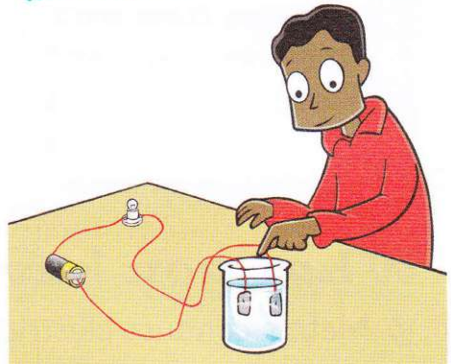
Investigating whether water conducts electricity

You will need:
a circuit with 3V battery as shown in the picture
distilled water
two teaspoons of salt
aluminium foil



Connect up the circuit with the battery, the bulb in the bulb holder and three lengths of wire.

Fold the pieces of aluminium foil and press them to the bare ends of the wire.



Pour 250 ml of distilled water into the beaker. Dip the aluminium foil ends into the water.

Predict whether the bulb will light up.
Test the circuit by holding the bare ends of the wires together. Does the bulb light up?

Add two teaspoons of salt to the water and stir it. Now dip the aluminium foil ends into the salt water. Predict whether the bulb will light up.
Observe whether the bulb lights up.

Questions

1. Did your results support your predictions?
2. Compare the result you got with pure water and with salty water.
3. What conclusion can you make about whether water conducts electricity?
4. Would you be a good or a bad conductor of electricity? Explain why.
5. Look at the picture of Lan in the bathroom. What is she doing that is dangerous? Explain why it is dangerous.

What you have learnt

- Pure water does not conduct electricity.
- Water with salts dissolved in it does conduct electricity.

Talk about it!
How do you know that the water in our bodies is salty?

5.3 Do different metals conduct electricity equally well?

Words to learn
ampere
multimeter
connectors

Measuring current

Current is the rate at which the electric charges flow. You will measure current in Activity 5.3.

We measure current by the number of charges that flow through a point in a circuit in one second. We measure current in units called **amperes** or amps for short. We use an instrument called a **multimeter** to measure current. The multimeter has **connectors**.

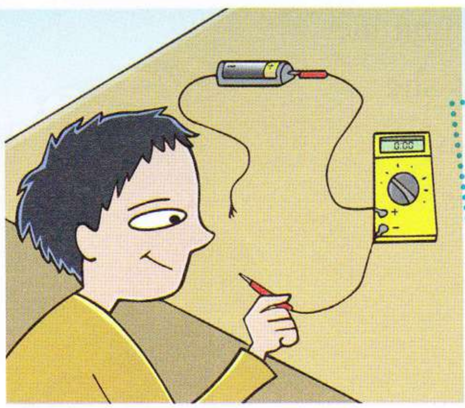
A multimeter.

Metals and alloys

Many objects are made of a combination of different metals. These are called alloys. Stainless steel is a mixture of iron, nickel and chromium. Brass is a mixture of copper and tin.

Activity 5.3

Investigating how well metals conduct electricity



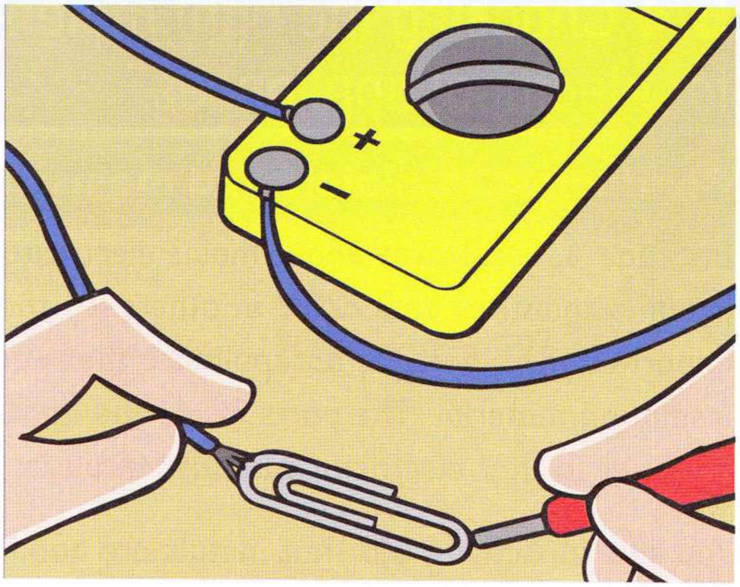
You will need:
plastic-covered wire
sticky tape • a screwdriver
a 1.5V cell • a multimeter
some metal objects

Safety
Do *not* touch any bare electric wires.

Set up your circuit like this. Connect the positive end of the multimeter to the positive terminal of the battery. Check that it works. Hold the plastic coated wire and let the bare end touch the connector of the multimeter. A reading on the multimeter shows that the circuit works

This is your testing equipment to see how well metals conduct electricity. Before you begin, predict which metals will be the best conductors. Record your predictions in a table.

If the multimeter doesn't show a reading first time then check again. Record your results in a table.



Test each metal. Hold the bare end of one wire to one end of the object. Hold the connector of the multimeter to the other end of the object. Read the current in amps on the multimeter.

Questions

1 Did all the metals conduct electricity?
2 Which metal was the best conductor? How did you know this was the best conductor?
3 How well did your results support your predictions?
4 What conclusion can you make from your results?

Challenge

Gold is a very good conductor of electricity. Why isn't gold wire used in circuits?

What you have learnt

- All metals conduct electricity but some metals conduct electricity better than others.

Talk about it!

Why are lightning conductors made from copper?

5.4 Choosing the right materials for electrical appliances

Word to learn

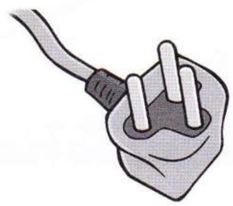
plug

Conductors, insulators and mains electricity

In Stage 4, you learnt about mains electricity, which has a voltage of 110 V in some countries and 220 V in others. At these high voltages, safety is very important. The parts of an appliance that you touch must be made from an insulating material. The parts inside the appliance are made from conducting material so that electricity can pass through.

You saw in Activity 5.3 that metals are good electrical conductors. The parts of electrical appliances that let electricity pass through are made of metal.

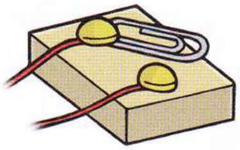
For example, metal is used for the metal pins in a plug. The pins allow electricity to travel from the wall socket, through the plug, and into an appliance such as a kettle or television.



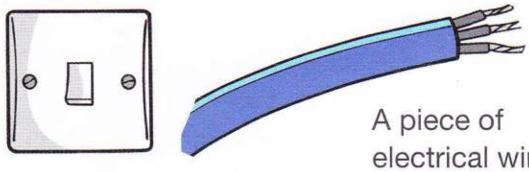
When we handle the plug, we only touch the cover. This is made of plastic, which is a good insulator.

Look at the diagrams. Discuss the use of conductors and insulators in these components.

A switch. You made one like this in stage 4.



A switch cover plate for mains electricity

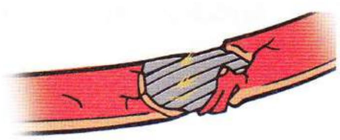


A piece of electrical wire.

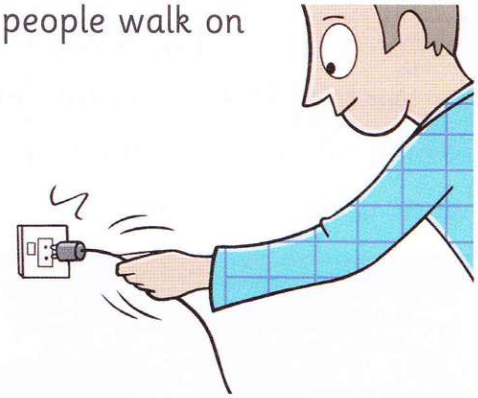
Using mains electricity safely

If mains electricity flows through your body, then you will get an electric shock. You will be badly burnt, your heart could stop and you could die.

Damaged electrical wiring is a major cause of accidents with electricity. Plastic insulation often wears off the copper wires. You can get a shock if you touch the wires.



Here are two ways that electrical wires get damaged.



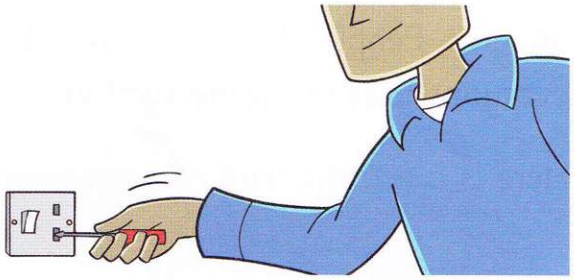
Never place an electric wire under a carpet. When people walk on the carpet, the plastic wears off the copper wires. When copper wires touch each other, electricity flows between them and this can start a fire.

Never pull a plug out like this. This damages the cord and the wires become bare. Grip the plug to pull it out of the socket. Turn off the switch before you pull out the plug.

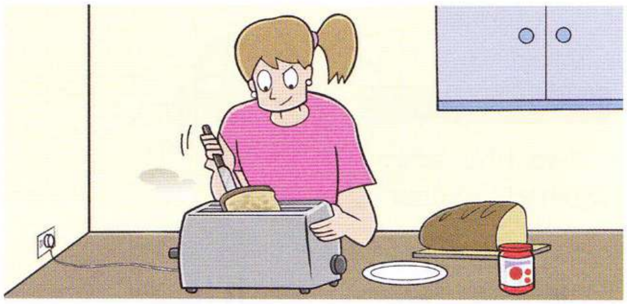
Questions

1 Find appliances at home or at school that use conductors and insulators.
   a List the appliances.
   b Choose **one** example. Draw it and label the materials used. Say whether they are conductors or insulators.
2 a Predict what could happen to the people in Picture A and Picture B.
   b Explain why this could happen.
3 Make a safety poster warning people about the dangers of electricity.

A



B



What you have learnt

- Electrical appliances are made up of materials that conduct electricity and insulating materials that do not conduct electricity.
- Knowing about electrical conductors and insulators helps us to use electricity safely.

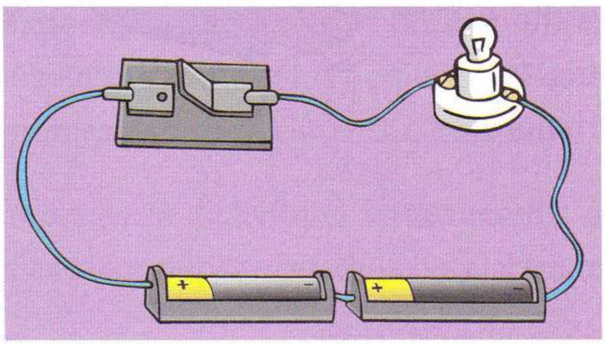
Talk about it!

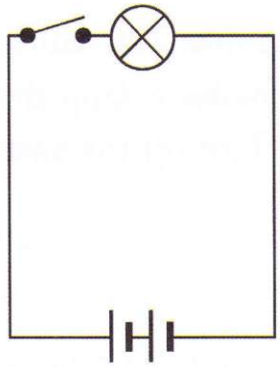
Talk about electrical conductors and insulators in your classroom.

5.5 Circuit symbols

Words to learn
series circuit
circuit diagram

So far we have shown circuits using pictures like the one on the left. This is a series circuit, which means there is only one path for the flow of electricity. Describe what is in this circuit.

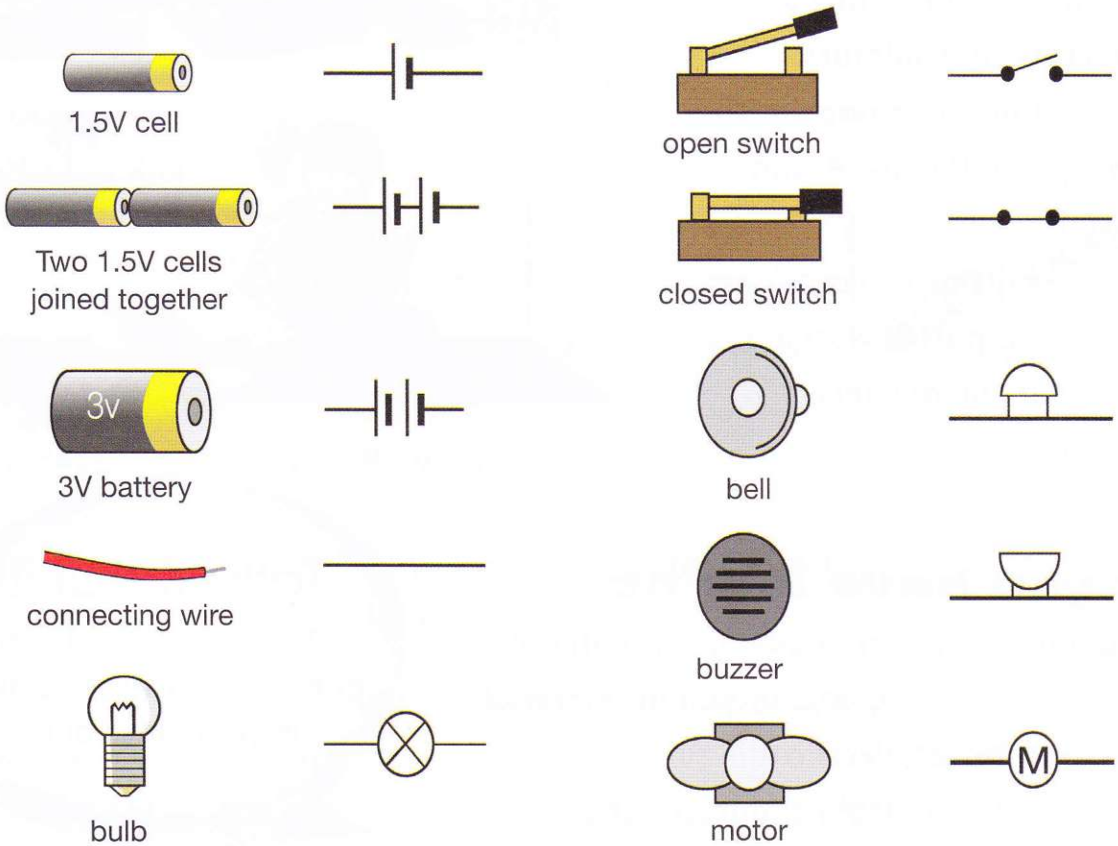




The picture on the right is a circuit diagram of the same circuit.

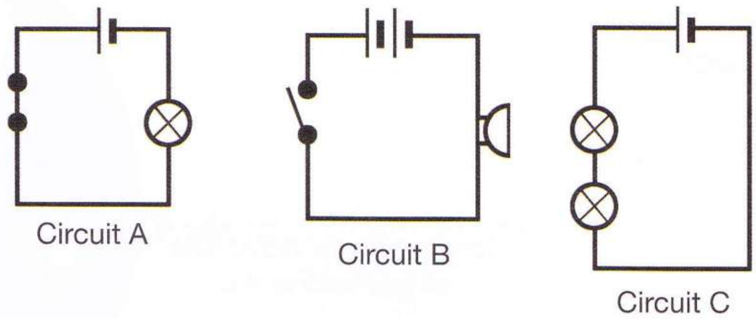
We use symbols to draw circuit diagrams. This is much quicker than drawing pictures. People all over the world can understand circuit diagrams because everyone uses the same symbols.

Here is a list of circuit components and their symbols.



Questions

1 Look at circuit diagrams A, B and C.



a Identify the circuit that shows:

i a battery, a buzzer and a switch.

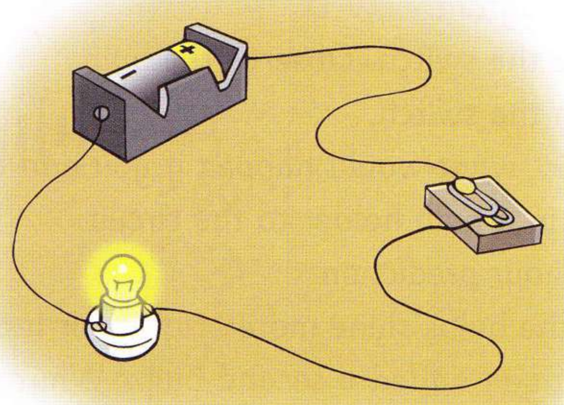
ii a cell, a bulb and a switch.

iii a cell and two bulbs.

b Which circuit shows the switch open?

c Which circuit has the biggest energy source? How do you know?

2 Draw a circuit diagram to represent the circuit on the right.



3 Draw a circuit diagram to show a circuit with a 3 V battery, two bulbs and a closed switch.

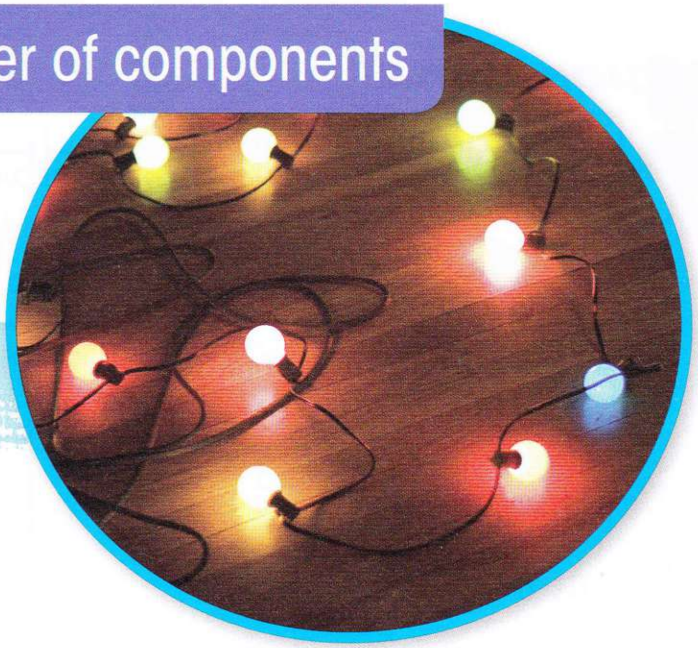
What you have learnt

- Circuit symbols represent the components of an electric circuit.
- A circuit diagram shows where components are found in the circuit.

Talk about it!

What other symbols do we use every day when we communicate?

5.6 Changing the number of components



Some circuits have lots of components.

Activity 5.6a

Making a circuit with more components

Make the circuit using one of the bulbs as shown in this diagram.

Close the switch. Observe the bulb.

Open the switch.

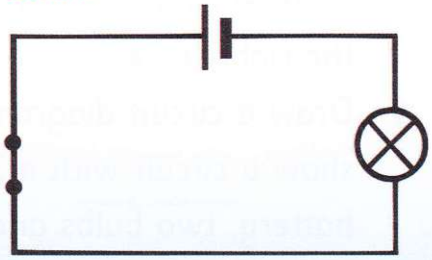
Predict what would happen if you add one more bulb in a bulb holder to the circuit.

Test your prediction.

Did the bulbs shine more brightly or less brightly when you added a second bulb? Why?

You will need:

a 1.5 V cell • two bulbs in bulb holders • a switch
150 cm wire • a sharp knife
scissors • sticky tape



Activity 5.6b

Discussing and planning your own investigation

Here are two questions for you to test.

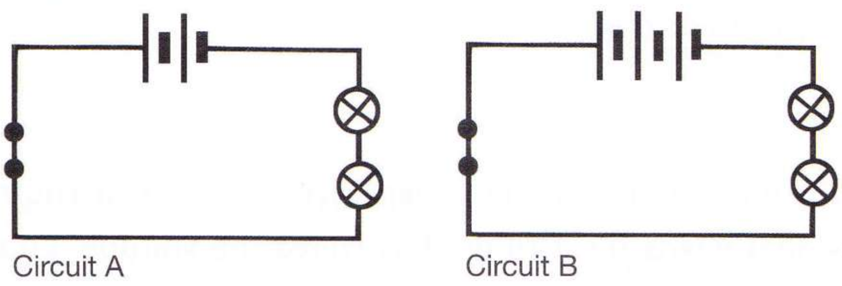
1. If you remove a bulb from a circuit with two 1.5 V cells joined to make a 3 V battery and three bulbs, will the bulbs glow more brightly or less brightly?
2. If you add a third 1.5 V cell to the same circuit you used in 1, will the two bulbs glow more brightly or less brightly?

Discuss how you will plan an investigation to answer these two questions.
Choose what components you need to make your circuit.
Use your knowledge of electrical circuits to predict what will happen when you carry out the tests.
Make your circuit. Observe what happens when you remove the bulb and then when you add another cell. Does the evidence support the predictions you made?
Repeat any observations that you are not sure of.
Use your results to answer the questions that you were asked to test.

Questions

1 Draw a circuit diagram for each of the circuits you made in Activity 5.6b.

2 Look at Circuit A and Circuit B.
Predict in which circuit the bulbs will be brighter.



3 Suggest another circuit question that you could investigate.

What you have learnt

- Removing or adding bulbs from a circuit causes them to glow more or less brightly.
- Adding or removing cells used in a circuit causes bulbs to glow more or less brightly.

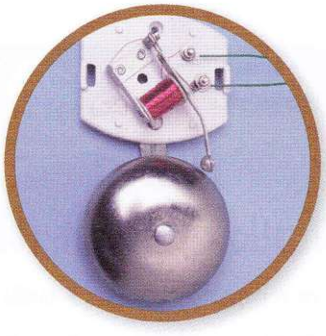
Talk about it!
If a circuit doesn't work, what must you check?

5.7 Adding different components

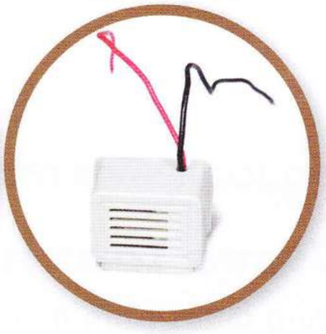
Different components need different strengths of electricity. You can put buzzers, bells and motors in a circuit instead of a bulb. These components need a stronger supply of electricity than a bulb.

Voltages

The strength of electricity is measured in a unit called a volt (V). The strength of electricity that a component needs for it to work is called the voltage. Look at the voltage of these components:


This bell needs 6 V to work.


This bulb needs 1.5 V to work.


This buzzer needs 3 V to work.


This motor needs 24 V to work.

If you put a 3 V buzzer into a circuit you need a 3 V battery to make the buzzer work. You can make a 3 V supply by joining two 1.5 V cells.

Activity 5.7

Building circuits using different components

You will need:
two batteries • a switch
a buzzer • connecting wires
a motor • a bell

Plan and build a circuit with a battery, a switch and a buzzer.

Test whether adding another battery will make the buzzer sound louder.

Decide how you will change the circuit if you replace the buzzer with a motor or a bell.

Discuss how you will make the circuits. Choose what components you need.

Predict what will happen before you make each circuit.

Make your first circuit. Does the buzzer work?

Add another cell to the battery. Observe any differences.

Make the changes you planned to replace the buzzer with a motor or a bell.

Predict what will happen. Does the evidence support the predictions you made?

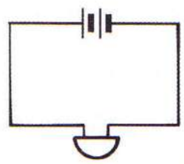
Repeat any observations that you are not sure of.

Questions

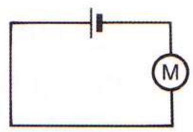
1 Draw a circuit diagram for each of the circuits you made in Activity 5.7.

2 Think about when you added an extra cell to the battery in your buzzer circuit.
What was your conclusion about the effect of this?

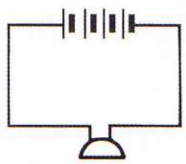
3 Look at Circuits A, B and C. The bell and buzzer need 6 V to work and the motor needs only 1.5 V.
a Predict which of these circuits will work.
b Explain why the other circuit does not work.



Circuit A



Circuit B



Circuit C

What you have learnt

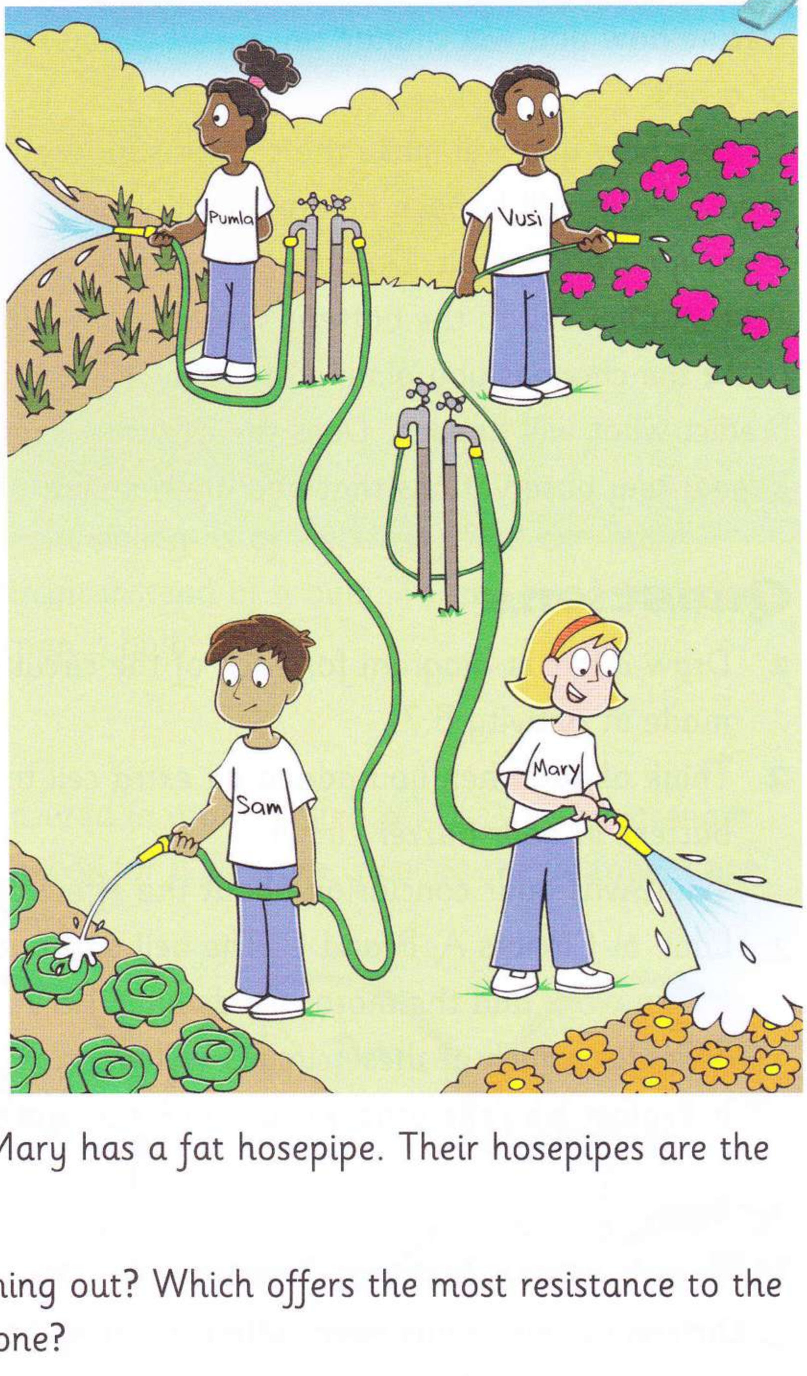
- Different components need different strengths of electricity to work.
- Changing the number of cells affects how well components work.

Talk about it!
What do you think a 1.5V and a 12V motor could be used for?

5.8 Length and thickness of wire in a circuit

Words to learn
pressure
resistance

Look at the children watering the garden. The **pressure** of water coming from the taps is the same for each of the four hosepipes. The hosepipes supply different amounts of **resistance** to the water passing through them. If there is a lot of resistance in the hosepipe, less water comes out than if there is not much resistance in the hosepipe.



Sam has a long hosepipe and Pumla has a short hosepipe. Their hosepipes are the same thickness. Look at the long hosepipe and the short one. Which has the most water coming out? Which hosepipe offers the most resistance to the water, the long one or the short one?

Vusi has a thin hosepipe and Mary has a fat hosepipe. Their hosepipes are the same length.

Which has the most water coming out? Which offers the most resistance to the water, the thin one or the fat one?

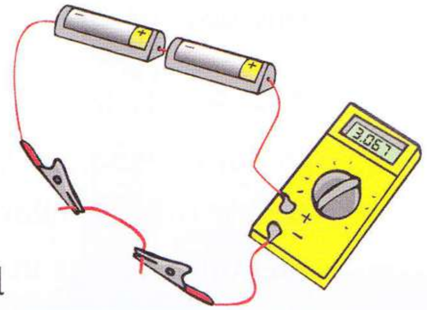
You can apply what you know about water flow in hosepipes to electric current flow in wires.

Activity 5.8

Changing the thickness of wire in a circuit

You will need:
two 1.5V cells • wire (thick and thin resistance wire)
a multimeter • crocodile clips

Set up a circuit as shown in the diagram.
Insert 10 cm of thin resistance wire into the circuit.
Measure the current on the multimeter.
Now replace the thin resistance wire with the same length of thick resistance wire. But before you do this, predict whether the multimeter reading will be higher or lower.
Test your prediction.
Do you think changing the length of resistance wire will change the multimeter reading? Discuss how to test this and how much evidence you will need.
Test your prediction.



Questions

1 a Copy this sentence, choosing the correct word where there is a choice.
Long or thin hosepipes give more/less resistance to water flow than short or fat hosepipes.
b Write a similar sentence about the flow of electricity through different wires.

2 a How did changing the resistance wire from thin to thick change the multimeter reading?
b Explain why this happened.

3 a How did changing the length of resistance wire change the multimeter reading?
b Explain why this happened.

Challenge

Extension cables are often 30 m long. Why are these cables made of thick wire rather than thin wire?

An extension cable.

What you have learnt

- Changing the length or thickness of wire in a circuit will change the strength of current.

Talk about it!

How has thin wire been put to good use in a light bulb?

5.9 How scientists invented batteries

All the circuits you have made have included a cell or a battery. These batteries contain chemical substances that react together. This reaction supplies the energy needed to push the electricity round the circuit. How did scientists make this discovery?

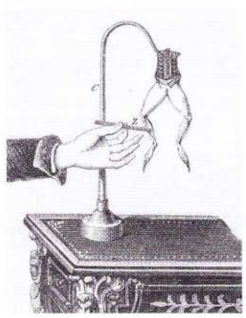
The Baghdad battery

In June 1936 workers found an ancient tomb while they were constructing a new railway near the city of Baghdad, in present-day Iraq. Archaeologists identified things in the tomb to be 2000 years old. At this time people called the Parthians lived in this region.

One of the old objects or relics they found in the tomb was a clay jar. The jar had an iron rod coming out of the centre, surrounded by a tube made of copper. Scientists made copies of it relic. When they filled the tube with an acid such as vinegar, it produced between 1.5 and 2 volts of electricity between the iron and copper. Archaeologists think that people who lived 2000 years ago could have used batteries like this to cover metal objects with gold.

Galvani's discovery

Luigi Galvani was an Italian doctor. About 1780 he discovered current electricity. He hung a frog's leg on copper hooks over an iron railing and noted that the leg muscles twitched. Galvani was correct when he said that the twitchings were caused by electrical current, but he thought that the current came from the frog's leg nerves and called it "animal electricity."

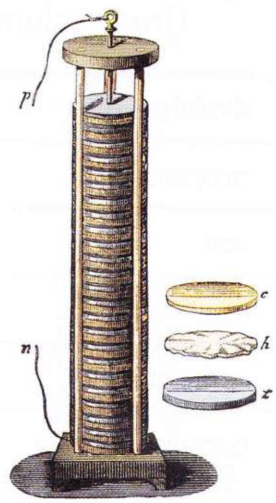


The voltaic pile

Alessandro Volta was an Italian university professor. He repeated Galvani's experiments many times with different materials. From these experiments he came to the conclusion that it was the two different metals, copper and iron, not the frog's leg that produced the electricity.

The frog's leg contained a fluid which conducted the current. It twitched because the electricity was flowing through it.

In 1800, after many experiments, he developed a type of battery that he called the voltaic pile. This consisted of a pile of zinc and copper discs. Between each disc there was a piece of cardboard that he had soaked in salt water. A wire connecting the bottom zinc disc to the top copper disc could produce a continuous flow of sparks.



Volta built different piles using thirty, forty or sixty discs. He measured the reaction with different numbers of discs and discovered that the electric shock increased in intensity with the number of discs he used in the pile.

Later, scientists improved Volta's battery by doing more experiments.

Questions

1 What did Galvani observe in his experiments with frog's legs?
2 What did these observations lead Galvani to conclude?
3 How did Volta use creative thinking to develop Galvani's ideas further?
4 What measurements did Volta make to provide evidence for the strength of electric current?
5 Describe the differences between Galvani's and Volta's explanations for how an electric current flowed.
6 What electrical unit is named after Volta?

What you have learnt

- Scientists have combined evidence from observation and measurement with creative thinking to suggest new ideas and explanations for batteries and electricity.

Talk about it!
How could people have invented batteries 2000 years ago?

5 Check your progress

1 Copy the words in column A and write their correct meanings (from column B) next to them.

Column A	Column B
ampere	a picture of a circuit using symbols
volt	a device to connect two wires together
multimeter	the unit for measuring the strength of electricity
series circuit	the unit electric current is measured in
circuit diagram	a piece of equipment for measuring current, voltage and resistance
resistance	a device for connecting an electric wire or cable to an electricity supply
connector	a circuit where the electricity only has one path to flow along
plug	the amount of restriction of flow of electricity

2 What is the difference between:

a a cell and a battery

b an electrical conductor and an electrical insulator

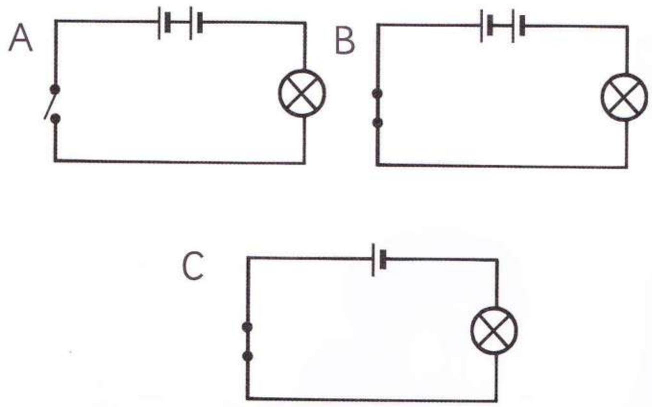
c pure water and distilled water?

3 Draw a circuit diagram including these components to make the circuit:

4.5 V battery   connecting wire   switch   two bulbs

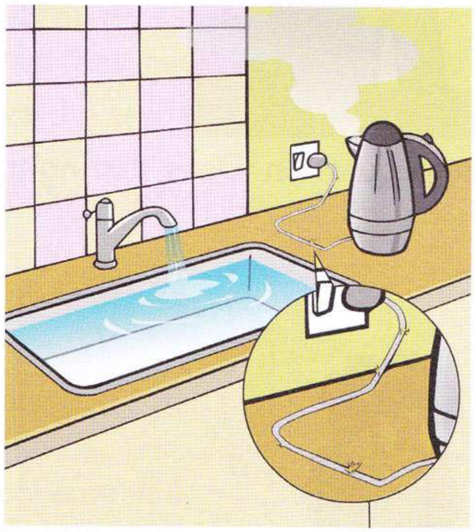
4 In which of the circuits A, B and C will the bulb not light up?

Explain your answer.



5 Explain why plug covers are made of plastic and electrical wire is made of copper.

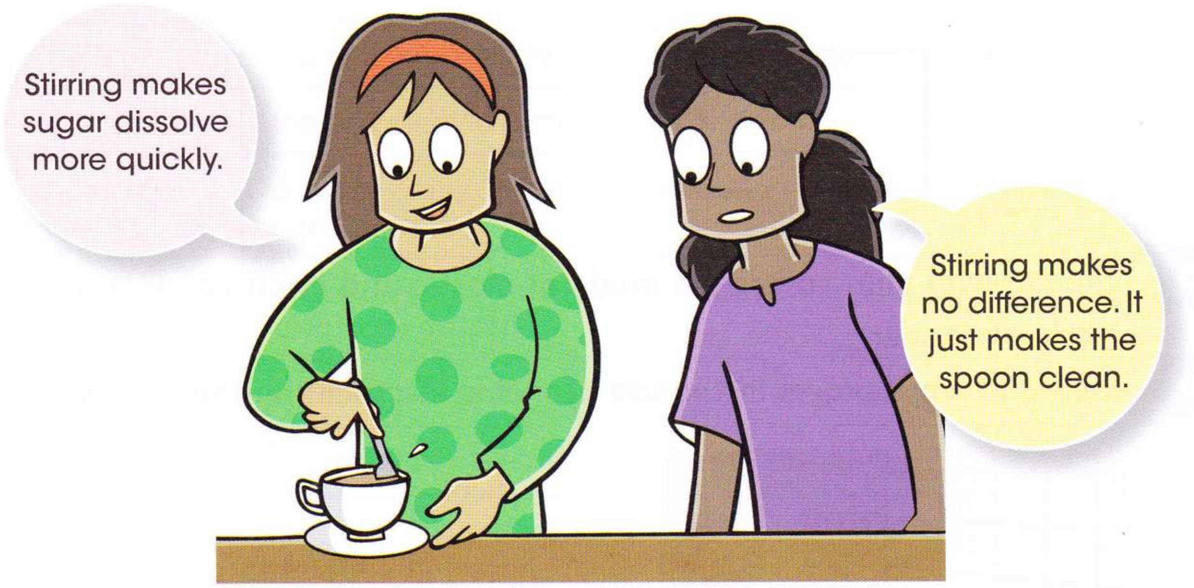
6 Identify **two** dangers in the use of mains electricity in the picture.



Reference

How to plan an investigation

Making an idea into a question



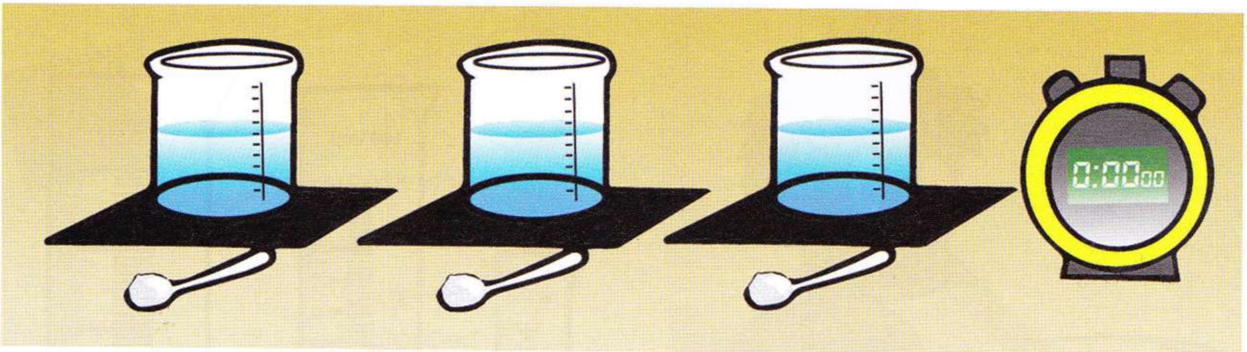
Amna wants to test her idea. She makes it into a question 'Does stirring make sugar dissolve more quickly?'.

Choosing the equipment

They decide to dissolve the sugar in hot water and use clear containers. They put the containers onto black card. This will help them to see the sugar.

Neta gets a stopwatch so that they can measure how long the sugar takes to dissolve.

No stirring | Stir 3 times every 2 minutes | Stir 3 times every minute



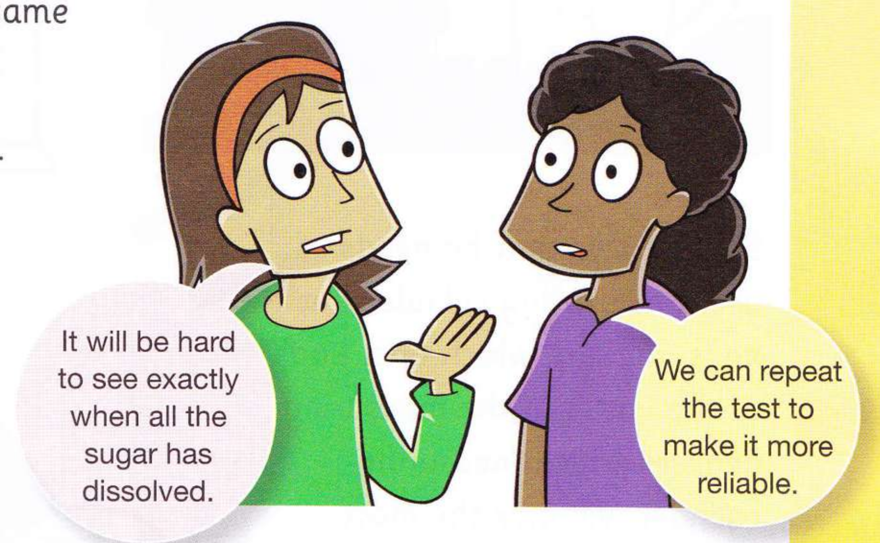
Making the test fair

What do they need to keep the same to make the test fair?

They make a list of the variables.

Variables
Amount of sugar
Amount of water
Temperature of water
Amount of stirring

Making the test accurate



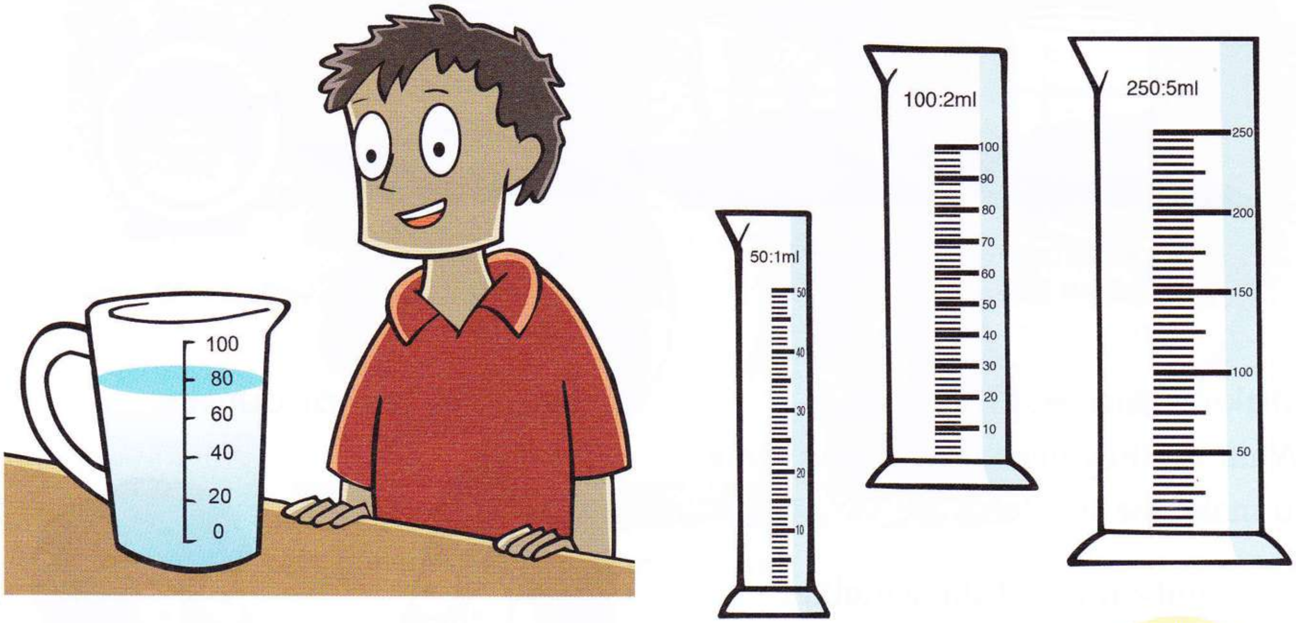
It is not important who stirs the sugar in this investigation.

Choosing equipment

It is important to choose the right science equipment for an investigation.

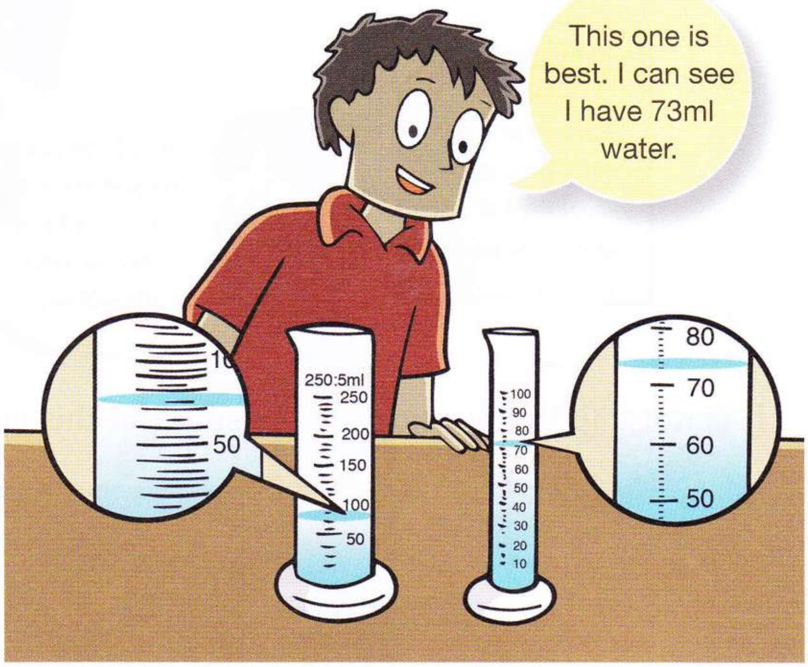
Using the right equipment can make measurements more accurate.

Sunil wants to measure how much water he has. He can see it is between 70 and 80 ml but he wants an accurate measurement.



Sunil knows that he needs to use a measuring cylinder but he is not sure which one. Look at the water in the measuring beaker. Which measuring cylinder will give the most accurate measurement?

The 50 ml measuring cylinder is too small.

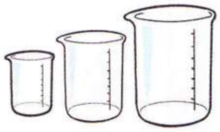


Sunil tries the others.

For an accurate measurement, use the smallest measuring cylinder that the liquid will fit into.

Use this page to help you choose what you need for your investigation.

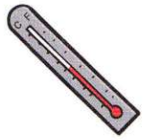

scales


measuring beakers

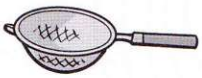

digital timer


dropper


measuring spoons

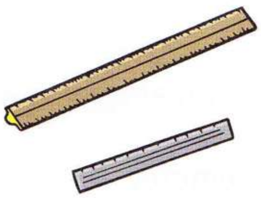

thermometer


filter paper

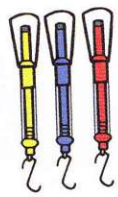

sieve

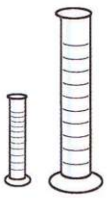

bulb in holder


scales


rulers

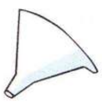

multimeter


forcemeters


measuring cylinders


1.5 V cell

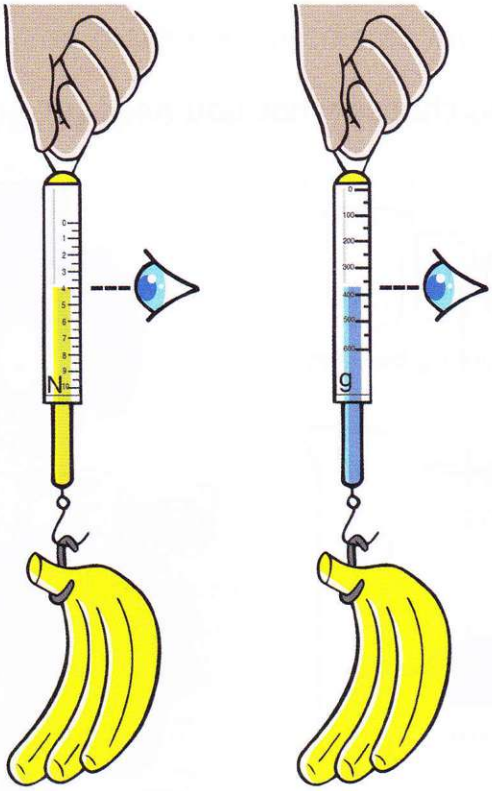

motor


funnel dropper


tape measure

Using forcemeters scales

Using a forcemeter



Turn the nut to check the forcemeter is set to zero.

Put the object on the forcemeter.

Put your eye level with the pointer and read the scale.

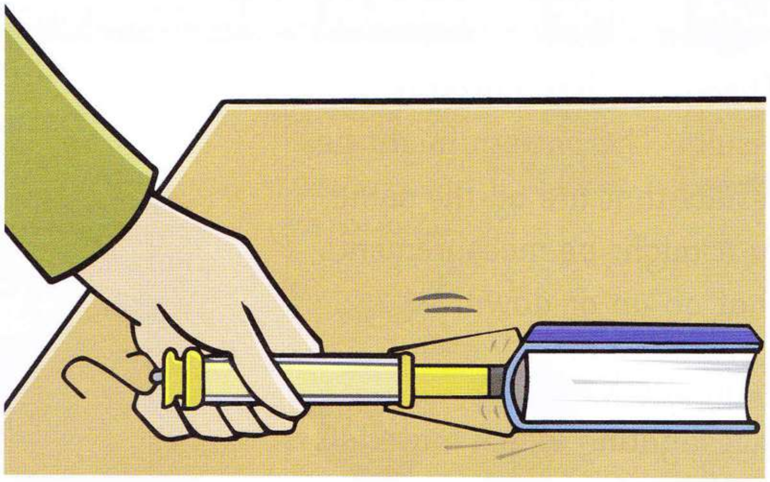
The weight of the bananas is a force of four newtons.

Many forcemeters also have a scale that will show the mass of an object in grams or kilograms.

The bananas have a mass of about 400 g.

Some forcemeters can also be used to measure the size of a pushing force.

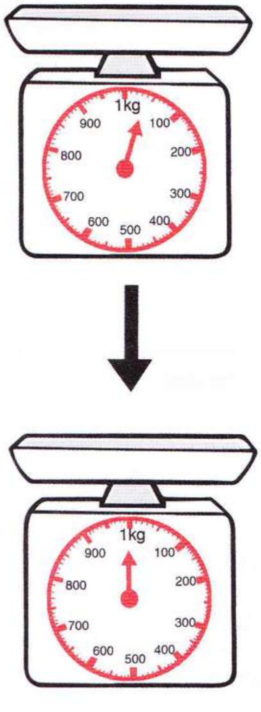
A force of about 2.5 N is needed to push this book across the table.



Using scales

These scales are not set to zero.

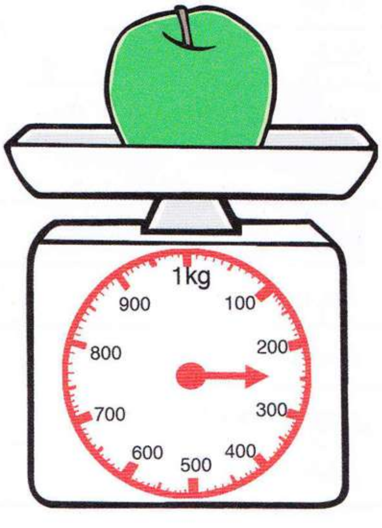
Look for a wheel at the back of the scales. Turn the wheel to set the scales to zero.



Put an object on the scales.

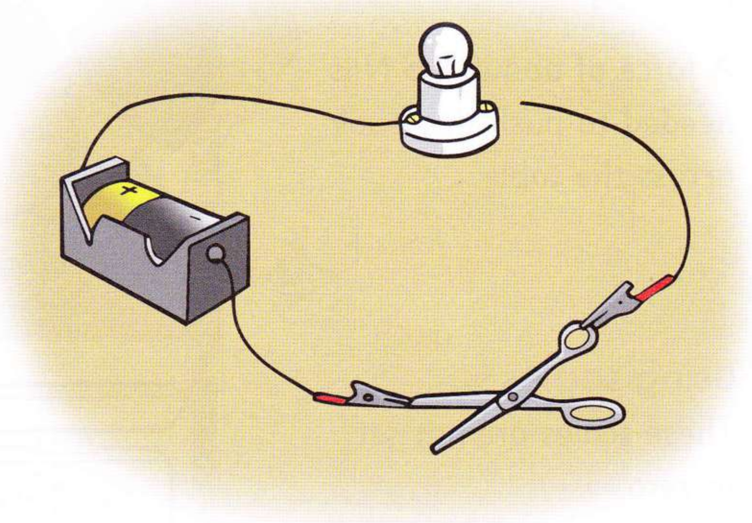
The scales will show the mass of the object.

This apple has a mass of 250 g.



Looking for patterns in results and making conclusions

There are often patterns in results. The pattern might be results that are all the same, or it might be measurements that go up or down.



Femi and Kwasi are investigating which materials conduct electricity.

They are testing objects made from different materials. The bulb lights when the material conducts electricity.

Here are their results.

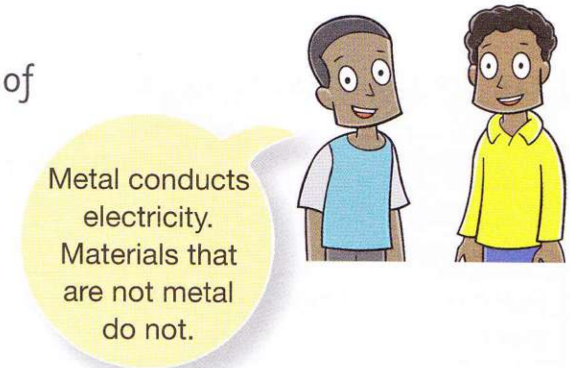
Object	Material	Bulb
scissors	metal	on
ruler	wood	off
cup	plastic	off
cup	glass	off
key	metal	on
coin	metal	on
book	paper	off
spoon	metal	on
spoon	wood	off
pencil lead	graphite	on
pen	plastic	off

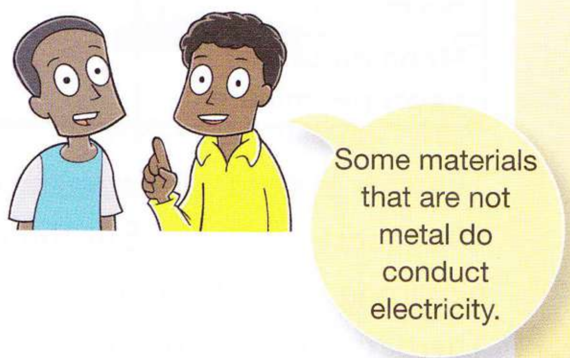
Femi has seen a pattern in the results. Some of the results are the same. He uses the pattern to make a conclusion. Is Femi correct?

Kwasi has seen a result that does not fit the pattern.

To check that they have not made a mistake, they repeat the test with the graphite. The bulb lights up every time. So Femi's conclusion is not right.

They make new conclusions.





Using patterns to check that repeated measurements are reliable

Yoko and Marja are investigating how running affects pulse rate. They want to know if their pulse rate is different when they run at different speeds.

Yoko runs the same distance each time but at three different speeds.

To make their results reliable, Yoko runs at each speed three times. They measure her pulse rate after each time. They are going to take the average pulse rate for each running speed by finding the mean.

Here are their results so far.

Exercise	Running very fast	Running quite fast	Running slowly
Pulse Rate 1 in beats per minute	190	102	155
Pulse Rate 2 in beats per minute	195	172	153
Pulse Rate 3 in beats per minute	188	178	210
Mean pulse rate in beats per minute			

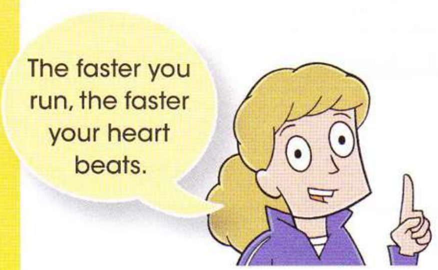
The girls look for patterns in their results. The numbers for running very fast are almost the same. But there are two measurements in the results that could be wrong. Look for numbers that do not fit the pattern.

The girls repeat two measurements to check that they are reliable. Then they calculate the mean.

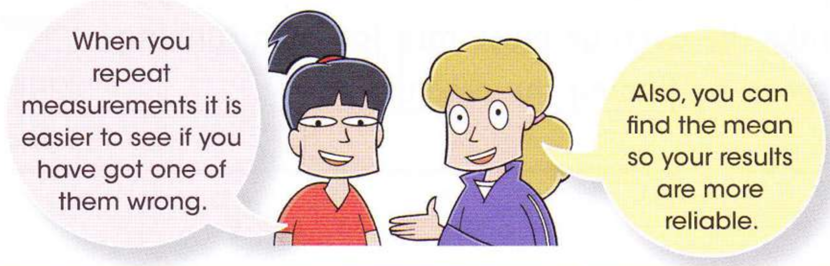
Their results now look like this.

Exercise	Running very fast	Running quite fast	Running slowly
Pulse Rate 1 in beats per minute	190	102 169	155
Pulse Rate 2 in beats per minute	195	172	153
Pulse Rate 3 in beats per minute	188	178	210 148
Mean pulse rate in beats per minute	191	173	152

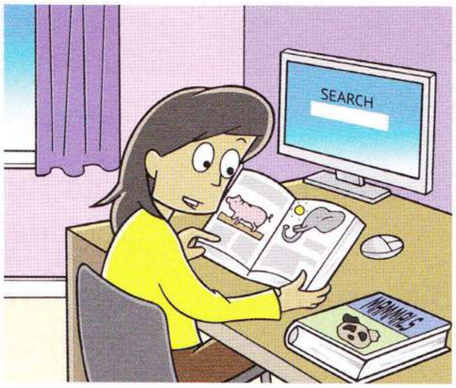
Marja makes a conclusion.



The girls explain why they repeated their measurements.



Researching questions



Sometimes a science investigation is not the best way to answer a question. You may not have the equipment you need or enough time. The answers to many questions can be found in reference books or on the internet. Mai is researching food chains.

Choosing key words

First you should think about which words to look for. These should be key words for the topic you are researching. Mai could look for *diet*, *consumer* and *prey*.

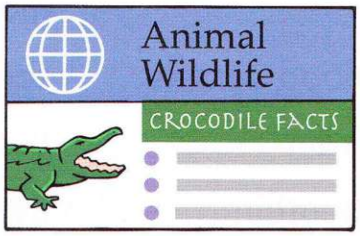
Using reference books

Scan the contents page for these words and look them up in the index.

Try looking up *consumer* and *prey* in the index to this book. Can you find out about the diet of an animal?

Using the internet

Think carefully about the words you type into a search engine. Searches for 'Crocodile diet' and 'What do crocs eat?' will list different websites.



Not all the information the internet is correct, so look carefully at the websites that come up on your search. Some are more likely to be correct than others.

Mai has found two websites with information about what crocodiles eat. Which do you think is more reliable?

To find reliable websites, look for those that come from large organisations and are written by experts. Unreliable websites often have adverts and do not look as good.

Glossary and index

		Page
acid rain	rain that contains dissolved nitric oxides or sulfur dioxide; these compounds make the rain acidic	34
air resistance	the force caused by air pushing against moving objects	72
ampere	the unit used to measure electric current	80
asthma	an allergic reaction that causes a person to have difficulty breathing	32
atmosphere	the mixture of gases surrounding the Earth	32
audit	a sorting and checking exercise	39
balanced (forces)	when two forces acting on an object are equal and opposite	62
battery	a source of electrical energy that consists of more than one cell	76
blood vessels	special tubes that carry the blood	9
brain	the organ that controls all body functions	18
breathing	the way we take air into our bodies and let it out of our bodies	12
bronchitis	a lung infection that can be caused by polluted air	32
circuit diagram	a picture of a circuit that uses symbols to represent components	84
circulation	the pumping of blood all around the body	8
circulatory system	the system formed by the heart, blood vessels and blood to carry food and oxygen around the body	9
compost	rotted vegetables and garden waste that is used as a fertiliser	37

conclude	to decide something is true after looking at all the evidence you have collected	53
conductor (of electricity)	a material that allows electricity to pass through it	76
connector	a device to connect two wires together	80
conserve	to keep safe, to protect from extinction	31
consumer	a living thing (usually an animal) that eats another plant or animal	24
deforestation	removal of trees by humans	30
depict	when you depict an idea you show it using a diagram or drawing	22
desert	regions with very little rainfall	28
dialysis	a way to remove wastes from the blood with a machine if the kidneys do not work properly	17
digestion	the process of breaking down food into very tiny particles	14
digestive system	the organs needed for the process of digestion including the stomach and intestines	14
disease	an illness which stops your body from working properly	17
dissolve	when a substance, often a solid, mixes with a liquid and becomes part of the liquid	46
distilled (water)	water that has been boiled and the steam has condensed to give pure water	78
drag	another name for air resistance	72
energy	when something has energy, it can make things move and cause things to change; all living things need energy to exist	24,66
environment	our natural surroundings	30

excretion	the process of removing of waste products from the body	16
exert	to push or pull to create a force	60
factor	an item to consider when dealing with a problem or investigation	25
filter	a sieve which lets through liquids and dissolved substances but not insoluble substances	48
filtering	a method to separate mixtures made of a solid and liquid using a filter	48
food chain	a way to describe the feeding relationship between plants and animals	22
force	a push or a pull that tries to change the position or shape of an object	58
force diagram	drawing that shows the direction and size of forces acting on an object	6
friction	a force which tries to stop things sliding past one another	68
global warming	the gradual increase in temperatures throughout the world	30
gravity	the force that pulls objects towards the Earth	58
greenhouse gas	a gas that traps heat causing the temperature of the atmosphere to rise, for example, carbon dioxide	31
heart	a special muscle that pumps blood around the body	8
insoluble	cannot dissolve	46
insulator (of electricity)	a material that does not allow electricity to pass through it	76
intestines	the organ which breaks down food into tiny particles that can move into the blood; undigested food is pushed out at the end of the intestines	14
irreversible	cannot be changed back to what it was before	43

kidney	bean-shaped organs that filter blood to remove waste products	16
kilogram	measure of mass equal to 1000 g	58
landfill (site)	where waste products from a town or city are disposed of or buried	36
lubricate	to put a substance, such as oil, on a surface in order to reduce friction	69
lungs	the organs we use for breathing	12
mass	the amount of matter in an object, measured in kilograms	58
mixture	forms by when two or more different substances mixed together but are not chemically joined	44
multimeter	a piece of equipment for measuring current, voltage and resistance	80
negative	something that does not have a good effect	30
nerves	fibres which carry messages to and from the brain	18
nervous system	the brain and nerves	18
net (force)	the overall force when two or more opposite forces are not in balance	63
newton	the unit used to measure weight	58
organ	a part inside the body that carries out a specific function to keep us alive	6
organ system	different organs that work together to carry out a certain function in the body	6
pest	an unwanted plant or animal, such as an insect that eats your flowers	22
plankton	tiny plants and animals that live in the sea	29
plug	a device for connecting an electric wire or cable to an electricity supply	82
pollutants	substances which cause pollution	32

pollution	making the environment dirty with waste products	32
positive	something that has a good effect	36
predator	a consumer that eats other animals (which are their prey)	26
pressure	the force that is put on something	10, 90
prey	an animal that is eaten by another animal (a predator)	26
producer	a plant that produces energy from sunlight	29
pulse	a small beat felt under the skin due to the pressure of blood as the heart pumps it around the body	10
pure (water)	water that contains no impurities such as salts	78
rate	how fast something happens	52
react	when substances are mixed together and change chemically to form a new substance	44
recycling	to re-process something and make into a new product	36
reduce	to decrease	36
resistance	the amount of opposition to the flow of current	90
resource	a store of something necessary for life, such as water, energy and minerals	38
reversible	can be changed back to what it was before	42
saliva	liquid produced in the mouth	15
savannah	grassland regions with a tropical climate	28
separate	to divide or split something into different parts	44
series circuit	a circuit where the electricity only has one only path to flow along	84
sieve	a material or piece of equipment with holes in it that will only allow substances of a certain size to go through the holes	45
soluble	can dissolve	46

solute	the material that is dissolved	50
solution	a mixture of one substance in another, where the dissolved substance can no longer be seen	50
solvent	the liquid in which a solute dissolves	50
sort	to put things in groups according their type	45
species	a particular type of plant or animal	23
stomach	the organ which mixes chewed food with digestive juices to form a thick liquid	14
surface area	the size of the outside part of an object	71
suspension	a cloudy mixture of insoluble solid particles in a liquid	47
tropical	tropical countries lie between the tropics where the climate is hot and wet; 23 degrees north or south of the equator	28
tumour	a growth on body organs	19
unbalanced forces	when two or more forces acting in opposite directions on an object are not the same size	63
uniform	the same throughout	51
unique	not like anything else	29
urine	the liquid waste excreted by the kidneys	16
weight	the amount of force that pulls objects towards the Earth	58
wetland	A wetland is a place that is covered in shallow water most of the time.	48
windpipe	the tube that carries air from the nose and mouth to the lungs and back again	12
work	the amount of energy transferred when a force makes an object move	66

Acknowledgements

The authors and publisher are grateful for the permissions granted to reproduce copyright materials. While every effort has been made, it has not always been possible to identify the sources of all the materials used,or to trace all the copyright holders. If any omissions are brought to our notice, we will be happy to include the appropriate acknowledgements on reprinting.
The publisher is grateful to the experienced teachers Mansoora Shoaib Shah, Lahore Grammar School, 55 Main, Gulberg, Lahore and Lynne Ransford for their careful reviewing of the content.

p. 7 Alexander Semenov/ Science Photo Library; p. 10 Lucian Coman/ Shutterstock; p. 14 bikeriderlondon/ Shutterstock; p. 16 Stuart Monk/ Shutterstock; p. 17 Picsfive/ Shutterstock; p. 19 Gemenacom/ Shutterstock; p. 22 Malcolm Schuyl/ Alamy; p. 24 Ralph Loesche/ Shutterstock; p. 26*tr* Travel USA/ Alamy; p. 26*bl* Cathy Keifer/ Shutterstock; p. 26*br* Mike Raabe/Design Pics Inc./ Alamy; p. 27 nico99/ Shutterstock; p. 29 digitalunderwater.com/ Alamy; p. 30 Sue Cunningham/Worldwide Picture Library/ Alamy; p. 32*t* ssuaphotos/ Shutterstock; p. 32*b* John McKenna/ Alamy; p. 34 Vanessa Miles/ Alamy; p. 35*t* Rolf Bender/ Frank Lane Picture Agency; p. 35*c* Carolina Biological Supply Company/ Phototake/ Alamy; p. 35*b* Imagebroker/ Frank Lane Picture Agency; p. 36 Tony Wharton/ Frank Lane Picture Agency; p. 38 Kuzma/ Shutterstock; p. 38 Rebecca Hosking/ Frank Lane Picture Agency; p. 42 Bochkarev Photography/ Shutterstock; p. 43*tr* pogonici/ Shutterstock; p. 43*tl* Abel Tumik/ Shutterstock; p. 43*b* i love images/ Alamy; p. 45 Twin Design/ Shutterstock; p. 46 Elisabeth Coelfen/ Alamy; p. 47 GIPhotoStock/ Science Photo Library; p. 48 cvalle/ Shutterstock; p. 49 Gallo Images/ Alamy; p. 50 Iakov Filimonov/ Shutterstock; p. 51*t* Helene Rogers – Commercial/Art Directors & TRIP/ Alamy; p. 51*b* Robyn Mackenzie/ Shutterstock; p. 55 Jason Patrick Ross/ Shutterstock; p. 56 Robyn Mackenzie/ Shutterstock; p. 58 and p. 59*t* Martin F. Chillmaid/ Science Photo Library; p. 59*b* Dennis Hallinan/ Alamy; p. 60 Todd Warnock/Digital Vision/ Getty Images; p. 61 Rolf Richardson/age fotostock/ Alamy; p. 63 Fuse/ Getty Images; p. 65 Horizon International Images Limited/ Alamy; p. 66 Chris Cooper-Smith/ Alamy; p. 68*l* Rafa Irusta/ Shutterstock; p. 68*r* Elnur/ Shutterstock; p. 69 Thomas Müller/imagebroker/ Alamy; p. 71 Petar Ivanov Ishmiriev/ Shutterstock; p. 72 Richard Thornton/ Shutterstock; p. 73 Tom Tschida/ NASA; p. 74 Jack Sullivan/ Alamy; p. 78*b* stockyimages/ Shutterstock; p. 78*c* majeczka/ Shutterstock; p. 78*t* Tabby Mittins/ Shutterstock; p. 80 Bragin Alexey/ Shutterstock; p. 83 worldpix/ Alamy; p. 86 © Cynthia Classen/Flickr Open/ Getty Images; p. 88*l* sciencephotos/ Alamy; p. 88*cl* ekipaj/ iStockphoto; p. 88*cr* Krys Bailey/ Alamy; p. 88*r* David J. Green – engineering themes/ Alamy; p. 91 Christopher Brignell/ Thinkstock; p. 92*t* Bowl, Iran, Sasanian period, 4th-5th century (silver and gilt), Persian School/ Freer Gallery of Art, Smithsonian Institution, USA/ The Bridgeman Art Library; p. 92*b* Mary Evans Picture Library/ Alamy; p. 93 Sheila Terry/ Science Photo Library

Cover artwork: Bill Bolton

l = left, *r* = right, *t* = top, *b* = bottom, *c* = centre

CAMBRIDGE PRIMARY
Science
Learner's Book 6

Cambridge Primary Science is a flexible, engaging course written specifically for the Cambridge Primary Science curriculum framework (Stages 1–6). The course offers plenty of teaching ideas to give flexibility, allowing teachers to select activities most appropriate to their classroom and pupils. An enquiry-based style of teaching and learning is stimulated, with the Scientific Enquiry objectives integrated throughout to encourage learning of these skills alongside the scientific concepts. The language level is carefully pitched to be accessible to EAL/ESL learners, with concepts illustrated through diagrams to allow visual understanding and learning.

This Learner's Book for Stage 6 covers all the objectives required by the curriculum framework in an engaging and visually stimulating manner.

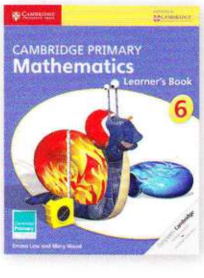
The Learner's Book contains:

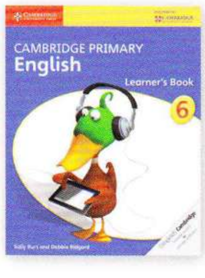
- useful illustrations that explain concepts to help visual learners and those with lower literacy
- activities to develop Scientific Enquiry skills and support learning through discovery
- key vocabulary pointed out as 'Words to learn' throughout
- 'Talk about it!' features that give suggestions for classroom discussion
- key learning points given as 'What you have learnt' summaries
- at the end of each unit, 'Check your progress' questions that offer opportunity for assessment.

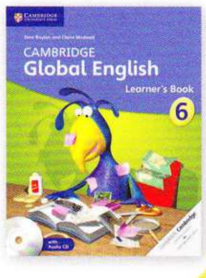
Other components of Cambridge Primary Science 6:

Activity Book 6 ISBN: 978-1-107-64375-8
Teacher's Resource 6 ISBN: 978-1-107-66202-5

For our full range of Cambridge Primary titles, including Mathematics, English and Global English, visit
education.cambridge.org/cambridgeprimary







Completely **Cambridge**
Cambridge resources *for* Cambridge qualifications

Cambridge University Press works with Cambridge International Examinations and experienced authors, to produce high-quality endorsed textbooks and software that support Cambridge Teachers and encourage Cambridge Learners.

CAMBRIDGE
UNIVERSITY PRESS

Achievement through excellence

ISBN 978-1-107-69980-9

9 781107 699809 >

Good Luck!