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LEARNER'S BOOK 7

Mary Jones, Diane Fellowes-Freeman & Michael Smyth

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> Introduction

Welcome to Stage 7 of Cambridge International Lower Secondary Science. We hope this book will show you how interesting and exciting science can be.

Science is everywhere. Everyone uses science every day. Can you think of examples of science that you have seen or used today?

Have you ever wondered about any of these questions?

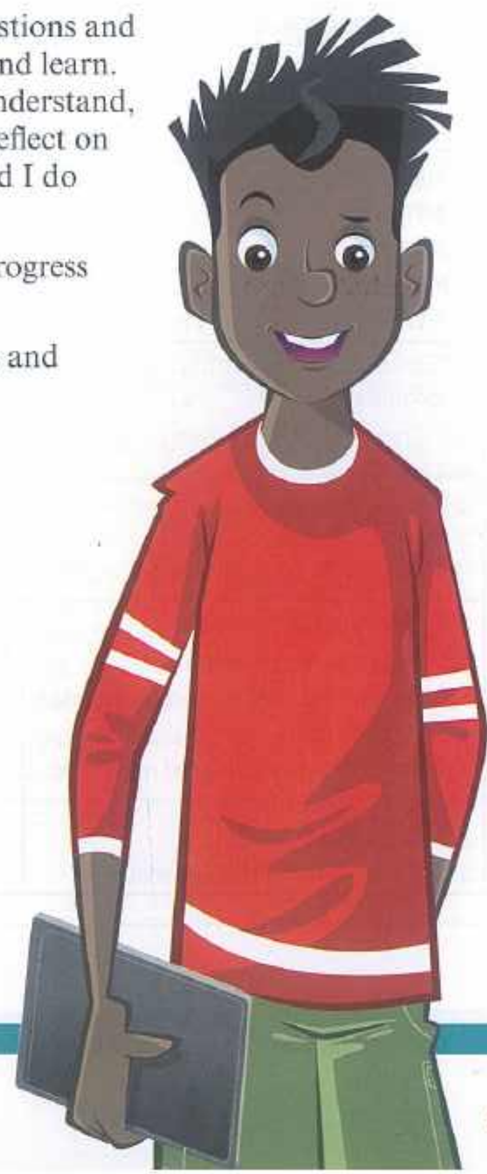
- What am I made of?
- Where do all the dead plants, animals and their waste disappear to?
- Why does frozen water behave differently to liquid water?
- What happens in a chemical reaction?
- What is electricity?
- How did the planets form around the Sun?

You will work like a scientist to find answers to these questions and more. It is good to talk about science as you investigate and learn. You will share your ideas with classmates to help them understand, and listen to them when you need reassurance. You will reflect on what you did and how you did it, and ask yourself: 'would I do things differently next time?'

You will practise new skills and techniques, check your progress and challenge yourself to find out more.

You will make connections between the different sciences and how they link to maths, English and other subjects.

We hope you enjoy thinking and working like a scientist.



Mary Jones, Diane Fellowes-Freeman, Michael Smyth

Contents

How to use this book

This book contains lots of different features that will help your learning. These are explained below.

This list sets out what you will learn in each topic. You can use these points to identify the important topics for the lesson.

> **In this topic you will:**
> - begin to learn about cells
> - find out about the parts of a plant cell, and what they do
> - make a model of a plant cell
> - use a microscope to look at plant cells.

This contains questions or activities to help find out what you know already about this topic.

> **Getting started**
>
> Plants and animals are living organisms. They are made of units called cells.
>
> With a partner, think about answers to these questions:
> - How big do you think a cell is?
> - How can we see cells?
> - Can you describe what a cell looks like?
>
> Be ready to share your ideas with the class.

Important words are highlighted in the text when they first appear in the book. You will find an explanation of the meaning of these words in the text. You will also find definitions of all these words in the Glossary and Index at the back of this book.

> **Key word**
>
> stain

You will have the opportunity to practise and develop the new skills and knowledge that you learn in each topic. Activities will involve answering questions or completing tasks.

> **Activity 1.2.1**
>
> **Structure and function in animal cells**
>
> Work with a partner.
>
> Here is the start of a table that you can use to summarise how each kind of specialised animal cell is adapted to carry out its function.
>
> Copy the start of the table onto a piece of paper. Then complete the entries for the red blood cell.
>
> You could include a small drawing of a red blood cell underneath its name in the first column.
>
> Next, add entries for a neurone and a ciliated cell. Remember to give your table a title.
>
> When you are ready, copy your completed table onto a large sheet of paper, ready to be displayed.

Name of cell	Function of cell	Specialised structure	How this helps the cell to carry out its function
red blood cell	transports oxygen	has haemoglobin [illegible]	haemoglobin carries oxygen

This provides an opportunity for you to practise and develop scientific enquiry skills with a partner or in groups.

> **Think like a scientist**
>
> **Making a model of a plant cell**
>
> In this task, you will make a model to represent a plant cell. You will then think about the strengths and **limitations** (weaknesses) of your model.
>
> Here is a list of materials and objects you could use to make your model.
> - transparent boxes
> - cardboard boxes
> - small and large plastic bags filled with water
> - green peas, green beads or green grapes
> - transparent food wrap
> - empty plastic bags
> - purple grapes
> - coloured modelling material
>
> In a group of three or four, discuss how you can use some of these materials and objects to make a model of a plant cell. Then make your model.

After completing an activity, this provides you with the opportunity to either assess your own work or another student's work.

Think like a scientist: Self-assessment

Think about how you did this task.

For each of these statements, rate yourself:

☺	😐	☹
if you think you did it very well, with no help	if you did it quite well, or needed some help	if you didn't do it all, or needed a lot of help

- I cut a piece of the inside layer of onion that was about 1 cm square.

This contains questions that ask you to look back at what you have covered and encourages you to think about your learning.

- Write down one thing that you did really well in this activity.
- Write down one thing that you will try to do much better next time. How will you do this?

This list summarises the important material that you have learnt in the topic.

Summary checklist

- [ ] I can list the seven characteristics of living things
- [ ] I can describe the meaning of each of these characteristics

At the end of each unit, there is a group project that you can carry out with other students. This will involve using some of the knowledge that you developed during the unit. Your project might involve creating or producing something, or you might all solve a problem together.

Project: Cells discovery timeline

This project is about how scientific knowledge gradually develops over time. You are going to work in a group to do research, and then use your findings to help to make a time line.

Science never stays still. When one scientist makes a new discovery, this suggests new questions that other scientists can investigate.

You are going to help to produce a timeline. The timeline will show how scientists gradually discovered that all living things are made of cells.

Here are some of the important steps that occurred. Your teacher will allocate one or two of these steps to your group. You will then help to find out more about these steps, and produce an illustrated account of what happened. Try to include an explanation of how the work of earlier scientists helped this step to take place.

1625 Galileo Galilei builds the first microscope.

1665 Robert Hooke looks at cork (from tree bark) through a microscope, and describes little compartments that he calls cells.

These questions look back at some of the content you learnt in each session in this unit. If you can answer these, you are ready to move on to the next unit.

Check your Progress

1 Different cells have different functions.
Choosing from this list, name the cell that each function describes.

red blood cell **root hair cell** **palisade cell** **nerve cell** **ciliated cell**

a Moves mucus up through the airways.

b Absorbs water from the soil.

c Makes food by photosynthesis. [3]

2 The diagram shows an animal cell.

1 Cells

1.1 Plant cells

In this topic you will:

- begin to learn about cells
- find out about the parts of a plant cell, and what they do
- make a model of a plant cell
- use a microscope to look at plant cells.

Getting started

Plants and animals are living organisms. They are made of units called cells.

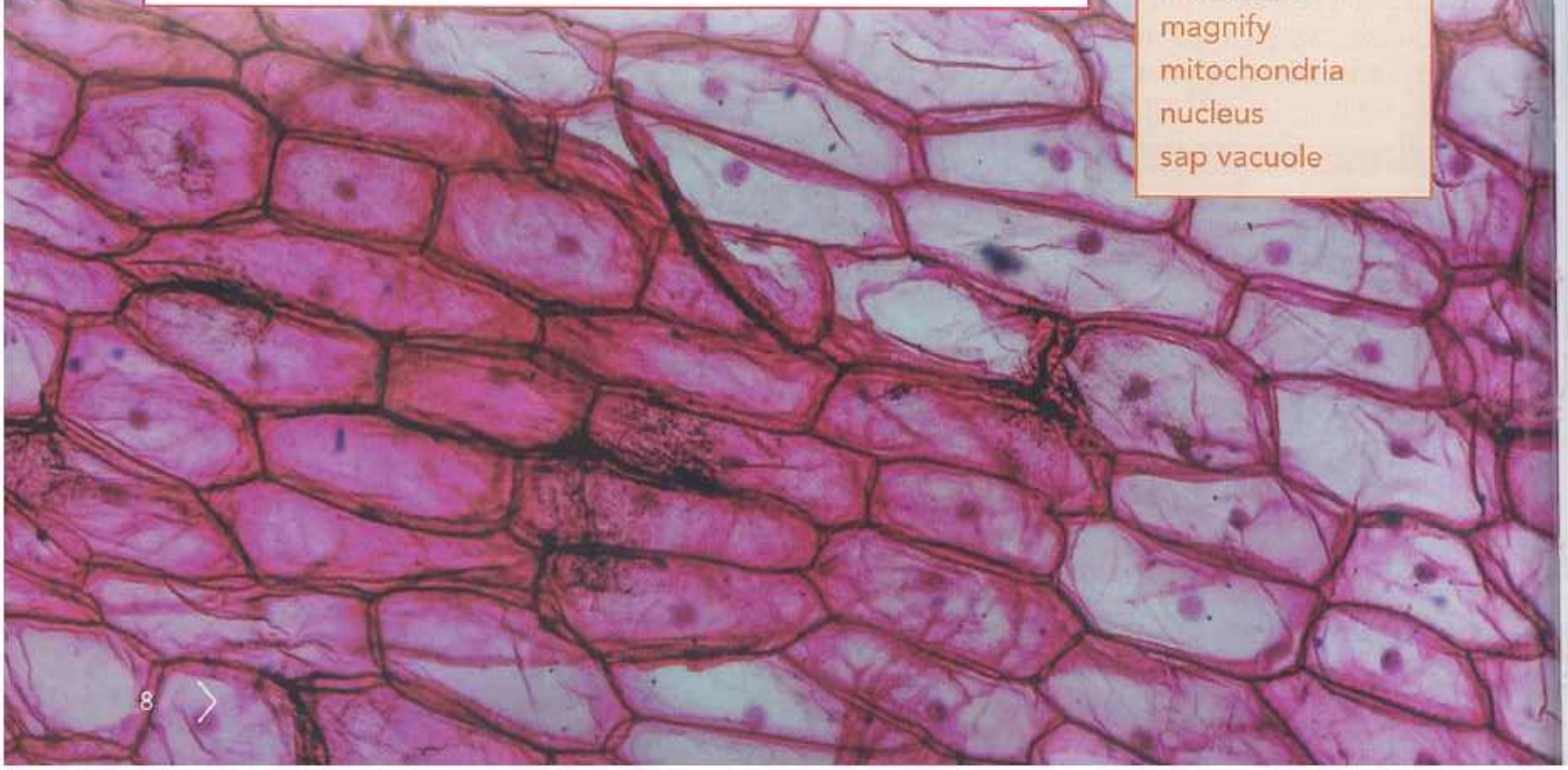
With a partner, think about answers to these questions:

- How big do you think a cell is?
- How can we see cells?
- Can you describe what a cell looks like?

Be ready to share your ideas with the class.

Key words

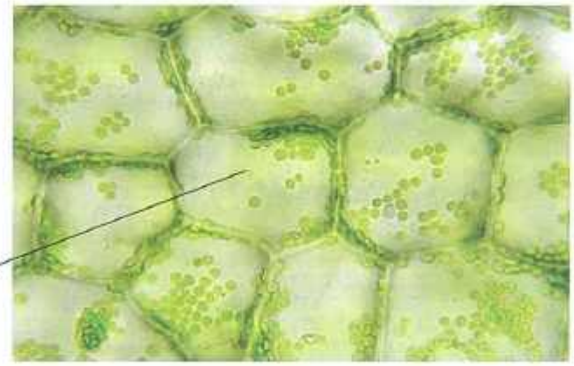
cell
cell membrane
cell wall
cellulose
chlorophyll
chloroplast
cytoplasm
limitations
magnify
mitochondria
nucleus
sap vacuole



Cells

If you study a plant by observing part of it through a microscope, you will see that it is made up of a very large number of tiny 'boxes'. These are called **cells**. All living organisms are made of cells.

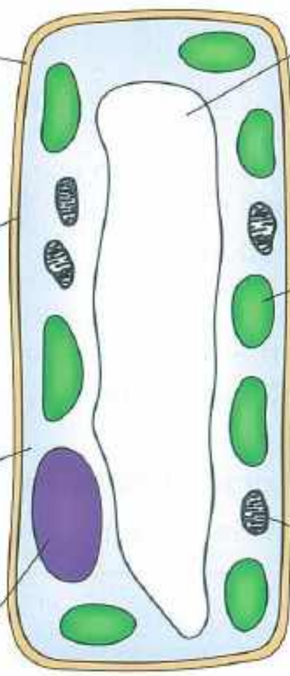
Cells are so small that you cannot see them with your eyes alone. The photograph of the plant cells was taken through a microscope. The microscope **magnifies** the view of the cells, so that they look much bigger than they really are.



Part of a leaf seen through a microscope

Parts of a plant cell

The diagram shows a plant cell from a leaf.



cell wall
Every plant cell has a cell wall. The cell wall is strong and stiff. It holds the plant cell in shape. Plant cell walls are made of a substance called **cellulose**.

cell membrane
All cells have a cell membrane. The cell membrane is very thin and flexible. It is like the thin skin of a soap bubble. It lies along the inner edge of the cell wall. The cell membrane controls what goes in and out of the cell.

cytoplasm
All cells have cytoplasm. Cytoplasm is like clear jelly. Chemical reactions happen inside the cytoplasm. These reactions keep the cell alive.

nucleus
Most cells have a nucleus. The nucleus controls the activities of the cell.

sap vacuole
This is a large, fluid-filled space inside a plant cell. The liquid inside it is a solution of sugars and other svubstances dissolved in water. The solution is called cell sap.

chloroplast
Plant cells that are in the sunlight often contain chloroplasts. This is where plants make their food. Chloroplasts look green because they contain a green substance called **chlorophyll**.

mitochondrion
All plant cells have mitochondria (singular: mitochondrion). Inside mitochondria, energy is released from food.

Diagram of a leaf cell

Questions

1 Look at the photograph of the plant cells on this page. What do you think the little green circles inside the cells are? Why are they green? What happens inside them?

2 Describe four differences between a cell wall and a cell membrane.

How have you tried to remember the difference between a cell wall and a cell membrane? How successful do you think you have been?

Think like a scientist

Making a model of a plant cell

In this task, you will make a model to represent a plant cell. You will then think about the strengths and **limitations** (weaknesses) of your model.

Here is a list of materials and objects you could use to make your model.

- transparent boxes
- cardboard boxes
- small and large plastic bags filled with water
- green peas, green beads or green grapes
- transparent food wrap
- empty plastic bags
- purple grapes
- coloured modelling material

In a group of three or four, discuss how you can use some of these materials and objects to make a model of a plant cell. Then make your model.

Be ready to explain your model to others.

Questions

1 Compare your model cell with the models made by other groups.

Are there are any features of your model that are better than those in the other groups' models?

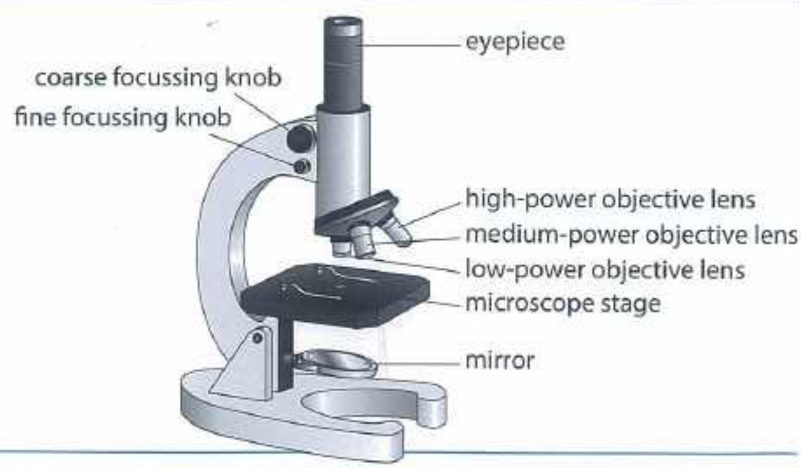
Are there any features of other groups' models that are better than yours?

2 Discuss how well your model cell represents a real plant cell.

Microscopes

Scientists who study living organisms often use microscopes to help them to see very small things.

The diagram shows a microscope. Look at a real microscope and find all of these parts on it.



A microscope

Think like a scientist

Looking at plant cells through a microscope

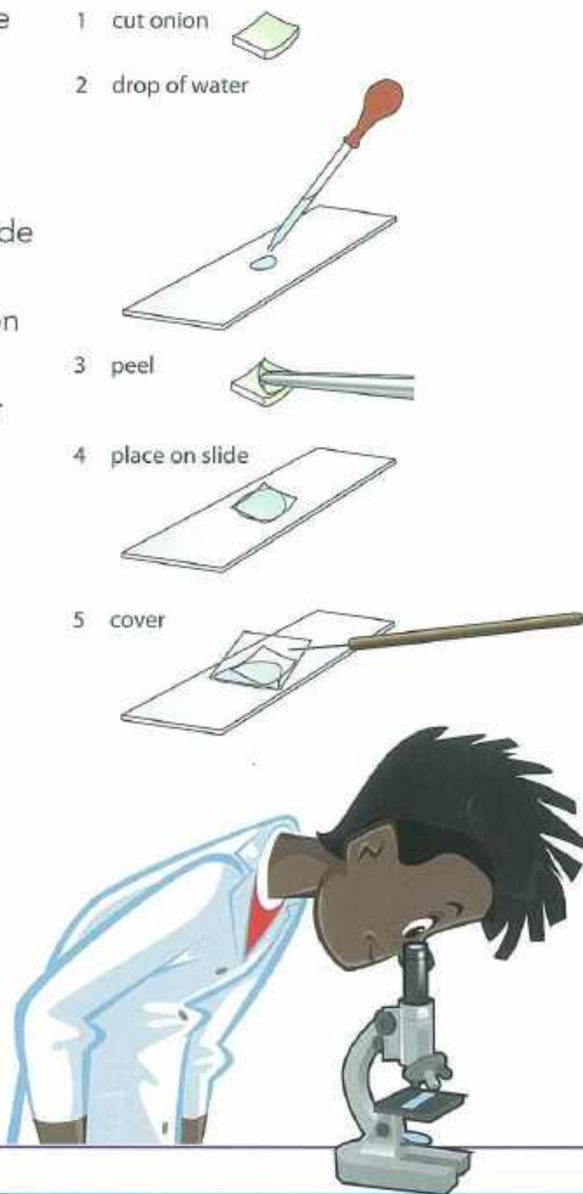
This task gives you practice in using scientific equipment and doing practical work safely.

You will need:

- a microscope, a microscope slide, a cover slip, a piece of onion bulb, tweezers (forceps), a small sharp knife, a dropper pipette, a small container of water

Safety Take care with the sharp knife. Cut the onion with the blade pointing away from you, so that if it slips you don't cut your fingers.

1. Collect a small piece of onion. Cut out a piece about 1 cm square.
2. Use a dropper pipette to put a small drop of water into the middle of a clean microscope slide.
3. Very carefully, peel the thin layer from the inside of your piece of onion.
4. Gently push the layer into the drop of water on the slide. Spread it out as flat as you can.
5. Collect a very thin piece of glass called a cover slip. (Take care – cover slips break very easily!) Gently lower the cover slip over your piece of onion on the slide. Try not to get air bubbles under the cover slip.
6. Turn the objective lenses on the microscope until the smallest one is over the hole in the stage.
7. Put the slide onto the stage of the microscope, with the piece of onion over the hole.
8. Look down the eyepiece. Slowly turn the focussing knob to move the lens away from the slide. Stop when the piece of onion comes into focus.
9. Make a drawing of some of the cells you can see.



Continued

Questions

1 Suggest why the cells from the onion do not look green.

2 Describe any difficulties you had with this activity. How did you solve them?

Self-assessment

Think about how you did this task.

For each of these statements, rate yourself.

🙂	😐	☹️
if you think you did it very well, with no help	if you did it quite well, or needed some help	if you didn't do it all, or needed a lot of help

- I cut a piece of the inside layer of onion that was about 1 cm square.
- I was able to spread the piece of onion flat in the drop of water.
- I put the cover slip over the onion without getting any air bubbles.
- I saw onion cells down the microscope.
- I focussed the microscope so that I could see the cells really clearly.

- Write down one thing that you did really well in this activity.
- Write down one thing that you will try to do much better next time. How will you do this?

Summary checklist

- [ ] I can name all the structures in a plant cell, and describe what they do.
- [ ] I can make a model of a plant cell, and discuss its strengths and limitations.
- [ ] I can use a microscope to look at plant cells.

1.2 Animal cells

In this topic you will:

- find out how animal cells differ from plant cells
- use a microscope to look at some animal cells.

Getting started

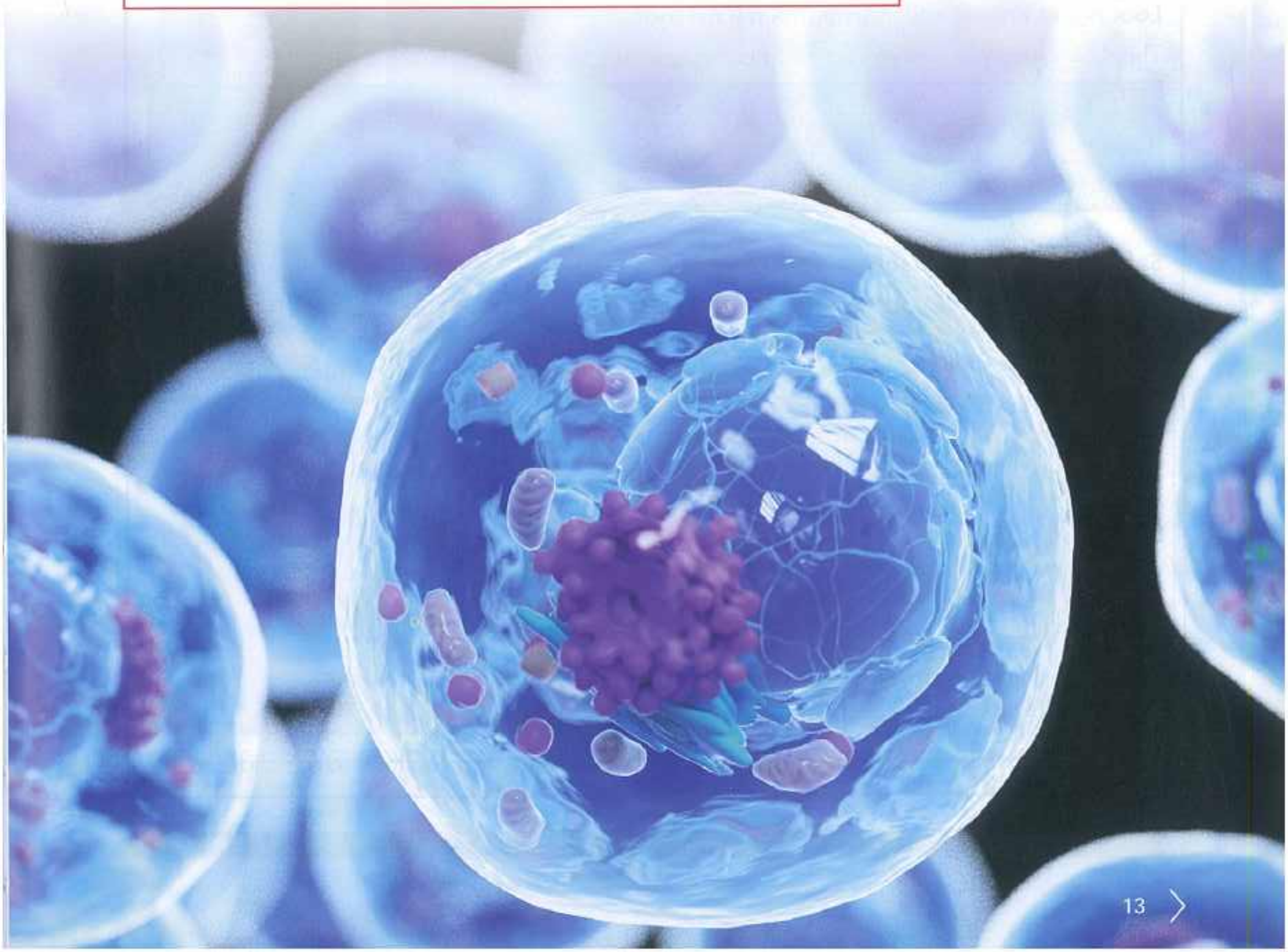
There are five parts of a plant cell with names beginning with the letter c.

Make a list of these five parts. Think about how you can remember what each of the words means.

Be ready to share your ideas.

Key word

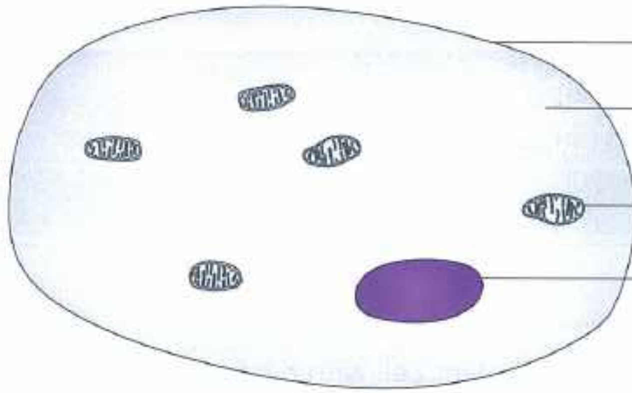
stain



Parts of an animal cell

All animals are made of cells. You are an animal, and your body is made of cells. No one knows exactly how many cells there are in a person. One estimate is about 100 trillion. That is 100 000 000 000 000 cells.

Animal cells are similar to plant cells in several ways. They have a cell membrane, cytoplasm, mitochondria and a nucleus.



An animal cell

Think like a scientist

Looking at animal cells through a microscope

This task gives you more practice in using scientific equipment safely.

You will need:

- a microscope, a microscope slide, a cover slip, a cotton bud, some methylene blue, a dropper pipette, safety glasses

Safety Put on your safety glasses.

1. Very gently rub the cotton bud along the inside of your cheek. This will collect some loose cells.
2. Rub the cotton bud on the surface of a clean microscope slide. You will not be able to see the cells yet, because they are so small.
3. Use a dropper pipette to add a drop of methylene blue to the cells. Methylene blue is a dye that will **stain** the cells blue, making them easier to see.
4. Carefully lower a cover slip over the drop of blue stain.
5. Put the smallest objective lens over the stage.
6. Put the slide onto the stage, with the part you want to look at over the hole in the stage.
7. Looking from the side, turn the focussing knob until the lens is close to the slide.

Continued

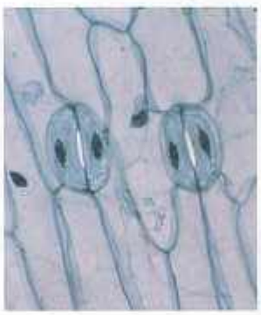
8 Look down the eyepiece. Slowly turn the focussing knob to move the lens upwards. Stop when you can see the cells.

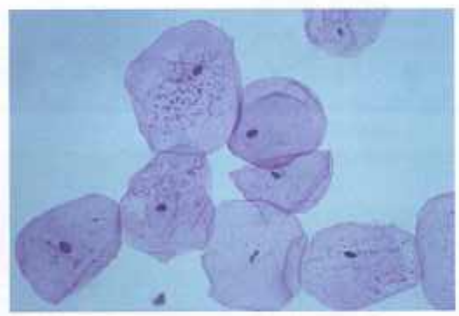
9 Turn the lenses until a larger one is over the stage. Look down the eyepiece. You should be able to see a more magnified view of the cells.

10 Make a drawing of one or two of the cells you can see. Label your drawing.

Questions

1 The photographs show some cells, seen through a microscope.





For each photograph, decide whether the cells are plant cells or animal cells. Explain your decision.

2 Think about the model of a plant cell that you made.

What would you change to make it into a model of an animal cell?

Activity

Building up pictures of plant and animal cells

You will need:

- fifteen cut-out oval pieces of card or paper, each about 1 cm long, five coloured red and ten coloured green
- one cut-out circular piece of grey card or paper, about 1 cm in diameter
- long pieces of string or wool
- a long piece of wide tape
- glue or double-sided sticky tape
- a very large sheet of paper

Continued

1 In a group of two or three, use the materials to build a picture of a plant cell. It is up to your group to decide exactly how to use the materials to make your picture. You may not want to use all of the materials.

2 Ask your teacher, or other people in your class, to check that you have put all the right pieces in the right places.

3 Now remove some of the pieces, to change your picture into an animal cell.

Self assessment

Compare your picture with the pictures made by other groups.

What differences are there between them?

Now that you have seen the other pictures, is there anything you would like to change in yours?

- What have you done that helps you to remember the differences between animal cells and plant cells?
- Do you think that you can always decide whether a picture shows an animal cell or a plant cell? What is the most important feature to look for?

Summary checklist

- [ ] I can use a microscope to look at animal cells.
- [ ] I can describe similarities and differences between plant cells and animal cells.
- [ ] I can decide whether a picture of a cell shows an animal cell or a plant cell, and give reasons.

1.3 Specialised cells

In this topic you will:

- learn about some specialised animal and plant cells
- explain how the structure of these specialised cells helps them to carry out their functions.

Getting started

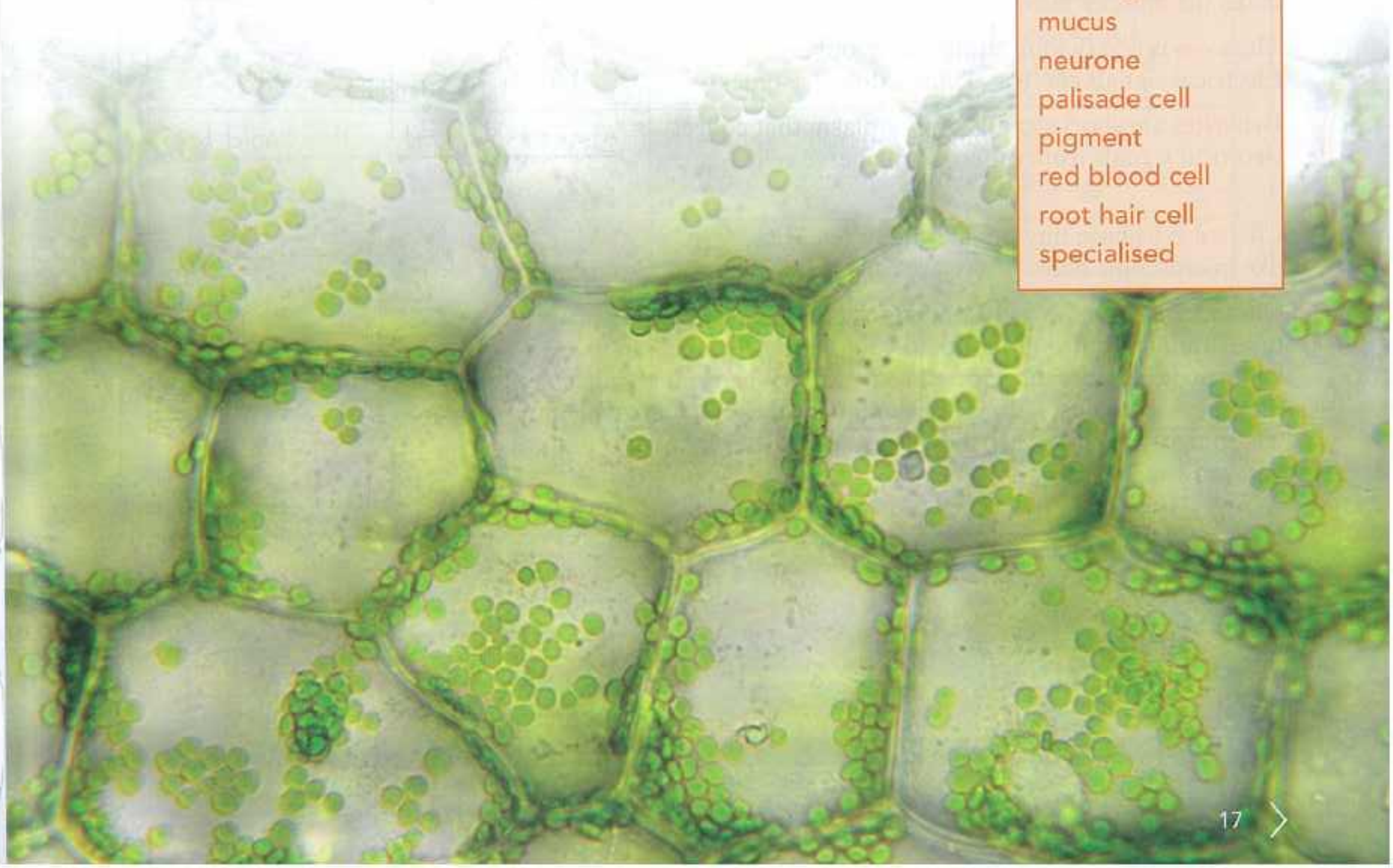
With a partner, think of a suitable way to complete each sentence.

- Cell membranes …
- Cell walls …
- A nucleus …
- Chloroplasts …

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

Key words

absorb
adapted
axon
capillary
cilia
ciliated cell
dendrite
function
haemoglobin
mucus
neurone
palisade cell
pigment
red blood cell
root hair cell
specialised



Some specialised animal cells

Not all of the cells in your body are the same. There are many different kinds of cell in your body. Each kind of cell has a particular **function**. The function of a cell is the job that it does, or the role that it plays.

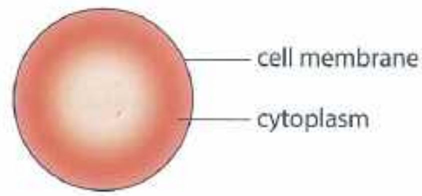
Each cell is **specialised** to carry out its function. This means that it has a structure that helps it to do its function really well. The cell is **adapted** to carry out its function.

The diagrams show three kinds of specialised cell in the human body.

Red blood cells are smaller than most other cells in the body. This allows them to get through tiny blood **capillaries**, so they can deliver oxygen to every part of the body.

The cytoplasm contains a red **pigment** (colour) called **haemoglobin**. This carries oxygen around the body.

The cell has no nucleus. This leaves more space for haemoglobin.

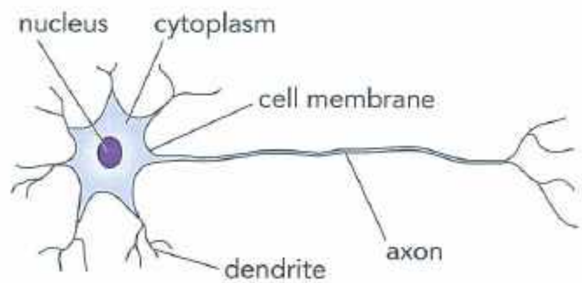


A red blood cell

Neurones carry electrical signals from one part of the body to another. They help all the different parts of the body to communicate with each other. For example, they can carry signals from the brain to muscles, to make the muscles move.

The **axon** is a very long strand of cytoplasm. Electrical signals can travel along this very quickly.

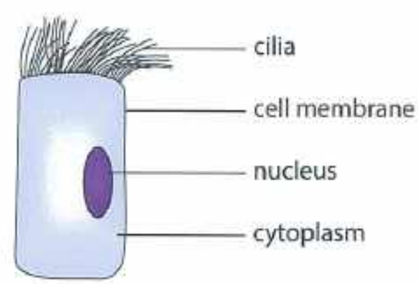
Dendrites are short strands of cytoplasm that collect electrical signals from other nearby nerve cells.



A neurone

Ciliated cells have tiny threads along one edge, like microscopic hairs. These are called **cilia**. The cilia can move.

One place in the body that contains ciliated cells is the lining of the tubes leading from your mouth to your lungs. Other cells in this lining make a sticky substance called **mucus**. When you breathe in, the mucus traps dust and bacteria in the air, to stop them going into your lungs. The cilia sweep the mucus up to the back of your mouth and you swallow it.



A ciliated cell

Questions

1 List **two** things that red blood cells, neurones and ciliated cells have in common.

2 How can you tell that all of these three cells are animal cells, not plant cells?

Activity 1.3.1

Structure and function in animal cells

Work with a partner.

Here is the start of a table that you can use to summarise how each kind of specialised animal cell is adapted to carry out its function.

Copy the start of the table onto a piece of paper. Then complete the entries for the red blood cell.

You could include a small drawing of a red blood cell underneath its name in the first column.

Next, add entries for a neurone and a ciliated cell. Remember to give your table a title.

When you are ready, copy your completed table onto a large sheet of paper, ready to be displayed.

Name of cell	Function of cell	Specialised structure	How this helps the cell to carry out its function
Red blood cell	transports oxygen	has haemoglobin in its cytoplasm	haemoglobin carries oxygen
Neurone			

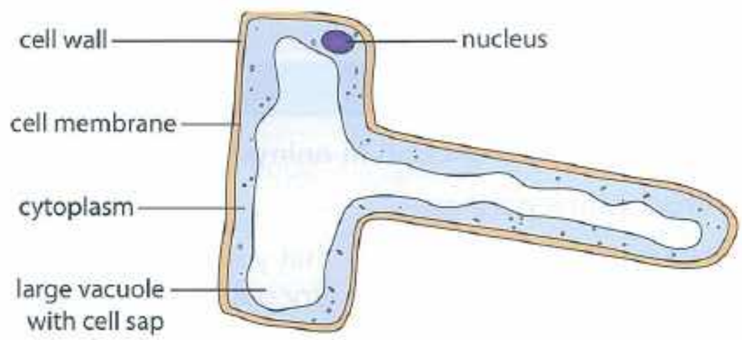
Some specialised plant cells

Plants also contain specialised cells.
Here are two examples.

Root hair cells are found on the outside of plant roots.

Their function is to **absorb** (soak up) water from the soil.

Each cell has a long, thin extension that allows water to move easily from the soil into the cell.

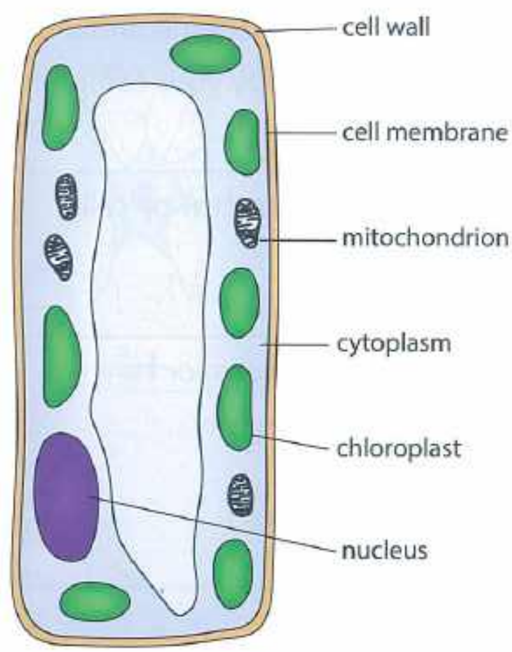


A root hair cell

Palisade cells are found in the leaves of plants. Their function is to make food by photosynthesis.

They have a lot of chloroplasts containing chlorophyll.

The chlorophyll absorbs energy from sunlight, which is used to help the plant make food.



A palisade cell

Questions

3 Suggest why root hair cells do not contain chloroplasts.

4 Water moves through several parts of the root hair cell, as it goes from the soil into the sap vacuole. List these parts, in order.

Activity 1.3.2

Structure and function in plant cells

Make a table to summarise how the structures of the two kinds of specialised plant cell are related to their functions.

Peer assessment

Exchange your table with a partner.

For each of these statements, rate your partner's work.

if you think they did it very well

if they did it quite well, but it could be improved

if they didn't do it all, or it needs a lot of improvement.

- They made a clear table with ruled lines.
- They gave the columns in the table headings to make clear what each one shows.
- They headed the rows in the table with the names of the two kinds of plant cell.
- They wrote short, very clear descriptions of how the cell is specialised.
- The table is very clear and you can understand it easily.

Summary checklist

- [ ] I can name three kinds of specialised animal cell, and two kinds of specialised plant cell.
- [ ] I can explain how the structure of each kind of specialised cell is related to its function.
- [ ] I can design and construct a table to summarise information.

1.4 Cells, tissues and organs

In this topic you will:

- find out about tissues, organs and organ systems in living organisms
- recognise and name human organs that are part of different organ systems.

Getting started

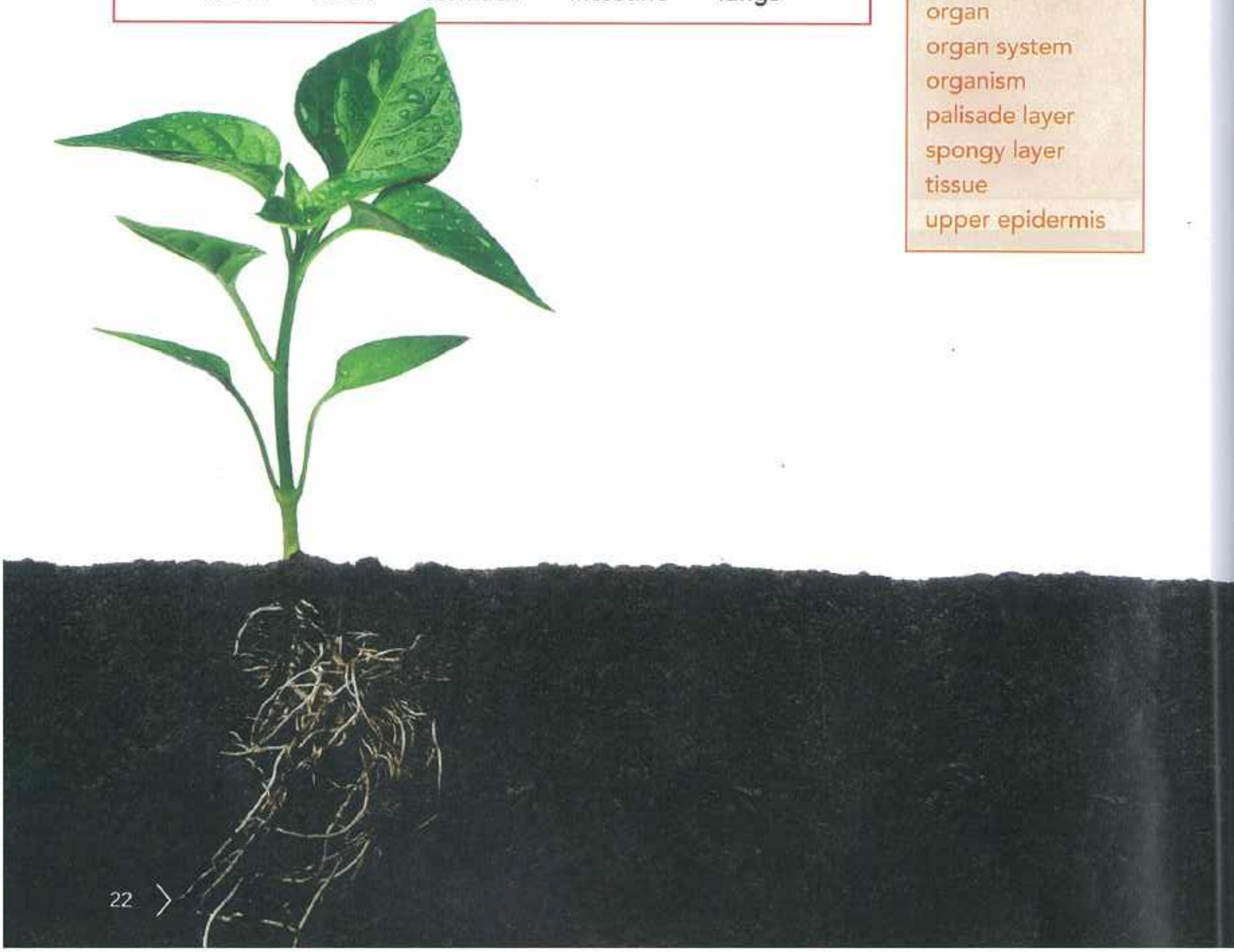
Draw an outline of a human body.

Sketch and label each of these organs on the outline.

brain **heart** **stomach** **intestine** **lungs**

Key words

ciliated epithelium
lower epidermis
onion epidermis
organ
organ system
organism
palisade layer
spongy layer
tissue
upper epidermis



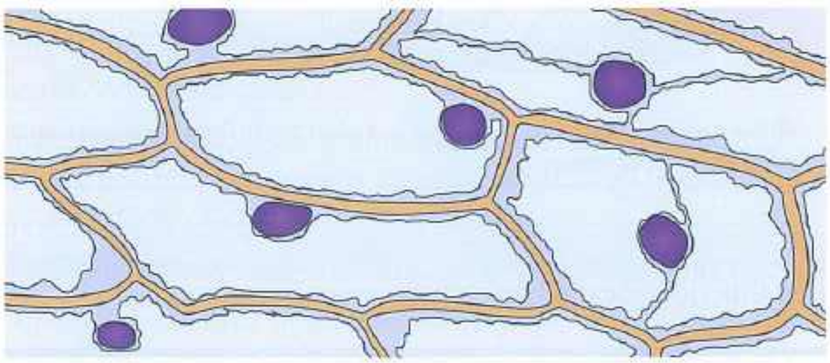
Tissues

Living things, including animals and plants, are called **organisms**. There are many different kinds of cell in an animal or a plant. Most of them are specialised to carry out a particular activity. Usually, many cells of the same kind are grouped together.

A group of similar cells, which all work together to carry out a particular function, is called a **tissue**.

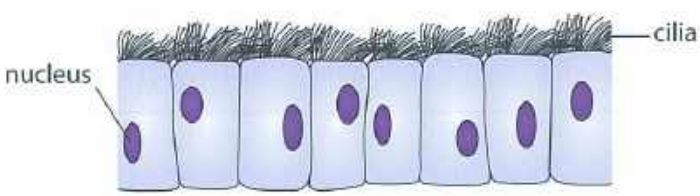
The diagrams show a tissue from a plant, and a tissue from an animal.

This is a diagram of a tissue from inside an onion. It is called an **onion epidermis**. This tissue covers the surface of the layers inside the onion.



Onion epithelium

This is a diagram of **ciliated epithelium** – the tissue that lines the tubes leading down to our lungs. The cilia all wave together, like grass in the wind.



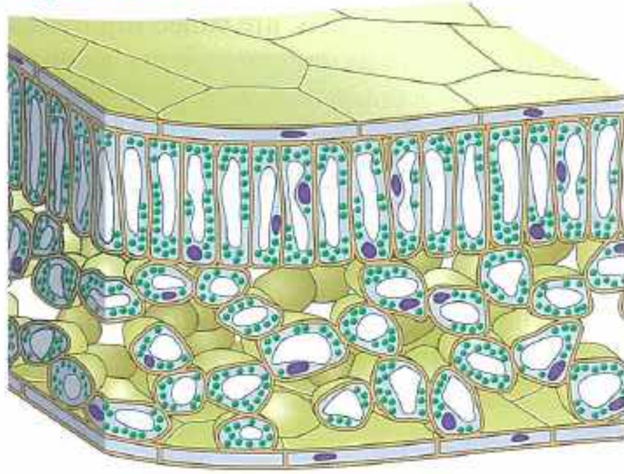
Ciliated epithelium

Questions

1 What is the function of the ciliated epithelium tissue? (Think about the function of a ciliated cell.)

2 The word 'tissue' has an everyday meaning and a different scientific meaning. Write two sentences, one using the word 'tissue' with its everyday meaning, and one using the word 'tissue' with its scientific meaning.

Organs and organ systems



This is part of a leaf, cut open. A leaf is a plant organ, and contains several different kinds of tissue.

The bodies of plants and animals contain many different parts, called **organs**. For example, your organs include your brain, heart and muscles. Plants' organs include leaves, roots and flowers.

Each organ is made up of several different kinds of tissue, working together. For example, your brain contains neurones, and also several other kinds of cell. A plant root contains root hair cells, and also several other kinds of cell.

Organs also work together. A set of organs that all work together to carry out the same function is called an **organ system**.

Activity 1.4.1

Organs and systems in humans

Your task is to find out the names and functions of the different organs that are part of one system in the human body.

Choose from: digestive system, circulatory system, respiratory system or skeletal system.

When you have found this information, decide how to display it. Perhaps you could make a presentation, or a large drawing with labels and descriptions.

Question

3 Copy and complete each sentence, using words from the list.

organism **tissue** **organ** **organ system**

A group of similar cells is called a ____________ .

An ____________ is a structure made of many different tissues.

An ____________ is a group of organs that carry out a particular function.

An ____________ is a living thing. It may contain many different organ systems, organs and tissues.

Summary checklist

- [ ] I can give examples of tissues and organs in animals and plants.
- [ ] I can explain the meanings of the words tissue, organ and organ system.

Project: Cells discovery timeline

This is the type of microscope that Robert Hooke used.

This project is about how scientific knowledge gradually develops over time. You are going to work in a group to do research, and then use your findings to help to make a timeline.

Science never stays still. When one scientist makes a new discovery, this suggests new questions that other scientists can investigate.

You are going to produce a timeline. The timeline will show how scientists gradually discovered that all living things are made of cells.

The list below shows some of the important steps that occurred.

In your group, choose **one** of these steps to investigate. Make sure that you do not choose the same step as another group.

Help your group to find out more about this step. Then help to produce an illustrated account of what happened.

Try to include an explanation of how the work of earlier scientists helped this step to take place.

1625 Galileo Galilei builds the first microscope.

1665 Robert Hooke looks at cork (from tree bark) through a microscope, and describes little compartments that he calls cells.

1670 Anton van Leeuwenhoek improves the microscope and is able to see living cells in a drop of pond water.

1833 Robert Brown discovers the nucleus in plant cells.

1838 Matthias Schleiden proposes that *all* plant tissues are made of cells. Theodor Schwann proposes that is also true of animal cells.

1845 Carl Heinrich Braun proposes that cells are the basic unit of all life.

1855 Rudolf Virchow says that all cells only arise from other cells.

Check your Progress

1.1 Different cells have different functions.

Name the cell that carries out each function.

Choose from the list.

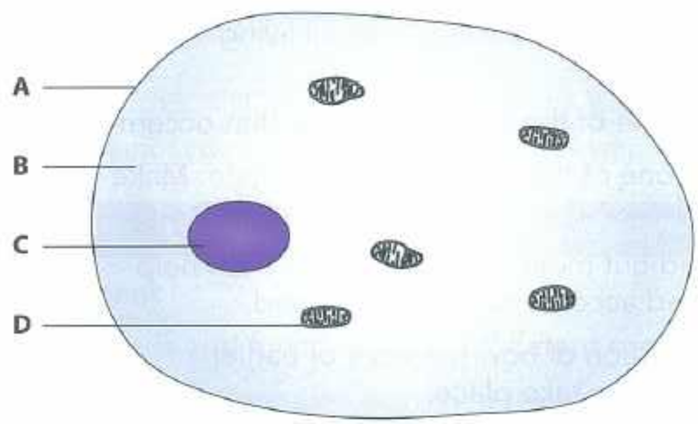
red blood cell **root hair cell** **palisade cell** **neurone** **ciliated cell**

a Moves mucus up through the airways. [1]

b Absorbs water from the soil. [1]

c Makes food by photosynthesis. [1]

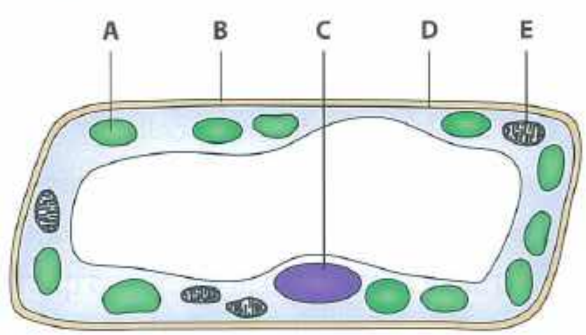
1.2 The diagram shows an animal cell.



a Name the parts labelled **A**, **B**, **C** and **D**. [4]

b Describe **two** ways you can tell that this is an animal cell and not a plant cell. [2]

1.3 The diagram shows a plant cell.



For each letter, A–E, write the name of the cell part and its function.
Choose from these lists: [5]

Names:

mitochondrion   cell membrane   nucleus   cell wall   chloroplast

Functions:

holds the cell in shape

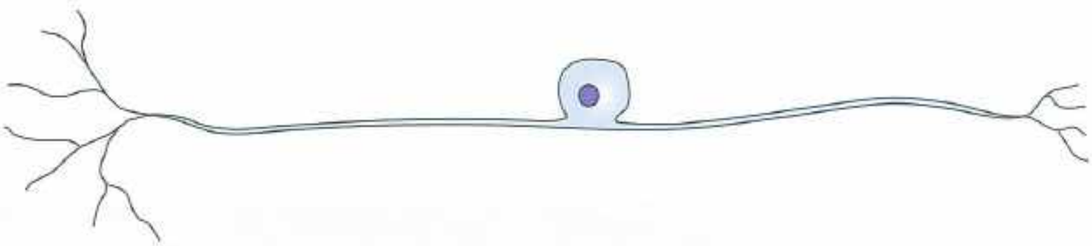
controls what goes in and out of the cell

where photosynthesis takes place

where energy is released from nutrients

controls the activities of the cell

1.4 The diagram shows a specialised cell from the human body.



a What is the name of this cell? [1]

b What is the function of this cell? [1]

c Describe how the cell is adapted to carry out its function. [1]

d Name the system in the human body that this cell is part of. [1]

1.5 These sentences are about the way that cells are grouped together in complex organisms.

Copy and complete each sentence. Choose from the list.

cell   tissue   organ   organ system

a In a complex organism, such as a human or a plant, similar cells are grouped together to form a ____________ . [1]

b The stomach is an example of an ____________ . [1]

c The heart and blood vessels are all part of the same ____________ . [1]

2 Materials and their structure

› 2.1 Solids, liquids and gases

In this topic you will:

- sort the states of matter into solids, liquids and gases
- learn about the properties of solids, liquids and gases
- use particle theory to describe the structure of solids, liquids and gases
- use particle theory to learn about the properties of solids, liquids and gases.

Getting started

1 Name two solids, two liquids and two gases.

2 Copy and complete the table. Use the substances you listed in Question 1. Discuss your reasons for each decision with your group.

Substance	Solid, liquid or gas	I know this because…
Example: tap water	liquid	I can pour it.

Key words

compressed
flow
hypothesis
matter
particle
pour
property
states of matter
theory
vacuum
vibrate
volume

Looking at states of matter

Everything you can see and feel is called **matter**. Scientists sort matter into three groups or states called 'solids', 'liquids' and 'gases'. These **states of matter** behave in different ways. The ways they behave are called their **properties**.

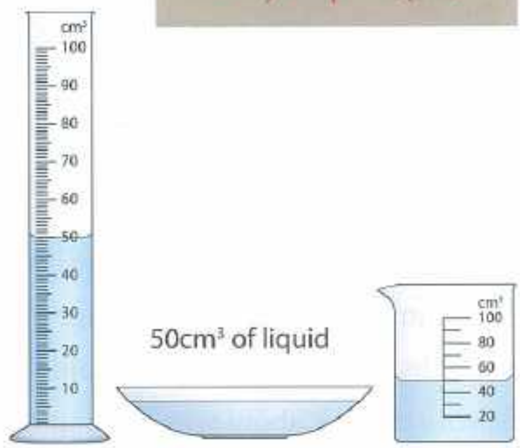
Solids

Solids keep the same shape. Solids take up the same amount of space. Solids keep the same **volume**. Solids cannot be **compressed** (squashed) or **poured**.

Liquids

Liquids take the shape of the container they are in. Liquids can be poured. Liquids cannot be compressed. Liquids take up the same amount of space, whatever shape their container.

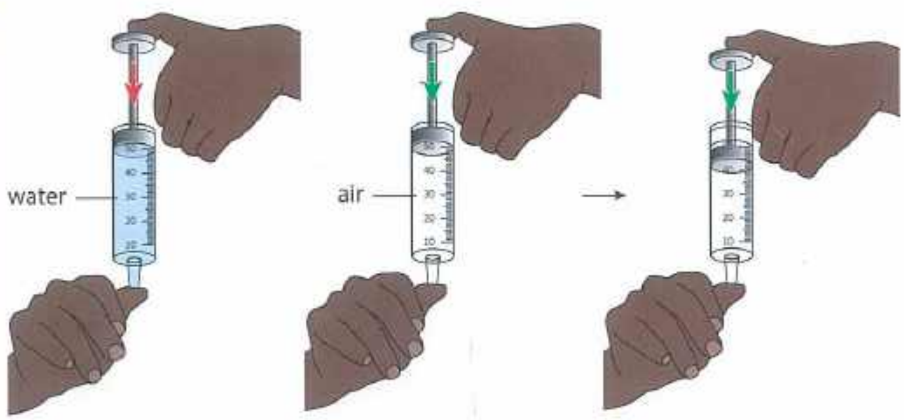
The volume of a liquid does not change.



Gases

Gases **flow** like liquids. They will fill any closed container they are in.

Gases are very easy to compress. The volume of a gas can change. Gases weigh very little. Generally, you cannot see or feel gases, but you can sometimes smell them, and you can feel air moving on your face.



Questions

1 What are the three states of matter?

2 Which state of matter can be compressed (squashed) easily?

3 Which state of matter cannot be poured?

4 List the properties of solids.

5 Name a property of liquids that they do not share with solids.

6 Name a property of gases that they share with liquids.

7 Name a property of gases that they do not share with solids or liquids.

Scientists look at what matter does

Scientists try to explain what they see. Here are some examples of how matter behaves that scientists have tried to explain.

- You can smell food cooking in another room.
- Some substances get bigger when you heat them.
- Liquids, such as water, change to a gas when you heat them.
- Substances change from liquid to solid if you cool them.

Scientists think about why these things happen and try to come up with ideas to explain it. They form an **hypothesis**, which is a suggestion for an explanation. This hypothesis can then be tested by carrying out more investigations.

When an hypothesis has been tested and widely accepted as valid by other scientists, it is called a **theory**.

The best theory to explain how matter behaves uses the idea of **particles**. Particles are tiny portions of matter. This theory says that all matter is made up of tiny particles arranged in different ways.

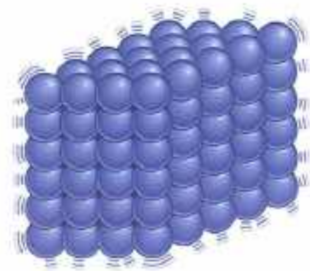
Particle theory

All matter is made up of tiny particles that are much too small to see. The particles are arranged differently in solids, liquids and gases.

Solids

In solids the particles are arranged in a fixed pattern. The particles are held together strongly and are tightly packed together. This is why solids have a fixed shape.

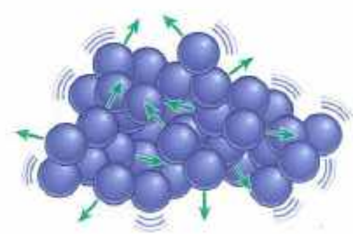
The particles in a solid can **vibrate** (make small movements) but they stay in the same place.



In solids the particles are packed together and can vibrate. They stay in the same place.

Liquids

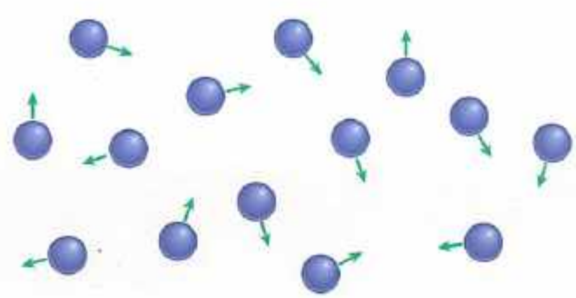
In liquids the particles touch each other. The particles are held together weakly. The particles can move past one another but they still touch each other. Liquids can change shape.



In liquids the particles touch each other, can move and can change places.

Gases

In gases the particles do not touch each other. They are a long way apart. The particles spread out by themselves. The particles can spread out to fill up the space they are in. Gases can change shape.



In gases the particles are far apart and can move about freely.

Think like a scientist

Modelling the particles in solids, liquids and gases

In this task, you will describe the strengths and weaknesses of a model.

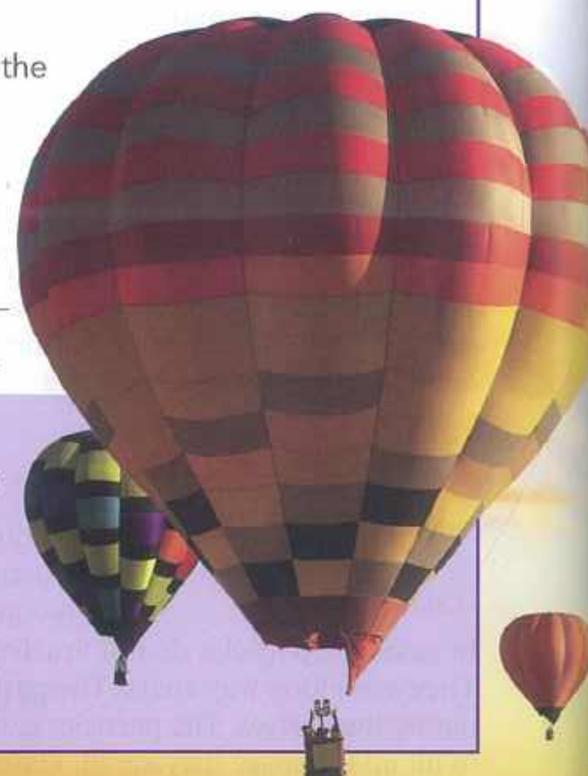
Work in a small group.

- Arrange yourselves in a pattern, as if you are the particles in a solid.
- Now arrange yourselves as if you are the particles in a liquid.
- Now arrange yourselves as if you are the particles in a gas.

Questions

1 With a partner, discuss and describe the ways in which the particles are arranged in the three states of matter.

2 Copy and complete these sentences to describe how particles are arranged in solids, liquids and gases.
   - In solids, the particles are arranged __________
   - In liquids, the particles are arranged __________
   - In gases, the particles are arranged __________



Self-assessment

In what ways was your group a good model for the particle theory? Think about how well you did for each of the solid, liquid and gas models.

- Were you in regular rows?
- Were you touching the people around you?
- Could you change your position?

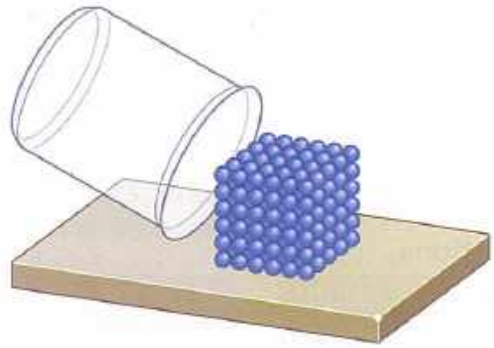
Explaining the properties

Matter can only flow (be poured) if the particles can move past one another.

Matter can only change volume if the particles in it can spread out or move closer together.

Solids

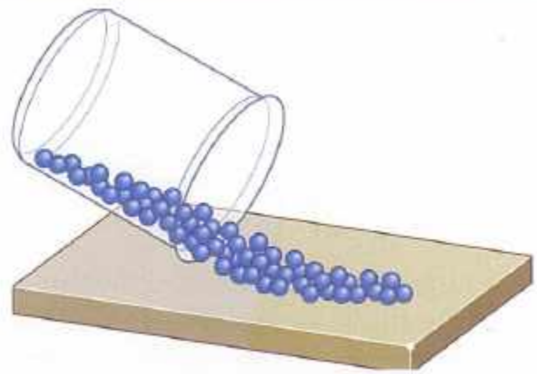
The particles in a solid are very close together. This makes it difficult for the volume of a solid to be made smaller. Solids have a fixed shape because attractive forces hold the particles together. These forces stop the particles from moving around. The particles can only vibrate. This means that a solid cannot flow.



Solids cannot flow.

Liquids

The volume of a liquid cannot be changed. The particles are very close together and cannot be compressed. The particles touch each other but they can move past each other. The attractive forces between the particles are weak enough to allow them to move but strong enough to hold them together.



Liquids can flow.

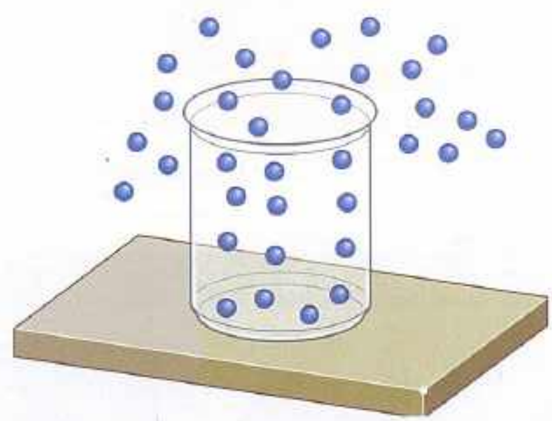
Gases

Particles in a gas are a long way apart so they can move quickly in all directions. The particles can move easily because there are no attractive forces between them. This means that gas has no fixed shape or volume.

When you compress a gas, the particles move closer together and the gas takes up less space.

No particles?

A space where there are no particles at all is called a **vacuum**. A vacuum contains nothing.



Gases can flow and spread out.

Think like a scientist

Particle theory

Scientists observe the world around them and think carefully about what they see. Development of the particle theory was based on the observations that scientists made about how solids, liquids and gases behave.

Scientists saw that most solids cannot be compressed. Can you think of any solids that do not fit the rules of particle theory? Think about the properties of a sponge or a marshmallow. Can a sponge be compressed?

Questions

1 Use particle theory to explain how a sponge can be a solid, but it can also be compressed.

2 How well does particle theory explain the properties of solids, liquids and gases?

3 What are the strengths of the particle theory?

4 What are the weaknesses of the particle theory?

Activity

States of matter

On a large piece of paper, draw three large squares and label them 'solid', 'liquid' and 'gas', like this. Leave space around them.

In each square, draw how the particles are arranged in that state of matter.

In the spaces around the squares, write the properties of the three states of matter.

Summary checklist

- [ ] I can classify matter as a solid, liquid or gas.
- [ ] I can list the properties of solids, liquids and gases.
- [ ] I can describe the way in which particles are arranged in solids, liquids and gases.
- [ ] I can explain the properties of solids, liquids and gases using particle theory.

> 2.2 Changes of state

In this topic you will:

- practise measuring the volume and the temperature of a liquid
- learn what happens when matter changes state
- investigate the temperature increase when you heat water.

Getting started

With a partner, draw three diagrams to show the particle structure of a solid, a liquid and a gas.

Be ready to show the class when you are asked to do so.

Key words

axis
boil
boiling point
change of state
condensation
condense
evaporation
freeze
measuring cylinder
melt
melting point
meniscus
steam
thermometer
water vapour

Changing state

If you leave ice in a warm place it **melts** and becomes liquid water. The temperature at which a solid melts is called the **melting point**.

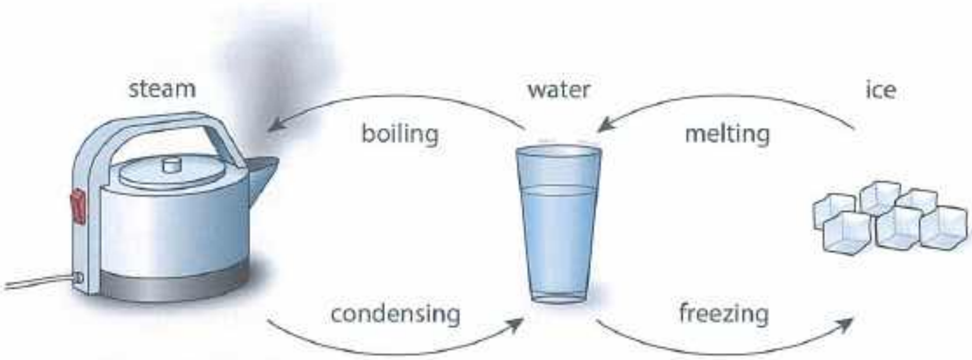
Water on the ground will gradually disappear as it changes to **water vapour**, an invisible gas. This is called **evaporation**. The warmer the water, the more quickly it evaporates.

If you heat water until its temperature reaches 100 °C, it will **boil**. All of the water rapidly changes to **steam**. Steam is water heated to the point that it turns into a gas. 100 °C is the **boiling point** of water.

If the water vapour or steam touches something cold, it **condenses** and changes back to liquid water. This is called **condensation**.

If you put liquid water in the freezer, it **freezes** and becomes ice.

These changes are known as **changes of state**.



Activity 2.2.1

Which change of state?

Work in pairs.

Cut out nine rectangles from a piece of A4 card. Write these words onto the cards: **melt, freeze, condense, boil, liquid, gas, solid, from, to**.

One of you should have the change of state cards (**melt, freeze, condense, boil**). The other should have the remaining cards (**liquid, gas, solid, from, to**).

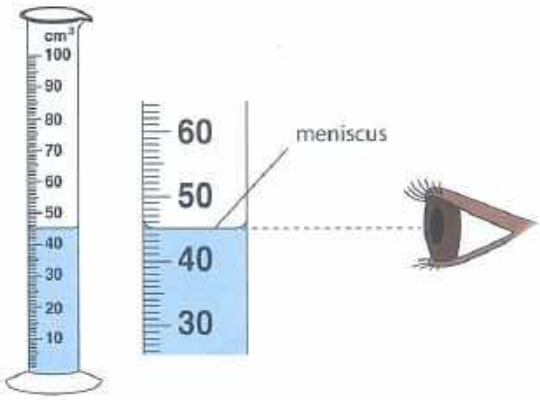
Hold up a change of state card. Your partner should then select the correct cards to show which state is changing to which other state. For example: '**freeze**' would be from '**liquid to solid**'.

Swap the sets of cards so that you take turns.

Measuring

Measuring volume

When you measure the volume of a liquid you use a **measuring cylinder**. The liquid forms a curve at the top. This is called the **meniscus**. You measure the volume from the bottom of the meniscus. To do this, you must make sure that your eye is level with the meniscus.



Measuring the volume of water in a measuring cylinder.

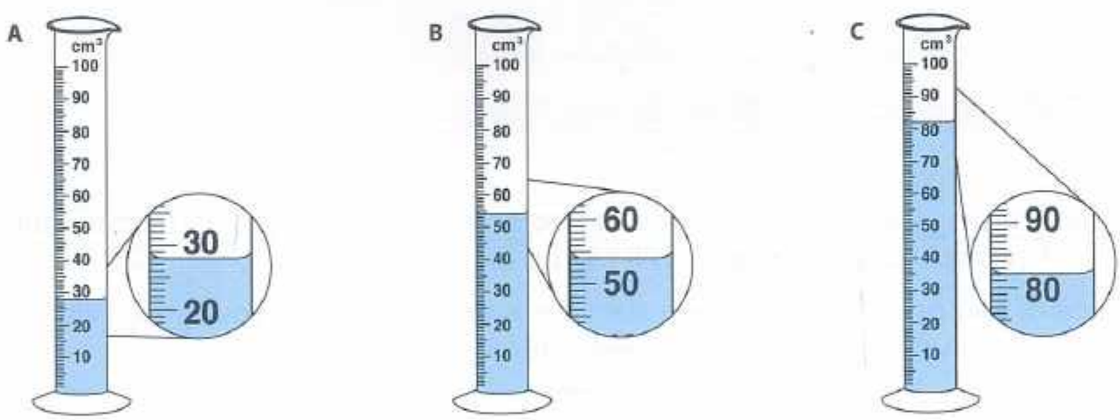
Measuring temperature

When you measure the temperature you use a **thermometer**. The liquid inside the thermometer expands as it gets hotter, so it rises up inside the thermometer. You read the temperature from the scale. Make sure that your eye is level with the top of the liquid in the thermometer.

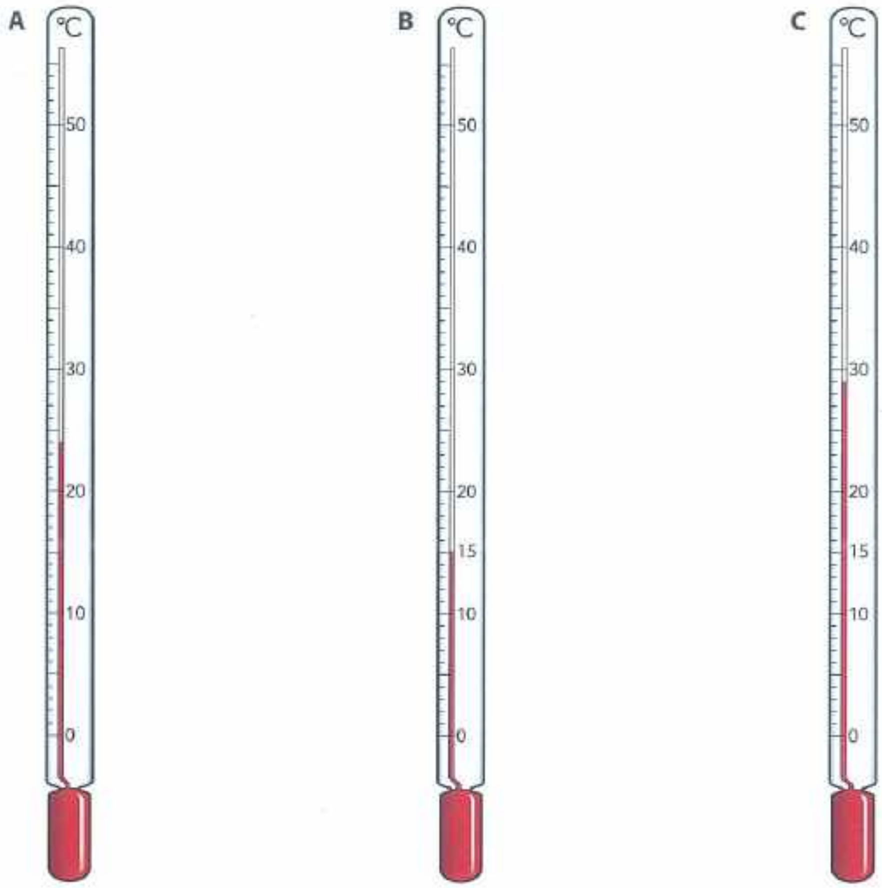
A thermometer

Questions

1 Look at the diagram. What is the volume of water in each measuring cylinder?



2 What are the temperatures shown on the thermometers?



Think like a scientist

Measuring the temperature when you heat water

In this task you will take accurate measurements.

You will need:

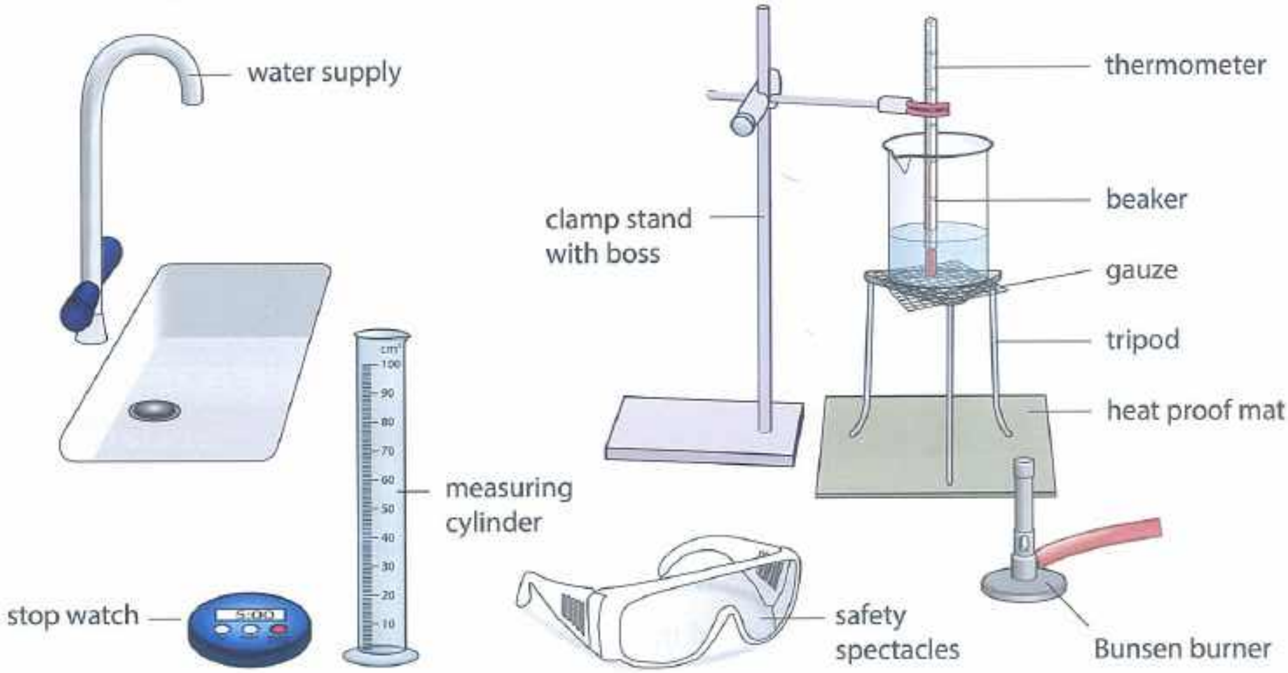
- beaker, Bunsen burner, clamp stand, gauze, measuring cylinder, thermometer, tripod

Safety

Wear safety spectacles. Take care when handling hot water. Always stand up to carry out practical work. If you spill any hot water it will not be on you.

Work in groups of two or three. Before you start the activity, discuss in your group what other safety measures you will take. Check these with your teacher.

Continued



1 Accurately measure 150 cm^3 of water into a beaker.

2 Place a thermometer with its bulb in the water. Use a clamp stand, as shown in the illustration. This is so that you measure the temperature of the water, not the temperature of the bottom of the beaker.

3 Measure the temperature.

4 Record this in a table. (Copy and extend the one below.)

Time in minutes	Temperature in °C
0	
1	
2	
3	
4	

Continued

5 Heat the water.

6 Use the thermometer to measure the temperature every minute.

7 Repeat until the water is boiling vigorously.

Questions

1 Plot your temperature measurements on a graph. Put the time along the horizontal **axis** and the temperature on the vertical axis.

2 Describe your graph. You could complete these sentences.

- When we heated the water, the temperature ____________
- The longer we heated the water, the ____________the temperature ____________
- The increase in temperature was ____________

You could mention how quickly the temperature increased and if the temperature increased by the same amount each minute.

3 What happened to the temperature of the water when it was boiling?

4 Why do you think this happened?

5 The thermometer is held in the water so that it does not rest on the bottom of the beaker. Why?

- Describe any problems you had with this investigation. How did you solve them?
- Think about how you carried out this investigation. What did you do to keep safe? Could you have made the investigation any safer?

Summary checklist

- [ ] I can name the three states of matter.
- [ ] I can use the correct terms to say how water changes from solid to liquid to gas.
- [ ] I can use a thermometer and a measuring cylinder accurately.
- [ ] I can carry out an investigation safely.

› 2.3 Explaining changes of state

In this topic you will:

- use the particle theory to explain what happens when matter changes between states
- use a model to illustrate the particle theory.

Getting started

1 For each process, write down the changes of state. The first one has been started for you.

- Melting: solid to ____________
- Condensing: ____________
- Freezing: ____________

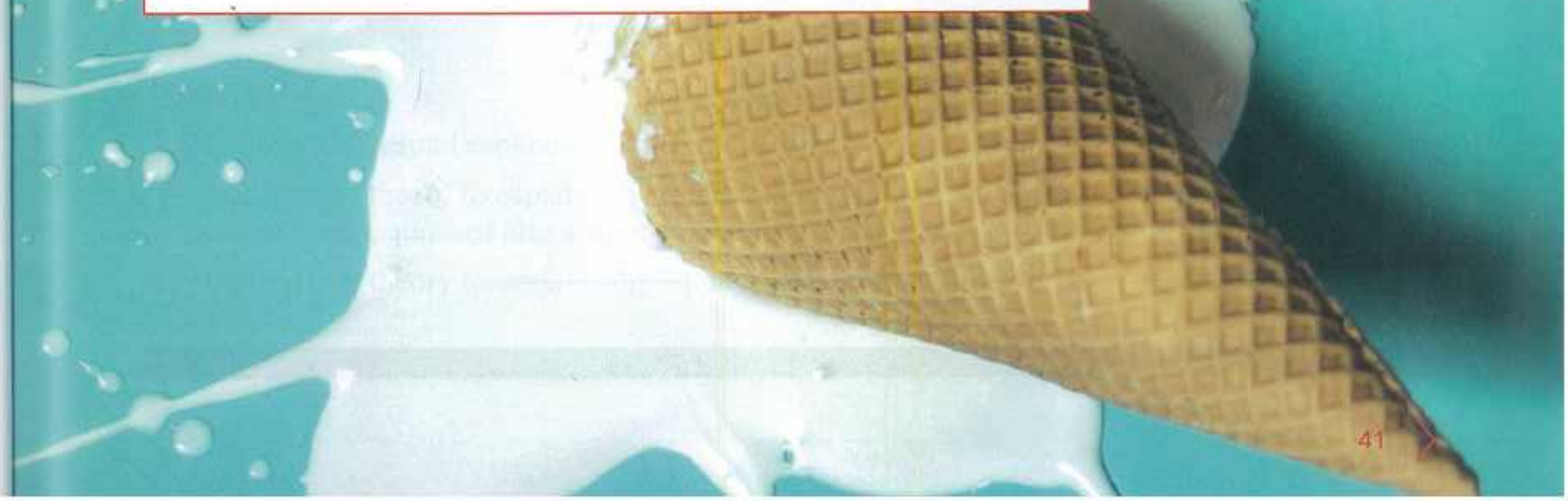
2 For each statement, decide if it applies to a solid, a liquid or a gas. Some may apply to more than one state of matter.

particles in regular rows	**can be poured**	**can be compressed**
particles spread out	**has a fixed volume**	**can change its shape**
cannot be compressed	**has a fixed shape**	

Check with a partner. Are you correct?

Key words

attractive force
expand
heat energy
transferred



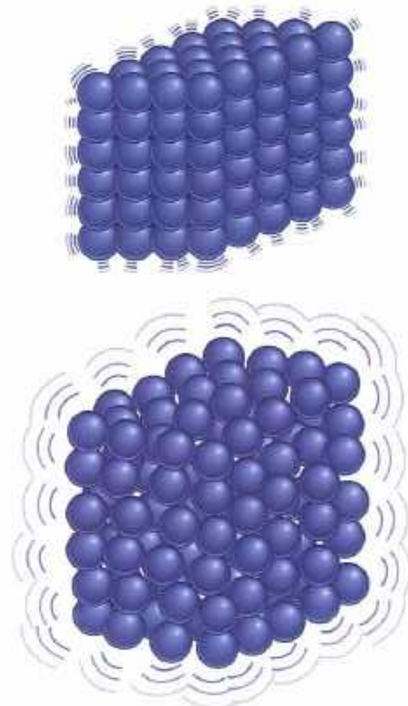
Changes of state

Heating solids

When solids are heated they **expand** (get bigger).

The particles in solids are arranged in a fixed pattern.
The particles are held together strongly and are tightly packed.

The particles in the solid vibrate. When the solid is heated, **heat energy** is **transferred** to the particles in the solid.
The more energy the particles have, the more they vibrate.
As the particles vibrate more, they take up more space.
The particles are still held in position by the **attractive forces** between them.



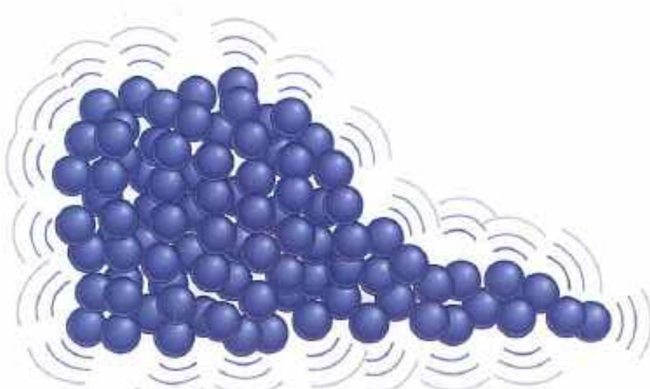
When a solid is heated, the particles vibrate more and take up more space.

Melting solids

When solids are heated more strongly, they melt. They become liquid. (Heating more strongly means that even more heat energy is transferred to the particles.)

The particles in a solid vibrate more and more as heat energy is transferred to them. The particles vibrate so much that the attractive forces between them are not strong enough to hold them in a fixed pattern. The particles can slide past one another – they can now move, not just vibrate.

The forces are still strong enough for the particles to stay in touch with one another. The more the liquid is heated, the more energy is transferred to the particles and the more the particles vibrate and move.



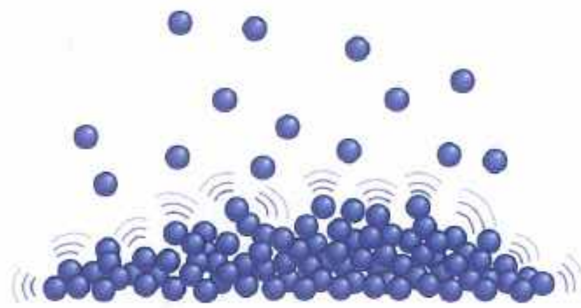
The particles vibrate so much that some escape the strong forces and can move around as a liquid.

Boiling liquids

When liquids are heated, they evaporate and boil.

The particles in liquids touch each other.
The particles are held together weakly.

The particles move more as heat energy is transferred to them. Some particles have enough energy to break the weak attractive forces holding them together. These particles can move freely and escape as gas particles.

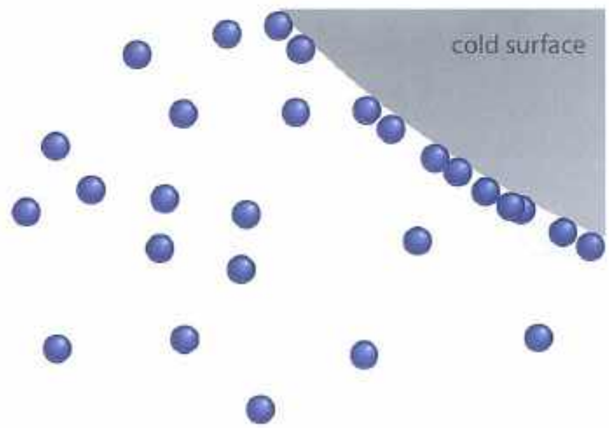


The particles move so quickly that some escape as a gas.

Cooling gases

The particles in a gas are free to move anywhere and spread out. There are no forces holding them. When a gas gets cooler it condenses to form a liquid.

When gas particles reach a cold surface, some of the heat energy from the particles transfers to the surface. The particles move less and get closer together. They form a liquid.



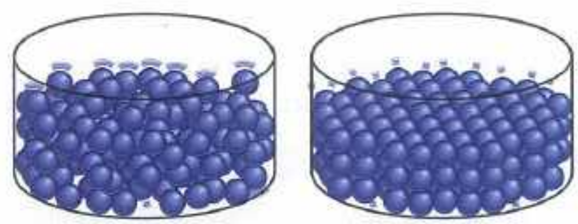
When the particles hit a cold surface, their movement slows down.

Freezing liquids

When a liquid freezes it becomes a solid.

The particles in a liquid can move and flow past each other. As heat energy is transferred from the particles to the surroundings, the particles move more slowly and the liquid gets cooler.

The cooler the liquid, the less energy the particles have. The less energy the particles have, the less able they are to move or slide past one another. Eventually, the particles have so little energy they cannot move and flow anymore – they can only vibrate. They become arranged in a fixed pattern to form a solid.



Particles in a liquid (left). Particles in a solid (right).

Questions

1 Explain why a solid expands when it is heated.

2 Use particle theory to explain why solids and liquids cannot be compressed (squashed into a smaller volume).

3 Use particle theory to explain why liquids and gases can flow.

4 Use particle theory to explain how a liquid changes to a gas.

5 Use particle theory to explain how a liquid changes to become a solid.

6 Use particle theory to explain what happens when steam in the bathroom hits a cold surface, such as a mirror.

7 Copy this flow chart. The arrows represent the processes involved when matter changes state. Add the name for each process, A–D.

solid → liquid → gas
A .... B ....

solid ← liquid ← gas
C .... D ....

Think like a scientist

Modelling changes of state

In this task, your class will model the changes of state by arranging yourselves as particles. You will need a lot of space.

Solid to liquid

- As a class, arrange yourselves as if you are the particles in a solid.
- Imagine the particles are being heated. Move as if you are being heated gently. Move as the particle theory suggests you should.
- Imagine the particles are now being heated strongly, so that the solid melts and becomes a liquid. Remember to behave as the particle theory suggests you should.

Question

1 Describe how you had to act to illustrate the behaviour of particles as a solid melts. Think about how you behaved. Was the model a good or a bad model for particle theory? Explain.

Liquid to gas

- As a class, arrange yourselves as if you are the particles in a liquid.
- Imagine the particles are being heated. Move as if you are being heated gently.
- Imagine the particles are now being heated strongly so that the liquid boils. Remember to behave as the particle theory suggests you should.

Continued

Question

2 Describe how you had to act to illustrate the behaviour of particles as a liquid evaporates and then boils. Think about how you behaved. Was the model a good or a bad model for particle theory? Explain.

Gas to liquid

- As a class, arrange yourselves as if you are the particles in a gas.
- Imagine part of the room is a cold surface. As you move near to the surface you must behave as particle theory suggests. You should start to condense to form a liquid.

Question

3 Describe the way you had to behave to illustrate the behaviour of particles as a gas condenses. Think about how you behaved. Was the model a good or a bad model for particle theory? Explain.

Liquid to solid

- As a class, arrange yourselves as the particles in a liquid. Make sure you move as particle theory suggests.
- Now imagine the liquid has been placed in a freezer. Behave as particle theory suggests, as you become a solid.

Question

4 Describe the way you had to behave to illustrate the behaviour of particles as a liquid freezes to form a solid. Think about how you behaved. Was the model a good or a bad model for particle theory? Explain.

- How did you learn and remember the structure of solids, liquids and gases as states of matter?

Summary checklist

- [ ] I can describe how particles behave, depending on how much energy they have.
- [ ] I can explain that energy can be transferred to or from particles.
- [ ] I can describe the effects of the energy on the forces holding the particles together.

2.4 The water cycle

In this topic you will:

- learn about the water cycle
- use scientific words to describe stages of the water cycle.

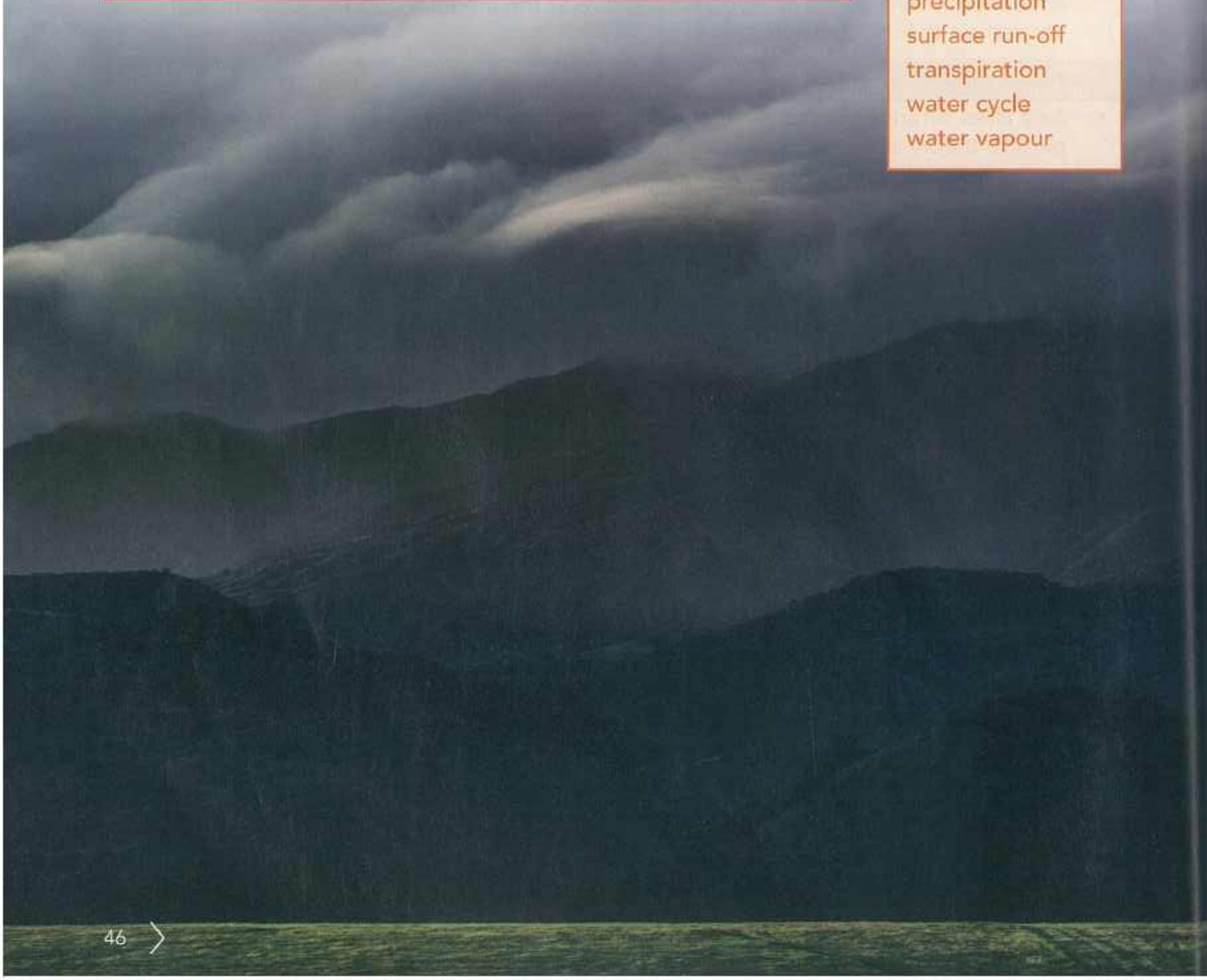
Getting started

Spend one minute thinking about where rain comes from. Then spend two minutes discussing your ideas with a partner.

Now write down your ideas and show them to your teacher.

Key words

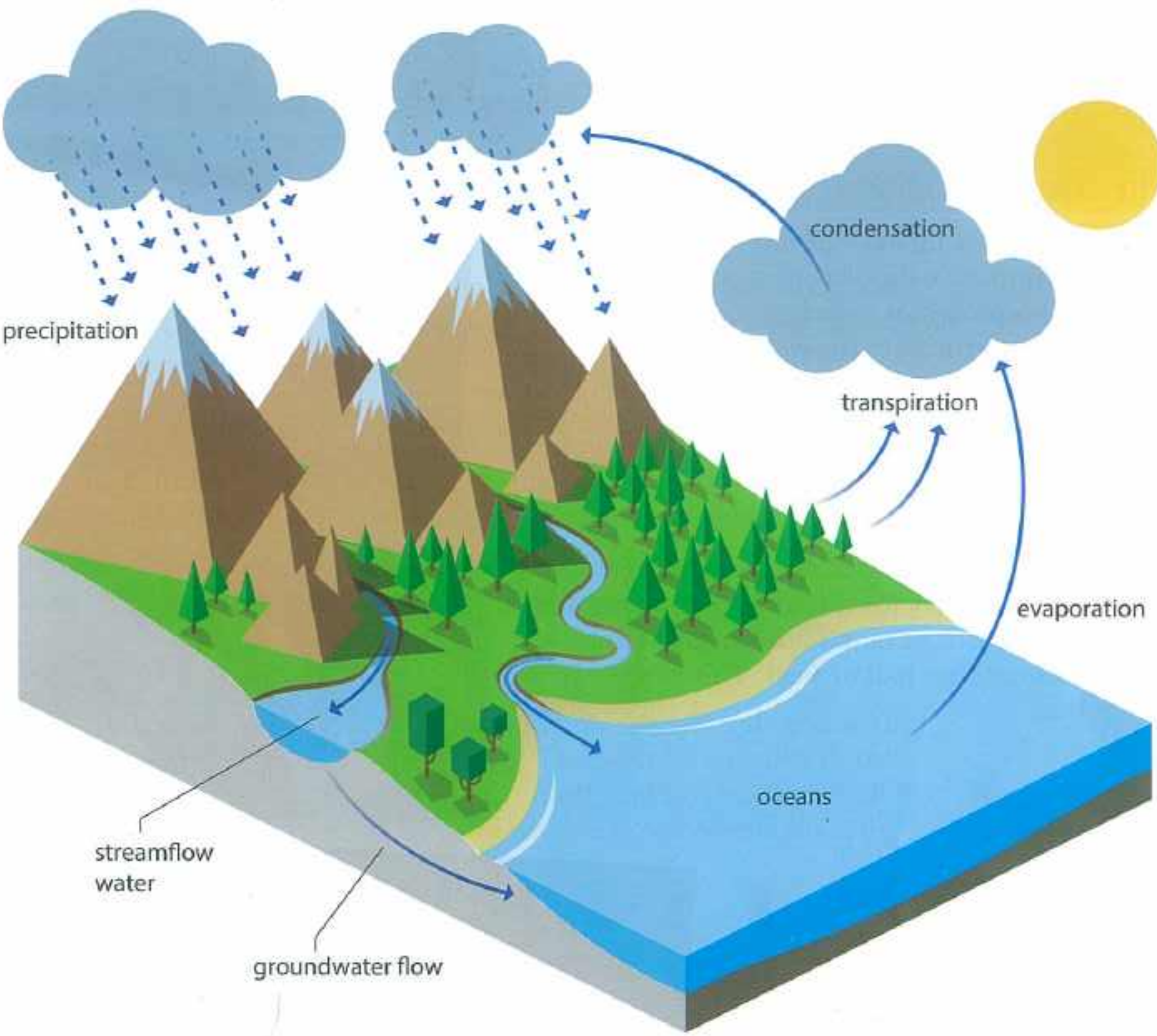
atmosphere
groundwater
open water
precipitation
surface run-off
transpiration
water cycle
water vapour



The water cycle

Water is vital for all living things. Our bodies are made up of at least 60% water.

Water on Earth is constantly moving. The water moves between rivers, lakes, oceans, the **atmosphere** and the land. It is recycled over and over again in a continuous system called the **water cycle**. You are still using the same water that the ancient Greeks and the Romans used. The Earth has been recycling water for more than four billion years.



What happens during the water cycle?

Water moves into the atmosphere

Energy from the Sun heats the Earth and the temperature of the water in the rivers, lakes and oceans increases. When this happens, some of the liquid water forms **water vapour**, which moves into the atmosphere. This is called evaporation. This happens because some of the particles in the liquid water gain enough energy to break free from the forces holding them together and they change to a gas. Water can also evaporate into the atmosphere from plants; this is called **transpiration**.

Water in the atmosphere cools down

As the water vapour goes up into the atmosphere, it cools and changes back into little droplets of water in the air, forming clouds. This process is called condensation. It happens because the particles in the water vapour lose energy and cannot move so quickly. Air currents high in the atmosphere move the clouds around the world.

Water falls from clouds

When a lot of water has condensed, the water droplets in the clouds become too heavy for the air to hold them. The droplets fall back to Earth as rain. If the drops become colder they may form snow, hail or sleet. This process is called **precipitation**.

Water falls on the Earth

The precipitation that falls then collects in rivers and **open water** such as large lakes and the oceans.

How it is collected depends on where it lands. Some precipitation will fall directly onto the rivers, lakes and oceans and will evaporate, then the cycle starts again.

If the precipitation falls on plants it may evaporate from the leaves back to the atmosphere or trickle down to the ground. The plant roots in the ground may then take up some of this water.

Water in the ground

Some of the water from precipitation will soak into the soil and rocks as **groundwater**. Some of this water will stay in the shallow soil layer and will move towards streams and rivers. When groundwater soaks deeper into the soil, it refills underground stores.

In cold climates the precipitation may build up on land as snow, ice or glaciers. If the temperatures rise, this solid snow and ice will melt into liquid water, which soaks into the ground or flows into rivers or the ocean.

Some of the precipitation will soak into the soil and move through the ground until it reaches the rivers or the open water, large lakes and the oceans.

Water that reaches the surface of the land may flow directly across the ground into the rivers, lakes and oceans. This water is called **surface run-off**. When there is a lot of surface run-off, soil can be carried off the land and into the rivers. This can cause them to become silted up and blocked.

Activity 2.4.1

Water cycle poster

Make a poster to show the water cycle. Remember to use the scientific terms. You should make your poster as clear and colourful as you can.

Peer assessment

Swap your poster with someone else in your class. What do you like about their poster? Think of at least two things. How could they improve their poster?

Questions

1. What are the different types of precipitation?
2. How does rain form?
3. Use particle theory to explain how a pool of water on the road disappears.
4. Where does your drinking water come from?
5. What methods have people used to ensure they always have a supply of water? You may need to do some research.
6. What do we use water for in our bodies?
7. What other things do we use water for?
8. Think about all the water you used today. Try to work out how much water you use in one day.

Summary checklist

- [ ] I can use scientific vocabulary to describe the water cycle.
- [ ] I can use particle theory to explain what happens in each part of the water cycle.

2.5 Atoms, elements and the Periodic Table

In this topic you will:

- learn what an atom and an element are
- find out about different atoms and elements
- learn about the Periodic Table
- use symbols to represent the names of elements.

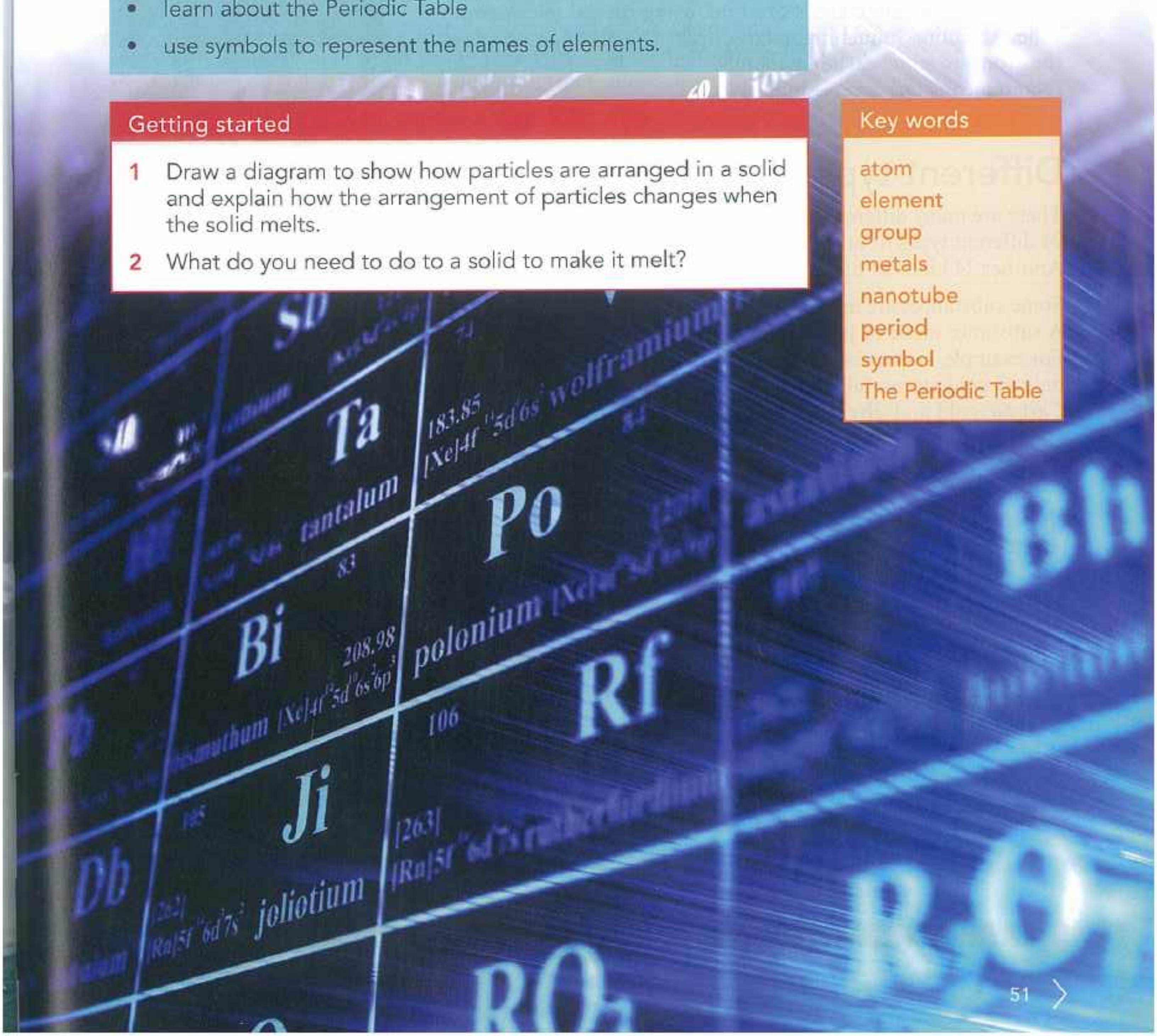
Getting started

1 Draw a diagram to show how particles are arranged in a solid and explain how the arrangement of particles changes when the solid melts.

2 What do you need to do to a solid to make it melt?

Key words

atom
element
group
metals
nanotube
period
symbol
The Periodic Table



What are atoms?

Over 2000 years ago, a Greek philosopher called Democritus suggested that everything was made up of tiny pieces. Democritus suggested that, if you could keep on cutting up a substance into smaller and smaller pieces, you would end up with a very small piece that could not be cut up any more.

Democritus called his tiny pieces of matter **atoms**.
Atom means 'cannot be divided'.

We now know that atoms really do exist. Today we can even see some of the large kinds of atom, using special microscopes called scanning tunnelling microscopes. The photograph shows the atoms in some carbon **nanotubes**.
(Nano means 'very, very small'.)

Nanotubes

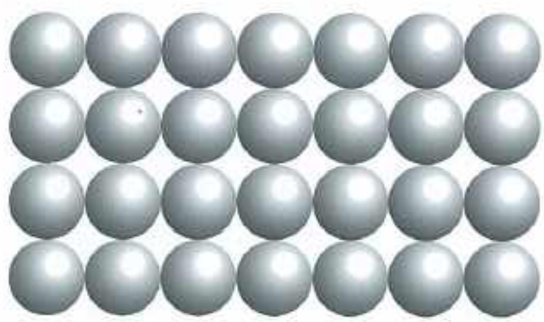
Different types of atom

There are many different types of atom. Scientists have discovered 94 different types of atom that occur naturally in the universe. Another 24 kinds of atom have been made in laboratories.

Some substances are made up of just a single kind of atom.
A substance made of just one kind of atom is called an **element**.
For example, carbon is made only of carbon atoms. Gold is made only of gold atoms. Silver is made only of silver atoms.
Carbon, gold and silver are examples of elements.

Each type of atom has different properties. This is why different elements have different properties.

These rings are made from pure silver.



If you could see some of the atoms in the silver ring, they would look something like this.

Questions

1 What are atoms?

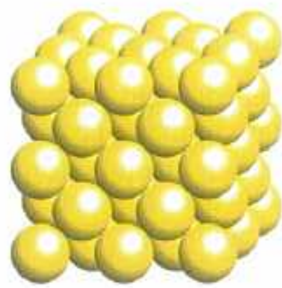
2 If there are 94 different kinds of naturally occurring atom, how many different naturally occurring elements are there?

Atoms joining together

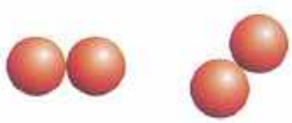
In six of the elements, such as neon (which is a gas), atoms move around freely, not attached to one another. But in most elements, such as gold and other metals, atoms are packed closely together.

In a small number of elements, such as oxygen and sulfur, atoms join together to form small particles. An oxygen particle is made from two oxygen atoms. A sulfur particle is made from eight sulfur atoms.

Atoms of neon



Atoms of gold



Particles of oxygen

Particle of sulfur

Arranging the elements

Scientists have developed a very useful way of arranging the elements. This is called the **Periodic Table**.

The full Periodic Table containing all of the 118 known elements (that is 94 natural and 24 man-made) is very large and complex. (There may be one on the wall of your science laboratory.) You are just going to look at the first 20 elements.

metals (yellow): Li, Be, Na, Mg, Al, K, Ca
non-metals (blue): H, He, B, C, N, O, F, Ne, Si, P, S, Cl, Ar

		H hydrogen						He helium
Li lithium	Be beryllium		B boron	C carbon	N nitrogen	O oxygen	F fluorine	Ne neon
Na sodium	Mg magnesium		Al aluminium	Si silicon	P phosphorus	S sulfur	Cl chlorine	Ar argon
K potassium	Ca calcium							

Groups and periods

The Periodic Table is organised into rows and columns. The rows are called **periods**. The columns are called **groups**.

The atoms are organised so that, as you read across each row (period) from left to right, the atoms increase in mass. Hydrogen atoms have the smallest mass, then helium atoms, then lithium atoms, and so on.

Chemical symbols

Each of the elements has been given a **symbol**.
This is a useful shorthand way of referring to them.

Sometimes the symbol is the first letter of the English name of the element. For example, the symbol for oxygen is **O**.

Sometimes the symbol is the first letter of the English name plus another letter from its name. For example, the symbol for helium is **He.**

Sometimes the symbol is taken from another language. For example, the symbol for sodium is **Na**, from the old Latin name '**na**trium'.

The first letter of the symbol is always upper case and the second letter, if there is one, is always lower case.

Questions

3 What are the names of the elements with the symbols Mg, Be, Li and N?

4 Find the symbols for the elements aluminium, boron, fluorine and potassium.

5 Which element has atoms with the smallest mass?

6 Which of the elements in the first 20 elements of the Periodic Table has atoms with the greatest mass?

7 Give the names (not symbols) of **two** elements in the same period as magnesium.

8 Give the symbols (not names) of **two** elements in the same group as helium.

Metals and non-metals

The Periodic Table is organised so that elements with similar properties are close together.

In the diagram of the Periodic Table, all the elements that are **metals** are in yellow boxes. All the elements that are non-metals are in blue boxes.

Activity

Learning the symbols for the elements

Here is a list of twenty elements and their symbols. Your task is to make up a game to help you learn them. You could make one set of cards with the names on them and another set with the symbols on them. Think how you could use these to make a game.

Your game could be for one or two people, you decide.

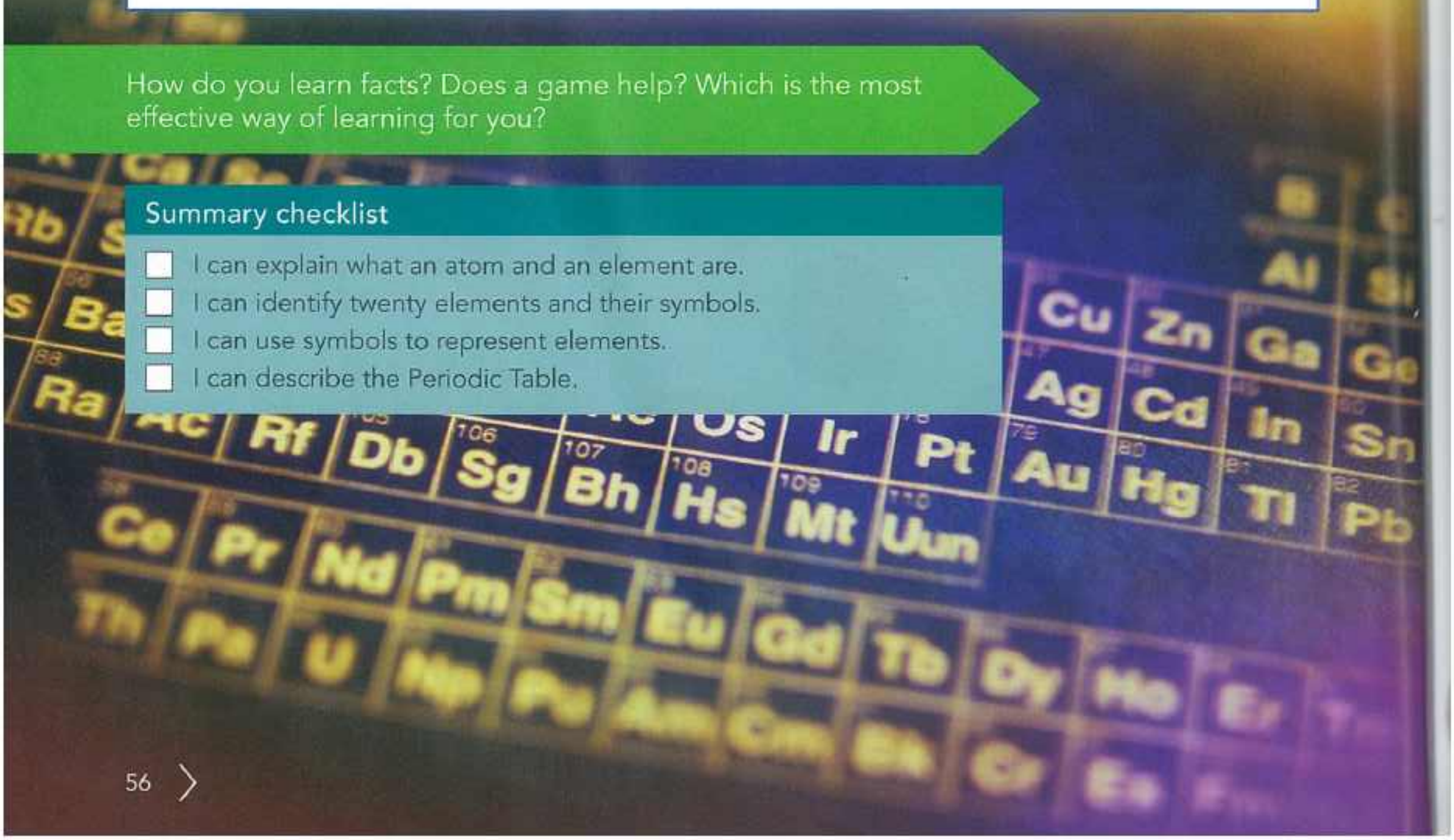
Element	Symbol
Hydrogen	H
Helium	He
Lithium	Li
Beryllium	Be
Boron	B
Carbon	C
Nitrogen	N
Oxygen	O
Fluorine	F
Neon	Ne

Element	Symbol
Sodium	Na
Magnesium	Mg
Aluminium	Al
Silicon	Si
Phosphorus	P
Sulfur	S
Chlorine	Cl
Argon	Ar
Potassium	K
Calcium	Ca

How do you learn facts? Does a game help? Which is the most effective way of learning for you?

Summary checklist

- [ ] I can explain what an atom and an element are.
- [ ] I can identify twenty elements and their symbols.
- [ ] I can use symbols to represent elements.
- [ ] I can describe the Periodic Table.



> 2.6 Compounds and formulae

In this topic you will:

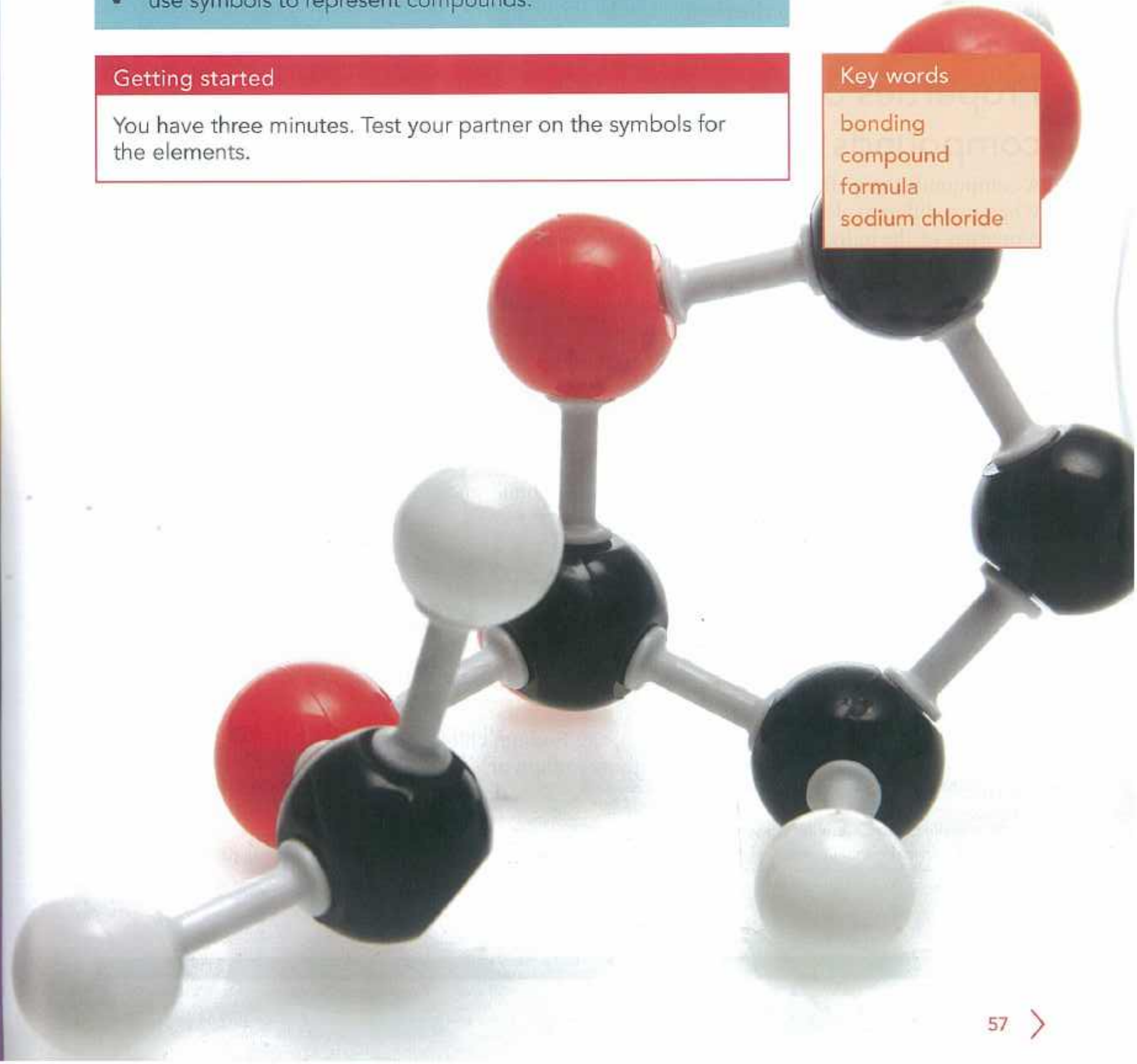
- learn about the differences between elements and compounds
- learn how to name compounds
- use symbols to represent compounds.

Getting started

You have three minutes. Test your partner on the symbols for the elements.

Key words

bonding
compound
formula
sodium chloride



What is a compound?

You have looked at elements in the Periodic Table. An element is made up of only one type of atom. Many substances are made up of more than one type of atom. If the different types of atom are joined tightly together, then the substance is a **compound**.

The chemical term for two atoms joining tightly together is **bonding**. In a compound, two or more different kinds of atom are bonded. For example, when sodium atoms bond with chlorine atoms, they form the compound **sodium chloride**.

Properties of elements and compounds

A compound is very different from the elements from which it is made. When two different elements are bonded, they completely lose the properties of the individual elements. The compound has totally new properties.

The first two photographs show the two elements sodium and chlorine. The third photograph shows the compound that is made when sodium and chlorine atoms bond together. This compound – sodium chloride – is not at all like either sodium or chlorine.

Sodium, an element

+

Chlorine, an element

→

Sodium chloride, a compound

You may have eaten some sodium chloride today. Sodium chloride is common salt. You would not want to eat any sodium or chlorine, though.

Questions

1 Describe **two** ways in which sodium chloride is different from sodium.

2 Describe **two** ways in which sodium chloride is different from chlorine.

Naming compounds

Each compound has a chemical name. The chemical name usually tells you the elements that the compound is made from.

There are important rules to remember when naming compounds.

- If the compound contains a metal, then the name of the metal comes first in the name of the compound.
- If the compound contains a non-metal, the name of the non-metal is usually changed. For example, the compound made from sodium (a metal) and chlorine (a non-metal) is not sodium chlorine, but sodium chlor**ide**.
- When two elements form a compound the name often ends in '**ide**'.

Questions

3 Which **two** elements are combined in sodium chloride?

4 Which **two** elements are combined in hydrogen sulfide?

5 Which **two** elements are combined in magnesium oxide?

6 A student wrote this name for a compound made of calcium and sulfur:

sulfur calcium

What is wrong with this name?
Write the correct name for the compound.

Some compounds contain two different elements, plus a third element – oxygen. These compounds often have names ending with '**ate**'. For example, a compound of calcium, carbon and oxygen is called calcium carbonate.

These are crystals of copper sulfate. Copper sulfate is a compound made up of copper, sulfur and oxygen.

Questions

7 Which **three** elements are combined in calcium nitrate?

8 Which **three** elements are combined in magnesium carbonate?

9 Which **three** elements are combined in lithium sulfate?

Sometimes, the name of a compound tells you how many of each kind of atom are bonded together.

A particle of carbon dioxide

A particle of carbon monoxide

Carbon **di**oxide particles are made up of one carbon atom joined to two oxygen atoms. 'Di' means two.

Carbon **mono**xide particles are made up of one carbon atom joined to one oxygen atom. 'Mon' or 'mono' means one.

Particle diagrams

Particle diagrams, like those for carbon dioxide and carbon monoxide, show which atoms of which elements make up the particle.

It is easy to decide if a substance is a compound by looking at the particle diagram. If there are different kinds of atom bonded together, then it is a compound.

A particle of carbon dioxide, CO_2

A particle of water, H_2O

A particle of oxygen, O_2

A particle of methane, CH_4

Carbon dioxide, water and methane are all compounds because their particles are made up of different kinds of atom. Oxygen is an element because the atoms in the particle are both oxygen atoms.

Using formulae

Every compound has a chemical name. For example, the compound of sodium and chlorine is sodium chloride. Some compounds also have an everyday name. For example, sodium chloride is also known as common salt.

Every compound also has a **formula** (the plural of this word is *formulae*). The formula contains the symbols of the elements that are bonded together in the compound.

The table shows the chemical names and formulae of six compounds.

Chemical name	Formula	What the compound contains
calcium oxide	CaO	one calcium atom bonded with one oxygen atom
carbon dioxide	CO_2	one carbon atom bonded with two oxygen atoms
carbon monoxide	CO	one carbon atom bonded with one oxygen atom
hydrogen sulfide	H_2S	two hydrogen atoms bonded with one sulfur atom
calcium carbonate	$CaCO_3$	one calcium atom, one carbon atom and three oxygen atoms bonded together
sodium hydroxide	$NaOH$	one atom of sodium, one atom of oxygen and one atom of hydrogen bonded together

Be very careful reading the symbols of the elements. You do not want to confuse the symbol for carbon, C, with the symbol for calcium, Ca.

The little number written below and to the right of some symbols tells you how many atoms of each element are found in the particle of the compound. If there is no number, it means there is just one atom of that element.

Questions

10 Which of these substances are elements, and which are compounds? Explain your answer.

K O_2 $NaCl$ Al Ca $CaCl_2$ H_2

11 The formula for sulfur dioxide is SO_2.

- **a** How many different elements are combined in sulfur dioxide?
- **b** How many atoms of oxygen are combined with each atom of sulfur?

12 The formula for water is H_2O.

- **a** Which two elements are combined in water?
- **b** What does the formula tell you about the numbers of each kind of atom that are combined together?

13 The compound with the formula CO is called carbon monoxide. Suggest why it is not simply called 'carbon oxide'.

14 Suggest the names of the compounds with these formulae:

- **a** MgO
- **b** $NaCl$
- **c** $CaCl_2$.

15 The formula for sodium hydroxide is NaOH; the formula for potassium hydroxide is KOH.

Which **two** elements do you think are contained in all hydroxides?

16 What is the name of the compound with the formula LiOH?

17 How many different elements are combined together in LiOH?

Activity 2.6.1

Making models of particles

You are going to make models of at least five of the compounds mentioned in this topic.

You will need:

- coloured card or paper, scissors and glue

1. Cut out circles of different colours to represent the different atoms of the elements.
2. Write the symbol for that element on the atom.
3. Arrange them to form the formula of one of the compounds mentioned in this topic.
4. Stick them on to a poster and write the name of the compound and its formula underneath.
5. Display them in your classroom.

Summary checklist

- [ ] I can explain the difference between elements and compounds.
- [ ] I can name compounds.
- [ ] I can use symbols to represent elements and compounds.

2.7 Compounds and mixtures

In this topic you will:

- make a compound and a mixture
- learn about the difference between a compound and a mixture
- give examples of mixtures.

Getting started

- Which of these are elements and which are compounds?

nitrogen carbon dioxide calcium chloride sodium

O_2 CaO CH_4 H_2O K

- What is the difference between an element and a compound?
- Discuss with a partner and be prepared to share with the class.

Key words

composition
evaporating basin
filings
mineral
mixture
natural emissions
pipe-clay triangle
pure

Compounds and mixtures

When atoms of elements are bonded tightly to form a compound, the properties of the compound are completely different from the properties of the elements that it is made from.

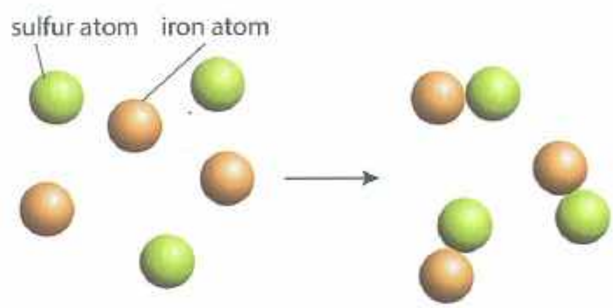
For example, iron is a metal. It is hard, grey, strong, conducts heat and electricity and is magnetic.

Sulfur is a non-metal. It is yellow, brittle, does not conduct heat or electricity and is not magnetic.

This miner is carrying baskets of sulfur from the crater of a volcano in Indonesia.

This blacksmith is using iron to make a bracelet.

When these two elements are heated, they combine together to form the compound iron sulfide. Iron sulfide is not magnetic and does not conduct heat or electricity.



When iron and sulfur are heated together, iron atoms and sulfur atoms bond together to form the compound iron sulfide.

Think like a scientist

Using iron and sulfur

You are going to use iron and sulfur to make a mixture and a compound. This will help you understand the differences between a mixture and a compound.

You will need:

- safety glasses, beaker, stirrer, boiling tube, test tube holder, Bunsen burner, powdered sulfur, iron filings, mineral wool

Safety

Do not touch your face or eyes when handling the iron filings. The pieces have sharp edges and can damage your skin and eyes. Wear safety glasses. Use the mineral wool to plug the mouth of the boiling tube. Carry this activity out in a well-ventilated room.

Mixing iron and sulfur

1. Place some iron **filings** in a beaker.
2. Add some yellow powdered sulfur.
3. Stir the mixture so that the two elements are spread out evenly.

   You now have a **mixture** of iron and sulfur. The iron and sulfur both still have their properties. They have not changed chemically in any way. The different properties of the two elements can be used to separate them from the mixture.
4. Use a magnet to remove the iron filings.

Making a compound from iron and sulfur

1. Make a mixture of iron and sulfur, just as you did in steps 1–3.
2. Heat some of the iron and sulfur mixture in a boiling tube.
3. Stop heating as soon as the mixture starts to glow. The iron and sulfur will combine together and form iron sulfide.
4. Leave the tube to cool.
5. Use a magnet to try to separate the iron. You can try through the wall of the tube.

Continued

Questions

1 Describe the appearance of:
   a a mixture of iron and sulfur
   b the iron sulfide.
2 Can you remove the iron from the iron sulfide by using a magnet? Explain your answer.

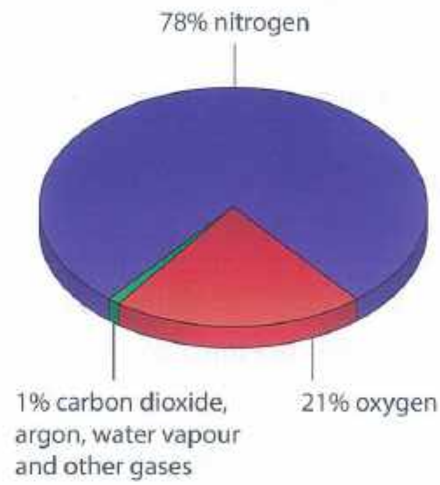
Air is a mixture

When you mix iron and sulfur together, you make a mixture of two elements.

In science, the word **pure** is used to describe something that only contains a single substance. Pure water contains only water, with no other substances mixed with it.

A mixture is not pure. It is made up of different kinds of particle that are mixed together. The mixture may be of elements, compounds or both. There are solids, liquids and gases that are mixtures.

For example, air is a mixture of several different elements and compounds. Air contains nitrogen, oxygen, carbon dioxide, water vapour and small quantities of some other gases.

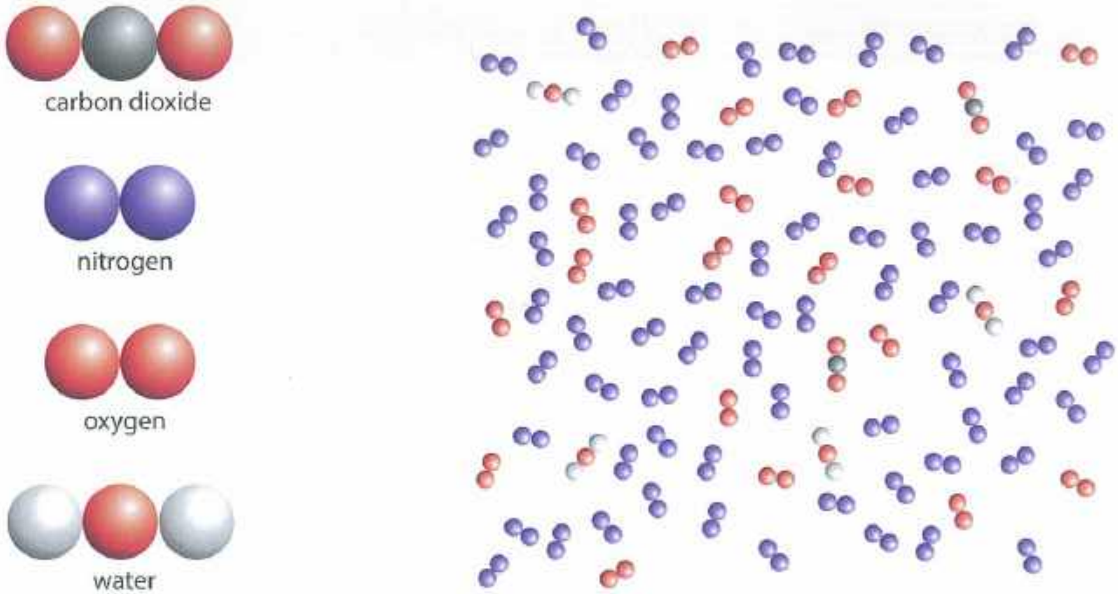


A pie chart showing the composition of air.

The **composition** of air varies because the amount of water vapour changes all the time, depending on the weather.

The amount of carbon dioxide and other gases also change. This can be a result of **natural emissions**, such as when animals and plants produce carbon dioxide when they respire. Plants also use carbon dioxide when they make food, so this removes carbon dioxide from the air. The changes in the composition of air can also be as a result of human activity increasing the amount of carbon dioxide that is given out as a result of burning fossil fuels. Other forms of pollution also change the composition of the air.

The composition of air has changed over millions of years; at one time there was much less oxygen in the atmosphere.



Air is a mixture of several elements and compounds.

Questions

The diagram shows some particles in air. The red circles represent oxygen atoms. The black circles represent carbon atoms. The blue circles represent nitrogen atoms. The white circles represent hydrogen atoms.

1 Which is the most common element in air?

2 How many different kinds of substance are shown in the diagram?

3 Which is the least common compound in this sample of air?

Mineral water is a mixture

The label on a bottle of mineral water lists many **minerals**. There is more than just water in the bottle. The bottle contains a mixture of water and other substances.

The minerals are dissolved in the water. The mineral water is a solution. A litre of water may have about of minerals dissolved in it.

TYPICAL ANALYSIS mg/l	
CALCIUM	55
MAGNESIUM	19
POTASSIUM	1
SODIUM	24
BICARBONATE	248
CHLORIDE	37
SULPHATE	13
NITRATE	< 0.1
IRON	0
ALUMINIUM	0
DRY RESIDUE AT 180°C	280
pH AT SOURCE	**7.4**

The label shows the minerals found in mineral water.

Question

4 Look at the picture of a mineral water label.

List the **three** most abundant minerals in this bottle of mineral water.

Think like a scientist

Is water really a mixture?

You are going to investigate if drinking water contains anything other than water.

You will need:

The apparatus shown in the diagram.

Safety

Wear safety glasses. Take care during step 2 as the solution may start to spit. Do not touch the evaporating basin with your hands – use tongs.

Read the health and safety notes before you start.

1 Put some water in the **evaporating basin** and heat it until it boils.
2 Once the water starts to boil, turn the heat down and continue to heat it gently.
3 When you have evaporated off some of the water (or the solution has started to spit) remove it from the heat.
4 Leave the evaporating basin to cool. The water may take a day or two to evaporate completely. It will depend on the temperature.

Questions

1 Use ideas about particles to explain why the water evaporated.
2 What was left in the evaporating basin?
3 Where has this substance come from?
4 Was the water you used pure water, or was it a mixture of water and other substances? Explain your answer.
5 Why did you need to wear safety glasses?

Summary checklist

- [ ] I can distinguish between a compound and a mixture.
- [ ] I can explain the difference between a compound and a mixture.
- [ ] I can give examples of mixtures.

Project: What's in the parcel?

Imagine you are given a parcel. You've been told you cannot open it for a few days. But you're desperate to know what's inside!

What would you do?

- How could you get some information about what is inside?
- What sort of things could you find out?
- What sort of things could not be found out without looking inside?

Each group will be given a parcel with a number on it.

1 Your group has a few minutes to find out as much as they can about what is in the parcel but you **must not open the parcel**.

2 Discuss ideas in your group and try to give reasons for your ideas.

3 Write down your ideas on a piece of paper or a sticky note.

4 Swap parcels with another group. Repeat steps 1 and 2. Write your ideas on a new piece of paper or sticky note.

5 Repeat until you have tried to discover what is inside all the parcels.

When all the groups have examined all the parcels, work together as a class to create a poster about **how** you carried out the investigation.

Each group will share their ideas, **with reasons** on each parcel, with the whole class. By discussing this with all the other groups the class can work together to reach some conclusions for each parcel.

This is how scientists work. They cannot always see or touch what they are investigating. Scientists have to use the information that is available to come with ideas.

Check your Progress

2.1 Which state of matter has the strongest forces between its particles? [1]

2.2 Name the state of matter that fits each description.

- **a** Particles do not touch one another. [1]
- **b** Particles are close together in a regular pattern. [1]
- **c** Particles are closely packed but not in a regular pattern. [1]

2.3 Water in a puddle on a pathway disappears on a warm day. Explain what happens to the water particles. [2]

2.4 **a** Which are the **two correct** statements about liquids? [2]

- **i** Liquids can flow and be poured into a container.
- **ii** The particles in liquids are far apart.
- **iii** The particles in liquids are arranged randomly.
- **iv** The particles in a liquid can only vibrate.
- **v** Liquids only form at temperatures above 100 °C.

b A liquid changes to a solid when it freezes.

Describe what happens to the particles during this process. [2]

2.5 Which of these terms matches the two facts?

precipitation **evaporation** **condensation** **groundwater**

- **a** This falls from clouds.

  Rain, snow and hail are forms of this. [1]
- **b** This is what happens when water vapour cools down.

  This is a change from water vapour to a liquid. [1]
- **c** When this happens, liquid water changes to water vapour.

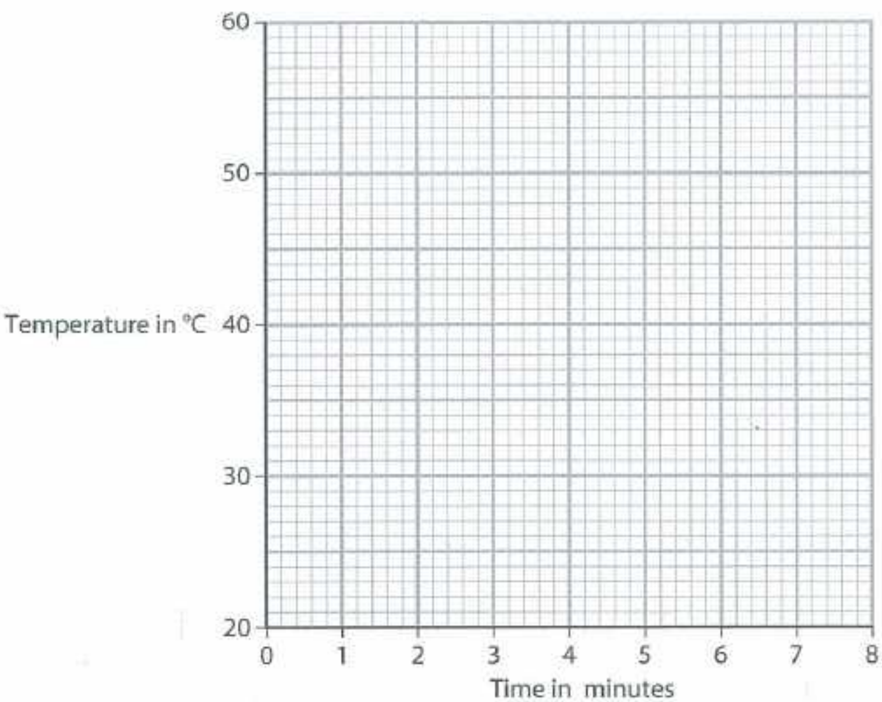
  Water from rivers and the ocean is taken up into the atmosphere. [1]

2.6 Zara heated a liquid and recorded its temperature every minute.

Here are her results.

Time in minutes	Temperature in °C
0	20
1	25
2	19
3	39
4	47
5	56
6	58
7	59
8	58

a Copy the axes and labels below onto graph paper.



Plot Zara's results on the grid. [4]

b Draw a line of best fit through the points you have plotted. [1]

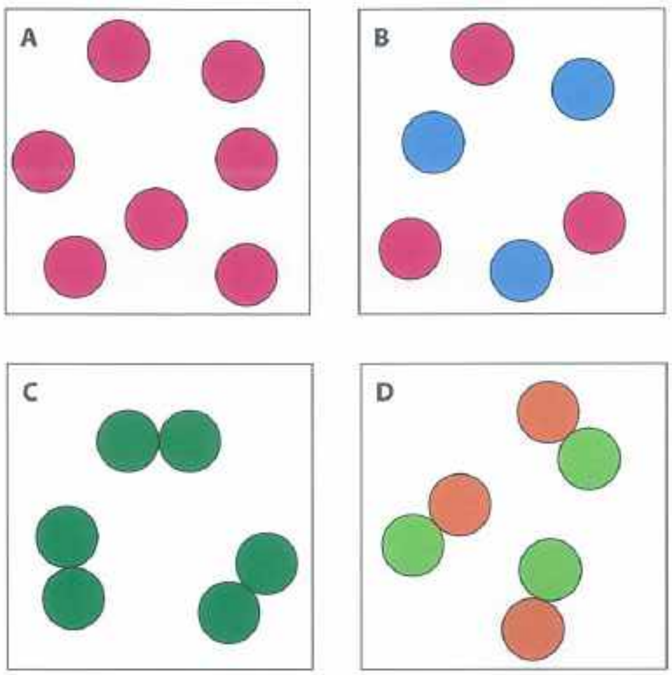
c Which reading does not fit the pattern? [1]

d Suggest a reason for this. [1]

e What happens to the temperature between 5 and 8 minutes? [1]

f Explain why this happens. [1]

2.7 The diagrams in the boxes show different arrangements of particles, where each colour represents a different atom.



Give the letter of the diagram that represents:

a particles of a compound [1]

b particles of an element [1]

c atoms of a mixture [1]

d atoms of an element. [1]

2.8 a Give the symbol for each element.

- **i** magnesium [1]
- **ii** oxygen [1]
- **iii** hydrogen [1]
- **iv** calcium [1]
- **v** boron [1]

b Name the element with the given symbol.

- **i** C [1]
- **ii** Na [1]
- **iii** K [1]
- **iv** Cl [1]
- **v** Si [1]

c Explain why scientists use symbols for the elements. [1]

d Explain why some symbols, such as Cl and Si, have two letters. [1]

3 Forces and energy

3.1 Gravity, weight and mass

In this topic you will:

- understand that the force of gravity acts between objects
- learn about what affects the strength of the force of gravity on an object
- practise using the correct terms 'weight' and 'mass'.

Getting started

Work individually to answer these questions.

1 Describe how gravity affects an object such as a textbook.

2 Copy and complete this sentence by choosing the correct word from the list.

length **mass** **volume** **weight**

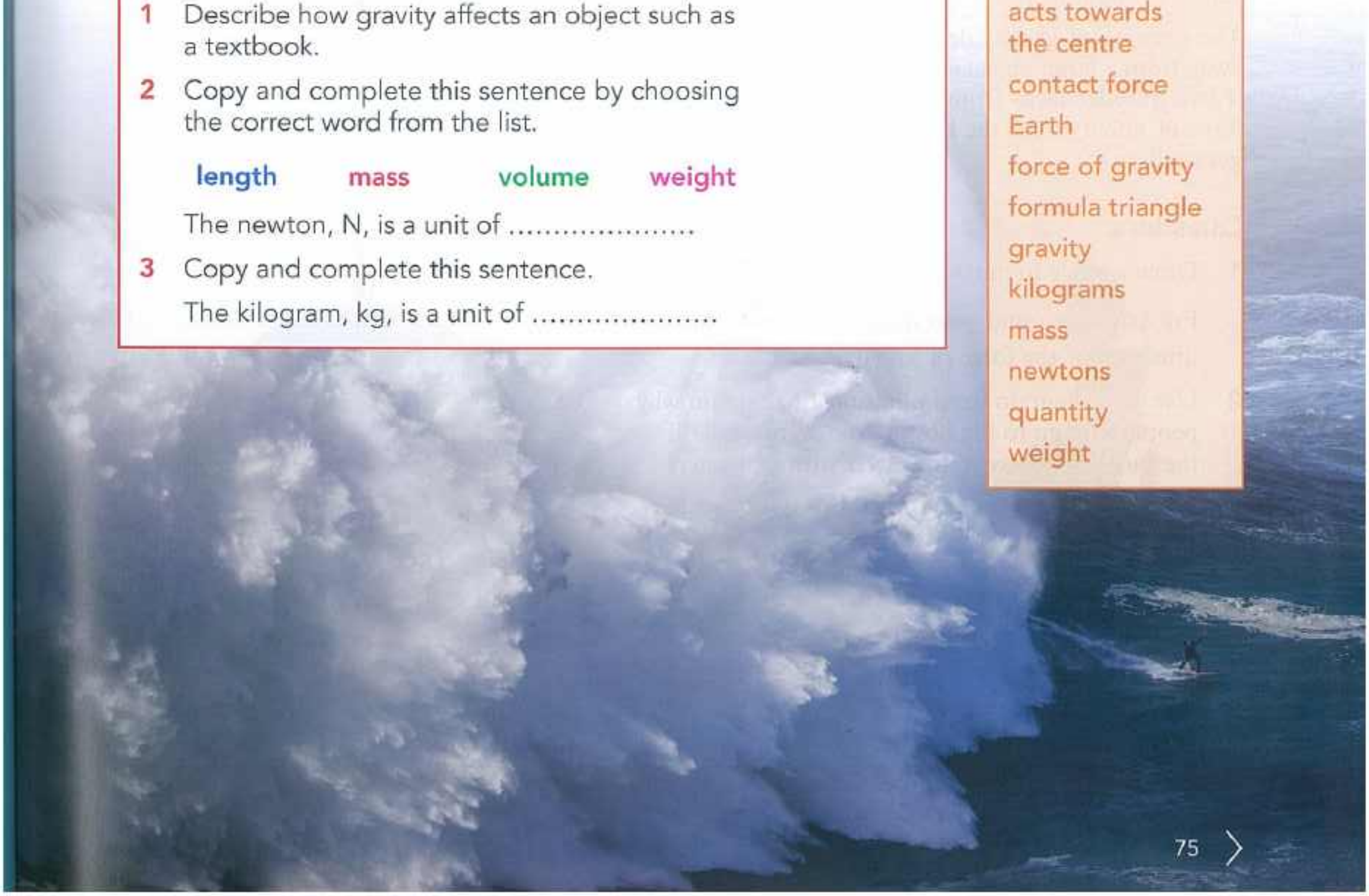
The newton, N, is a unit of ....

3 Copy and complete this sentence.

The kilogram, kg, is a unit of ....

Key words

accurate
acts towards the centre
contact force
Earth
force of gravity
formula triangle
gravity
kilograms
mass
newtons
quantity
weight



Gravity

When you drop an object, it falls to the ground.

What pulls the object down?

The **Earth** you live on is a large object with a **mass** of about 6 000 000 000 000 000 000 000 000 kg.

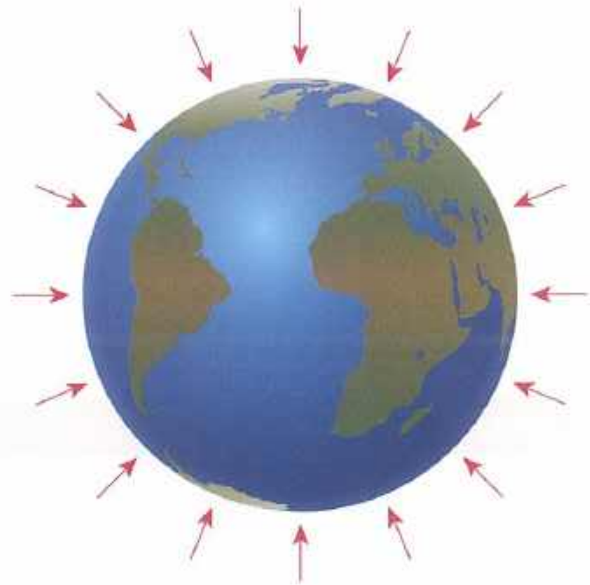
Objects with large mass, such as the Earth, cause strong forces of **gravity**.

All objects, even pens and pencils, cause forces of gravity. Objects with small mass, such as pens and pencils, cause very weak forces of gravity. That means we do not notice other objects being attracted to them.

The force of gravity caused by an object **acts towards the centre** of the object.

You can imagine the Earth as a giant ball in space. The **force of gravity** at positions around the Earth acts towards the centre. That means when you drop an object, the object falls in a line that points towards the centre of the Earth.

The strength of gravity decreases as you go further away from a large object such as Earth. For example, if you travelled away from Earth in a spacecraft, the force of gravity from the Earth acting on you would get smaller.



The force of gravity caused by the Earth acts toward the centre of the Earth.

Questions

1 Draw a circle to make a diagram of the Earth.

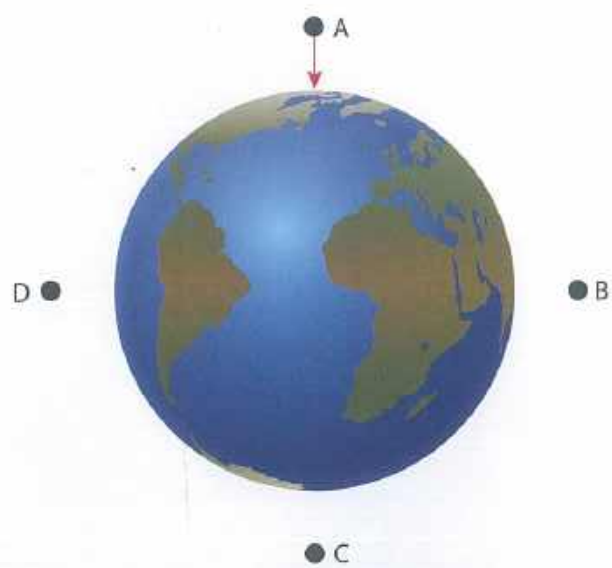
Put arrows around your diagram to show the direction of the force of gravity.

2 Use your diagram from question 1 to explain why people who go to the South Pole do not fall off the Earth. Discuss your answer with a partner.

3 The diagram shows the Earth. It is not to scale.

A ball is dropped from four different places, A, B, C and D.

On a new diagram, draw arrows to show the direction in which each ball will fall. The first one has been done for you.



4 The Moon has a mass of about 70 000 000 000 000 000 000 000 kg.

Some people think there is no gravity on the Moon. Are they correct? Use the information in this question to explain why.

Weight

The force of gravity on an object is called its **weight**.

It is difficult to lift a heavy object because gravity is pulling it towards the centre of the Earth. By lifting, you are pulling against gravity.

Weight is a force and it is measured in **newtons**, N. The weight of an apple is about 1 N. That means gravity from the Earth is pulling on the apple with a force of 1 N. You need to apply a force of 1 N to hold the apple.

The weightlifter in the picture is holding about 1000 N!

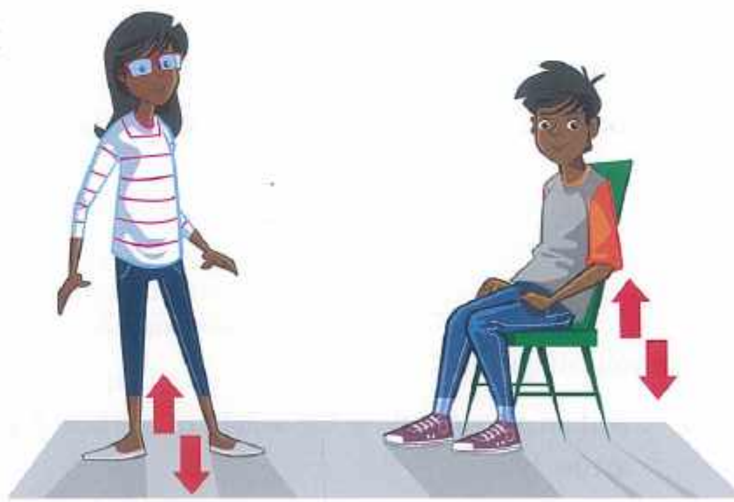
The force of gravity is making it difficult to hold these weights. You can see the effect of the force bending the bar.

The contact force

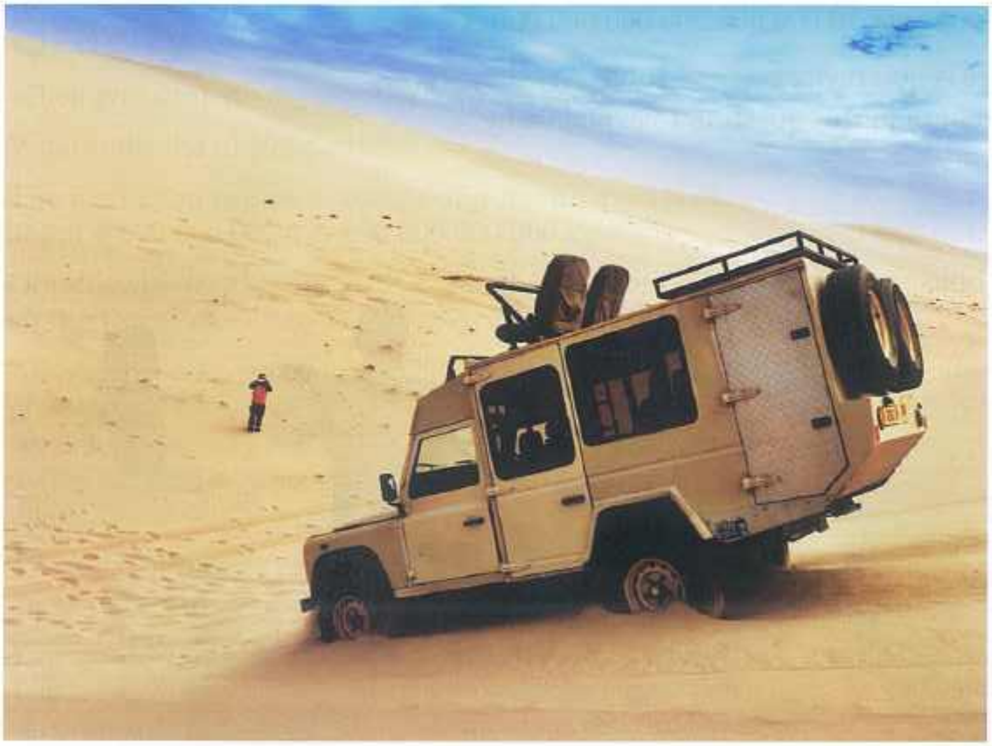
When a book with a weight of 5 N is resting on a desk, gravity is still pulling it down with a force of 5 N. So why is the book not moving down through the desk?

The answer is because the desk is pushing back up on the book with an equal force of 5 N.

This force from the desk is called the **contact force**. The contact force acts up from any surface to support an object. The contact force is always equal to the weight of the object when the surface is not moving.



Your weight pulls you down, but an equal contact force pushes you up.



The weight of this vehicle is greater than the contact force from the sand.

Sometimes the weight of the object is larger than the contact force. If this happens, the surface will break, or the object will sink into the surface.

Can you think of any other examples where the weight of an object is larger than the contact force? Discuss your answers in pairs.

Questions

5 The diagram shows a box on a desk. Copy this diagram.

On your diagram:

a add an arrow to show the weight of the box. Label this arrow *W*.

b add an arrow to show the contact force from the desk. Label this arrow *C*.

6 A large rock rests on the ground. The weight of the rock is 8000 N.

Write down the size of the contact force from the ground.

7 An elephant is standing on four feet. The weight of the elephant is 40 000 N. The weight acts equally on each foot.

Calculate the contact force from the ground on each of the elephant's feet.

8 A car travels into soft mud. The contact force needed to support each wheel is 24 000 N.

  a At first, the contact force from the mud on each wheel is 2000 N. Explain why the wheels will start to sink.

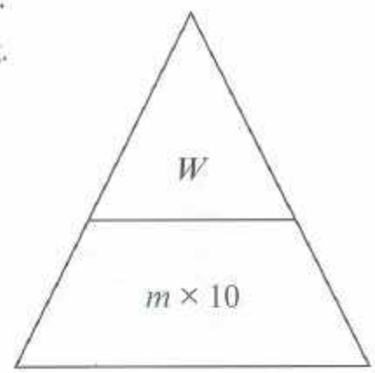
  b The contact force from the mud increases with depth. Explain what will happen to stop the wheels sinking.

Weight and mass

Weight is the force of gravity on an object. It is measured in newtons, N.

Mass is the **quantity** of matter in an object. It is measured in **kilograms**, kg.

People often confuse mass with weight. They often say things such as: 'The weight of my bag is 10 kg.' This sentence is not correct because it makes a statement about weight, but gives a mass. The correct sentence is: 'The mass of my bag is 10 kg.'



On Earth, the force of gravity is 10 N on every 1 kg of mass.

Writing this as an equation:

$$\text{weight (N)} = \text{mass (kg)} \times 10 \text{ (N/kg)}$$

or, using letters:

$$W = m \times 10$$

You can use a **formula triangle** for this equation.

To use a formula triangle, cover the part of the equation that you want to find. Then, do the calculation that is shown in the uncovered part.

For example, if you want to find the mass, you cover the m.

The uncovered part is then $\frac{W}{10}$

Divide the weight by 10 to get the mass.

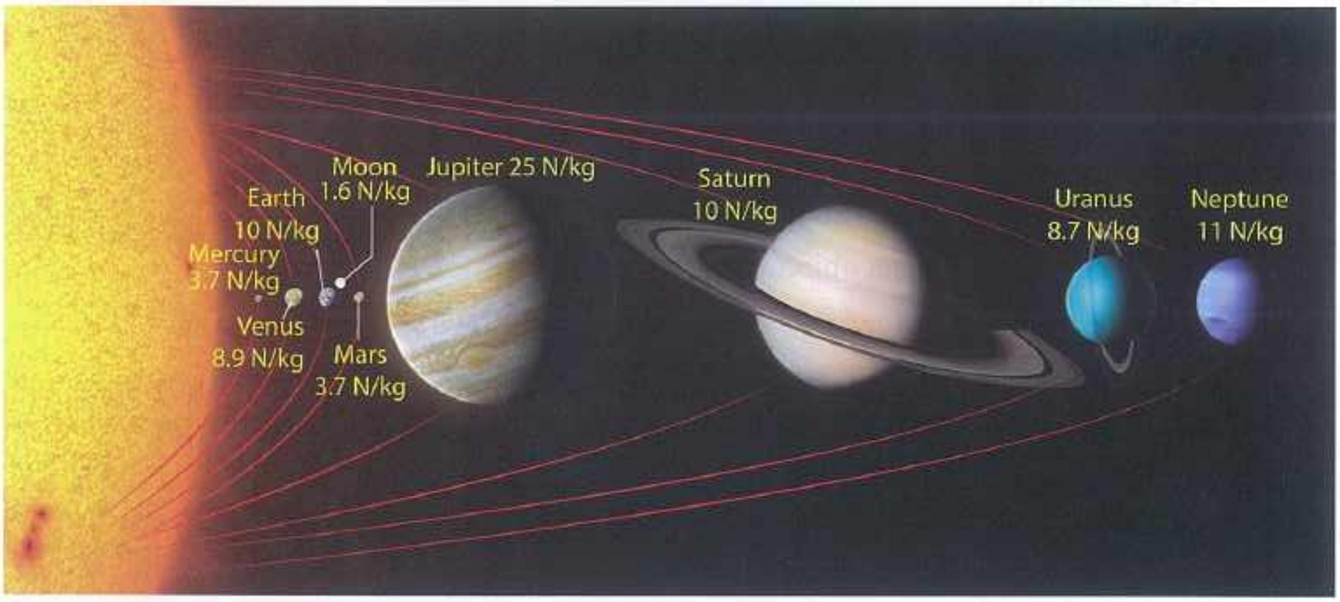
Remember that m must be in kg.

The force of gravity that pulls on 1 kg tells you the strength of gravity. On Earth, this is 10 N

As 10 N acts on 1 kg, you say this as '10 newtons per kilogram', or 10 N/kg. For example, if a person has a mass of 45 kg, their weight on Earth is $45 \times 10 = 450$ N.

You can use the equation to calculate mass if you know the weight. For example, a computer games console has a weight of 28 N. The mass of the console is $\frac{28}{10} = 2.8$ kg.

The strength of gravity is not 10 N/kg in all parts of the Solar System.



The diagram shows the strength of gravity in some other parts of the Solar System.

The weight of an object changes when the strength of gravity changes. If you want to calculate your weight somewhere different from Earth, you can use the same equation but you must change the number 10 to the value of the strength of gravity wherever you are calculating it.

The mass of an object does not change.

Questions

9 The strength of gravity is 10 N/kg on Earth.

- **a** Calculate the weight of an adult who has a mass of 75 kg.
- **b** Calculate the mass of a car that has a weight of 8500 N.

10 Use the information in the diagram of the planets on the previous page to answer these questions.

- **a** Give the location where your weight would be greatest.
- **b** Name the planet where you would have the same weight as on Earth.
- **c** Calculate the weight of a 25 kg mass on Mars.
- **d** Explain how your mass on Earth would compare with your mass on Mercury.

11 When you stand on scales you see your mass in kg. Explain whether it is your mass or your weight that makes the scales work.

Discuss your answer with a partner.

12 In 1969, a spacecraft carrying people went from the Earth to the Moon. The people explored part of the Moon. The spacecraft then brought the people back to Earth.

Explain why a larger force is needed for a spacecraft to go from Earth to the Moon than to come back from the Moon to the Earth. Use the information in the picture from the previous page. Assume the mass of the spacecraft is the same on both journeys.

Activity

Mass or weight?

On a large piece of paper, draw a table with two columns: one for mass and one for weight.

Each of the statements below should start with **either** the word 'mass' **or** the word 'weight'.

Work in pairs to decide in which column to put each of the statements.

When you have decided, write the statement in the appropriate column.

The statements are:

... of an object is affected by the strength of gravity on a planet.

... is measured in newtons, N.

... is measured in kilograms, kg.

... is not affected by gravity.

... of an object decreases as the object moves further away from Earth.

... is the quantity of matter in an object.

continued...

Continued

... can be measured in grams, g.

... is the force needed to lift an object.

... is equal to the contact force on a level surface that is not moving.

... is the property of a planet that makes it have gravity.

- How did you decide which statements were about weight and which were about mass?
- Did your strategy work?
- Could you use this strategy again, or would you change it?

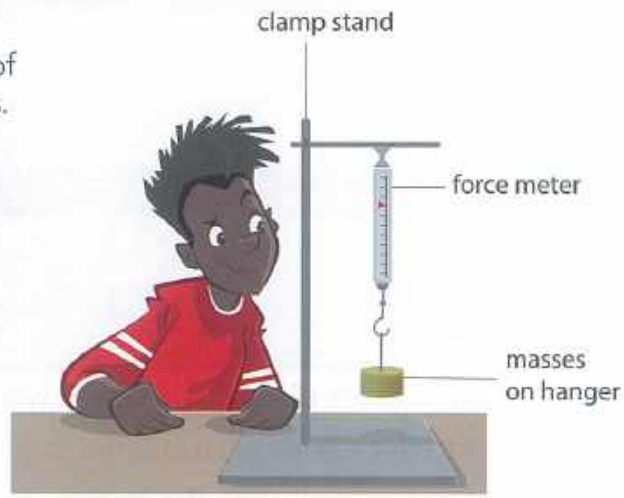
Think like a scientist

Linking weight and mass

In this investigation, you will find the weights of some masses and draw a graph of your results.

You will need:

- force meter, clamp stand, mass hanger and masses



Finding the weight of a mass.

Set up the equipment as shown in the diagram. Make sure the clamp stand will not fall over. Keep the force meter clamped as low as possible.

1 Start by hanging the force meter from the clamp stand. Leave enough space to hang the masses, remembering that the spring will extend.

2 Hook the 100 g mass hanger to the force meter. Record all your results using the kg unit for mass. Remember that 100 g is 0.1 kg.

3 Using the force meter, carefully measure the weight. Remember that this result is in newtons, N.

4 Increase the mass by adding one100 g mass at a time. (That is the same as adding 0.1 kg each time.) Use the force meter to measure and record the weight after every increase.

Continued

5 Record the weights in a table. Remember to put the units in the column headings and not in the table itself.

6 Measure the weights as accurately as possible. Being **accurate** means being close to the true value.

7 Your results should go from 0 up to 1.0 kg.

8 Draw a line graph of your results. Put *mass in kg* on the horizontal axis and *weight in* N on the vertical axis.

Questions

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

As the mass gets bigger, the weight gets … .

When the mass doubles, the weight … .

2 Is the weight of 1.0 kg exactly 10 N as in the equation $W = m \times 10$? If not, what is the weight of 1.0 kg?

3 The strength of gravity at the Earth's surface varies slightly between 9.7639 and 9.8337 N/kg

Explain why you can use the value of 10 N/kg instead of these more accurate values.

Self-assessment

1 For each of these statements about your experiment, decide how well you think you did.

- I worked safely, taking care not to drop any masses or knock the clamp stand over.
- I took the reading from the force meter as accurately as possible.
- I continued to record actual results, even when I thought I could see a pattern developing.
- I wrote down or drew my results clearly, so that someone else could understand them.
- I made my graph accurate and clear.

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

3 Write down:

- **one** thing that you could do better next time
- how you will try to improve next time.

Summary checklist

- [ ] I can describe why objects such as planets have gravity.
- [ ] I can describe how the force of gravity acts around the Earth.
- [ ] I can describe weight as the force of gravity on an object.
- [ ] I can describe mass as the quantity of matter in an object.
- [ ] I can understand the difference between weight and mass.
- [ ] I can use the mass of an object and the strength of gravity to calculate weight.

3.2 Formation of the Solar System

In this topic you will:

- learn about how scientists think the Solar System was formed
- think about objects in space growing larger and increasing in mass
- understand that as these objects increase in mass, their gravity increases
- understand that as their gravity increases, they can attract even more mass.

Getting started

Choose one correct answer to each question.

1 An object causes a strong force of gravity. What must the object have?

large size **large mass** **small size** **small mass**

2 Which of these objects has the largest mass in the Solar System?

Earth **Jupiter** **Sun** **Neptune**

3 Which of these objects is at the centre of the Solar System?

Earth **Moon** **Mercury** **Sun**

Key words

axis
contradict
evidence
formed
model
nebula
observe
orbit
plane
spin
support

Where did the Solar System come from?

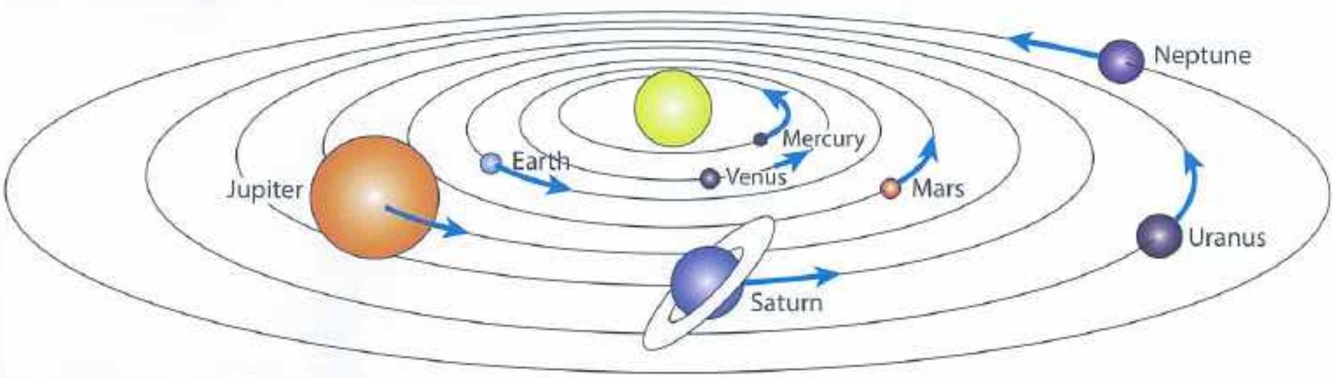
When the Solar System **formed**, there were no people to **observe** how it was made. Observe means to watch something happening. So how do we know what happened?

Scientists can try to solve a problem like this in two different ways.

- They can look for **evidence**, in the form of facts from observations or experiments to support their theory, and then try to explain what they have found.
- They can think of a testable theory, called an hypothesis, and then look for evidence to support the hypothesis.

Facts about the Solar System

Look at the diagram of the Solar System.



Here are some facts about the Solar System:

- All the planets in the Solar System follow a path or **orbit** around the Sun in the same direction.
- The Sun and all the planets (except Venus and Uranus) **spin** on their **axes (singular: axis)** in the same direction.
- Most of the moons of the planets orbit their planets in the same direction as the planets rotate around the Sun.
- The direction of spin of the Sun and the planets (except Venus and Uranus) is the same as the direction in which the planets orbit the Sun.
- All the planets orbit the Sun in the same **plane**. Objects that are in the same plane could all be placed on the same flat surface, just like all the objects on a desk. That means the Solar System looks flat.

Scientists can use these facts as evidence.

Watching the birth of stars

Scientists can see distant stars forming in other parts of space. These stars are being formed from clouds of dust and gas.

A cloud of dust and gas in space is called a **nebula**. The picture shows one of these clouds of dust and gas. You can see the young stars in the cloud.

Some young stars can also be seen with a flat disc of dust around them.

Scientists think our Solar System was formed this way.

The Orion Nebula – stars are being born here.

Using models

Scientists cannot observe a star or Solar System forming in an experiment.

Instead they use computers to create **models**. A model is a way of representing something that is difficult to observe directly.

The scientists put many of the known laws of physics into a computer program. Then the computer uses this information to predict what will happen, starting with a cloud of dust and gas.

The result is a prediction that a star will form, surrounded by planets.

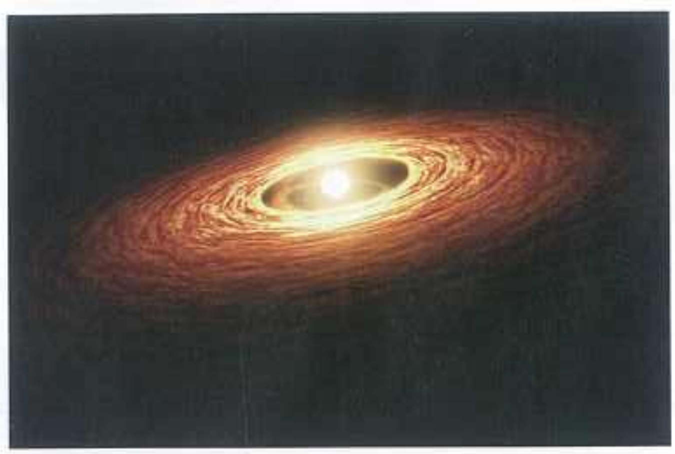
How do stars and planets form out of dust and gas?

The picture shows what scientists think our Solar System looked like as it was forming.

You saw in Section 3.1 that any object can act as a source of gravity.

All the particles of dust and gas in the pictures have their own weak gravity.

The particles of dust and gas pull on each other with very weak forces due to their own gravity. As they stick together, their total mass increases. As their mass increases, so does the strength of their gravity. That means they attract more dust and gas with a stronger force.



This is how our Solar System may have looked 4.6 billion years ago.

This starts to form a small ball.

Gradually, this ball gets bigger.

If the ball gets beyond a certain size, it will get hot enough to become a star. Otherwise it will become a planet.

It takes millions of years to form a star or a planet.

Most of the facts about the Solar System **support** or agree with this hypothesis.

The fact that Venus spins on its axis in the opposite way to all the other planets seems to **contradict** this hypothesis. Contradict is the opposite of support – it means to go against something.

Scientists think the planet Jupiter almost reached the size to be a star.

Questions

1 Use words from the list to copy and complete this sentence.

different directions	**the same direction**
opposite directions	**random directions**

All the planets in the Solar System orbit the Sun in ….

2 All the planets in the Solar System orbit the Sun in the same plane.

Explain what 'the same plane' means.

3 Which of these is the name given to a cloud of dust and gas in space?

planet **star** **nebula** **moon**

4 Name the force that can pull particles of dust and gas together in space.

Activity

Solar System story board

Work in groups.

Use a large piece of paper to make a storyboard to tell people about how the Solar System formed. A storyboard is a series of drawings that tell a story. There can be writing with the drawings.

In your storyboard you should show:

- a nebula and what it contains
- how a star such as the Sun forms
- how planets form around the Sun.

Include in your storyboard reasons why:

- all planets orbit the Sun in the same direction
- most of the planets spin on their axes in the same direction.

Self-assessment

1 For each of these statements about your experiment, decide how well you think you did.
   - I contributed ideas to the group.
   - I worked in a team, cooperating with others.
   - I thought the storyboard communicated ideas clearly.
2 Write down the most interesting thing you learned about the formation of the Solar System.
3 Write down one thing that still puzzles you about the formation of the Solar System.

Think like a scientist

Using models

In this task you will be thinking about how scientists use models and how they use an hypothesis.

Scientists use computers to model how the Solar System was formed.

One reason for using a model is that it takes millions of years to form a star and planets from a cloud of dust and gas. A model can speed this up.

Continued

Questions

1 Suggest **one** other reason for using a model in this way.

2 Models are not real, so may not be accurate.

Which term describes this?

an error **a mistake** **a limitation** **a strength**

3 Look at the facts about the Solar System given earlier in this section.

Scientists use facts like these to support their hypothesis of how the Solar System formed. An hypothesis is a theory or idea that is testable.

a Give **two** facts about the Solar System that seem to contradict this hypothesis.

b Explain why these facts seem to contradict the hypothesis.

4 Which **two** of these statements describe the hypothesis of how the Solar System formed?

- It has been proven to be correct.
- Most, but not all, of the evidence supports it.
- The model that is used has limitations.
- It can be fully tested by experiments.

Summary checklist

- [ ] I can recall that there are clouds of dust and gas in space.
- [ ] I can recall that stars and planets are formed from dust and gas.
- [ ] I can understand that gravity can pull particles of dust and gas together.
- [ ] I can describe how stars and planets are formed.
- [ ] I can understand how scientists use a model to test an hypothesis.

> 3.3 Movement in space

In this topic you will:

- learn about what keeps the planets in orbit around the Sun
- understand why planets move at different speeds
- discover why objects moving in space do not slow down as they do on Earth.

Getting started

1 Write the names of the planets in order, starting with the one that is closest to the Sun.

2 Name the object that orbits the Earth and not the Sun.

Key words

air resistance
circular
speed
vacuum

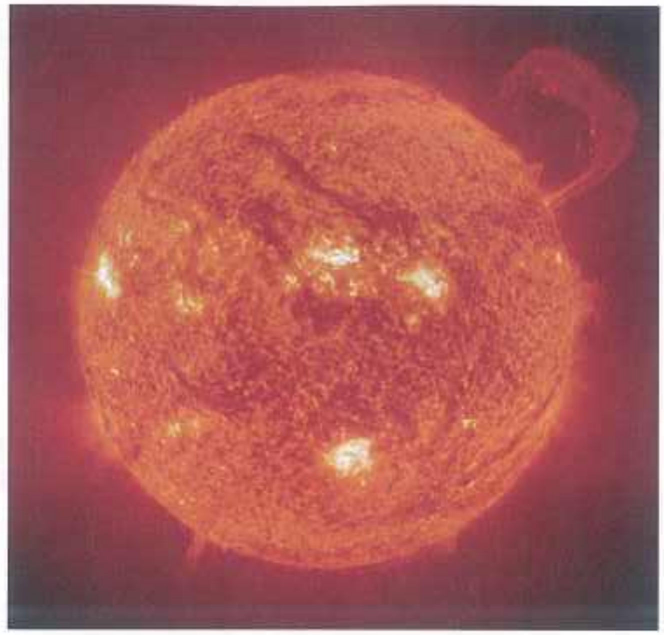
The Sun

In Section 3.1 you saw that objects with more mass have more gravity.

The Sun is the object with the largest mass in the Solar System.

The mass of the Sun is 330 000 times greater than the mass of the Earth. In fact, the mass of the Sun is more than the mass of all the other planets added together!

The strength of gravity on Earth is 10 N/kg. On the Sun it is 270 N/kg



This photograph of the Sun was taken from a spacecraft using a special camera. You should **never** look directly at the Sun or try to photograph it yourself.

The Sun's gravity

The Sun's gravity is 27 times stronger than the Earth's gravity.

It holds all the planets in their orbits. The Sun's gravity gets weaker as the distance from the Sun increases.

The planet Neptune is 30 times further from the Sun than Earth is. The mass of Neptune is about 17 times the mass of Earth. So although the Sun's gravity gets weaker, it is strong enough to hold Neptune in orbit.

Orbits of planets

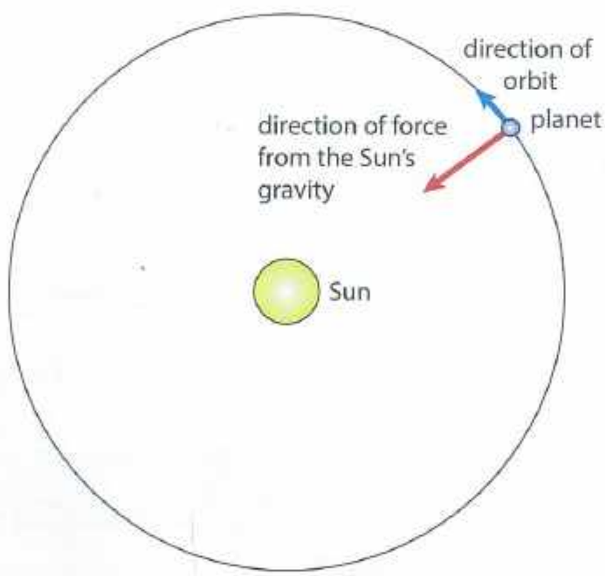
The orbits of the planets, including Earth, are almost **circular**. Circular means in the shape of a circle.

To keep any object moving in a circle, there needs to be a force causing it to turn.

The diagram shows how the force of gravity acts on a planet to keep it in orbit.

The force of gravity from the Sun that acts on a planet always acts towards the Sun.

If this force did not act, the planet would travel off in a straight line into space!



The force of gravity from the Sun keeps a planet in orbit. The diagram is not to scale.

Mercury, which is the closest planet to the Sun, has the strongest pull from the Sun's gravity.

This causes Mercury to orbit with the highest **speed** of all the planets. The average speed of Mercury around the Sun is 170 000 km/h! The average speed of the Earth around the Sun is about 100 000 km/h.

Speed in space

On Earth, all objects that move have forces acting on them to slow them down.

Air resistance is one of those forces. It is caused by a moving object having to push against the particles in the air. Air resistance acts in the opposite direction to movement.

The faster an object moves, the greater the air resistance on the object.

Look at the picture of the aeroplane wing.

This aeroplane has landed and is using extra air resistance to help it slow down.

The aeroplane can slow down faster with extra air resistance. The shape of the wing can be changed to produce extra air resistance.

In space there is no air. There are very, very few particles in space. A space where there are no particles is a **vacuum**.

Look at the spacecraft in the picture.

This spacecraft reached a speed of 266 000 km/h in July 2016.

This spacecraft, called the Juno probe, would have a lot of air resistance if it were moving on Earth.

In space, where there is a vacuum and no air resistance, the Juno probe reached a speed of 266 000 km/h as it passed Jupiter. It became the fastest object that people had ever made.

This speed would not be possible for the Juno probe on Earth because of air resistance.

Earth and the other planets are also moving in a vacuum. This means there is no air resistance to slow them down.

The only force acting on the planets is from gravity.

Questions

1 State the direction in which the force of gravity from the Sun pulls on a planet.

2 Other objects, such as comets and asteroids, also orbit the Sun. Suggest what keeps these other objects in orbit around the Sun.

3 The Sun has the strongest gravity in the Solar System.

Suggest which object in the Solar System has the second strongest gravity.

Discuss your answer in pairs.

4 State the word used to describe a space that has no particles in it.

5 Voyager 1 is a space probe launched in 1977. Voyager 1 is now outside the Solar System and is travelling at 64 000 km/h. Explain why Voyager 1 could not travel at this speed on Earth.

6 Which of these forces acts on the Earth as it orbits the Sun?

gravity only **air resistance only** **gravity and air resistance** **gravity, air resistance and friction**

7 The orbits of the planets are not exact circles. The distance from the Sun of each planet varies slightly as it goes around in its orbit. This change in distance makes the speed of the planet change slightly.

Suggest how the speed of a planet changes with distance from the Sun during its orbit.

Activity

Planet speeds

The table, which continues on the next page, shows the average speed of each planet's orbit around the Sun.

The speeds are given in kilometres per second (km/s) as they are so fast.

Name of planet	Speed of orbit in km/s
Mercury	48
Venus	35
Earth	30
Mars	24
Jupiter	13

Continued

Name of planet	Speed of orbit in km/s
Saturn	10
Uranus	7
Neptune	5

Use the information in the table to draw a bar graph.

Put the names of the planets, in order from Mercury, across the horizontal axis. Space them evenly so your bars are not touching.

Questions

1. Copy and complete the sentence.
   As the distance from the Sun increases, the speed of orbit of the planets … .
2. Explain the advantages of presenting this information in a graph rather than in a table.
3. Explain the reason for the trend in your graph.
4. Explain why a bar graph is used for this information rather than a line graph.

Self-assessment

1. For each of these statements about your activity, decide whether you did it very well, fairly well or not at all.
   - I drew a bar graph with the correct information.
   - My bars were evenly spaced and not touching.
   - All my lines were drawn with a pencil and ruler.
   - All my bars were the correct height.
   - I understood the advantages of drawing a graph to display information.
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

Discovering planets

In this task you will find out about how scientists discovered the planet Neptune.

The planet Uranus was discovered in the year 1781. It was thought to be the most distant planet from the Sun.

In 1821, a French scientist called Alexis Bouvard made calculations about the orbit of Uranus. He worked out where Uranus would be at different times.

Continued

1 The actual orbit of Uranus was different to the calculations.

Which one word best describes these calculations?

observations | predictions | conclusions | measurements

2 The planet was seen to move further away from the Sun at regular times.

These results were recorded.

Which word best describes these results?

observations | predictions | conclusions | secondary information

3 Scientists thought that another source of gravity was pulling Uranus further from the Sun.

Which word best describes this statement?

observation | conclusion | measurement | secondary information

4 Scientists then made predictions about another planet further away than Uranus.

They used the results from the orbit of Uranus to predict where this other planet would be.

Then, in 1846, scientists found another planet, which they called Neptune.

Neptune was very close to where they predicted it would be.

Use words from the list to copy and complete these sentences.

Uranus moving further away from the Sun ______________ the original prediction about its orbit.

Scientists found Neptune using careful ______________

testable | a fair test | contradicted | results

conclusions | supported | observations | measurements

Summary checklist

- ☐ I can name the force that keeps the planets in orbit around the Sun.
- ☐ I can describe the direction that this force acts on a planet.
- ☐ I can understand why planets closer to the Sun move faster.

› 3.4 Tides

In this topic you will:

- find out what tides are
- learn about tidal forces and where they come from
- discover how tidal forces affect the oceans and the land.

Getting started

Work in groups to answer these questions.

1. Which object has the strongest gravity in the Solar System?
2. What large object orbits the Earth?
3. What force keeps the object that orbits the earth in its orbit?

Key words

coastal
depth
earthquake
earth tide
force of attraction
harbour
tidal force
tidal range
tide

What are tides?

In some parts of the world, the **depth** of the ocean changes by several metres during the day. The depth is the distance from the surface of the water to the bottom of the ocean.

The picture shows the same place at two different times. The pictures were taken six hours apart.

This change in depth of the water is called a **tide**.

Tides change the depth of the oceans. High tide (left) and low tide (right) are six hours apart.

The difference in depth of the water between high and low tides is the **tidal range**.

The largest tidal range in the world is 16.3 m in the Bay of Fundy in Canada.

Some of the smallest tidal ranges in the world are less than 1 m in the Caribbean and Mediterranean seas.

Tides also cause the land to change in height through the day! This is called **earth tide**. The tidal range due to earth tide is about 30 cm

High tides are about 12 hours apart. Low tides are also about 12 hours apart. The time between high and low tide is six hours.

What causes tides?

The Moon orbits the Earth.

The Moon stays in orbit because of the force of gravity from the Earth but the Moon also has gravity, and this gravity pulls on the Earth.

As the oceans are made from water, the gravity from the Moon can pull the water more easily than the land.

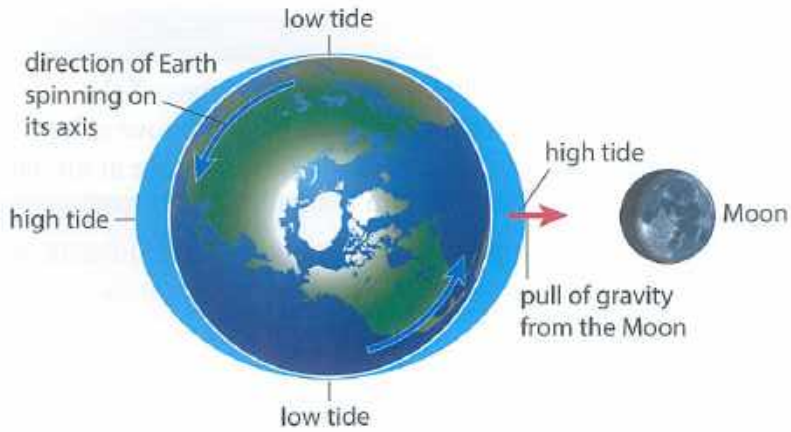
The pull from the Moon's gravity is called a **tidal force**. The diagram shows how this happens.

Look at the drawing of the Earth and Moon. The Earth is viewed from above the North Pole.

The side of the Earth closer to the Moon will have high tide.

The Earth takes 24 hours to spin on its axis.

This means that 12 hours later, the side that was closest to the Moon is now furthest away.



The blue shape around the Earth represents the ocean depth. The difference in depth is caused by the pull of gravity from the Moon. The drawing is not to scale.

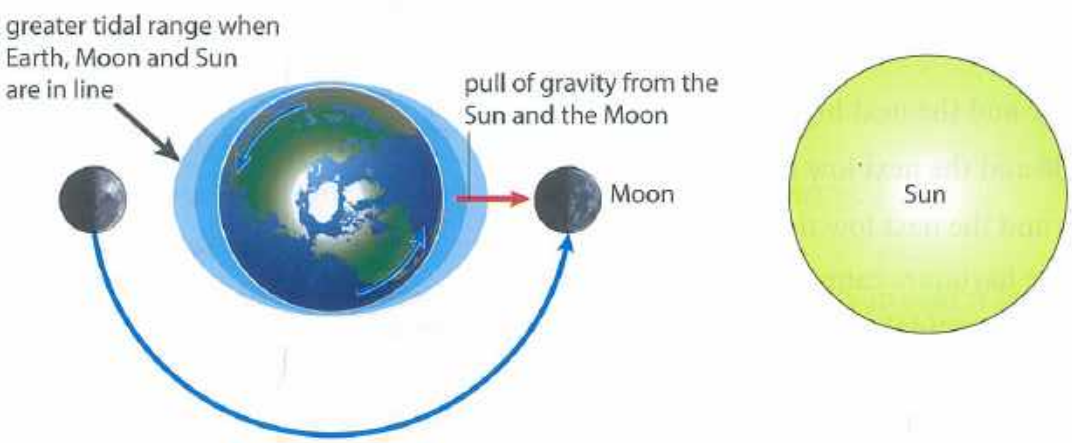
You can see from the drawing that the side furthest away also has a high tide.

This is why the time between high tides is 12 hours.

The Sun also produces a tidal force on Earth, but this is weaker as the Sun is further away than the Moon.

When the Sun and the Moon are in line with Earth, this produces a larger tidal force.

The next drawing shows how this happens.



Larger tidal forces affect the Earth when the Earth, Sun and Moon are in line. The drawing is not to scale.

Effects of tides

Some **harbours** can only be used at certain times of the day. If the water in the harbour is not deep enough, boats cannot move safely. Some harbours contain no water at low tide, so boats cannot move at all. Harbours are places where boats and ships can load and unload passengers and cargo.

In weather with strong winds, **coastal** areas are more likely to have flooding at times of high tides. Coastal areas are parts of the land that are close to the oceans.

The flow of water in and out of some coastal areas can be dangerous for small boats.

In some places, tides affect food chains, including the human food chain. For example, at low tide birds can eat some types of shellfish when they are not covered with water. Some types of fish move to find food according to tides in coastal areas.

Volcano eruptions have been linked with earth tides. By studying Earth tides, scientists may be able to predict when a volcano will become dangerous.

Earthquakes may also be linked with earth tides.

Movement of water with tides can be used to generate electricity.

Questions

1 Which of these causes the force of gravity for tides on Earth?

the Sun only **the Moon only** **the Sun and Moon** **the Sun, Moon and other stars**

2 What is the name given to the pull of gravity that causes tides?

high tide **low tide** **tidal range** **tidal force**

3 State the time between:

a one high tide and the next high tide

b one low tide and the next low tide

c a high tide and the next low tide.

4 Explain why some harbours cannot be used at low tide.

5 Explain why the largest tidal ranges happen when there is either a full moon or a new moon.

6 The average depth of water in a place near the coast of the Pacific ocean is 5.0 m.

The largest tidal range in that place is 2.0 m.

Calculate the maximum depth of water at that place.

Activity

Investigating tides

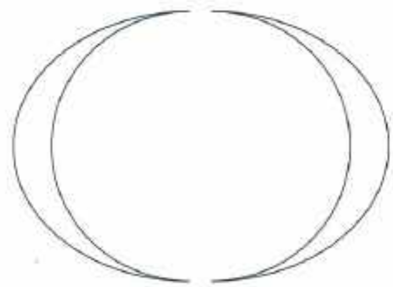
Work in groups.

You will need:

- card or paper, some circles to draw around, scissors

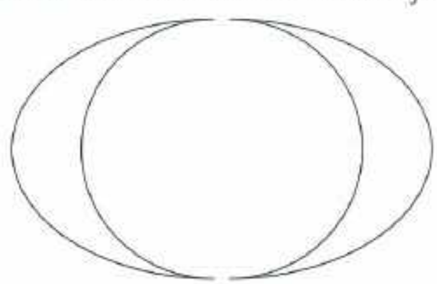
Take care when using scissors. Cut out a small, a medium and a large circle. Label these 'Moon', 'Earth' and 'Sun' in order of increasing size.

Next, cut out two thin crescents that will fit around your Earth, as shown here.



Call these two crescents 'set 1'.

Now, cut out two thicker crescents that will also fit around your Earth, as shown here.



Call these two crescents 'set 2'.

The crescents represent the ocean depth around the Earth.

Part 1: Why tides happen

For part 1, you do not need the shape that represents the Sun. Set it to one side for now.

Put the Earth and Moon on a desk about away from each other. This is not to scale.

Now put the crescents that represent the ocean depth, set 1, on either side of the Earth.

The deepest parts should be in line with the Moon.

Continued

Question

1 Why are the deepest parts of the oceans in line with the Moon?

Part 2: Times of the tides

Mark a point at the coast on your Earth. The activity will work best if you choose a point close to the edge of the circle, which is the equator.

Now, slowly turn your Earth. You should turn it in the opposite direction to the movement of the hands on a clock. You should only turn the Earth, not the ocean depth shapes as well.

Questions

2 How many high tides does your chosen point get in one full rotation?

3 How many low tides does your chosen point get in one full rotation?

4 The Earth takes 24 hours to rotate once like this. Try to use the model to explain why:

 a high tides are 12 hours apart

 b low tides are 12 hours apart.

5 The Moon does not stay in one place like this. It orbits the Earth.

 The Moon orbits the Earth in the same direction as the Earth rotates on its axis. A time of 29 days passes between the Moon being over the same position on Earth.

 a Explain whether high tides will happen at the exact same time each day.

 b Try to work out how much earlier or later high tides will be each day.

Part 3: Why tidal range also depends on the Sun

For part 3 you will need your shape that represents the Sun.

You will need to change the ocean depth shapes to set 2.

Put your Earth, Moon and Sun in a line like this (it is not to scale).

Questions

6 Explain why set 2 is now better than set 1 to show what happens with tides.

7 Name this phase of the Moon as it appears from Earth in this position.

Continued

8 Now move the Moon to the other side of the Earth, but keep the Moon, Earth and Sun in line.

Name this phase of the Moon.

9 a What can you conclude about the times when the highest tides happen, in terms of how the Moon appears?

b The length of time taken by the Moon to orbit Earth is called a lunar month. How many of these highest tides will occur each lunar month?

Self-assessment

In your groups, discuss each of these questions.

- What was my role in the group?
- How did my role help me understand the tides?
- How did other people in the group contribute to my understanding?

Think like a scientist

Discovering the causes of tides

In this task, you will find out about how scientists used evidence to discover what causes tides.

In 330 BCE, a sailor from Greece noticed that the depth of water in some parts of the oceans changed regularly.

He noticed that the depth increased to a maximum twice every day.

He thought that this was because of the Moon.

People in 330 BCE did not know about gravity.

1 Use words from the list to copy and complete the sentences.

a conclusion	an observation	a prediction
a measurement	an explanation	a model

The sailor noticed that the depth of water changed. This was ____________ .

The sailor thought that the change was caused by the Moon. This was ____________ .

The sailor did not know about gravity, so could not give ____________ for the tides.

Continued

Around the year 1600, a scientist from Germany suggested that there was a **force of attraction** between the Moon and water. He thought this force caused the tides.

People in 1600 still did not know about gravity.

This German scientist said that the force of attraction was magnetic.

We now know that the attractive force between the Moon and the water in the oceans is **not** magnetic.

2 Describe how you could test whether there is a magnetic force between the Moon and water in oceans.

People did not believe that the Moon or the Sun could have an effect on the oceans because gravity had not been described.

The problem of what causes tides was finally solved by Newton in the year 1687.

Newton had already described the effects of gravity.

He then used his ideas about gravity to calculate the tidal forces, without the need for experiments.

These calculations were accurate enough to show people that gravity from the Moon and the Sun caused the tides.

People then accepted that tidal forces were caused by gravity from the Moon and the Sun.

3 Which **two** statements explain why people accepted Newton's ideas about gravity?

- Newton did experiments on the tides that were fair tests.
- Newton provided evidence to support an hypothesis.
- Newton made observations whereas previous scientists did not.
- Newton made predictions that were shown to be accurate.

Summary checklist

- [ ] I can understand what tides are.
- [ ] I can understand where tidal forces come from.
- [ ] I can explain the part played by the Moon in causing tides.
- [ ] I can explain the part played by the Sun in causing higher tides.
- [ ] I can understand why there are two high tides and two low tides every day.

3.5 Energy

In this topic you will:

- find out what energy is
- learn about different energy stores and transfers
- discover some of the ways in which energy can be stored more easily than in others.

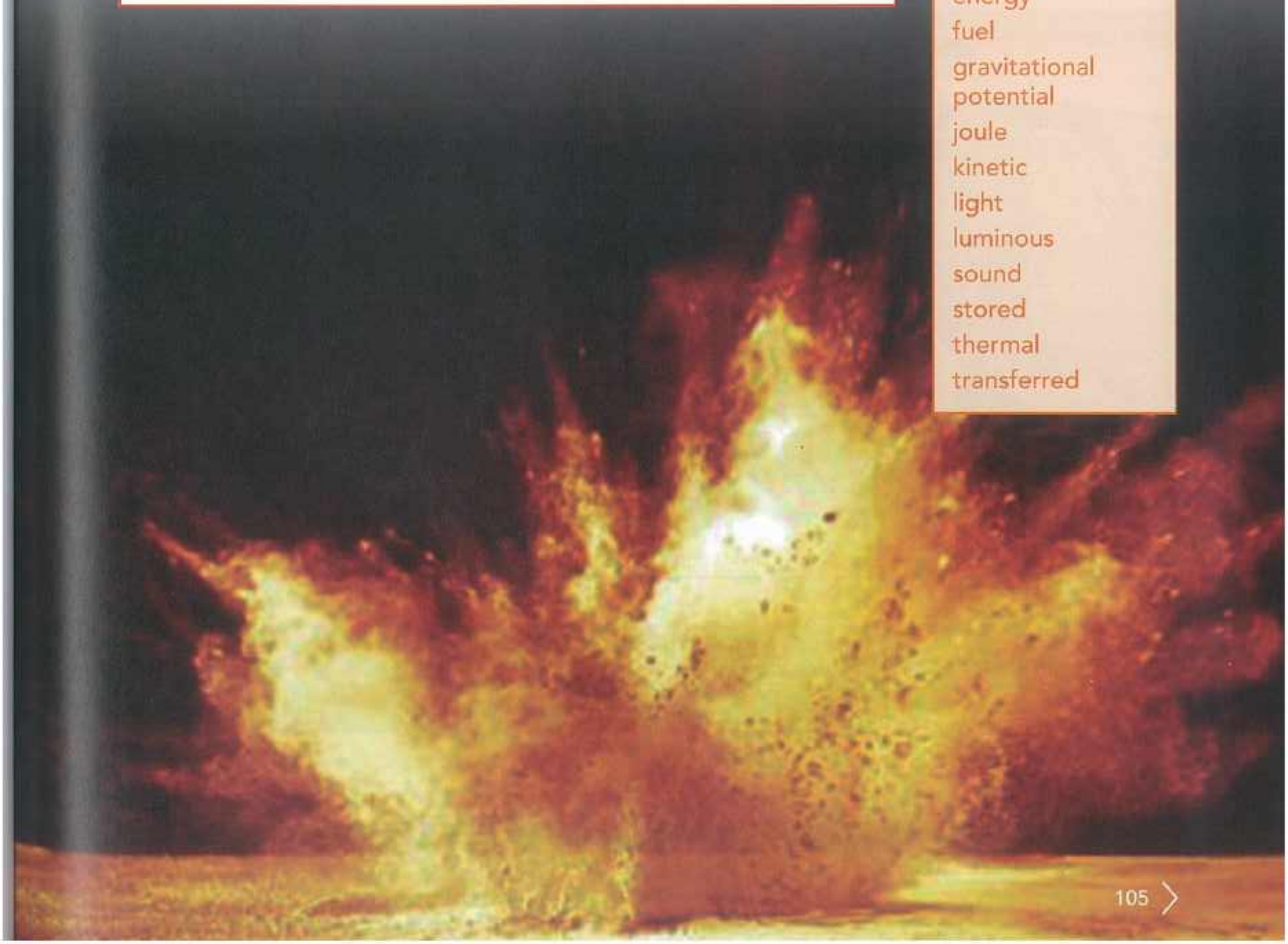
Getting started

With your partner, make a list of:

1 some things that you need energy to do
2 some of the types of fuel that you know.

Key words

chemical
elastic potential
electrical
energy
fuel
gravitational potential
joule
kinetic
light
luminous
sound
stored
thermal
transferred



What is energy?

Energy is something that must be changed or **transferred** in order to do something.

There are many different ways that energy can be **stored** or transferred. For example, kinetic energy is the energy in movement.

The unit for measuring energy is called the **joule** (J).

You need about:

- 2000 J to walk up the stairs between two floors in a building.
- 200 J for every metre you run
- 400 000 J to bring 1 litre of cold water to boiling point.

Energy stores and transfers

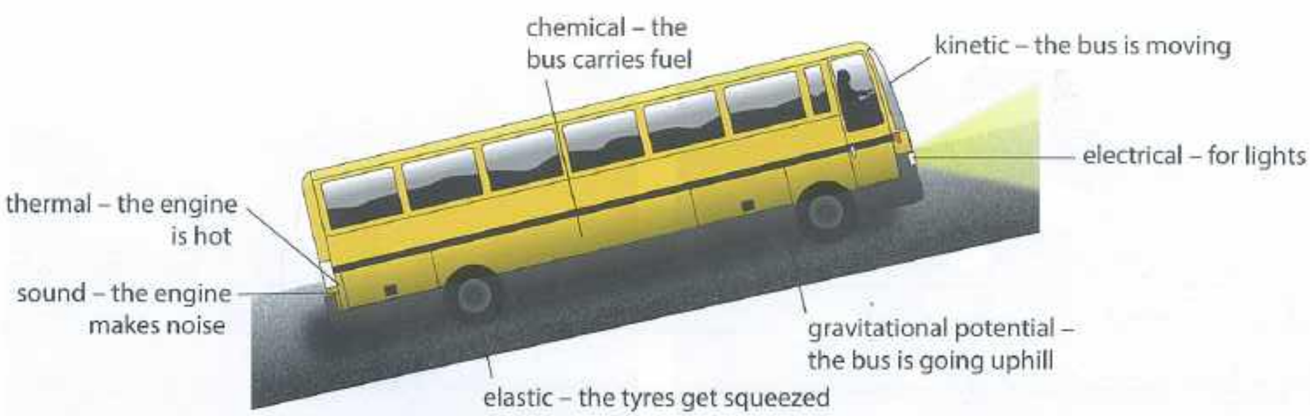
There are many different ways in which energy is being stored or transferred around you all the time.

These runners have kinetic energy because they are moving.

The table describes some of these stores and transfers.

Energy	Description	Energy store or energy transfer
kinetic	energy stored due to movement of an object	store
chemical	energy stored in food, batteries, chemical **fuels** such as wood, oil and coal	store
thermal	heat energy stored in hot objects and transferred to colder objects	store or transfer
elastic potential	energy stored when things are stretched or squeezed to change their shape	store
gravitational potential	energy stored when an object is lifted away from a source of gravity	store
electrical	the flow of current in a circuit transfers electrical energy	transfer
sound	energy transferred from vibrating objects	transfer
light	visible energy from **luminous** objects (objects that give out their own light) that you can see	transfer

Look at the descriptions of energy in the picture.



- How will you learn the different stores and transfers of energy?
- Can you think of a way to help you remember them?

Storing energy

Energy can be stored more easily in some ways than in others.

For example, you can keep uncooked rice for a long time. That is a store of chemical energy.

Coal and crude oil are stores of chemical energy that formed millions of years ago. This shows that some energy stores can last for a very long time. A battery is another example of how chemical energy can be stored. It is quite easy to store chemical energy.

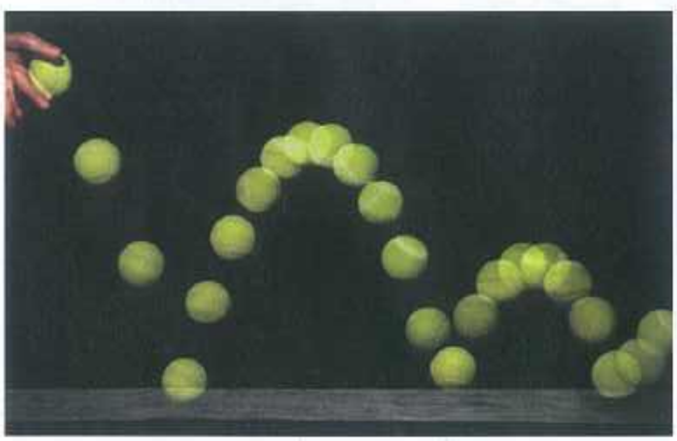
Gravitational potential energy is also easy to store. The picture shows a tank containing water. A pump has been used to lift up the water. The water stores gravitational potential energy.

Some energy stores only last for a short time.

Thermal energy (heat) is one example. Hot objects will eventually cool down (they will lose their store of thermal energy).

Kinetic energy is another example. Kinetic energy is more difficult than chemical or gravitational potential energy to store.

The tennis ball in the picture has a store of kinetic energy while the ball is moving, but the ball will eventually stop moving.



Questions

1 Look at the picture of the circuit.

Copy and complete these sentences. Choose from the stores and transfers of energy you have learnt about.

a ____________ energy is stored in the battery.

b ____________ energy is transferred in the wires.

2 Name the energy store in each of these. There may be more than one for each.

a food

b gasoline (petrol)

c a falling rock

d a book that has been lifted up onto a shelf

3 a Name two energy stores that will last for a long time.

b Name one energy store, apart from thermal energy, that will not last for a long time.

4 Describe an example that shows thermal energy cannot be stored for a long time.

5 The human population in the world is growing. Many countries are developing rapidly.

Explain how this is affecting the amount of energy being used in the world. Use some examples of different energy stores and transfers in your answer.

Discuss your answer with a partner.

Activity

Finding energy stores and transfers

You will need some magazines with pictures that can be cut out.

Work in pairs or small groups.

Look for pictures that show different energy stores and transfers. Some pictures may show more than one.

Cut out the pictures.

Stick the pictures on a large sheet of paper to make a poster.

Continued

Your poster should show as many energy stores and transfers as possible.

Make sure the energy stores and transfers in each picture are clearly labelled.

Peer assessment

Swap posters with another group.

1 Does the poster show all the energy stores and transfers?
2 Are all the energy stores and transfers clearly labelled?
3 What did you like about the other group's poster?
4 Suggest **one** way that the other group might be able to improve their poster.

Summary checklist

- [ ] I can recall the ways that energy is stored and transferred.
- [ ] I can describe each energy store and energy transfer.
- [ ] I can give examples of each energy store or transfer.
- [ ] I can understand that some energy stores last longer than others.

› 3.6 Changes in energy

In this topic you will:

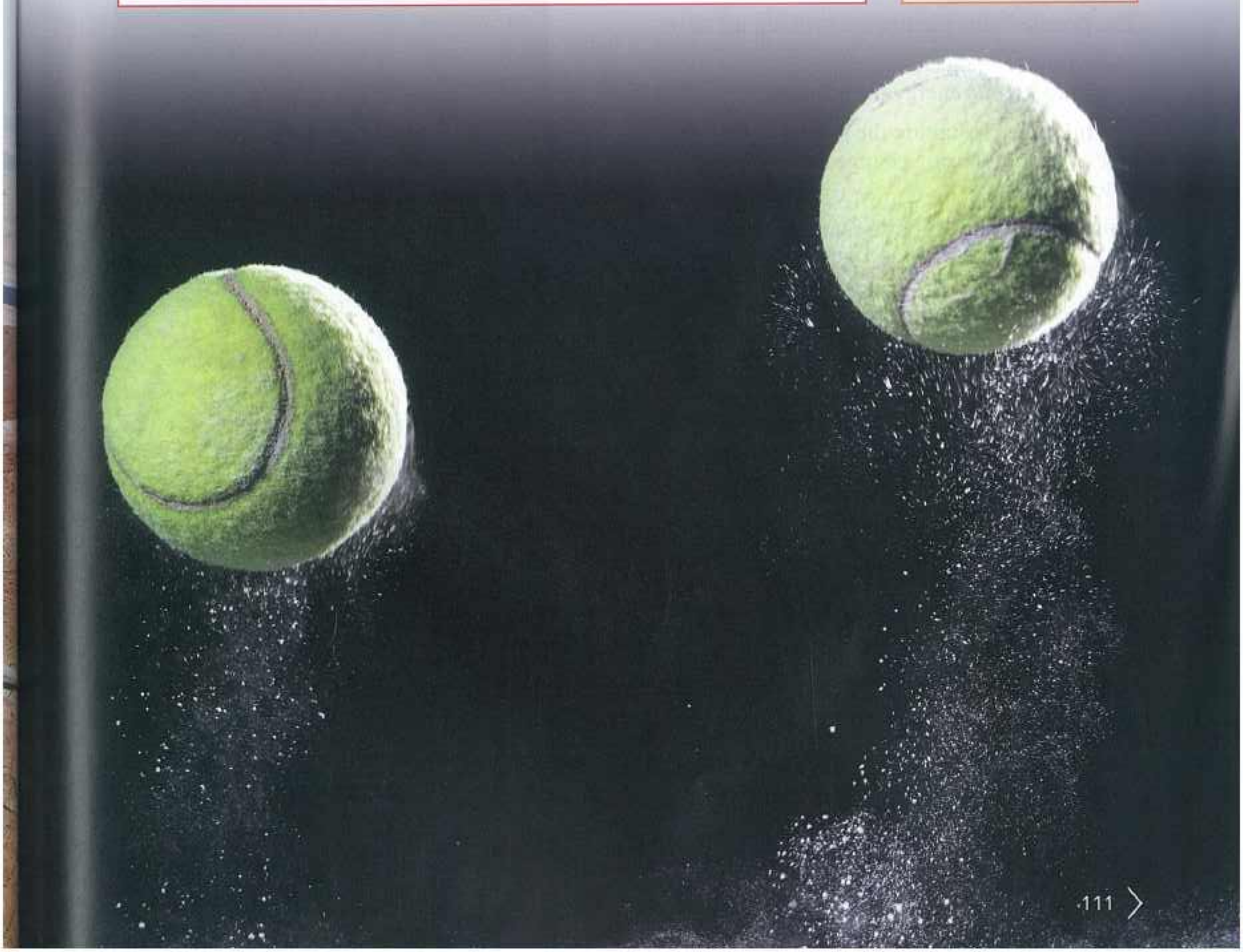
- learn about energy changing
- discover that energy changes when something happens
- learn how to give examples of changes in energy.

Getting started

1 Make a list of all the energy stores and transfers that you can remember.
2 Give an example of each store or transfer on your list.

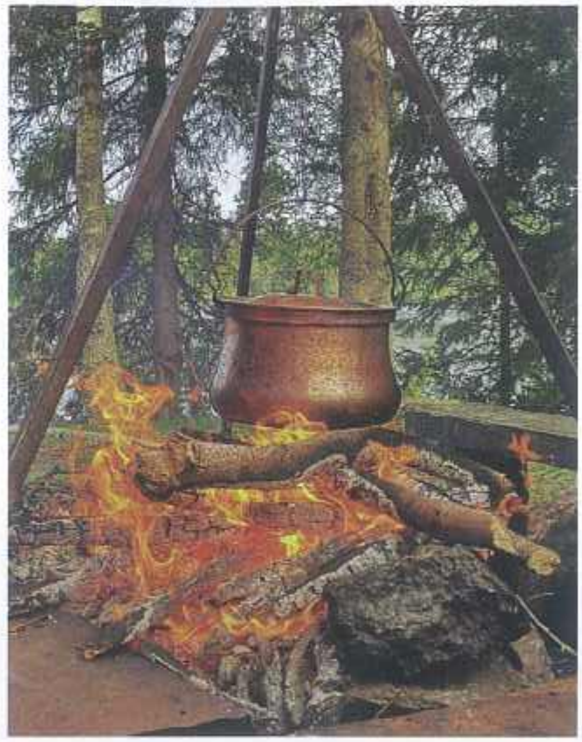
Key words

change
event
process



How does energy change?

In Section 3.5, you learned that energy is something that must be **changed** or transferred in order to do something. Before energy can be changed or transferred, it is stored. When energy is stored, the energy is not doing anything.



The picture shows a cooking pot being heated on a fire.Walking up stairs needs energy to be changed.

The fuel for the fire is wood. Wood is a store of chemical energy.

Burning the wood changes the chemical energy to thermal energy (heat).

The thermal energy is then transferred to the pot and the food inside.

The people in the picture are walking up stairs.

They are changing chemical energy from their food into kinetic energy for movement.

The movement is taking the people higher, so kinetic energy is being changed to gravitational potential energy.

This picture shows a power station.

This power station is using the chemical energy stored in natural gas.

The gas is burned, which changes chemical energy to thermal energy.

The thermal energy is then changed to kinetic energy in large generators that spin around.

The kinetic energy is then changed to electrical energy.

The electrical energy is then transferred through wires into homes and buildings.

Energy changes are not always helpful. Typhoons, hurricanes, earthquakes and tsunamis are some examples of how energy changes can be very dangerous.

Strong wind can transfer energy in a damaging way.

In all these examples, there is a **process** or **event** that changes or transfers the energy. For example, burning is a process.

Burning changes chemical energy stored in a fuel to thermal energy.

You can represent the processes as arrows and draw diagrams to show changes in energy.

Here are some other examples.

A fire that burns wood changes chemical energy to thermal energy.

chemical $\rightarrow$ thermal

A television converts electrical energy to sound and light.

electrical $\rightarrow$ sound

electrical $\rightarrow$ light

When a book falls from a shelf, that is an event. When the book is on the shelf, the book has stored gravitational potential energy. This energy is changed to kinetic energy as the book falls.

You can also represent events such as this in a diagram.

gravitational potential $\rightarrow$ kinetic

The energy changes shown in these diagrams are useful energy changes. That means the energy is changed in a way that we want.

Some energy changes result in wasted energy. You will learn more about wasted energy in Section 3.7.

Questions

1 Copy and complete the sentence.

When something happens, energy is __________ or __________ .

2 The useful energy change in a candle can be written as

chemical to light

Write down the useful energy change in each of these.

- a an electric lamp
- b a bus
- c a radio.

3 Draw diagrams to show the energy changes in:

- a a motorcycle that uses gasoline (petrol) for movement
- b a wood-burning fire used for cooking
- c a bird using movement to fly higher
- d a ball rolling down a hill.

Activity

Freezing water

Work in groups.

When you put water in the freezer, it turns into ice.

Discuss and then answer these questions about this process in your group.

1 What happens to the temperature of the water in the freezer?

2 How can you tell the temperature has changed in this way, without using a thermometer or touching the water?

3 How is energy being transferred when the water freezes?

4 Where does this energy come from?

5 Where does the energy go?

Continued

Once you have agreed on your answers, ask your teacher to check them.

Make a display to show the energy change when water freezes.

Your display could be a leaflet, a poster or a presentation.

Your display should give other people the correct information as clearly as possible.

Think like a scientist

Candle energy

You will now do an experiment to investigate a change in energy. Work in pairs or small groups.

You will need:

- candle, safety glasses, glass beaker or a metal can, tripod and gauze, thermometer, timer, heat-proof mat, stirring rod, cooking oil, matches

Set up the equipment as shown in the diagram.

Safety

Make sure the candle cannot be knocked over. Wear safety glasses. Keep paper away from the flame. Do not touch equipment until it has had time to cool.

1 Measure the temperature of the cooking oil and write this down.
2 Light the candle and place it under the beaker. Start the stopwatch or record the time.
3 Stir the cooking oil at regular intervals. Use the stirring rod. Do not stir with the thermometer!
4 Measure the temperature of the cooking oil every minute. Record both the time and the temperature.
5 Stop heating when the temperature of the cooking oil has gone up by 10°C.
6 Carefully blow out the candle.

Continued

7 Draw a table for your results.

8 Draw a line graph of your results. Put the temperature of the cooking oil on the vertical axis.

Questions

1 Explain why you should **not** use a thermometer for stirring.

2 Explain where the energy came from to heat the cooking oil.

3 Describe what happened to the candle during the experiment.

4 In this experiment, not all of the thermal energy is transferred to the cooking oil.
List **two** other things that get heated in this experiment.

5 Suggest changes to this experiment to transfer more of the thermal energy into the cooking oil.

6 Explain why a line graph is a better way to display the results from this experiment than a bar chart.

Self-assessment

Discuss each of these statements with your partner or small group.

- We worked safely at all times.
- We recorded all the results at the right times.
- We took readings from the thermometer as accurately as possible.
- We put the correct column headings with units in the table.
- We drew the graph correctly and it shows the trend in the results.

Summary checklist

- [ ] I can understand that energy can be changed.
- [ ] I can give examples of some changes in energy.
- [ ] I can draw diagrams to show energy changes.

> 3.7 Where does energy go?

In this topic you will:

- discover that when energy is changed, some of it may be wasted
- learn that some of this energy can never be recovered.

Getting started

Work with a partner. Discuss the energy that is changed or transferred in each of these processes.

- Burning wood for cooking.
- Walking up stairs.
- Cycling on a level road.

In each case, state where the energy comes from and the useful energy that is changed.

Key words

dissipated
recovered
useful
wasted energy

Useful and wasted energy

Every time you use energy to make something happen, energy is transferred or changed. Some of the energy transferred or changed is useful, but some of it is wasted.

Look at the picture of fuel being added to a motorcycle.

The motorcycle engine uses the chemical energy stored in the fuel.

This chemical energy is changed to **useful** kinetic energy to move the motorcycle and rider.

But chemical energy from the fuel is also changed into thermal energy and sound energy.

In fact, only about $\frac{1}{4}$ or 25% of the chemical energy in the fuel is used for movement.

The other $\frac{3}{4}$ or 75% of the energy is **wasted energy**. This wasted energy is **dissipated** and cannot be **recovered**. Dissipated energy is energy that spreads out where there is no use for it.

You cannot gather thermal energy or sound and bring them back into one place to be stored, changed or transferred.

Gasoline (petrol) is a store of chemical energy. The motorcycle engine changes only some of this into kinetic energy. The rest of the energy is wasted.

Look at the two types of lamp in the picture.

Both lamps A and B in the picture change electrical energy to light energy.

Lamp A only changes about 15% of the electrical energy into light. 85% of the electrical energy is wasted from this lamp. This is dissipated as thermal energy.

Lamp B changes about 50% of the electrical energy into light. 50% of the electrical energy is dissipated as thermal energy from this lamp.

A B

These two lamps emit the same brightness of light but they waste very different quantities of energy.

Every time energy is changed or transferred, there is some thermal energy wasted. This wasted thermal energy is dissipated.

Even when you want to produce thermal energy, some of it is wasted.

Look at the water being heated in this picture.

In the picture, chemical energy from wood is being changed to thermal energy by the process of burning.

Thermal energy is being used to heat the water.

Thermal energy is also being used to heat the rocks, the metal container and the air around it.

Some of the thermal energy is escaping in the steam.

The fire is also changing energy into light.

All these represent wasted energy that is dissipated and cannot be recovered.

For everything that uses energy change or transfer, some of that energy will always be dissipated.

Questions

1 Which of these terms describes energy that is dissipated?

energy that spreads out and becomes less useful	energy that becomes more useful
energy that can be used later	energy that is not useful but can be stored

2 Which of these can be dissipated?

Choose all that are correct.

chemical thermal light sound elastic

3 List all the energy changes in these processes.

List the energy as either useful or wasted.

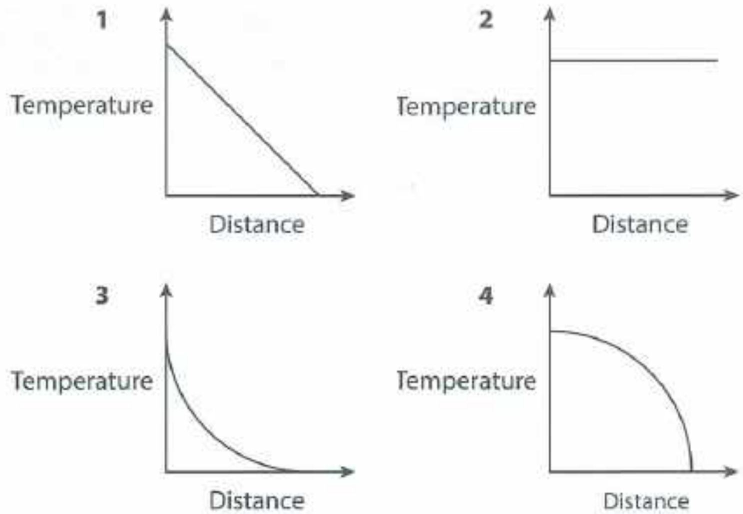
a Using electricity in a lamp.

b Using petrol (gasoline) in a car engine.

c Using electricity in a motor.

4 As you move away from a hot object, you feel less heat from it. The temperature will go down as you move further away.

Which of these graphs shows how the temperature changes with increasing distance from a hot object?



- How do you work out what the shape of a graph will look like?
- Can you explain why you chose the answer that you did? You can do this by describing what will happen to the temperature in each case.

Activity

Ripple tanks

Work in groups.

You will need:

- waterproof rectangular tray (about 40 cm × 20 cm × 5 cm), water, a ruler

Continued

Mop up any water that spills from the tray immediately.

1 Put water into the tray so the water is about 1 cm deep.

2 Lift the short edge of the tray a little above the desk. Then drop the tray. You should see a wave move across the water. The wave should start at the end that was dropped and move towards the opposite end.

3 Count how many times the wave moves backwards and forwards across the tray until you can no longer see it.

4 Change the depth of the water. Can you make the wave travel across the tray any more times by changing the depth of water?

5 Now try making the wave go across the tray by lifting and then dropping the long edge. Does the wave travel across the tray any more times in this direction?

Questions

1 State **one** variable that must remain the same when you change the direction of the wave.

2 Which way (along or across the tray) does the wave travel the longest **total** distance?

3 Name the energy that is stored by the wave as it moves.

4 Use words from the list to copy and complete the sentence.

stays the same **dissipates** **increases** **goes slower**

As the wave travels, the energy in the wave ....

Think like a scientist

Energy dissipation

In this task you will investigate the dissipation of energy.

You will need:

- hot tea in a cup, thermometer, plastic spoon, timer or clock with a second hand

Safety

Take care not to scald yourself with the hot tea. Do not attempt to drink the tea, even when it has cooled.

Work as a whole class.

Taking turns, measure the temperature of the hot tea every minute. Stir the tea before measuring the temperature. Use the spoon, **not** the thermometer, to stir the tea.

Record the time and the temperature in a place where the whole class can see the results.

Questions

Work on your own to answer the questions.

1 Plot a line graph with time on the horizontal axis and temperature on the vertical axis.

Make sure your line is as smooth as possible. It should go through all of the points if the temperatures have been measured correctly.

2 Describe the pattern shown in your graph. Use the words 'temperature' and 'time' in your description.

3 Explain why you should stir the tea before measuring the temperature.

4 The higher the temperature of the tea in the cup, the more thermal energy there is in the tea.

What do the results show about what happens to the thermal energy with time?

5 List some places where the thermal energy could have gone.

6 Suggest how you could:

a make the tea cool more quickly, **without** adding anything into the tea

b make the tea cool more slowly, **without** heating it again and **without** adding more hot tea.

7 Explain whether the tea in the cup will keep cooling, or whether it will stop cooling.

Did you have any idea what shape the graph might be:

- before you did the experiment?
- when you looked at the temperatures that were recorded?

Summary checklist

- [ ] I can recall that when energy is changed or transferred, some of the energy is useful and some is wasted.
- [ ] I can understand the meaning of the word 'dissipate'.
- [ ] I can understand that energy can be dissipated more easily in some ways than in others.
- [ ] I can understand that energy which has dissipated cannot be recovered.

Project: Discoveries about energy

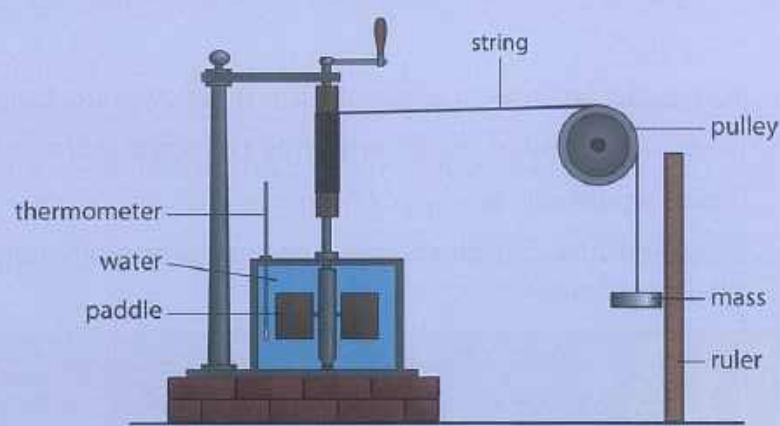
Background

James Prescott Joule was born in the year 1818.

Joule was interested in how things worked and where the energy came from to make things happen.

He made the machine shown in the picture.

He used the machine in the picture to show how energy could be changed.



James Prescott Joule made this machine in the year 1845.

When the mass was allowed to fall, it pulled on the string.

The string passed over a pulley and was wrapped around a piece of wood.

The piece of wood then rotated.

This made a paddle rotate.

The paddle rotated in water.

Joule discovered that when he did this, the temperature of the water increased.

Joule's ideas and his results from experiments challenged the accepted ideas about energy. His ideas were not accepted at first.

Continued

Your task

Make a presentation to tell others about how Joule's machine works.

Your presentation should include this information:

- The energy changes and transfers that happen in Joule's machine.

  You should include the terms:

  - gravitational potential
  - kinetic
  - thermal.
- What did Joule's result show?

  You should use all these words correctly:

  - mass
  - weight
  - gravity
  - height.
- You could finish your presentation by answering these questions.

  Do you think all of the energy was changed in the way that Joule had wanted?

  If not, where did any wasted energy go?

  Why were the old ideas about energy eventually rejected and Joule's ideas accepted?

Check your Progress

3.1 Write the word used to describe each of these.

- **a** The force of gravity on an object. [1]
- **b** The quantity of matter in an object. [1]

3.2 a Explain why the Sun has more gravity than any of the planets. [1]

b The strength of gravity on Earth is 10 N/kg.

Calculate the weight of each of these.

Show your working **and** give the unit in your answer.

- **i** a book of mass 1 kg [2]
- **ii** a calculator of mass 150 g. [3]

c In the year 1959 a spacecraft called Luna 2 was launched from Earth.

Luna 2 landed on the Moon.

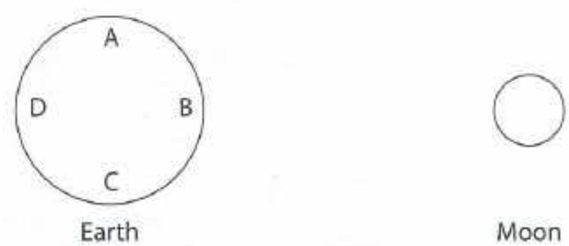
- **i** Describe how the **weight** of Luna 2 would compare between when it was on Earth and when it was on the Moon. [1]
- **ii** Describe how the **mass** of Luna 2 would compare between when it was on Earth and when it was on the Moon. [1]

3.3 a Explain what keeps the Earth in its orbit. [2]

b Explain why the planet Mercury travels faster in its orbit than Earth does. [1]

3.4 The diagram shows the Earth and Moon. The diagram is not to scale. [1]

a Write the letter or letters where there will be high tide on Earth in this diagram. [1]



b There is also low tide at a place in the diagram.

State the number of hours until the next low tide in the **same** place. [1]

c Draw a diagram to show the positions of the Earth, Moon and Sun that would produce the highest tides on Earth. [1]

d Use a word from the list to copy and complete the sentence. [1]

gravity **force** **mass** **energy**

The Moon causes a tidal .... on the Earth.

3.5 Which two measurements have the same units? Write the letter. [1]

A weight and mass

B mass and energy

C energy and force

D weight and force

3.6 **a** Which of these words means to spread out and become less useful? [1]

thermal **decrease** **dissipate** **loss**

b An electric motor works on electrical energy. [2]

The motor changes electrical energy in **three** ways.

Write the energy in the correct columns.

Useful	Wasted
____________	____________ ____________

3.7 Which row in the table shows the forces on a planet in orbit around the Sun?

Put a tick (✓) in the box beside the correct row. [1]

Air resistance	Gravity	
no	no	
no	yes	
yes	no	
yes	yes	

3.8 A container of water is placed over a fire that burns wood.

a Name the energy that is transferred from the fire to the water. [1]

b Not all of this energy is transferred to the water.

List **two other** places where this energy could go.

4 Grouping and identifying organisms

4.1 Characteristics of living organisms

In this topic you will:

- think about what makes living organisms different from non-living things
- learn about the seven characteristics of living organisms.

Getting started

In your classroom, find one living thing and one thing that has never been alive.

With your partner, make a list of things that the living thing can do, but the non-living thing cannot do.

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

Key words

excretion
growth
movement
nutrition
organism
reproduction
respiration
sensitivity

Living and non-living

How do you know when something is alive? If it is a person, you can check to see if they are breathing, or if they have a heartbeat.

Plants don't breathe or have hearts, yet they are alive.

Living things are called **organisms**. Living organisms have a set of seven characteristics that make them different from non-living things.

Questions

These questions are about the picture of the polar bears. Copy and complete the sentences.

Use these words. You can use each word once, more than once or not at all.

carbon dioxide chewing feeding growth movement
oxygen sight smell reproduce respiration

1 Another word for taking in nutrition is ....

2 Polar bears can sense things in their environment. For example, with their nose they can sense the .... of meat.

3 All living organisms excrete waste substances. Animals excrete .... when they breathe out.

4 Living organisms .... to make more of the same kind of organism.

5 Young plants and animals get bigger. This is called ....

6 All living organisms break down some of the food they eat, to provide them with energy. This happens in a process called ....

7 Most living organisms can change the shape and position of their bodies. This is called ....

Activity 4.1.1

Is a car alive?

The picture shows a car.

Here are some facts about cars.

- Cars use fuel and oxygen.
- Inside the engine of the car, the fuel and oxygen provide energy to make the car move.
- The engine produces waste gases, including carbon dioxide. These are given off in the exhaust of the car.
- Some cars have sensors. For example, they can sense when it is dark and turn the lights on automatically.

Questions

1 In your group, make a list of similarities between a car and living organisms.

2 Make a list of differences between a car and living organisms.

Summary checklist

- [ ] I can list the seven characteristics of living organisms.
- [ ] I can describe the meaning of each of these characteristics.

4.2 Viruses

In this topic you will:

- learn about the structure of a virus
- discuss whether viruses are non-living or living.

Getting started

Work with a partner to answer these questions.

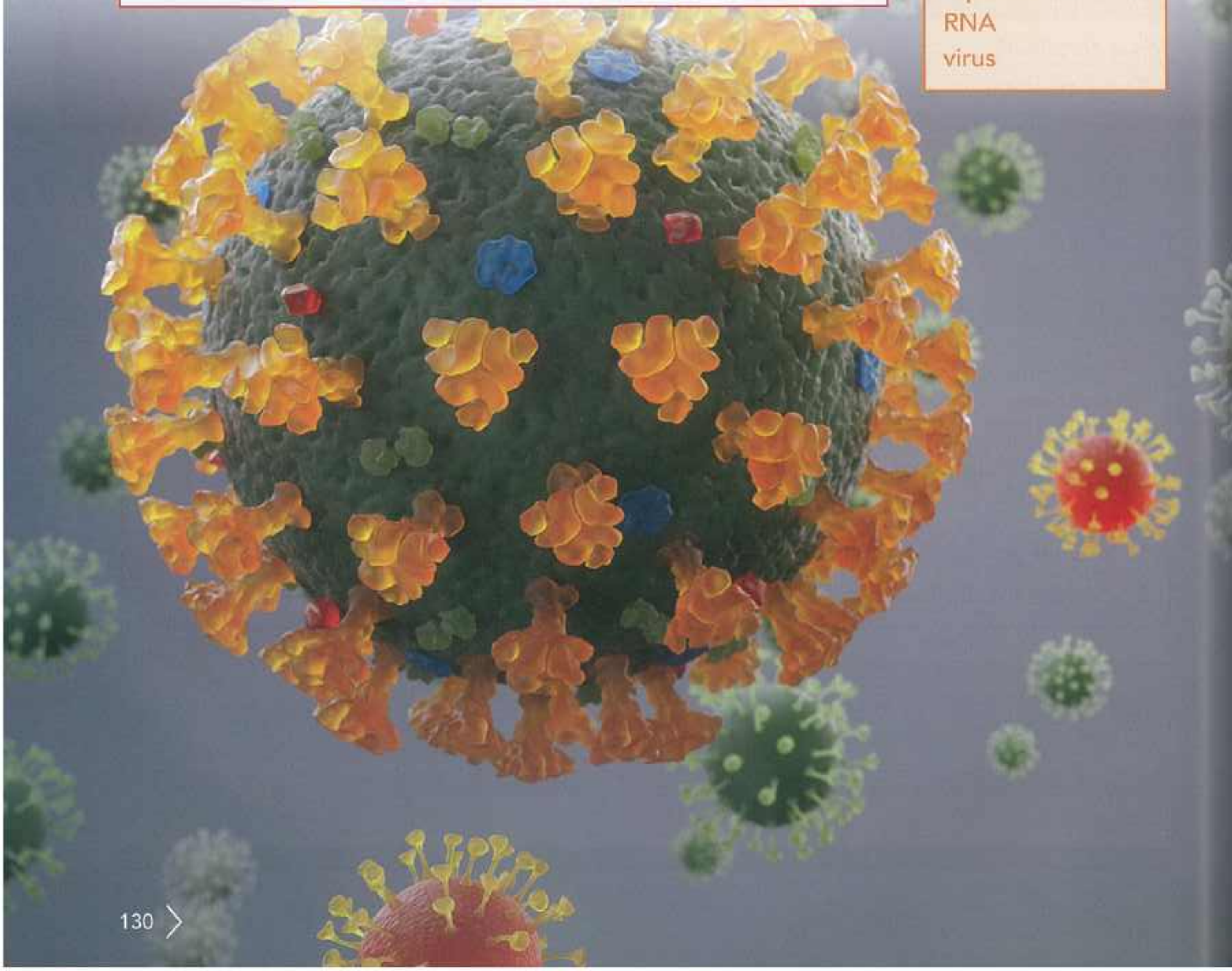
Respiration is one of the characteristics of living things.

List the other six characteristics.

Now explain the meaning of each of the words in your list.

Key words

electron microscope
influenza
protein
replicate
RNA
virus



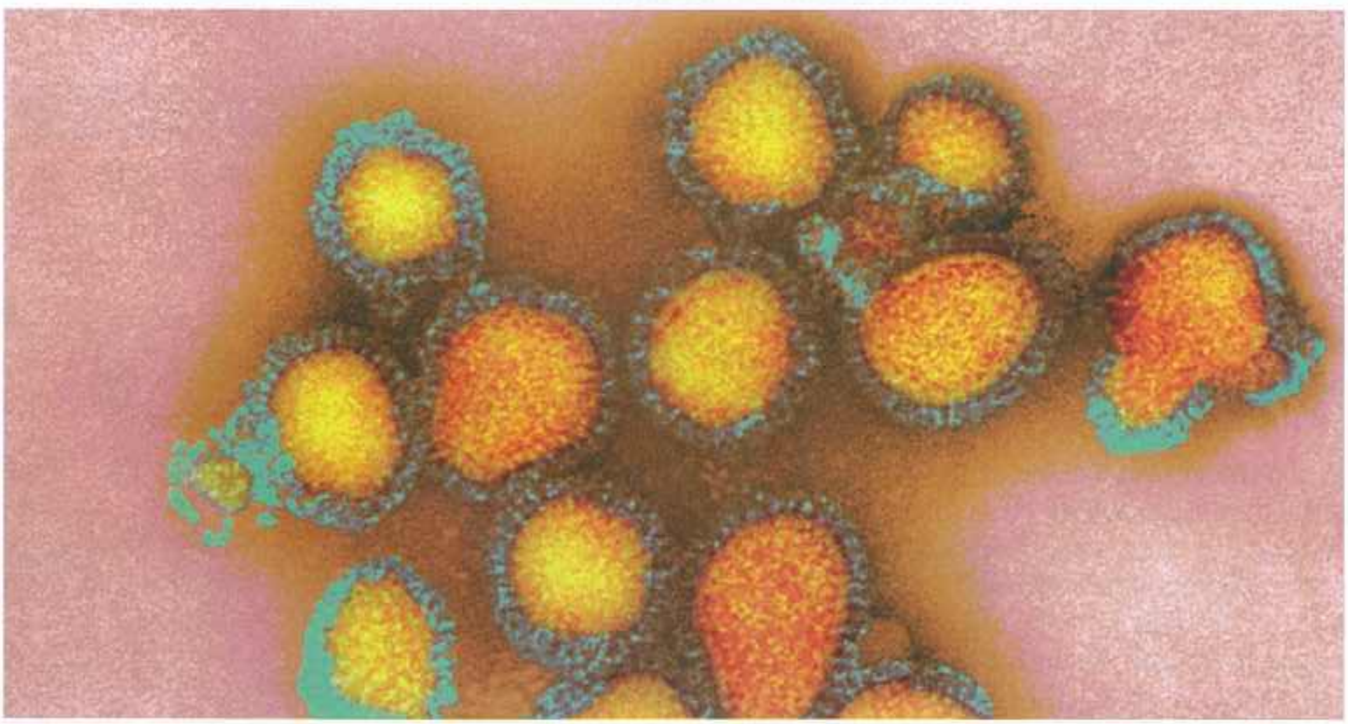
What is a virus?

Viruses are very, very small. A virus is much smaller than one of your cells. You cannot see a virus with the kind of microscope that you use in school. To see a virus, you need to use a special kind of microscope called an **electron microscope**.

Viruses are not made of cells. They do not have a cell membrane or cytoplasm. The blue-green outer layer in the photograph is a coat made of **protein**. There are little pegs on the outside of this coat.

The orange part inside contains a substance called **RNA**. The RNA is made of little threads that contain a set of coded instructions for making more viruses.

This scientist is working in Jakarta, Indonesia. She is using an electron microscope. The microscope is the grey object on the right-hand side of the photograph. It produces a picture on the screen in front of the scientist.



This photograph of viruses was taken using an electron microscope. The viruses in the photograph look 100 000 times bigger than they really are. It is almost impossible to imagine just how small a virus is.

Think like a scientist

Making a model of a virus

You will need:

- modelling clay, paper that you can tear into little pieces, push pins

Use the materials to make:

- an outer coat of protein
- some little threads of RNA, inside the protein coat
- some pegs on the outer coat.

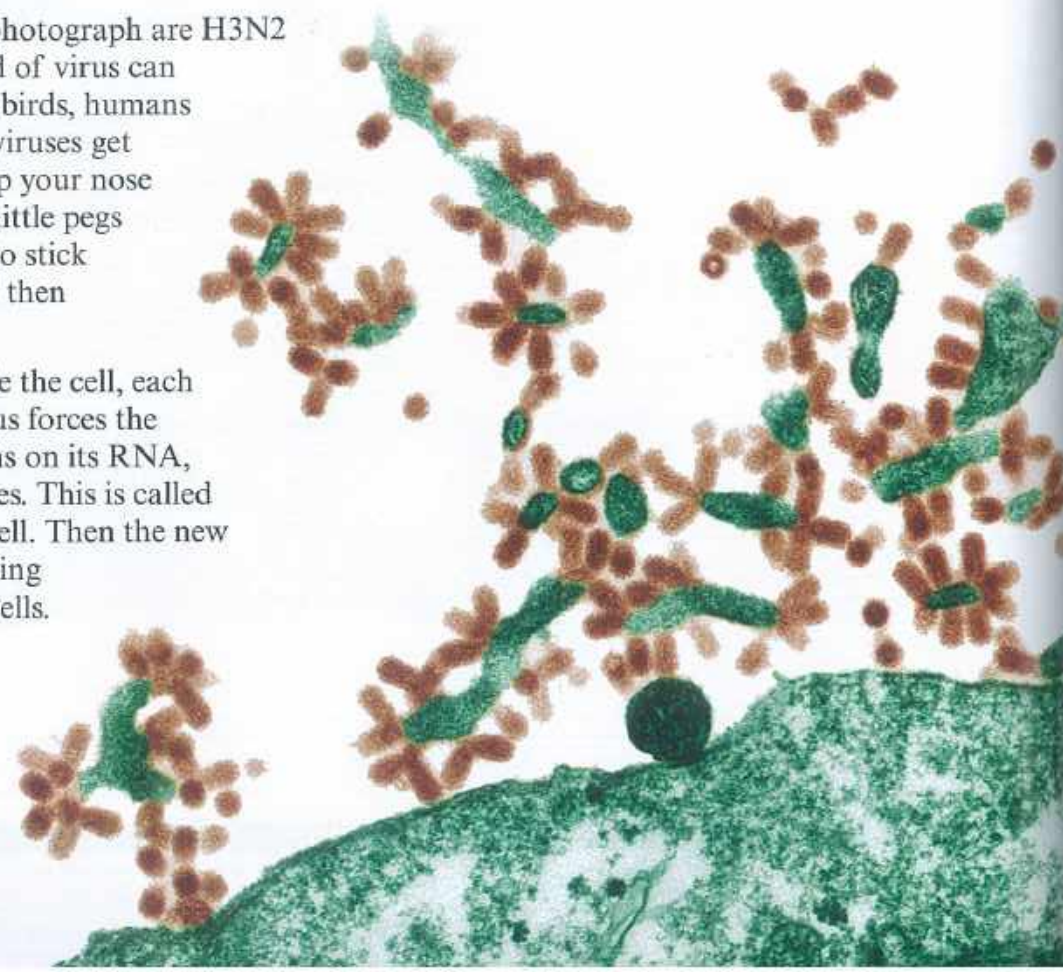
You could take a photograph of your model, then stick the photograph into your notebook.

How viruses replicate

Viruses cannot do anything at all on their own. They do not respire, feed, excrete or grow. They are not sensitive and cannot move. Viruses have to get inside a living cell before they can make copies of themselves.

The brown viruses in the photograph are H3N2 **influenza** viruses. This kind of virus can invade (get inside) cells of birds, humans and other mammals. The viruses get into your body by going up your nose when you breathe in. The little pegs on the virus's coat help it to stick onto one of your cells and then get inside the cell.

When the viruses are inside the cell, each virus bursts open. The virus forces the cell to copy the instructions on its RNA, and make many new viruses. This is called **replication**. This kills the cell. Then the new viruses burst out of the dying cell, ready to infect more cells.

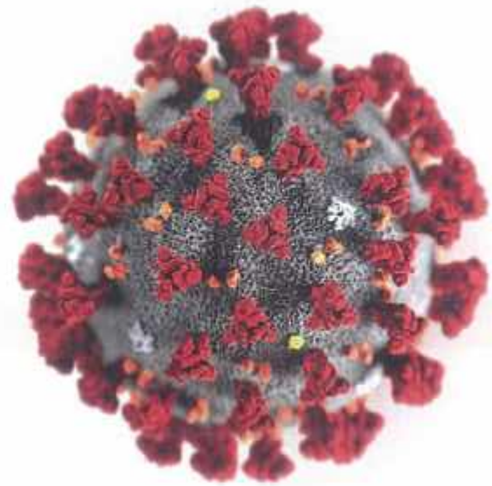


This makes the animal whose cells are infected feel ill. H3N2 viruses cause a very unpleasant and dangerous kind of influenza (flu). In 1968–1969, these viruses killed approximately one million people.

These flu viruses are just one of thousands of different kinds of viruses we know about. Each kind of virus has a particular kind of cell that it infects. Some viruses infect plant cells.

In 2019, a new virus appeared. We do not know exactly where it came from, but scientists think it developed in a wild animal and then spread to humans. The new virus is similar to the viruses that cause flu and colds. Its official name is SARS-CoV-2. The illness it causes is called Covid-19. This stands for coronavirus disease 2019. The virus quickly spread all over the world.

Many people get the virus without being ill at all, or just have mild symptoms. But in some people, it causes dangerous illness and even death. Scientists will work hard for many years to find the best ways of preventing this, including vaccination, and drugs to treat Covid-19.



This is a drawing of a SARS-CoV-2 virus. The red bits on the outside are called spike proteins. They help the virus attach to cells and get inside.

Activity 4.2.1

Are viruses alive?

Some scientists consider that viruses are living organisms. Others think that they are not.

In a group of three, discuss the question: Are viruses living organisms?

Make a list of reasons for your decision. Be ready to share your ideas with others.

Summary checklist

- [ ] I can describe what a virus is and how it replicates.
- [ ] I can give reasons for classifying viruses as living or non-living.

› 4.3 What is a species?

In this topic you will:

- look carefully for similarities and differences between organisms
- compare two different species of organism
- find out how scientists decide if two organisms belong to the same or different species.

Getting started

All living things belong to groups called **species**.

Imagine you are looking at two birds in your garden. They look quite similar, but are not exactly the same.

Discuss this question with your partner: How would you decide if the two birds belong to the same species or two different species?

Be ready to share your ideas.

Key words

fertile
identical
infertile
offspring
species
specimen
variation

Species

Scientists group living organisms into different kinds. Each kind of organism is called a species.

Activity 4.3.1

Comparing two species of elephant

With a partner, look at the two pictures of elephants. These elephants belong to two different species.

Make a list of the similarities that you can see between the two species of elephant.

Then make a list of differences that you can see between them.

Indian elephant

African elephant

Species and reproduction

All the organisms in a species share the same characteristics but they are not all **identical** to each other. For example, some Indian elephants have straighter tusks than others. They have pink markings on their skin in different places. There is **variation** between the individual Indian elephants.

Variation between individuals can sometimes make it difficult to decide whether two organisms belong to the same species. To be sure, scientists try to find out if they can reproduce with one another.

Indian elephants reproduce only with other Indian elephants. They do not reproduce with African elephants. Each species reproduces only with other members of its own species. When they have **offspring** (children), the offspring belong to the same species as their parents.

The offspring are **fertile**. This means they can also produce offspring.

Organisms that belong to different species cannot usually reproduce with one another.

Very rarely, two organisms from different species do reproduce together. This sometimes happens in a zoo. It can happen if two animals from different species are put into the same enclosure.

For example, a male lion and female tiger in a zoo sometimes reproduce together. They will only do this if they do not have a member of their own species to reproduce with.

The young animals that are produced are called ligers. Ligers are healthy animals. But ligers cannot reproduce. They cannot have offspring. They are **infertile**.

So, we can describe a species as a group of organisms that can reproduce together to produce fertile offspring.



A male lion (left) can breed with a female tiger (centre) to produce a liger (right).

Questions

1 Copy and complete these sentences.

Choose from these words.

bigger **different** **identical** **similar**

Organisms that belong to the same species usually look ____________ to one another.

They look ____________ from organisms belonging to other species.

2 Explain why biologists say that lions and tigers belong to different species, even though they can sometimes reproduce together.

Think like a scientist

Comparing organisms belonging to different species

This task will give you practice in looking very carefully at **specimens** (samples) of organisms. You will also practise describing similarities and differences.

You will need:

- specimens of two similar species of organism

Safety

If you handle live organisms, wash your hands carefully afterwards.

Look carefully at the specimens. The organisms belong to two different species.

Questions

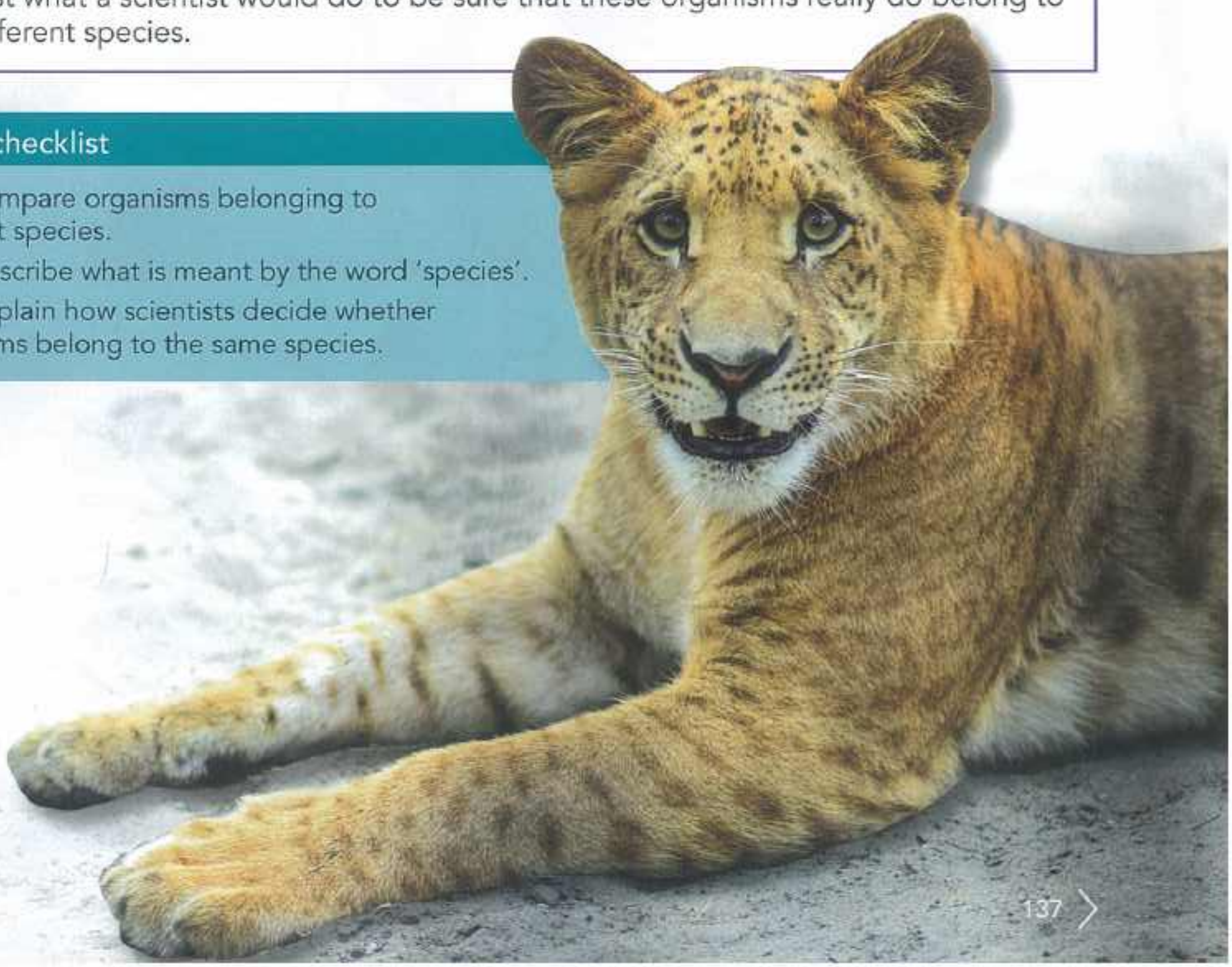
1 Write down **five** similarities between the two species.

2 Now write down some differences between them. Try to find at least **two** differences.

3 Suggest what a scientist would do to be sure that these organisms really do belong to two different species.

Summary checklist

- [ ] I can compare organisms belonging to different species.
- [ ] I can describe what is meant by the word 'species'.
- [ ] I can explain how scientists decide whether organisms belong to the same species.



4.4 Using keys

In this topic you will:

- learn how to use a key to identify an organism, or to classify it into a group
- change a key from one style to a different style.

Getting started

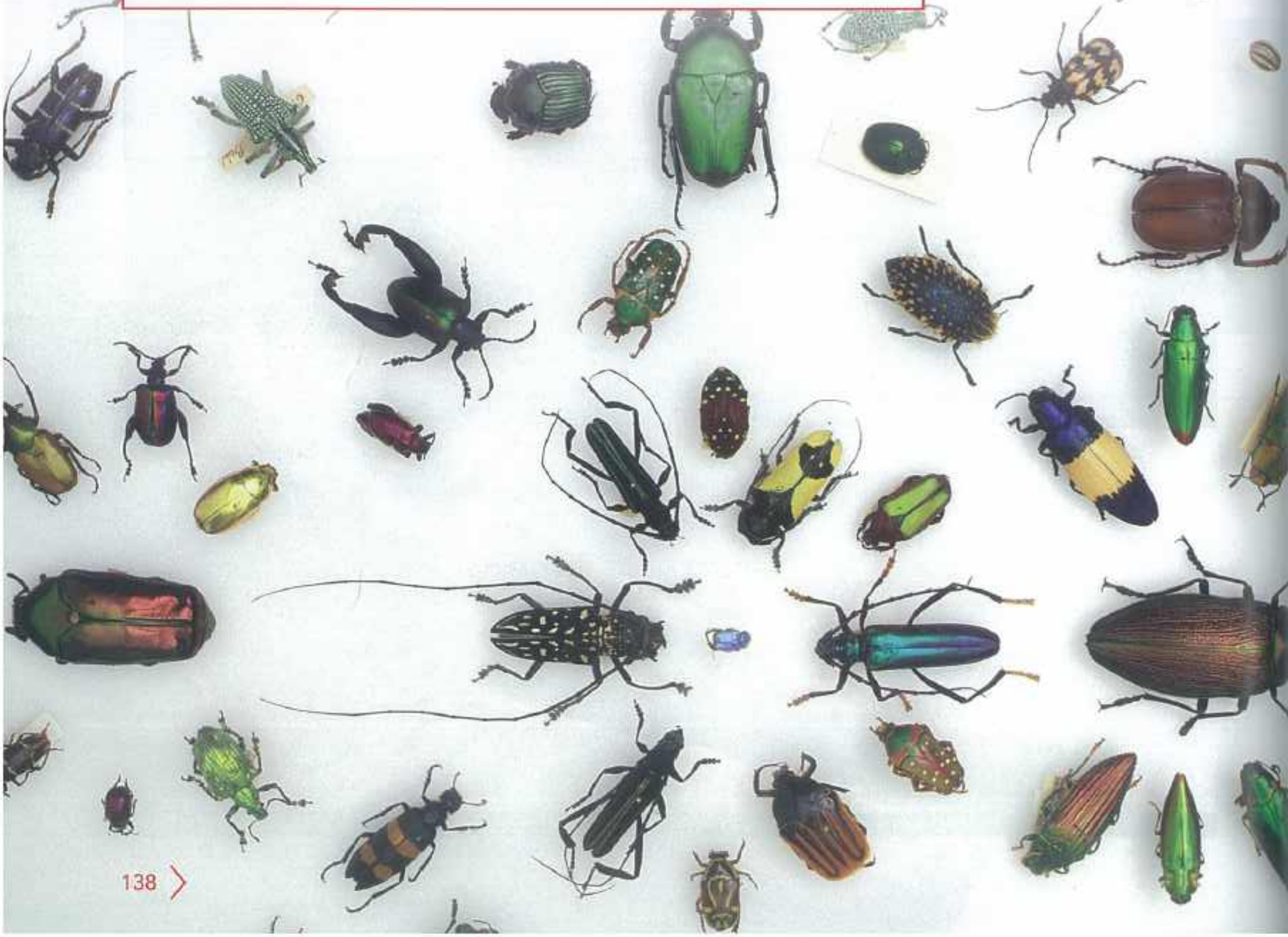
Discuss this question with a partner.

Imagine you have found an insect that you have never seen before. You want to know what its name is.

How would you try to find out? Try to think of at least three ways in which you could do this. Which way do you think would be the best?

Key words

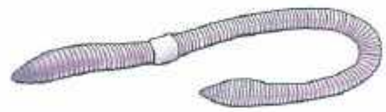
dichotomous key



Identifying organisms

Biologists often want to identify an organism that they have found. A good way to start is to look at pictures in a reference book, or on the internet. The biologist may be able to find a picture of the organism, with its name. But this does not always work.

Biologists also use **keys** to help them to identify organisms. A key is a set of questions about the organism you want to identify. The answer to each question takes you to another question. You work through all of the questions until you arrive at the name of the organism.

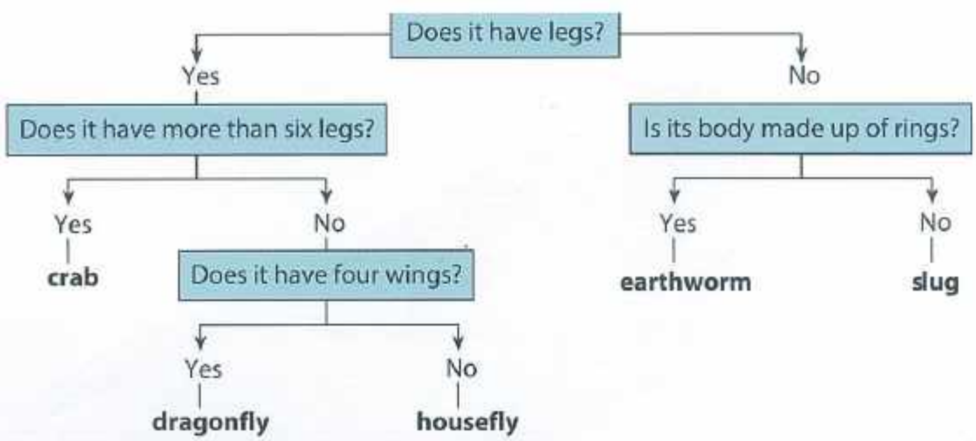


Here is a simple key to help someone to identify an organism. It is a **dichotomous** key. Dichotomous means 'branching into two'.

You will have to imagine that you have the whole animal to look at, not just these pictures.

To use the key:

- Choose one organism you want to identify.
- Starting at the top of the key, answer the first question – yes or no?
- Follow the line to the next question. Keep going until you arrive at the name of the organism.



Keys are sometimes arranged differently. Here is the same key set out in a different way.

Instead of a question, the key starts with a pair of statements to choose from.

Instead of arrows pointing to where you go next, there is a number telling you which pair of statements to go to next.

1	a	It has legs.	→ go to 2
	b	It does not have legs.	→ go to 3
2	a	It has exactly six legs.	→ go to 4
	b	It has more than six legs.	→ **crab**
3	a	Its body is made up of rings.	→ **earthworm**
	b	Its body is not made up of rings.	→ **slug**
4	a	It has four wings.	→ **dragonfly**
	b	It has two wings.	→ **housefly**

Try working through the key to identify the dragonfly.

You will work through steps **1a**, **2a**, **4a**.

Questions

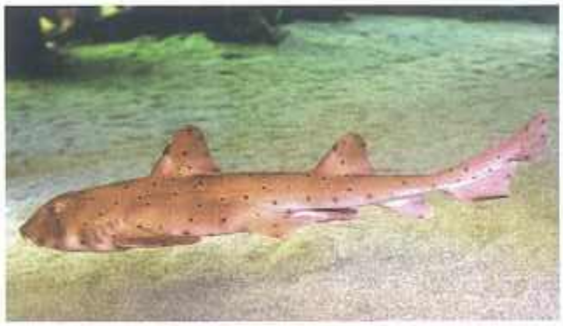
1. Using the key above, which steps would you go through to identify the earthworm?
2. Explain why the key is called a dichotomous key.

Think like a scientist

Using a key to identify species of fish

The pictures show four species of fish.

A



B

C

D

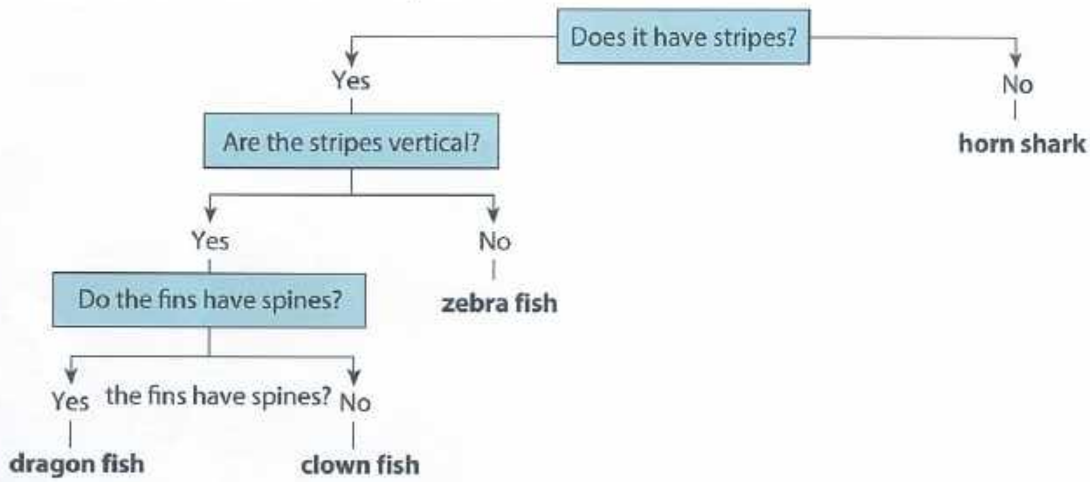
Continued

Questions

1 Use this key to identify the four species of fish.

Remember:

- Take one fish at a time. Start with fish **A**.
- Start at the top of the key and work your way through the questions and answers until you arrive at the name of the fish.
- Then do the same for fish **B**, and so on.



2 Here is the beginning of the same key, written out in the style that uses pairs of statements for you to choose between.

1 **a** The fish has stripes. .... go to 2

b The fish does not have stripes. .... horn shark

Write out the whole of the key in this style.

Which style of key do you find easier to use? Why do you think it is easier?

Summary checklist

- [ ] I can use a dichotomous key to identify an organism.
- [ ] I can write a key in a different style.

> 4.5 Constructing keys

In this topic you will:

- learn how to create your own key
- learn how to change your key following feedback.

Getting started

Here are four questions that could be part of a dichotomous key to identify some different plants.

- Is the plant tall?
- Do the flowers on the plant have five or more petals?
- Does the plant have dark green leaves?
- Are the leaves darker on the upper surface than on the lower surface?

With a partner, think about these four questions.

Which **two** questions would **not** be good to use in a key?

Explain your answer.

Constructing a key

Look at the photographs of four learners.

Imagine you are going to construct a key to help someone to identify these learners.

Step 1

Think of a way you can split the learners into two groups. For example, you could split them into male and female learners.

So, your first question could be: Is the learner female?

Step 2

Now look at just one of these groups – the female learners, for example. Think of a way to split these into two. For example, you could use the colour of their hair.

Step 3

Repeat Step 2 until you have thought of ways to identify each learner in turn.

Now use your ideas to complete the 'Think like a scientist' activity.

Deidre

Ben

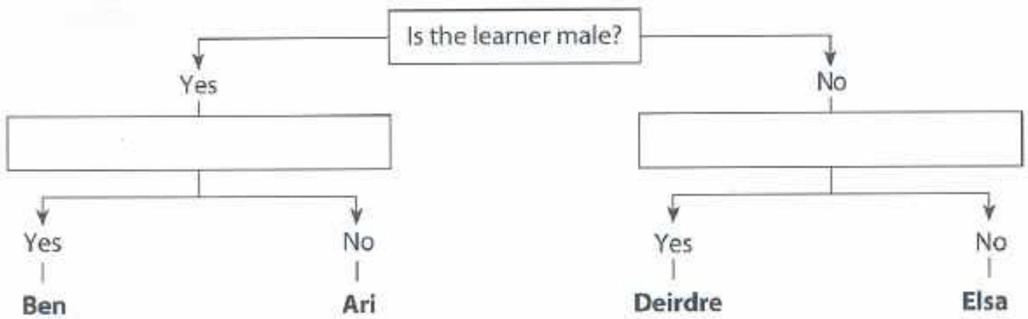
Ari

Elsa

Think like a scientist

Making keys to identify four learners

1 Copy this key and complete it, to help someone to identify each of the four learners in the photographs.



2 Now try writing your key in the other style, using pairs of statements, **1a** and **b**, **2a** and **b** and so on.

You could use the same pairs of features as for your first key, or you could challenge yourself to use different pairs.

Peer assessment

Exchange your key with a partner.

For each of the four statements below, give your partner:

2 marks if they did it really well

1 mark if they have done it quite well

0 marks if they have done it very badly, or not at all

- They have written a key that is made up of pairs of statements to choose from.
- It is easy to choose between the statements each time.
- There are no more than three pairs of statements to choose from.
- The key works – someone can use it to identify the four learners.

With your partner, look at the marks you have given each other.

What could each of you do better next time?

Think like a scientist

Writing a key to identify species of cat

The photos show four different species of cat.

Pallas's cat

Leopard

Lynx

Tiger

1 Write a key that someone can use to identify these four cat species. You can use either style of key.

2 Exchange your key with a partner and ask them to try it out. Does it work? Ask them for suggestions for improving it. Use their ideas to make some changes to your key so that it works better.

What problems did you have writing your key? How did you solve them?

Summary checklist

- [ ] I can write my own key.
- [ ] I can use feedback from a user to improve my key.

Project: Consequences of classifying organisms

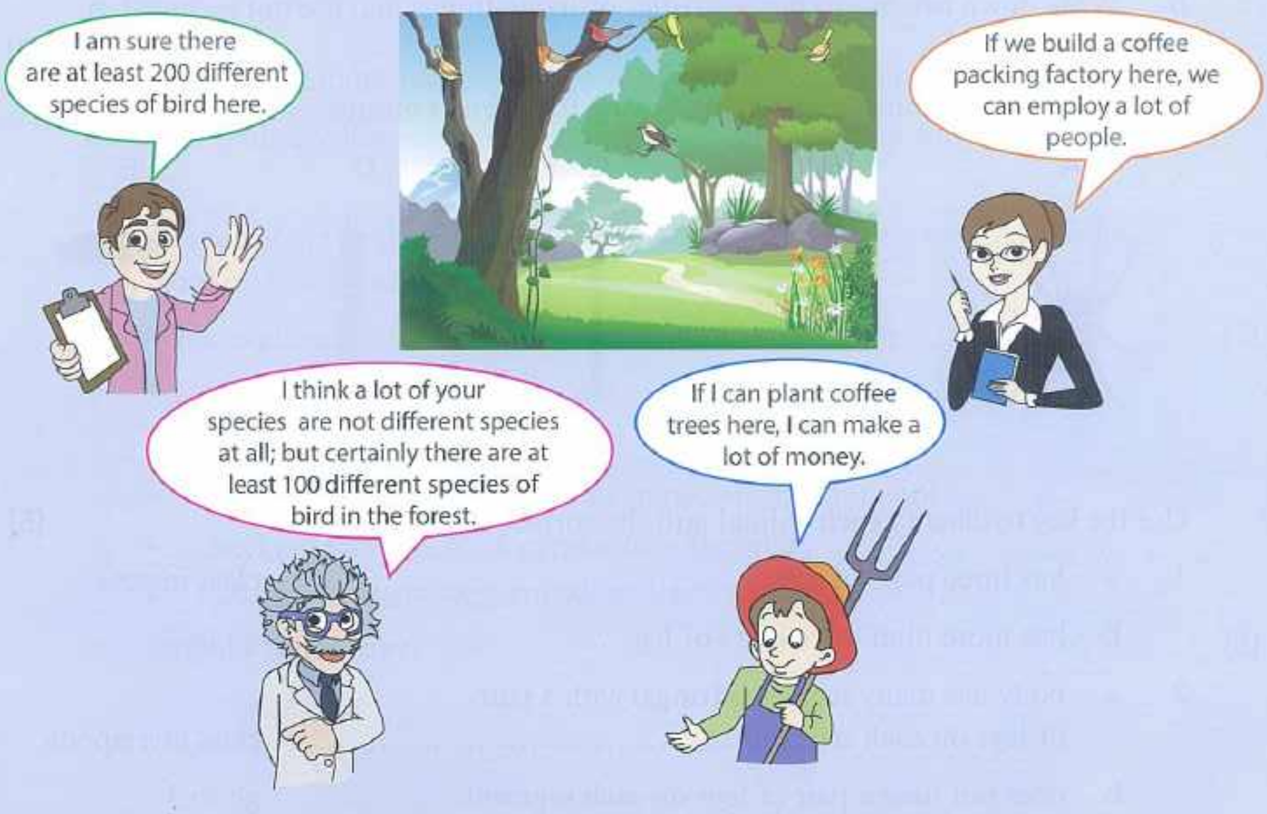
In this project, you will work in a group to think about how different decisions about classifying organisms can affect their chances of survival. You will produce a short play to show some of the viewpoints of people who may be affected by these decisions.

Biologists often disagree about whether two kinds of organism should be classified as the same species or as different species. This can cause arguments about whether to try to save a particular kind of organism, or to protect a habitat.

Imagine there is a small area of rainforest where farmers want to plant coffee trees. Coffee traders want to build a factory to process and pack coffee beans, to sell.

Some biologists say that there are 200 different species of birds that live in this forest. If the forest is cut down, some of these species may become extinct. But other biologists disagree. They say that 100 of these 'species' are not different species at all.

In your group, plan and act a short scene involving these people:



If you wish, you could include other people, such as children who like to play in the forest, or someone from an international conservation organisation.

Check your Progress

4.1 The list describes some of the features of a horse.

- It can move.
- It has a heart.
- It has hair.
- It feeds.
- It respires.
- It can sense changes in its environment.
- It has a brain.

a Write down each feature in the list that is a characteristic of **all** living things. [4]

b Write down **two** more characteristics of living things that are not included in part **a**. [2]

4.2 The pictures show some animals that belong to different groups.

A

B

C

D

E

Use the key to classify **each** animal into the correct class. [5]

1	a	has three pairs of legs..	class insects
	b	has more than three pairs of legs............................	go to 2
2	a	body has many segments (rings) with a pair of legs on each segment..	class myriapods
	b	does not have a pair of legs on each segment............	go to 3
3	a	has eight legs..	class arachnids
	b	has more than eight legs..	class crustacea

4.3 A scientist studies birds in New Zealand. The photographs show two kinds of parakeet that live there.

The scientist wants to find out if these two kinds of parakeet belong to different species.

Yellow-crowned parakeet

Red-crowned parakeet

She searches in suitable habitats for pairs of parakeets that are making nests.

She never finds a yellow-crowned parakeet that has paired up with a red-crowned parakeet.

a The scientist concludes that the yellow-crowned parakeet and red-crowned parakeet belong to two different species.

What evidence does she have for making this conclusion? **[2]**

b Suggest what the scientist should do to be even more certain that her conclusion is correct. Choose from:

- looking at stuffed specimens of parakeets in a museum
- checking more pairs of parakeets in the wild
- looking at other species of parakeets.

Explain your answer. **[2]**

4.4 The photograph shows six flowers, **A** to **F**.

A is Limnanthes

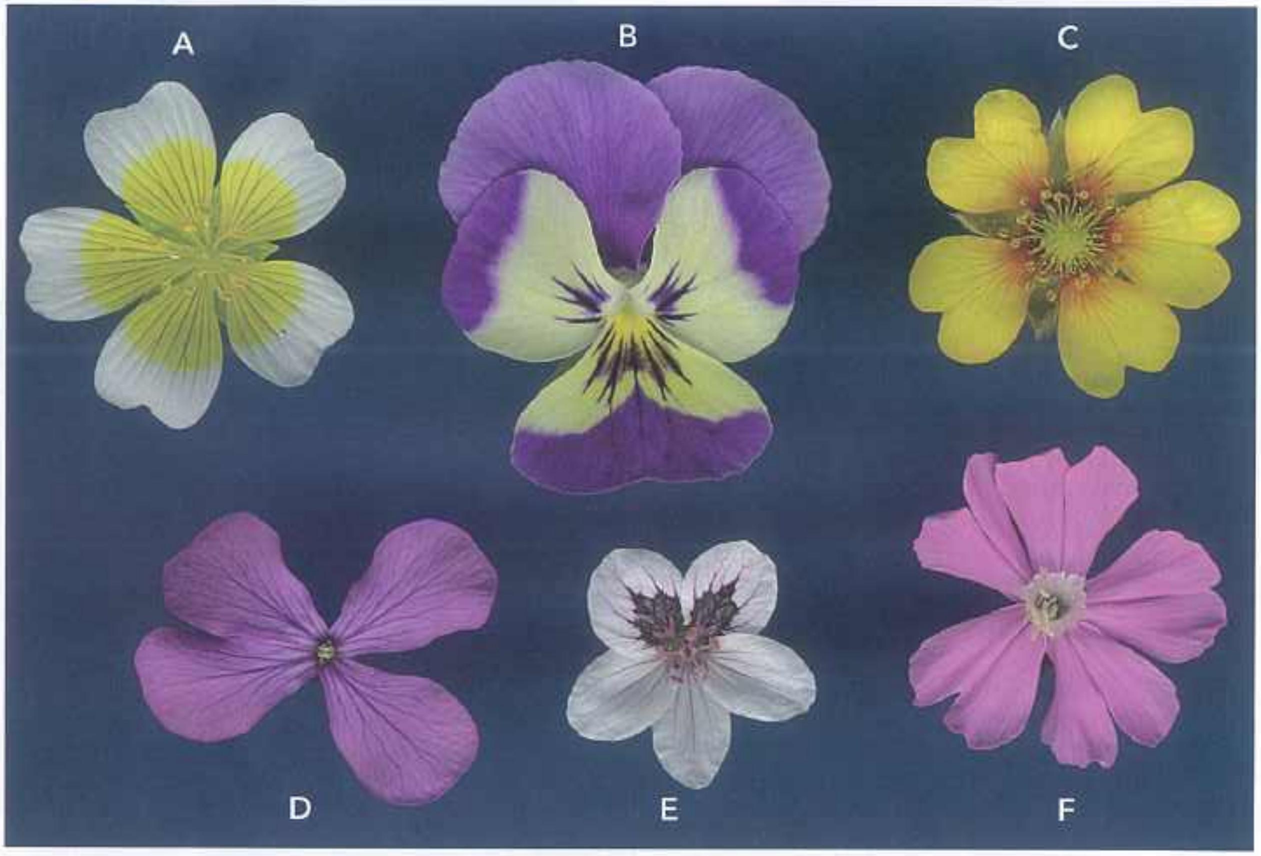
B is Viola

C is Potentilla

D is Lunaria

E is Erodium

F is Silene



Here is part of a key that someone could use to identify each of the flowers.

Copy and complete the key. **[4]**

1	**a**	The flower has exactly four petals. ……………………	**Lunaria**
	b	The flower has more than four petals. ………………..	go to 2

5 Properties of materials

5.1 Metals and non-metals

In this topic you will:

- list the properties of metals and non-metals
- learn about the uses of metals and non-metals.

Getting started

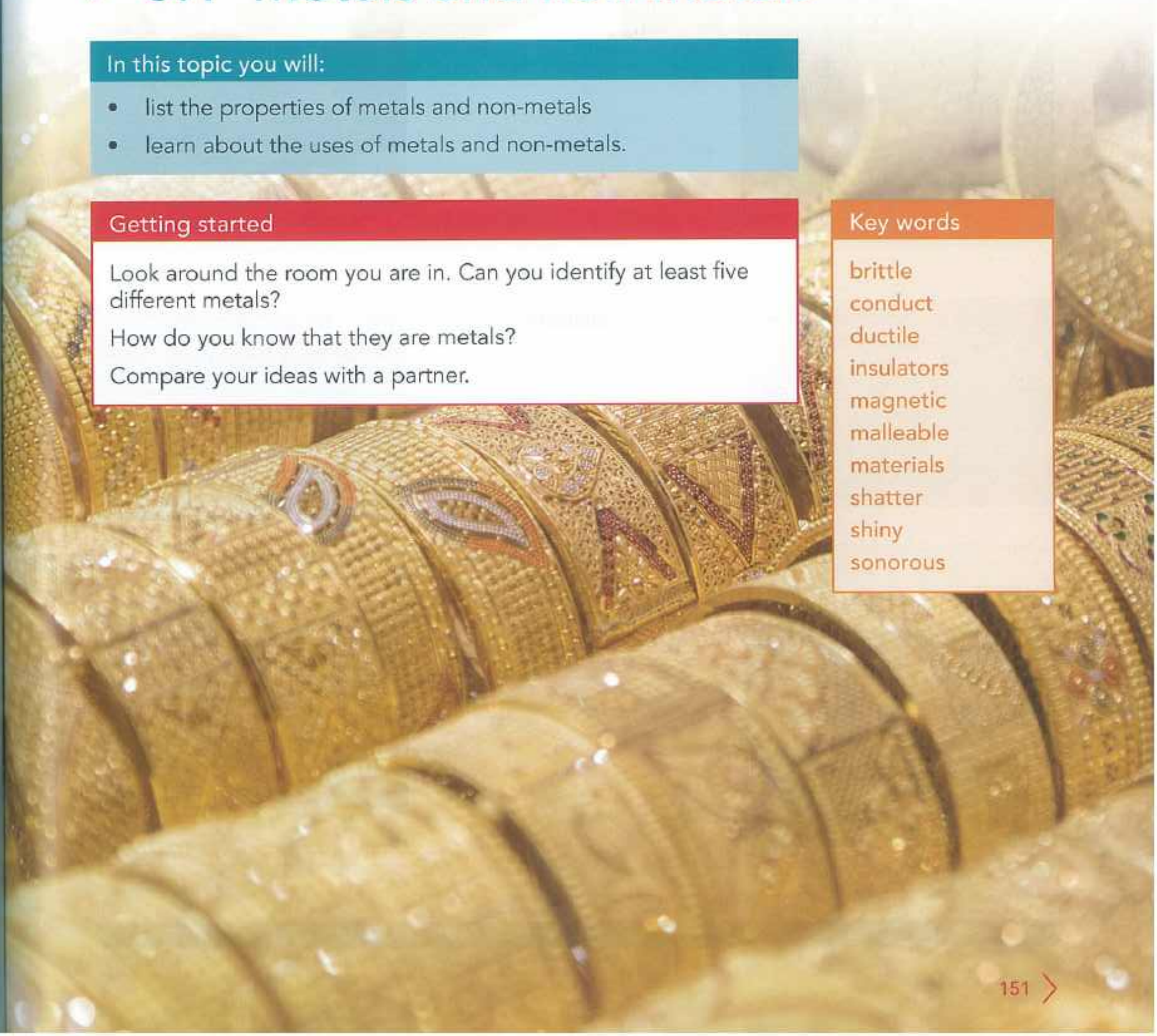
Look around the room you are in. Can you identify at least five different metals?

How do you know that they are metals?

Compare your ideas with a partner.

Key words

brittle
conduct
ductile
insulators
magnetic
malleable
materials
shatter
shiny
sonorous



Metals

Metals are very useful **materials**. Materials are the substances from which objects are made.

There are many different metals. Metals are used to do different jobs.

Metals are strong and tough. They do not shatter when dropped and they do not crack easily. They can hold large weights without breaking.

Iron is used for bridges because it is strong.

Metals are **shiny** when they are freshly cut or polished.

Gold is used for jewellery because it is beautiful, shiny and expensive.

Metals can be bent to shape them. Metals are **malleable**, which means they can be hammered into shape.

Iron is malleable.

Metals are **ductile**, which means that they can be drawn out into wires.

Copper is ductile.

Metals make a ringing sound like a bell when they are hit; the word for this is **sonorous**.

Cymbals make a ringing sound when hit.

Most metals do not melt easily. They have high melting points and high boiling points. Mercury is the only metal that is liquid at room temperature.

A lot of heat is needed to melt metal.

Metals are good conductors of heat. When you touch them they **conduct** heat energy away from the hand so they feel cold.

Steel conducts heat well, which is useful for cooking pans.

Some metals are **magnetic**. Iron, steel, nickel and cobalt are magnetic.

Some metals are magnetic.

Metals are good conductors of electricity. This means that an electric current can flow through them.

You need to remember that:

- the surface of most metals will become dull after a while
- big lumps of metal are hard to test for flexibility
- bottles and cups also make a 'ringing' sound when they are hit, but they are not made of metal.

Copper is used for electrical wiring because it conducts electricity well and is flexible.

Questions

1 List **ten** metals.

2 Why are gold and silver used for jewellery?

3 Why is copper so useful?

4 What do 'malleable' and 'ductile' mean?

5 What are Olympic medals made from?

6 Where are metals found in the Periodic Table?

Think like a scientist

Properties of materials

In this task you will investigate metal items such as electrical wire, scissors and a hammer.

1 Describe each item.

2 If you know what it is made from, name the metal. If you don't know, try to find out.

3 Suggest which property of the metal is important in the function of this item.

4 Make a table of your results like this:

Item	Metal	Useful property
Electrical wire	Copper	It conducts electricity. It is ductile.

Non-metals

Non-metals are often very useful because of the chemical reactions they have with other substances. There is a lot of variation between non-metals.

Properties shared by almost all non-metals

Non-metals look dull. They do not reflect light very well and the surface is not as smooth as metals.

Non-metals that are solids are **brittle**. If you drop them they may **shatter**.

Most non-metals do not conduct heat energy well. This is very useful because some of them can be used to make handles for cooking pans, for example.

Most non-metals do not conduct electricity. This is very useful because some can be used to make coverings for electric plugs and cables, for example. They are known as **insulators**; this means they do not conduct heat or electricity.

Properties shared by many non-metals

Non-metals are not as hardwearing as metals.

Many non-metals are gases.

The non-metals that are not gases have low melting points and low boiling points.

Sulfur is added to rubber to make it hard.

Pure oxygen is used in hospitals for people with breathing difficulties.

These balloons are filled with helium.

Chlorine is used to kill bacteria. For example, it can be dissolved in water and then added to swimming pools.

Carbon is used to purify water and to treat indigestion.

Silicon is used to make computer chips.

Questions

7 Name **five** non-metals, other than sulfur and helium.

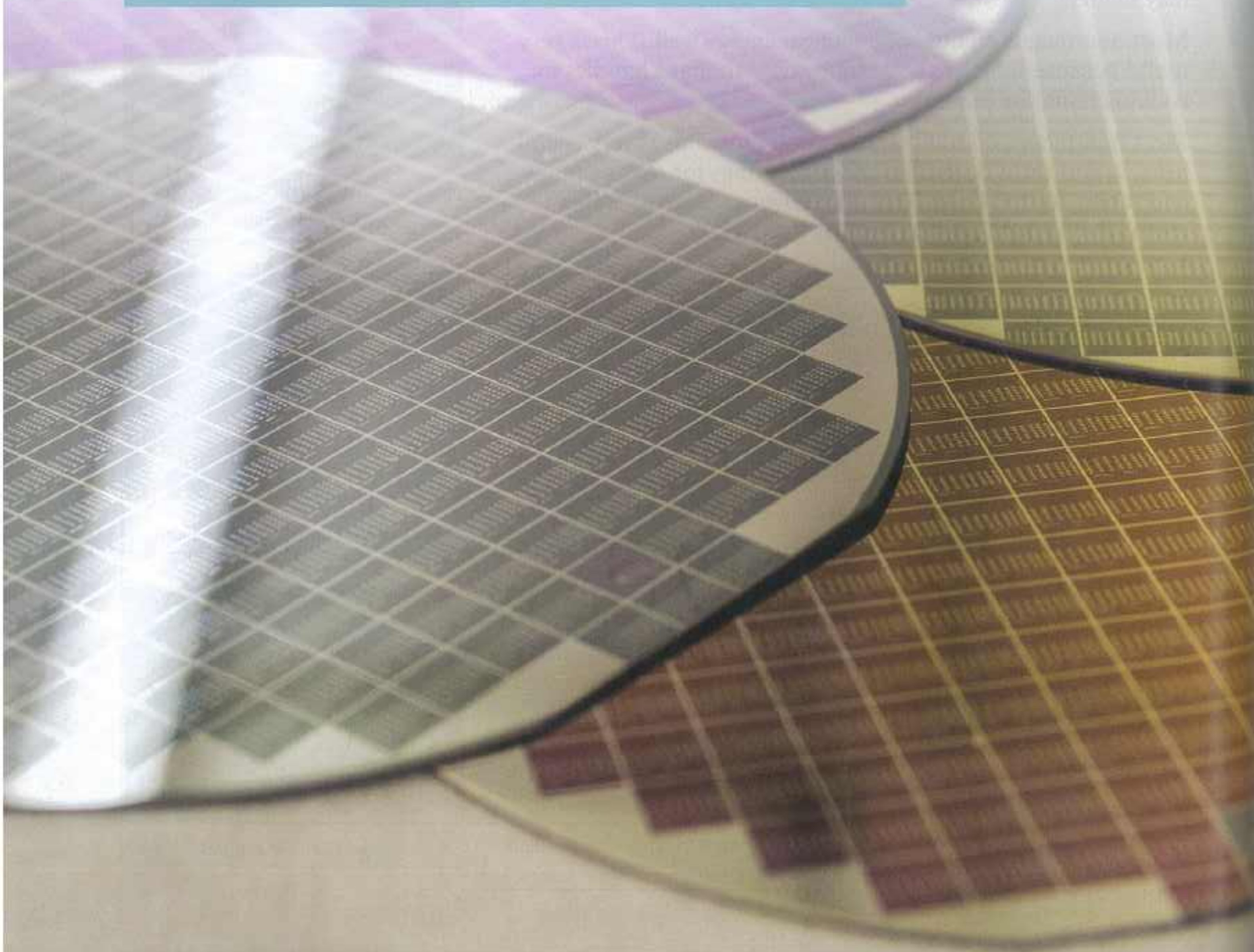
8 What is sulfur used for?

9 What property of helium makes it useful in balloons?

10 Where would you find the non-metals in the Periodic Table?

Summary checklist

- [ ] I can recognise the properties of metals and non-metals.
- [ ] I can identify the useful properties of metals and non-metals for a particular function.
- [ ] I can name ten metals and five non-metals.



> 5.2 Comparing metals and non-metals

In this topic you will:

- compare the properties of metals and non-metals
- investigate materials and decide if they are metals or non-metals
- find relevant information to answer questions.

Getting started

What do the terms 'ductile', 'sonorous', 'malleable' and 'brittle' mean?

Draw cartoon diagrams to help you explain their meanings.

Key words

contact
distinguish
examine

Comparing metals and non-metals

Metals and non-metals have different properties.

Metals	Non-metals
• Most are solid at room temperature. • They are shiny. • They do not shatter. • They conduct heat energy well. • They conduct electricity. • They are malleable. • They are ductile. • They are sonorous.	• Many are gases at room temperature. • They are dull. • They are brittle. • They do not conduct heat energy well. • Most do not conduct electricity.

Look carefully at this photograph of a market scene. What do you see?

Questions

1 List **five** objects in the photograph of a market that are made of metal and **five** that are made of non-metals.

2 A material is dull, brittle and does not conduct electricity. Is it a metal or non-metal?

3 Mercury is a metal. What unusual property does it have?

4 Write down two things that a metal can do better than a non-metal.

Think like a scientist

Investigating materials

In this task, you will be given a number of different materials to investigate. You will **examine** each material closely and test it so that you can **distinguish** (identify) which are metals and which are non-metals.

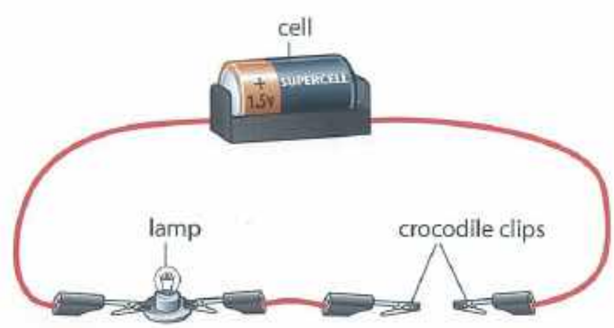
You will need:

- a selection of materials to test, electrical wires, a lamp, a cell (battery), crocodile clips

1 Ask a number of questions for each of the materials you investigate.
   - What does the material look like? Is it shiny or dull?
   - Does it make a ringing sound when you hit it?
   - Is it brittle?
   - Can you bend it?
   - Does it feel hot or cold?
   - Does it conduct electricity?

2 To test if the material conducts electricity, you can set up a circuit as shown in the diagram.

   Before you start, check that the lamp is working by connecting the crocodile clips together with no test materials. When you carry out the test make sure you have good **contact** between the crocodile clips and your test material.



Testing a material to see if it conducts electricity.

Question

1 Draw a table for your results. Decide if each material is a metal or and non-metal.

1 Were any of the materials difficult to place in the metals or non-metals group? Explain your answer.

2 Which do you think was the most useful test to distinguish between metals and non-metals?

Activity 5.2.1

Researching metals and non-metals

Choose **one** metal and **one** non-metal. Use reference books and the internet to find out about each of them. Make sure that the information you use is relevant (relates to the metal you have chosen and helps to answer the questions).

Here are some useful questions you could research.

- What is the metal or non-metal used for?
- What are its properties?
- How are these properties useful?
- Where is it found?
- Does the metal or non-metal need to be processed before it can be used? If so, how is this done?
- Are there any other interesting facts about it?

Present your research as reports or posters.

Write a paragraph comparing your metal and non-metal. Useful words and phrases might include 'whereas', 'lighter than', 'higher melting point than', 'compared with'. Make sure you actually **compare** the two and do not just list the two sets of properties. For example: Metals have shiny surfaces *whereas* non-metals have dull surfaces.

Summary checklist

- [ ] I can distinguish between metals and non-metals.
- [ ] I can carry out investigations to distinguish between metals and non-metals.
- [ ] I can find relevant information to answer questions.

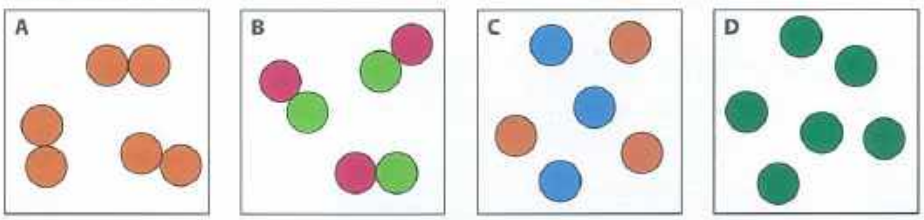
> 5.3 Metal mixtures

In this topic you will:

- learn about metal mixtures (alloys)
- use particle theory to explain the differences in the properties of metals and their alloys.

Getting started

Look at the diagrams of elements, compounds and mixtures below. Discuss with your partner which one is a mixture and give your reasons for choosing this one. Identify the other diagrams and be prepared to share your reasons for the choices with the class.



Key words

alloy
bronze
disrupt
steel

Alloys

Metal mixtures are called **alloys**. Alloys are made by mixing different metals together and melting them. The atoms of the different metals mix but do not bond together. The properties of the alloys are different from the metals they contain.

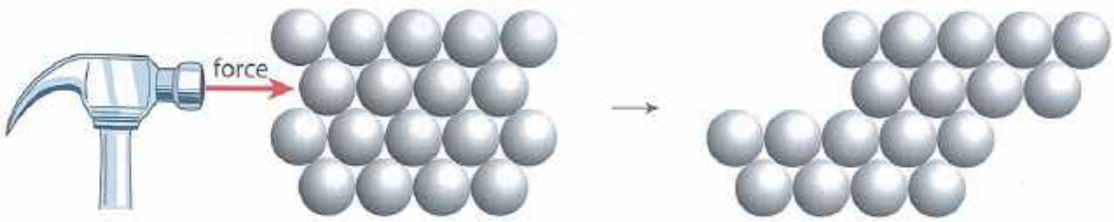
Bronze is an alloy made by mixing copper and tin. Bronze is harder than either copper or tin.

People learnt to melt copper and tin together to make bronze a very long time ago. This bronze head (left) was made in what is now Iraq, more than 4000 years ago. The statue on the right was made in Greece, about 2500 years ago

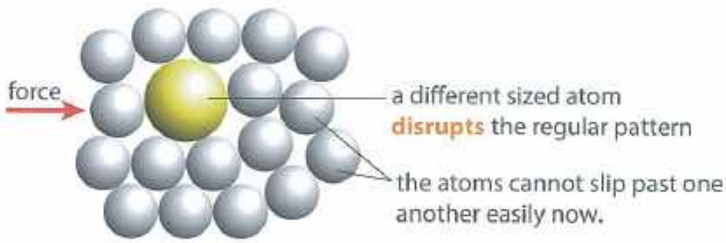
Steel is an alloy, but an unusual one because one of the elements in the mixture is not a metal. Steel is a mixture of iron and carbon. Pure iron is not hard enough to be very useful but when it is mixed with other elements to form steel it is much harder.

Sometimes, chromium and nickel are also added to steel. This type of steel does not rust and is used for cutlery.

The reasons why the alloys have different properties from the pure metal is to do with the arrangement of the particles of the elements. In a pure metal, the atoms are all the same size and arranged in regular rows. The layers can slide over one another easily. This is what happens when the metal is hit with a hammer. What do we call this property? This also happens when the metal is stretched out. What do we call this property?



When a force is applied, layers slide over one another easily in a pure metal.



An alloy. The layers of atoms can't slide over each other as easily now. They get stuck in place. This makes the alloy a lot harder and stronger than the original metal.

Think like a scientist

Modelling a metal and an alloy

You will need:

- The apparatus as shown in the diagram.

1 Make rows of small bubbles in the dish, as shown in the diagram. Push the syringe plunger in slowly and steadily to make sure the bubbles are all the same size. The bubbles represent the atoms in a metal.

2 Fill the dish with bubbles to model the close packed arrangement of atoms.

A Petri dish containing diluted washing up liquid.

Questions

1 Do the bubbles line up in rows?

2 What happens when a bubble bursts?

3 Can you see how easily the rows of bubbles slide past each other? Describe what you see.

Continued

Inject a larger bubble into the middle of the dish. You do this by pushing harder and for longer. You may have to have several goes to achieve it – it takes a bit of practice.

This is like adding an atom of a different metal. You now have a model of an alloy.

4 Can you see how this disrupts the regular pattern of bubbles? Describe what you see.

How good a model of the particle arrangement in an alloy was this? How well did it help you to understand the idea?

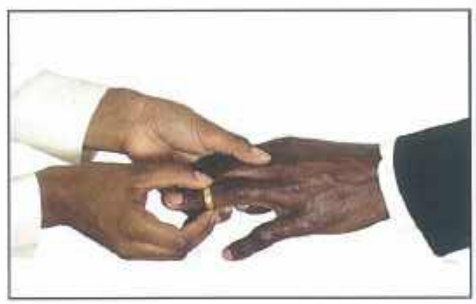
Alloys in everyday life

Coins

The coins in your pockets are made from alloys. Pure metals are too soft to withstand all the wear they get. The coins that look silver are not made of silver – it is too soft and far too expensive. The silver coins are made of alloys containing copper and nickel. The copper coins contain copper, zinc and tin. Coins must be hardwearing but also malleable enough to be stamped with complex patterns.

Jewellery

Most gold jewellery is not pure gold; it is an alloy of gold and copper. Pure gold is soft. If you used pure gold for something like a wedding ring (that gets a lot of wear and tear) it would wear away. A wedding ring should be made from something stronger. Pure gold is 24 carat: that means that 24 parts out of 24 are gold. 18 carat gold has 18 parts out of 24 of pure gold, and six parts of other metals such as copper, silver or zinc.



Aeroplanes

The metal used to build planes needs to be light but very strong. Planes are mainly made of aluminium, but pure aluminium would not be strong enough and the plane's wings would fall off because of the great stress put on them during flight. By adding magnesium and copper, an alloy called duralumin is formed. Duralumin is about five times stronger than pure aluminium.

Artificial joints

The joints in our bodies take a lot of wear and tear. Sometimes, the joints are attacked by arthritis. This is a very painful and crippling disease. Now people can be fitted with replacement joints. These are made of plastic and alloys, often alloys of titanium.

Titanium hip joint

X-ray of the pelvis showing a hip replacement.

Modern alloys

Modern alloys have been developed that have some very useful properties. Some glasses frames are made of shape memory alloy. If this alloy is bent, it will go back to its original shape by being heated. This alloy is called Nitinol. Nitinol is made of nickel and titanium.

Questions

1. What is an alloy?
2. Which properties of aluminium make it useful for building planes?
3. Why is an alloy of aluminium used for making planes instead of pure aluminium?
4. Pure gold is 24 carat gold. What does this mean?
5. Explain the difference between the purity of 18 carat gold and 24 carat gold.

6 Why do we not use pure silver for our coins?

7 Why do we not use pure copper for our coins?

8 What properties must an alloy used inside the body have?

9 Why are some glasses frames made from shape memory alloy?

Brass and bronze

Brass is an alloy of copper and zinc. There are different types of brass, made by using different amounts of copper and zinc. Sometimes, other elements such as lead, aluminium, manganese or silicon are added.

Look at the table of information about copper, zinc and brass.

Name	Copper 	Zinc 	Brass 
Element or mixture?	element	element	mixture
Appearance	reddish brown soft metal	silvery grey soft metal	golden yellow, reddish gold or silver soft alloy
Melting point	1085 °C	419.5 °C	900–1000 °C
Properties	very ductile and malleable	less ductile and malleable than copper	less ductile than copper; more malleable than zinc and copper
	conducts heat and electricity well	conducts heat and electricity less well than copper	conducts heat and electricity less well than zinc
			resistant to corrosion
Example uses	electrical wiring; central heating pipes	to cover iron in a thin layer to prevent it from rusting	musical instruments, plumbing

Look at the melting points: copper and zinc have just one temperature listed. However, brass has a range of temperatures. There are many different types of brass, which are made by using different amounts of copper and zinc. So, there is no specific melting point for brass; it depends on the proportions of copper and zinc that have been used.

Another alloy of copper is bronze. Bronze is an alloy that is made by mixing copper with tin. Sometimes, other elements such as manganese, phosphorous, aluminium or silicon are added. Mixing different amounts of copper and tin makes the different forms of bronze. Each different mixture has its own different melting point.

Name	Copper 	Tin 	Bronze 
Element or mixture?	element	element	mixture
Appearance	reddish brown soft metal	white metal	reddish brown not as bright as brass
Melting point	1085 °C	232 °C	860–1150 °C
Properties	very ductile and malleable	soft, ductile and malleable	less ductile than copper; hard; brittle
	conducts heat and electricity well	conducts electricity less well than copper	good conductor of electricity
		does not corrode readily	corrosion resistant
Example uses	electrical wiring; central heating pipes	coating the inside of food cans and in many different alloys	bronze sculptures; bells and cymbals; ship fittings (especially parts which are submerged under water); electrical connectors

Questions

10 Why is a range of temperatures given for the melting point of bronze?

11 Give one property that brass and bronze share.

12 Give one property that copper and zinc share.

13 Give one difference in properties between copper and tin.

Summary checklist

- [ ] I can describe some alloys and their uses.
- [ ] I can explain that alloys have different properties from the metals they are made from.
- [ ] I can explain the differences in the hardness of metals and their alloys using particle theory.

5.4 Using the properties of materials to separate mixtures

In this topic you will:

- use what you know about mixtures to separate them
- choose apparatus to carry out a practical task
- carry out practical work in a safe way.

Getting started

1. What is the difference between a mixture and a compound? Discuss it with a partner.
2. How could you separate a mixture of dry rice and peas? Discuss your ideas with a partner and be prepared to share them with the class.

Key words

condenser
conical flask
filter funnel
filter paper

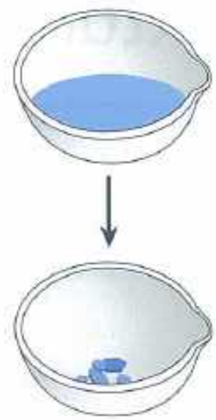
Making mixtures

Mixtures contain different substances that are not combined together chemically. You made a mixture with iron filings and sulfur in topic 2.7. You separated the iron and sulfur in your mixture by using a magnet. You used the difference in the properties of iron and sulfur to separate them. Iron is magnetic; sulfur is not magnetic.

Separating mixtures

Copper sulfate and water

The evaporating dish contains a mixture of water and copper sulfate. If it is left in a warm room, the water evaporates and leaves the copper sulfate behind in the dish.



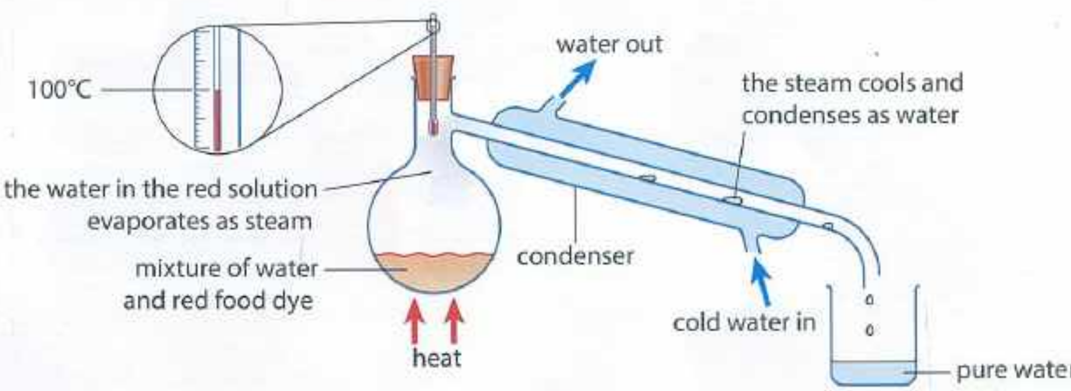
The water evaporates and leaves the copper sulfate in the evaporating dish.

Food dye and water

A mixture of food dye and water can be separated by using a piece of apparatus called a **condenser**. It is used to separate mixtures of two liquids.

The water and food dye mixture is heated and boils. The liquid water reaches the temperature where it changes state and becomes a gas. Water that is in the gas state is called steam when it has been formed by boiling the water. The gas travels along the tube into the condenser. The cold water that is circulating around the outside of the condenser cools the gas down. This makes the gas condense back into liquid water. The liquid water collects in the beaker. The food dye remains in the heated container.

The food dye and water have different properties that allow you to separate them – they have different boiling points.



Separating water from a mixture of food dye and water.

Questions

1 Explain how the water in the flask changes to a gas.

2 Explain how the steam changes back into a liquid in the condenser.

3 Which different properties of the water and the food dye are used to separate them?

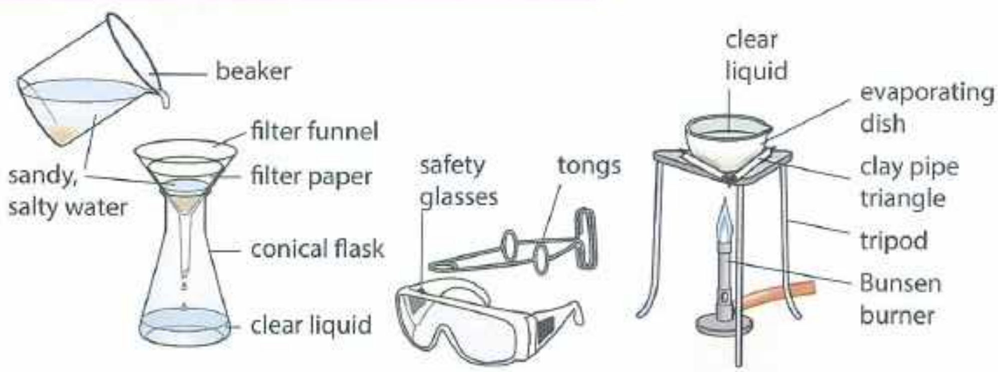
Think like a scientist

Separating sandy, salty water

Your task is to separate a mixture of sandy and salty water.

You will need:

- The apparatus shown in the diagrams.



1 Prepare a **filter paper** and place it in a **filter funnel**. Place the funnel in the **conical flask**.

2 Pour the mixture into the funnel. Take care to add it slowly so that the mixture does not go down the outside of the filter paper. Do not disturb the wet filter paper because it tears easily.

3 When you have filtered all the mixture, leave the filter paper in a warm place to dry.

4 Place the clear liquid from the conical flask in an evaporating basin. Wear safety glasses. Heat this gently. When the liquid starts to spit, remove it from the heat.

5 Leave the liquid in a warm place to evaporate.

Questions

1 Suggest why the sand remains in the filter paper.

2 One group of students thought their mixture was taking too long to filter so they used a pencil to stir it up while it was in the filter paper. Explain why this is not a good idea.

3 What safety precautions should you take when heating the salty water?

4 How could you obtain the water from your mixture?

5 The salt left in the evaporating basin is a little dirty. Suggest what you could do to get cleaner salt.

Now read the Reflection points on the next page.

How carefully did you carry out this practical task? How well did you consider safety? How could you improve the way you carry out a practical next time you do one?

Think like a scientist

Separating two solids

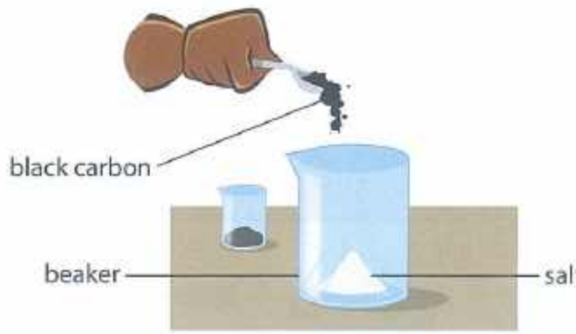
If you mix powdered black carbon and table salt together you have a mixture of two solids.

How can you separate the carbon from the salt?

What do you know about the properties of carbon powder and table salt that might be useful here?

Make a plan of how you could do this. Remember to think about safety.

Make a list of the equipment you would need.



Making a mixture of powdered carbon and table salt.

Discuss it in your group.

Share your ideas with the class.

Did you change any of your ideas when you discussed them with the class?

Carry out your plan, once it has been checked for safety.

Questions

1 Which properties of the two solids did you decide to use to help separate them?

2 Write down your final list of the equipment you will need.

3 Write an outline of your final plan. Explain how the steps will enable you to separate the two solids. Draw diagrams if that helps to make your plan more clear.

4 What safety precautions should you take?

Self-assessment

How successful were you in separating the two solids? How could you improve your results?

Summary checklist

- [ ] I can identify properties of different substances in a mixture and use those to separate them.
- [ ] I can choose appropriate equipment for a practical task.
- [ ] I can carry out a practical task safely.