

Solomon Islands  
**Science**  
Year **7**

Learner's Book

## Solomon Islands Curriculum Development Division

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# Introduction

The exciting new ***Solomon Islands Science Year 7 Learner's Book*** is part of a series of textbooks for learners in years 7, 8 and 9. This book:

- is relevant to learners and contains outcomes for post-primary learners
- encourages students to learn science concepts through hands-on and relevant activities
- features outcomes that are related to the day-to-day concerns and lives of learners
- expands learning beyond the science laboratory, as some activities take learners to their backyard and village environments to learn about science
- provides for both individual and group work. This allows learners to work at their own pace, encouraging them to discuss, reflect on and evaluate their own learning in science
- includes section reviews and summarises key points, thereby allowing learners to assess their own understanding of important science concepts
- comes with an accompanying teacher's guide to help teachers better evaluate their learners' performances.

This series of textbooks will intrigue and engage learners. ***Solomon Islands Science Year 7 Learner's Book*** has a wide range of contextualised activities and examples that further clarify issues featured in the syllabus. This book also helps learners to better understand science concepts and apply them in the context of life in Solomon Islands.

## CHAPTER

# 1

# What is science?

By the end of this chapter the learner should be able to:

- Apply safety procedures when doing science experiments in the science laboratory.
- List basic laboratory safety rules.
- Describe a living and a non-living thing.
- Describe the four main branches of science.
- Demonstrate the two types of observations: *qualitative* and *quantitative*.
- Explain inferring and prediction.
- List and draw basic science laboratory equipment.
- Write a scientific report of a simple science experiment that has been carried out.
- State the appropriate units used for these measurements: *length, height, distance, mass, time, speed, volume, temperature*.
- Demonstrate the uses of balances: *beam balance, electronic balance*.
- State scientific questions that scientists normally ask.
- List the five senses that scientists use for observation.
- Design a scientific experiment to solve a scientific problem.
- Describe at least five benefits science brings to our country.

- 1 What do you think science is?
- 2 Identify some of the dangers you may meet in the science laboratory. How might you avoid them?
- 3 Name as many types of science equipment as you can.
- 4 What should a report about a science experiment tell the reader?
- 5 A metre is one of the metric units used in science. Identify some more.
- 6 What does the word 'variable' mean?

## Specific learning outcomes

7.1.1. 7.1.1.2. 7.1.2.1. 7.1.2.2. 7.1.3.1. 7.1.3.2. 7.1.4.1. 7.1.5.1. 7.1.6.1. 7.1.6.2. 7.1.7.1. 7.1.7.2. 7.1.8.1. 7.1.9.1



## Challenges

# UNIT 1.1

## Doing science safely

### introduction

In science you will experience some dangerous situations. You will work with strong heat, acids and other **corrosive** substances. It is dangerous if any chemicals are splashed into your eyes. Other chemicals are **poisonous** and can make you very ill or can kill. Broken glass and equipment may cut you. Fragments of broken glass may enter the eye.

Before we can start any science we must agree on a set of laboratory **safety** rules. These rules will assist us in reducing any dangers.

The figure below shows some situations where students are doing something dangerous. Can you identify the dangers? What rules would you make to prevent these dangers happening?



Fig 1.1.1

What's wrong?

In the figure below, the students are doing the right thing. Can you identify what they are doing right?



What's right?

Fig 1.1.2

When working in a science laboratory, always look for unsafe activities and report these immediately to your teacher.



## [ Questions ]

**Checkpoint**

- Copy the following into your workbook. **Modify** any incorrect statements so they become true.
  - It is OK to pour *all* substances down the sink after an experiment.
  - Running and pushing people in the laboratory is *never* allowed.
  - It is OK to eat and drink in the laboratory.
  - Spilt chemicals can be left unattended.
  - The teacher must always be told if something goes wrong.
  - All solid objects should be put in the bin and not down the sink.
  - Safety glasses are optional when we use chemicals in the laboratory.
  - Chemicals should never be tasted or smelled.
  - To investigate a reaction in a test tube, look straight down the tube.
  - Always point test tubes away from yourself and others.
  - It is good science to mix unknown chemicals together.
- Describe** four dangers that you might have to deal with in a science laboratory.

**Think**

- Compare** the dangers that appear in science with the dangers that appear in other subjects such as:
  - Industrial Arts or Technology
  - Home Economics
  - Agriculture
- Explain** why safety rules in science might be different to the rules in other classes.
- Identify** five injuries that can happen in a science laboratory if simple safety rules are not obeyed.
- Suggest** a way of reducing the risk of those injuries occurring.

- Eye injuries are common in science laboratories. **Describe** two ways that eye injuries could occur and suggest how to minimise the risk of these injuries.
- Make a **list** of ten safety DOs and ten DON'Ts in the laboratory.

**Skills**

- Without using any words, **design** a simple two-colour sign to tell people about one of these:
  - there is a slippery surface ahead
  - crocodiles are in the waterways
  - you should not eat centipedes
  - earmuffs must be used in this area
  - fruit is good for you
- Design a series of simple signs to inform students of the science safety rules. The signs must be in two colours only and use only a few words.

## [ Extension ]

**Investigate**

- Find and draw the symbols commonly used to label these types of chemicals:
  - flammable
  - corrosive
  - explosive
- Define** these terms:
  - toxic
  - caustic
  - flammable
  - spontaneous combustion
- Draw what you think would be good symbols for the terms used in questions 2a and 2b.
- Find and draw the signs commonly used for the following:
  - an information sign showing that this is a wheelchair toilet
  - a warning sign that eye protection should be worn



5 What do you think these signs or labels mean?

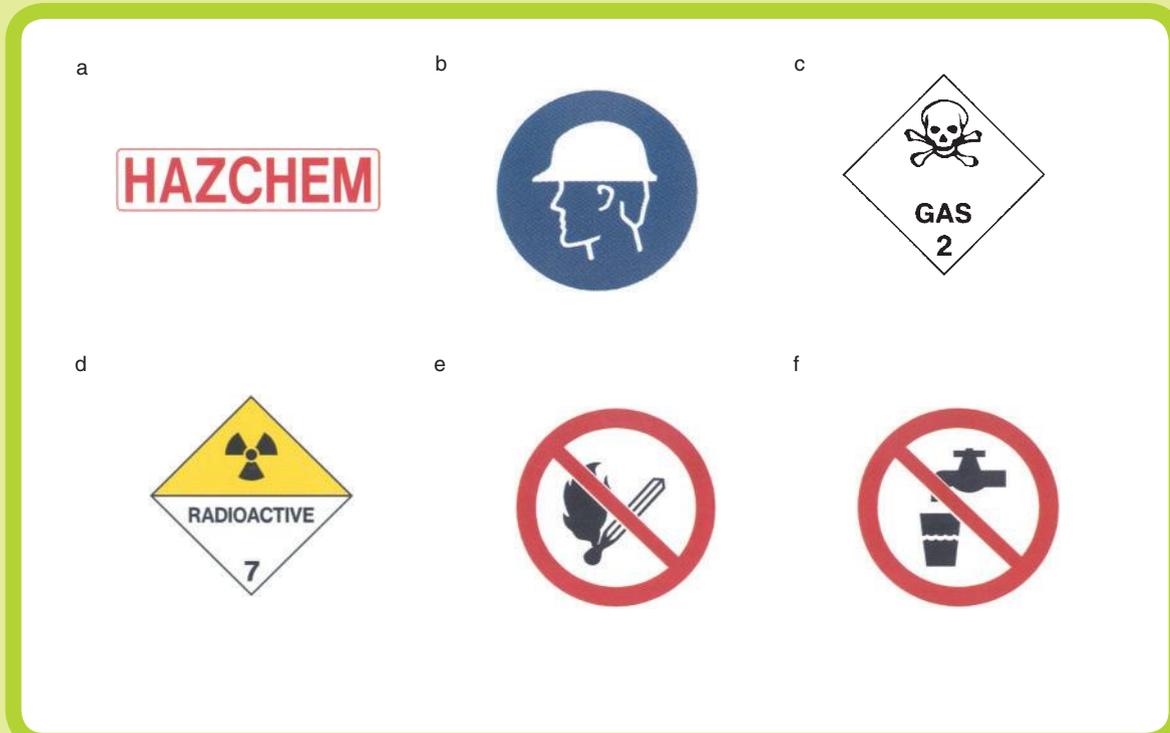


Fig 1.1.3

# UNIT 1.2

## Being alive

### introduction

If you were given a snake, a tape recorder, a pencil case and a tuna, you would have no difficulty sorting them into a group of living things and a group of non-living things. It would be a little more difficult if you were given some pond slime. Although it is living, it seems to be less lively than the water in a fast-flowing river. So how do we know that something

we are observing is living or not? In order to decide whether something is living or not we must use a set of characteristics.

Scientists use these characteristics to make it easier to work out if something is living or not. In this way we can all agree about what 'living' means.

Anything that has life is called an organism, including you.

### The characteristics of life

We can tell if something is living or not by looking at its **characteristics**. For example, two characteristics of village chickens are that they eat worms and walk around using their two legs. There are certain characteristics that all living things possess. All living things:

- take in and use energy
- take in and use gases from the air or water in which they live
- produce wastes
- respond to stimuli in their environment
- are able to move
- are able to reproduce
- grow.



Fig 1.2.1

The water moves, but is it living?



Coral eating a small octopus to gain energy

Fig 1.2.2

Animals meet all the characteristics of living things. Plants are living things too. However, their slow movement and growth make it difficult for us to notice it.

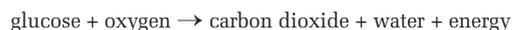
Some things that are not alive may possess some of the characteristics of living things, but not all of them. For example, the water in a river can move but it is not a living thing. Among other things, it does not use air or reproduce.

### Living things take in and use energy

Animals and plants take in and use energy. This energy is used to move, grow, reproduce and carry out activities.

Animals are **heterotrophs**. This means that they cannot make their own food. They need to eat frequently in order to survive. Animals need a lot

more energy than plants. They use glucose, a type of sugar, as their energy source. Glucose is used by organisms in a chemical reaction called **respiration**. In this reaction, glucose and oxygen are used to produce carbon dioxide, water and energy:



Plants also make energy by respiration. They are able to make their own glucose to carry out this reaction. Organisms that can make their own food are called **autotrophs**.

The chemical reaction that plants carry out to produce food is called **photosynthesis**. In photosynthesis, carbon dioxide and water are used to produce glucose and oxygen:

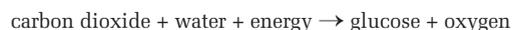


Fig 1.2.3

Plants absorb energy from the Sun and use it to make food.



This plant does not gain energy from the insects it traps—it gets nitrogen.

Fig 1.2.4

Plants capture energy from the Sun to make this reaction happen.

About two-thirds of the food that humans take in is used to keep us warm. If our bodies are not kept at 37°C, we will quickly become unwell. This is because we are **endothermic** (warm-blooded). Some animals, like crocodiles, don't use the energy from their food to keep themselves warm. Instead they use the warmth of the Sun. This means that, in spite of their large size, crocodiles don't eat very much food. Animals like this are said to be **ectothermic**.

## Activity 1

### Light and photosynthesis

**Aim** To investigate how the amount of light affects how much food a plant makes

#### Equipment

A plant that has been left in the dark for several days and a plant that hasn't OR a plant with several leaves that have been covered with aluminium foil for several days, ethanol, 1 large and 1 small beaker, iodine solution, heat mat, Bunsen burner, tripod, gauze, tweezers, watch-glass

#### Method

- 1 Take one leaf that has been left in the dark and one that has not. Make sure they are different sizes so they are easy to tell apart. Record their appearance.

>>

- 2 Set up a hot water bath.
- 3 Add the leaves to the small beaker and just cover them in ethanol.
- 4 Carefully place the small beaker in the hot water bath as shown in Figure 1.2.5. You may need to hold it with a test tube holder.

**CAUTION:** Ethanol is extremely flammable. Do not get it near the Bunsen burner flame.

- 5 Boil the leaves in the ethanol until most of the green colour has come out.

- 6 Remove them from the beaker with the tweezers and place them on the watch-glass.

- 7 Cover them with iodine solution and record their appearance.

### Questions

- 1 Iodine turns purple when it is mixed with starch. The greater the amount of starch in the leaf, the more photosynthesis has occurred. Identify which leaf had the most photosynthesis occurring.
- 2 Draw a conclusion from this practical.

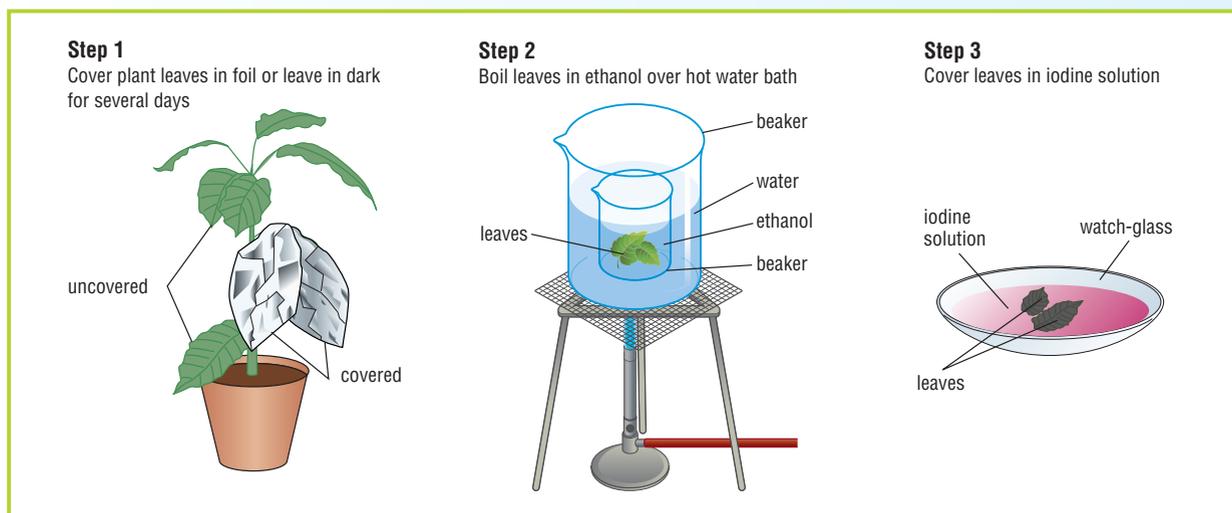


Fig 1.2.5 Light and photosynthesis

## Living things use air

Animals take in oxygen gas from the air. They use it for respiration. Mammals (including humans) and birds use lungs. Their lungs must stay moist so that gases can dissolve and pass easily into or out of the blood. Fish use gills and many very small animals, like frogs, use their whole body surface to obtain and release gases.

Like animals, plants take in oxygen for respiration. Plants take in carbon dioxide for photosynthesis. Plants use their leaves to obtain gases they need from the air. Leaves have special holes called **stomata**. They allow gases to pass in and out. Like lungs, the inside of the leaf is damp so that gases can dissolve and move around.

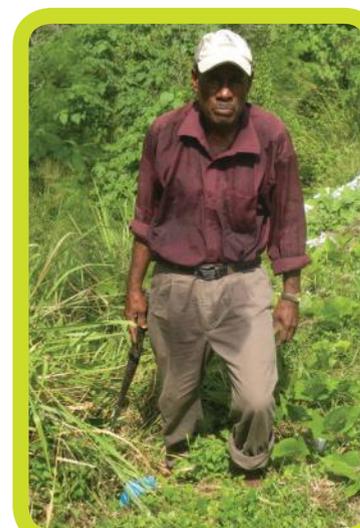
## Living things produce wastes

There are many chemical reactions taking place inside organisms all the time. These reactions produce wastes. Some wastes are poisonous. An example of

a waste product is carbon dioxide. Humans breathe out carbon dioxide. We also get rid of excess water by urinating and sweating.

Plants use their leaves to get rid of the waste oxygen produced by photosynthesis.

The removal of waste products from an organism is called **excretion**.



Sweating is one way in which humans excrete wastes.

Fig 1.2.6

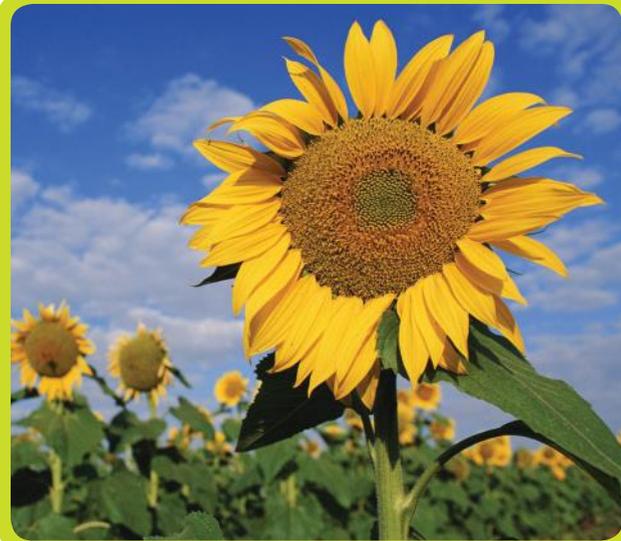
## Living things respond to stimuli

Organisms react to changes in their environment. The change is called the **stimulus**. It is the thing that causes or makes a **response**. If you hear a loud, unexpected noise you jump. The stimulus was the noise. The response is the jumping.

Plants also react to change. However, the response cannot be as easily seen as when an animal responds.

When a plant on a window ledge grows towards the light, it is responding to the stimulus of the sunlight. If you could sit and watch a field of sunflowers for a whole day, you would notice that the flowers follow the Sun around the sky.

Newly germinated vegetable seedlings in an experiment box would also grow pointing towards the hole made in the box through which sunlight enters. Gravity is another stimulus. You would observe after few days the roots of the plant in the tilted pot-plant growing downwards while the shoots respond upwards.



Sunflowers turn to follow the Sun.

Fig 1.2.7

## Living things move

The ability to move by itself is a very simple characteristic of life. Movement also plays a very important role in some of the other characteristics. Reacting to changes and feeding (collecting energy) often rely on movement.

In 1674, Antoni van Leeuwenhoek first used a very simple microscope to look at pond water. He saw tiny shapes that were moving about. Because they were

moving he decided they were alive. He had used one of the characteristics of life to decide that his new discovery was a living thing.



Fig 1.2.8

Hunting and escape rely on movement and response.

## Living things reproduce

All living things are capable of reproduction. They can make new individuals that are very similar to themselves. Reproduction can be **sexual** or **asexual**. Sexual reproduction requires two parents. Asexual reproduction needs only one parent.



Fig 1.2.9

Living things can reproduce—mating red-eyed tree frogs



Barramundi change gender during their lives.

Fig 1.2.10

## Activity 2

### The germinating seed

**Aim** To observe the changes that occur during growth and development of a living thing

#### Equipment

3 small glass or plastic containers, cotton wool, aluminium foil, sticky tape, 30 bean or corn seeds, plastic wrap, pin

#### Method

- 1 Put about 1 cm of cotton wool in the bottom of each container. Moisten it with a bit of water.
- 2 Add 10 bean or corn seeds to each one.
- 3 Place plastic wrap over the top to stop the seeds drying out.
- 4 Use the pin to make a small airhole in each piece of plastic wrap.
- 5 Completely cover one of the containers with the aluminium foil so that no light can get in.
- 6 Cover another container in a similar way but this time leave a 1 square centimetre window in the foil near the top of the container.
- 7 Leave the containers in a safe place for several days.
- 8 Remove the paper and note any difference in the seeds.

#### Questions

- 1 Sketch your results, labelling each container.
- 2 **Explain** what this experiment has shown.

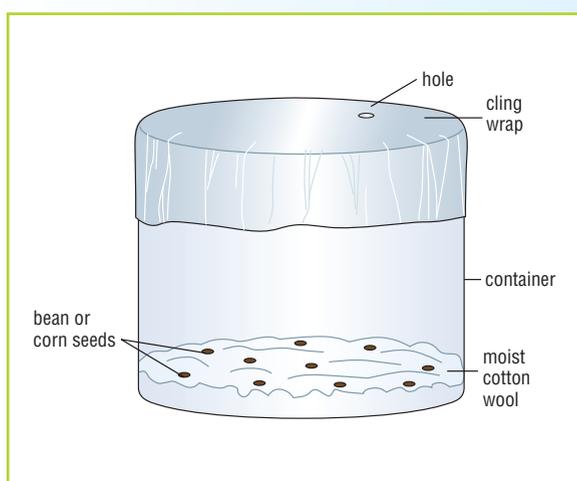


Fig 1.2.11 Germinating and growing seeds

## Living things grow and develop

As living things become older they tend to become larger, more complicated, or both. This is called **growth**. Some things grow very slowly. Some grow more quickly.

As humans grow they change shape. Have you ever noticed how large a baby's head is compared to its body? By the time you are fully grown, your head will be about one-tenth of your body length but a newly born baby's head makes up about a quarter of its length.

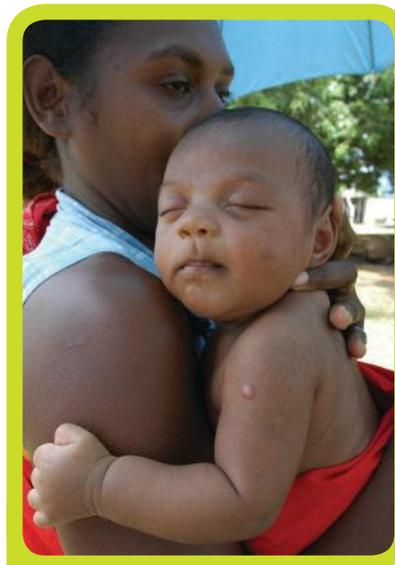


Fig 1.2.12 Babies' heads make up a quarter of their length.

### Cells

There is another characteristic that all living things share that you cannot see with the human eye. All living things are made up from at least one cell or from things that are made from cells, for example hair or fingernails. This is why we call cells 'the building blocks of life'.

As you will see in Chapter 7, nobody knew that living things were made of cells until the microscope was invented. A living thing grows because it has produced more cells. A fully grown blue whale contains more than one trillion cells!



Fully grown blue whale

Fig 1.2.13

# 1.2 [ Questions ]

## Checkpoint

### The characteristics of life

- 1 Explain** what a characteristic is.
- 2 State** two characteristics of humans.
- 3 List** the seven characteristics of living things.

## Think

- 4** Copy and complete the following equation for respiration:  
glucose + \_\_\_\_\_ → carbon dioxide + \_\_\_\_\_ + \_\_\_\_\_
- 5** People breathe through their lungs. **Explain** how other animals and plants breathe.
- 6 Identify** the term used for the removal of wastes from an organism.
- 7** A person runs up to a chicken and it flies away. In this case, **identify**:  
**a** the stimulus    **b** the response
- 8 Compare** endothermic animals and ectothermic animals by making a list of their differences.
- 9 Explain** the difference between sexual and asexual reproduction.
- 10 Explain** why people didn't know about cells until the microscope was invented.
- 11** Plants don't move very much. **Describe** an example of plants moving in their own way.
- 12 Clarify** whether organisms have to show all the characteristics of living things in order to be alive.
- 13 Identify** one non-living thing that displays a characteristic of a living thing.
- 14** Look around the classroom. **Identify** one living and one non-living thing that you can see.
- 15** Plants are living things, yet it is difficult to see some of the characteristics of life in them. **Explain** why.

## Analyse

- 16 Classify** the following things as living or non-living. Give a reason for your answer in each case.  
**a** a rat                    **b** a pen                    **c** a pineapple  
**d** a human                **e** a car                    **f** a tree  
**g** a cow                    **h** a rubbish bin
- 17** Some robotic toys seem to behave as if they are alive. For example, they indicate when they need 'feeding'.  
**a List** the characteristics of life that they show, and those they do not show.  
**b Evaluate** whether these toys could be alive.
- 18** During the *Apollo 13* mission, the astronauts had a problem with the device that removed carbon dioxide from the air they were breathing.  
**a Explain** where this carbon dioxide came from.  
**b Explain** why we don't have similar problems on Earth.

- 19** This is a story about a normal person. He does the same sorts of things that we all do but there is one big difference. Aliens from another planet are watching him! They are trying to decide whether he is alive. This is what they see him doing one morning.

*Jack wakes up when his loud alarm clock rings at 6.45 a.m. He reaches across to the bedside table and turns it off. He also turns on the bedside lamp. The bright light from the lamp makes him blink.*

*After a short while, Jack gets out of bed and walks to the bathroom. He goes to the toilet, takes a shower and walks down the stairs. He can smell toast cooking in the kitchen and he breathes in deeply to take in the wonderful smell. After eating his breakfast, he leaves the house and walks to the ferry. The cold Sydney air makes him cough as he gets on the ferry to go to work.*

**Construct** a table to **summarise** the things that Jack did during the morning that the aliens could use to prove he is alive.

## [ Extension ]

### Investigate

- 1** When people go to other countries, they often take travel guides with them. These point out the interesting places to see. These books contain a section on the wildlife of the area. Write a section for a travel guide to be used by an alien from another planet that would help them to decide what is and what is not alive on Earth.
- 2** NASA scientists have just found what they think may be evidence that there used to be life on Mars. **Research** what this evidence is and how it relates to the characteristics of life.
- 3** When we send space probes to other planets, we often look for evidence of water rather than 'little green men'. **Research** and **explain** why.

### Create

- 4** Create a new organism that shows all the characteristics of life.  
**a** Decide in which environment your organism will live.  
**b** Either **construct** a model of your organism using play dough, or present your organism as an artwork or poster.  
**c** Make a key to **explain** how your organism meets the requirements of life. For example, how does it make its energy, move about etc.?  
**d Evaluate** a classmate's organism and decide if it is truly alive.

# UNIT 1.3

## Observing

### introduction

Every one of us is a scientist already, since we are always observing and interacting with the world around us. To be a good scientist we must use these **observations** to think about what is happening.

### Observations—qualitative vs quantitative

Scientists make two types of **observations**. Sometimes observations are **qualitative**. They are written down in words only. Qualitative observations would be made about the noise a bird makes, the taste of ice-cream or the bubbles that appear when the top of a soft drink bottle is unscrewed.

Other observations are **quantitative**. These observations involve **measurements**. They are stated as numbers. Examples are the temperature of a room recorded as 25°C; the time being 12.45 pm; or the volume of a liquid in a can of Coke being measured as 300 mL.

### Inferring and predicting

From your observations, you can make an **inference**, or logical explanation, about what happened and

why it happened. You may then be able to **predict** how it could work in the future. Predictions must be logical and based on the observations made in your earlier experiments. You make observations, inferences and predictions every day, probably without knowing it:

*Observation:* The dog barked.

*Inference:* That possum is back again.

*Prediction:* The barking will frighten it away.

Sometimes the same observation can lead to different inferences and predictions:

*Observation:* The leaves are turning brown.

*Inference:* The tree is dying.

*Prediction:* I will have to get a new one.

or:

*Observation:* The leaves are turning brown.

*Inference:* It is a deciduous tree that loses its leaves in autumn.

*Prediction:* It will get new leaves in spring.

A calendar may assist you in deciding which is correct.

### Activity 3

- 5 Now cover the candle with a gas jar or beaker.
- 6 Record more observations.
- 7 Weigh the candle and lid again.

### The burning question!

**Aim** To observe a burning candle

#### Equipment

A candle, gas jar or beaker, metal or plastic lid or petri dish, matches, access to electronic scales

#### Method

- 1 Melt a little of the wax at the bottom of the candle and use it to stick the candle to the lid or petri dish.
- 2 Weigh the candle and lid or dish on the electronic scales. Record your result.
- 3 Light the candle.
- 4 Use all your senses (except taste) to write as many observations as you can.

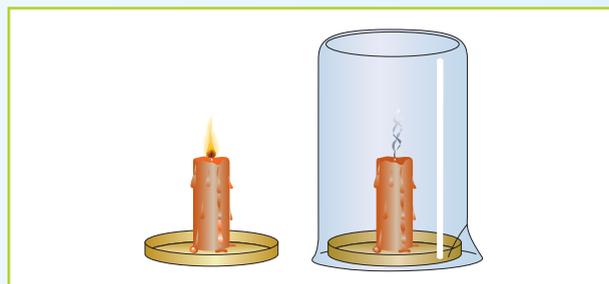


Fig 1.3.1

#### Questions

- 1 How many different observations did you make? For each observation, **state** whether it was qualitative or quantitative.
- 2 Compare the two weights. If they were different, **explain** why.

# 1.3

UNIT

## [ Questions ]

### Checkpoint

- Copy the following into your workbook and **modify** any incorrect statements so they become true.
  - A qualitative observation is one where numbers are involved.
  - If we use a thermometer, we are making qualitative observations.
  - The colour of a leaf is an example of a quantitative measurement.
  - An inference is a logical explanation about what happened in an experiment.
  - A prediction is a logical guess about what might happen in the future.
- List four observations about samples of:
 

a sugar	b water
c milk	d a \$1 coin
e the gas we breathe out	

### Think

- Label each sentence below as an observation, inference or prediction.
  - The missing fish were eaten by the cat.  
There will be no fish left in the pond after a while.  
The cat is on the edge of the fishpond.
  - One Olympian is bigger than the other.  
The bigger Olympian will win the event.  
One can lift a heavier weight than the other can.
  - The fish will be a big one.  
I've caught a fish.  
The line is stretched tightly and the fishing rod is bending.



Fig 1.3.2

- The gas we breathe out contains carbon dioxide. **Identify** this statement as an observation or prediction.

### Analyse

- Jill is doing the *wrong* thing in the diagram below. Before Jill passed out, she wrote down everything that she saw, heard and smelt in this experiment. **Describe** any observations that Jill would have made.

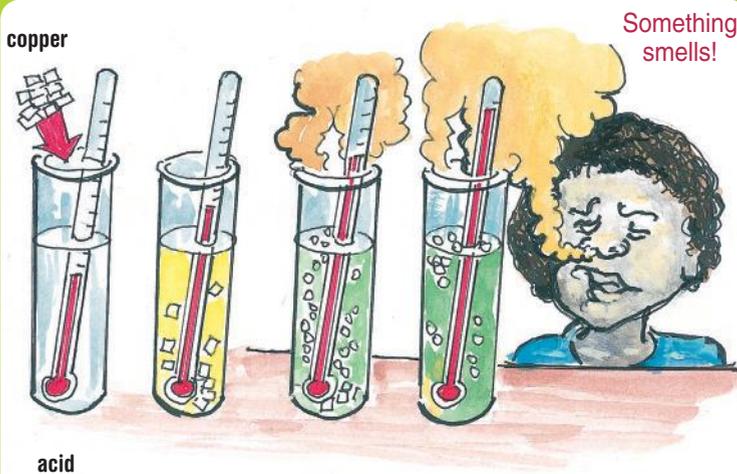


Fig 1.3.3

- While in hospital, Jill made some inferences and predictions about the experiment. **Identify** which are inferences and which are predictions.
  - A chemical reaction happened between the copper and the acid.
  - The dissolved copper turned the liquid green.
  - The reaction caused the brown gas.
  - A different acid might not produce brown gas.
  - A different metal might not dissolve.
  - Brown gas makes people pass out.
  - More copper would have made more brown gas.
  - Stronger acid would give us more brown gas.
- Without looking up from this page:
  - Identify** how many separate window glasses there are in this room.
  - Describe** the colour of your parents' eyes.
  - Describe** the colour and type of shoes your teacher is wearing today.
  - Accurately draw the Solomon Islands flag.
  - Identify** how many sharks there are on the fifty-cent coin.
  - Draw a map showing how to get from your classroom to the staff room.

>>



- 8** Below is a drawing of fossilised dinosaur footprints. **Describe** any observations that can be made about:
- a** the size of each footprint
  - b** the spacing of the footprints



Fig 1.3.4

- 9 State** inferences that can be made about:
- a** the number of creatures present
  - b** the speeds of the creatures

One scientist inferred that the larger dinosaur chased and ate the smaller one.

- 10 Identify** where on the diagram you think:
- a** the large dinosaur entered the picture
  - b** the small dinosaur began to run
  - c** the larger dinosaur caught the smaller one
  - d** the larger dinosaur first saw the smaller one
  - e** the smaller dinosaur realised it was being hunted
- 11 State** an inference about whether the larger dinosaur was carnivorous (meat eating) or herbivorous (plant eating).
- 12** Are you sure which dinosaur was the largest? Have you made an observation or inference here?
- 13 Describe** what you think happened to the dinosaur with the smallest feet. Is this an observation or an inference?
- 14 Infer** what else could have happened to this dinosaur.

## [ Extension ]

### Investigate

- 1** At home (or out of class), write a description of your teacher with sufficient detail to allow another person to identify them in a line-up. Include the clothes they were wearing when you last saw them.
- 2** Go outside and feel the weather. Write a description of what it is like *without* using any of the words normally used to describe weather, like rain, wind, temperature etc.

# UNIT 1.4

## Equipment

### introduction

When we do a job we usually use equipment or tools to make the job easier. It is the same in science. We use **equipment** to help us carry out experiments and to make more accurate observations. Some equipment is used to take accurate measurements in an experiment.

Thermometers are used to measure temperature. Stopwatches and electronic timers are more accurate than normal watches and clocks. They can be used for better timing. Other equipment magnifies very small objects that are normally difficult to measure.

Microscopes magnify very small objects. Telescopes magnify objects that are far away. Microphones and electronic amplifiers allow us to hear sounds that we cannot hear otherwise.

### Everyday laboratory equipment

In the school science laboratory, you will use a lot of equipment. As with all equipment there are special rules for using each item. Your teacher will instruct you on how to safely use each one.

Some that you will use are shown in Figure 1.4.1.

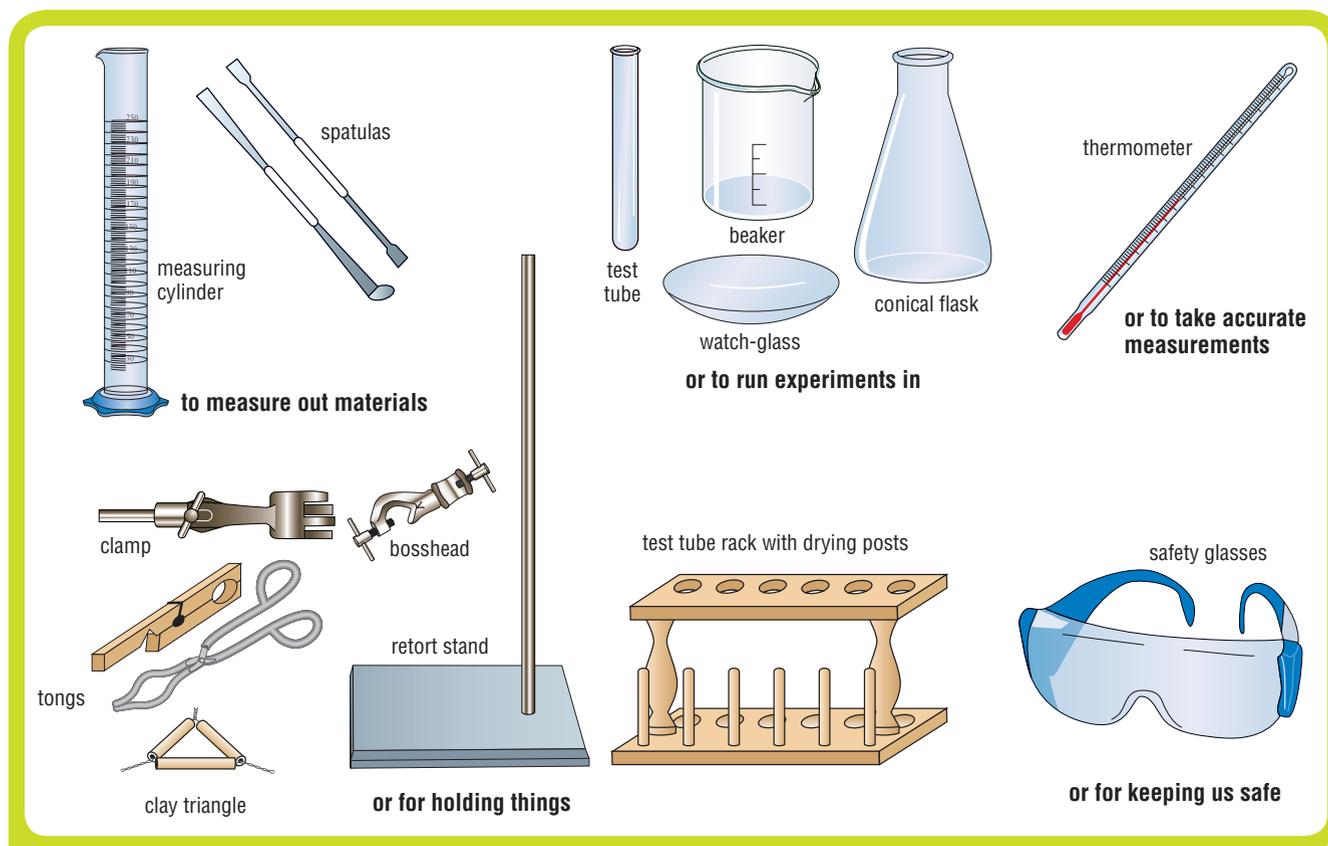


Fig 1.4.1

Laboratory equipment

## Scientific drawing

Diagrams of scientific equipment must be easy to draw and easy to read. You need not be an artist but you do need to follow conventions so that your diagrams can be understood by another scientist. Scientists draw their equipment as a **cross-section**: they 'split' the equipment down the middle. The drawings are simple lines and curves, and without any shading or colouring.

Figure 1.4.2 shows how scientists draw some of the most common equipment used in the laboratory.

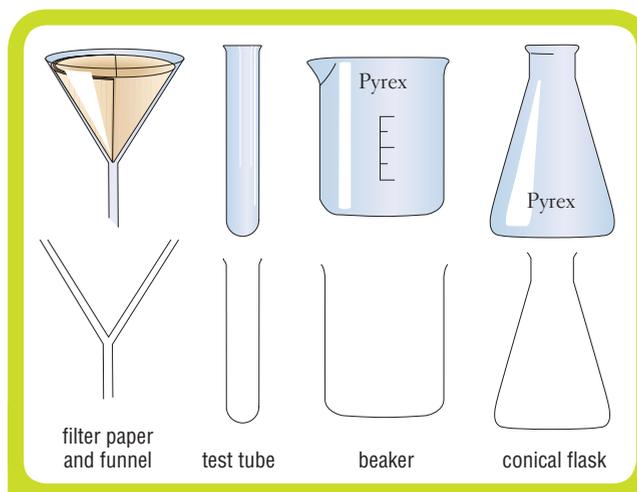


Fig 1.4.2 Drawing scientific equipment

## Activity 4

### What is it?

**Aim** To draw, classify and name common laboratory equipment

#### Equipment

A range of scientific equipment

#### Method

- 1 Divide a new page in your science workbook into a table with eight sections, as shown opposite.
- 2 Every piece of equipment you have been provided with must be drawn under *one* of the headings. Draw each piece:
  - a as realistically as you can
  - b in the proper scientific way

Write the name of each piece of equipment under the diagram.

Measuring equipment	Pouring equipment	Storage equipment	Equipment to run chemical reactions in
Safety equipment	Holding equipment	Cleaning equipment	Mixing equipment

## [ Questions ]

### Checkpoint

- 1 **Identify** the glass-like substance from which many pieces of science laboratory equipment are made. (Hint: the name is often printed on the sides of beakers and flasks.)
- 2 Copy the following and **modify** any incorrect statements so they become true.

- a A clay triangle is used to hold a watch-glass over a Bunsen burner.
- b Beakers are used for accurate measurement of liquids.
- c Conical flasks are useful for chemical reactions.
- d Test tubes are used for heating small amounts of liquids.
- e Thermometers are used to stir liquids.

>>

**Think**

- 3 Identify** a piece of equipment that you would use to:
- measure the temperature of boiling water
  - measure out exactly 55 mL of salt water
  - support a thermometer in a beaker
  - transfer a small amount of solid onto a balance
  - pour a liquid into a conical flask
- 4 Identify** a piece of equipment that you would need to make a good set of observations in the following:
- A plant is to be grown from seed.
  - Yeast releases a lot of heat when it is used in the fermentation of grapes.
  - Germs are being studied in a hospital.
  - The planet Mars is to be studied.
  - The speed of an athlete in a 100 m sprint is to be studied.
- 5 Describe** the similarities between:
- a beaker and a flask
  - a beaker and a measuring cylinder
  - tongs, a peg and a clamp
  - a clay triangle and a gauze mat
  - a test tube and an evaporating dish
- 6 Name** a piece of equipment that would assist the following scientists in making their observations.
- A microbiologist wants to study very small bacteria that have been causing infections.
  - A chemist is measuring the heat generated by a chemical reaction.
  - A physicist wants to accurately measure the time it takes for a stone to drop 2 m.
  - A botanist wants to measure the growth rate of a young tree.
  - An electrical engineer wants to measure the current flowing in an electrical circuit.
  - An astronomer wants to study the surface of the Moon.
- 7 State** where the following special safety equipment is located in your school laboratory.
- fire blanket
  - fire extinguishers (is there more than one type?)
  - gas control switch
  - electrical master switch
  - eyewash
  - broken glass container
  - bucket (maybe with sand or another chemical to soak up spills)
  - first aid cabinet
  - warning and safety signs

**Skills**

- 8** Draw a diagram representing a:
- beaker
  - conical flask
  - test tube
- 9** Draw a plan or bird's-eye view of the laboratory you are in, showing the location of all the special safety equipment. An example is shown in Figure 1.4.3.

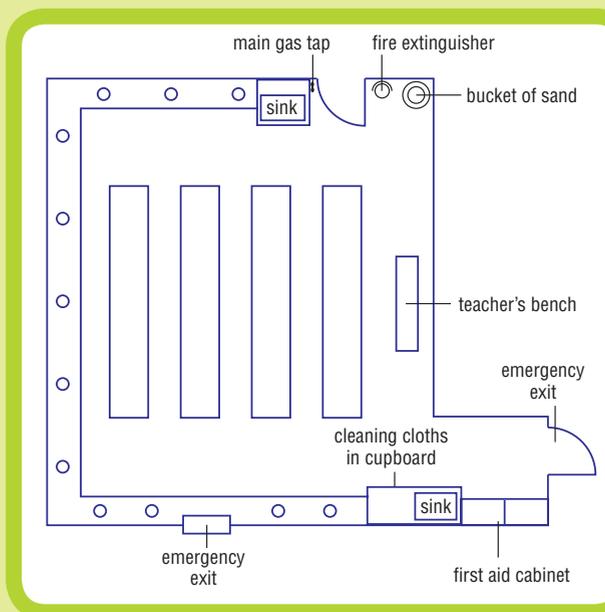


Fig 1.4.3

**[ Extension ]****Investigate**

Select one piece of equipment from the list below. Research what it looks like and how it is used.

- pipette
- thermometer
- mortar and pestle
- ammeter
- voltmeter
- sphygmomanometer

# UNIT 1.5

## Reporting

### introduction

Scientists need to record their information accurately so that others can repeat their experiments. To do this, they write a **scientific report**. A report is *not* a story and it is *not* a set of instructions. It tells the reader what happened.

A report should contain subheadings for the following sections:

- aim
- hypothesis (optional)
- equipment or materials
- method
- results and observations
- discussion or analysis
- conclusion.

### Aim

This is what you intended to do and achieve in the experiment.

### Hypothesis (optional)

Scientists always have an idea of what they think may happen or what they might find out in an experiment. Their 'educated guess' is called a **hypothesis**. (NOTE: Not all experiments require a hypothesis. Your teacher will tell you whether the experiment you are doing requires one.)

### Equipment or materials

All *important* equipment and chemicals needed in the experiment must be included. The sizes and quantities of the various pieces of equipment must also be included.

### Method

This is a detailed list and description of what was done in the experiment. To allow another scientist to be able to repeat the experiment, you must include what quantities were used and the exact order in which the experiment was performed. A diagram of the experiment (with all the equipment connected, not separate) can be very useful. A report is produced after the experiment is done so the methodology is written in past tense.

### Results and observations

You must include a complete list of measurements and observations you took in the experiment. It is usually clearer if the measurements are displayed in a table.

Headings and units (for example g, kg and t) are necessary.

### Discussion or analysis

This is where scientists discuss:

- any problems encountered in the experiment and what was done to overcome those problems
- what you think your results show about the experiment
- what you have found about the experiment from other sources such as textbooks, the Internet or encyclopaedias.

It can also include:

- graphs
- ideas for further experiments.

### Conclusion

This is where scientists summarise what they have found out in the experiment. The conclusion should be short. It must relate to the aim.

## Activity 5

### Spreading puddles

**Aim** To measure the area of water droplets

**Equipment**

Glass microscope slide, eyedropper, graph paper

**Method**

1 Construct the table below in your workbook.

Number of drops	1	2	3	4	5	6	7	8	9	10
Predicted area (squares)										
Actual area										

- 2 Collect a clean glass slide, an eyedropper and a piece of graph paper and place the graph paper under the slide.
- 3 Drop one drop of water onto the slide.

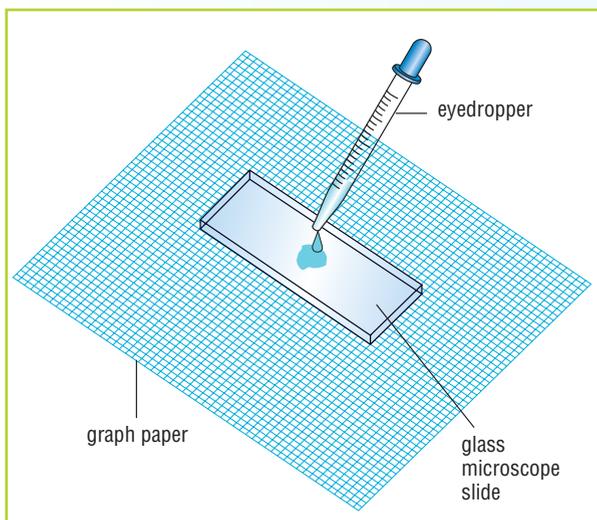


Fig 1.5.1 How big is the drop?

- 4 Estimate the area covered by the drop by counting the squares on the graph paper underneath. Count half-covered squares as full and less than half-covered as empty.
- 5 Add another drop of water. Be careful to keep it the same size. Estimate the area covered.
- 6 Repeat for three drops.
- 7 Predict the size for 4, 5 and 6 drops.
- 8 Check your predictions by counting the squares for 4, 5 and then 6 drops on the slide.

**Questions**

- 1 **Compare** the actual area to your predicted area. Comment on your prediction.
- 2 **Describe** any pattern you see connecting the number of drops with the area covered.
- 3 **Predict** the size for 7, 8, 9 and 10 drops.
- 4 **Present** your results as a line graph. Label area on the vertical axis and number of drops on the horizontal axis.

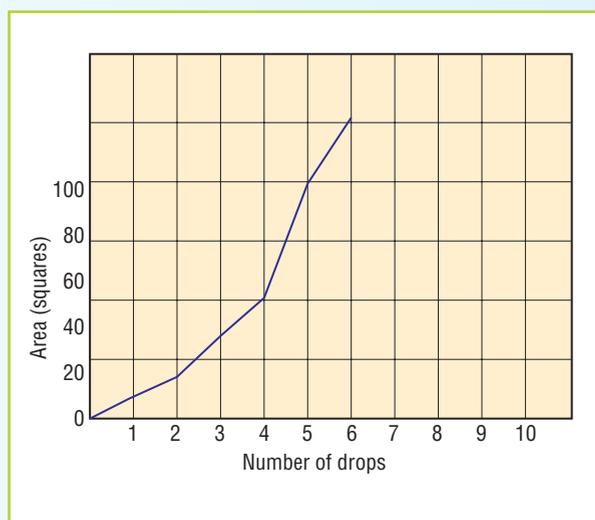


Fig 1.5.2

- 5 **State** a conclusion for this experiment.

## 1.5 [ Questions ]

**Checkpoint**

- 1 In your own words, **describe** what is meant by the term 'aim'.
- 2 **Explain** how a hypothesis is different to an inference.

- 3 **State** the meaning of the word 'tabulated'.
- 4 **Identify** two things that must always be included in result tables.
- 5 **State** two things that graphs must have on their axes.



FISHING LINES AND HOW THEY STRETCH  
Partners: Freda, Stavros and Jon

Aim:  
Our group tried to find out how stretchy fishing line was and what weight was needed to break it.

Hypothesis:  
We think that the fishing line will be able to hold 1.5kg because the packet says this is its maximum load.

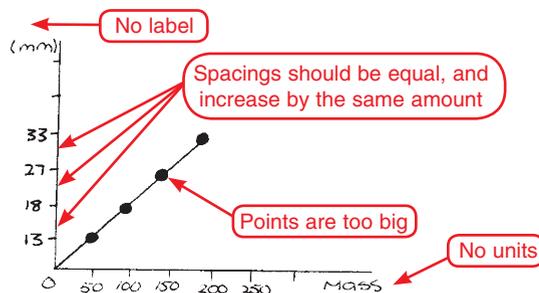
Method:  
A piece of fishing line was attached to the clamp of a retort stand. We added weights and measured how far the line stretched each time. The fishing line broke and then we stopped.

We wrote down all our results in a table.

Results:

Mass (g)	Stretch
None	None
50g	1.3cm
100	18 mm
150	27
200	3.3
250	Snap!

Discussion:  
The knot in the fishing line kept undoing. We tried different ways of tying the knot until it didn't undo any more. The ruler was not very accurate since it was very old and had lots of chips out of it. We drew this line graph to show our results:



Next time we could try different types of fishing lines to see how they performed.

Conclusion:  
Our group really enjoyed the experiment and learned lots about the strength and stretchiness of fishing lines.

## Analyse

Tony wrote the above report on an experiment he ran on the flexibility and stretch of a fishing line.

- Describe Tony's conclusion.
- Identify which section in Tony's report on the flexibility of fishing line is missing.
- Tony's hypothesis was excellent. Explain why.
- In the report the reader needs to guess some things if they are to repeat the experiment. List the things that the reader may need to guess in order to do the experiment.
- Describe two things that need to be added to Tony's results table.
- State one thing that needs to be added to the graph in the report.
- Explain whether the aim and the conclusion match.

- Propose a better conclusion for this experiment.
- For the detective investigation in Unit 1.7, state:
  - the aim
  - your hypothesis
  - your results or observations
  - your conclusion

## Extension

**Design** and carry out an experiment to see what type of soap solutions make the biggest soap bubbles. Use the headings of aim, hypothesis, method, results and conclusion in your report. Identify the variables that you are using and explain how you control them.

# UNIT 1.6

# Measurement

## introduction

**Measurements** are very important in science. They improve the accuracy of our observations. They also allow us to see any patterns that may exist.

and kilometres are used for length. Seconds, minutes and hours are used for time.

## How do I take accurate measurements?

A **mistake** is something that can be avoided with care. **Errors** are *not* mistakes, but are small changes in measurements that cannot be avoided even though you are careful. A **reading error** is always made when we guess a measurement because it falls between markings.

Scientists use units from the **metric system** for their measurements. Grams are used for measurements of small masses (lighter objects), like the mass of a one-dollar coin or a pencil. Kilograms or tonnes are used for big masses (heavier objects). Centimetres, metres

Measurement	Commonly used metric units	Abbreviations
Length, height and distance	millimetre, centimetre, metre, kilometre	mm, cm, m, km
Mass (sometimes incorrectly called weight)	milligram, gram, kilogram, tonne	mg, g, kg, t
Time	second, minute, hour	s, min, h
Speed	kilometres per hour, metres per second	km/h (sometimes shown on roads signs as kph), m/s
Volume of a liquid	millilitres, litres, megalitres	mL, L, ML
Temperature	degrees Celsius, kelvin	°C, K



Fig 1.6.1 What do you notice about the American spelling of centimetres?

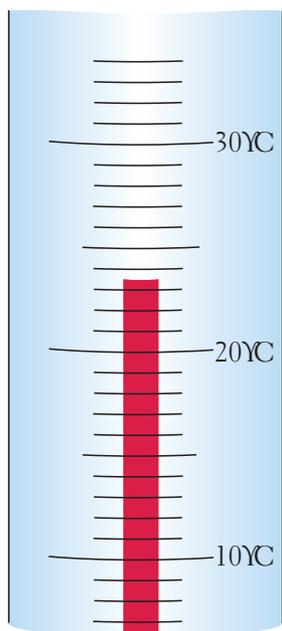


Fig 1.6.2

We cannot always be sure of measurements exactly—for example, is the temperature shown here 23.4°C, 23.5°C or 23.6°C?

Another important error is caused by not positioning your eye directly in line with the measurement. This is called **parallax** error.

A common problem when using measuring devices is called **zero error**. This is when the device reads some value even though nothing is being measured. An example is a weighing scale that measures 0.12 kg when nothing is on it.

To minimise errors, scientists follow these rules or conventions:

- Always read measuring devices from directly in front.
- Always check that the measuring device has the correct starting point, such as zero.
- Always write down measurements as soon as they are taken. *Do not try to remember measurements.*
- Always write down the units of the measurements.
- Always use correct abbreviations for units.

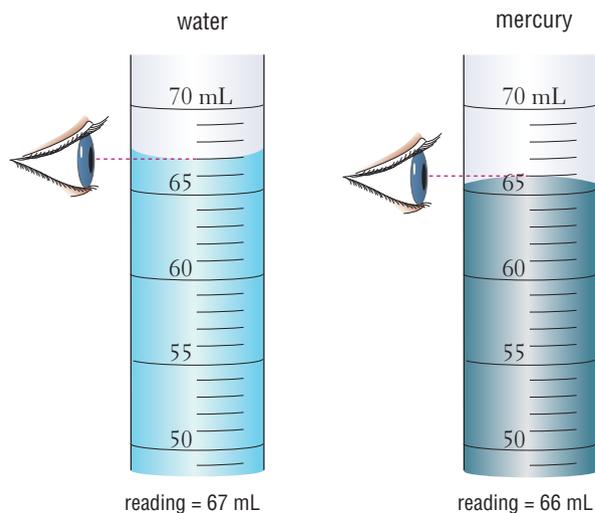
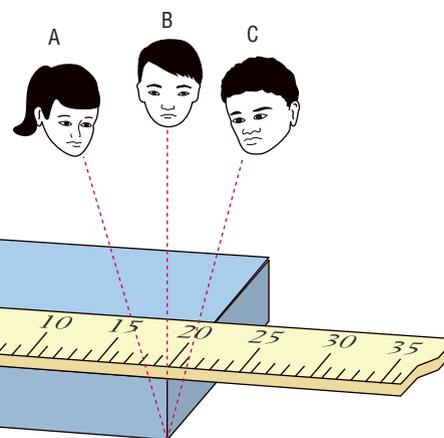


Fig 1.6.3

The meniscus in a measuring cylinder—for water the meniscus curves up at the edges, and for mercury it curves down at the edges.



Parallax error—who is reading it correctly, A, B or C?

Fig 1.6.4

- If possible, write all measurements in a table.
- Do not use fractions such as  $\frac{1}{2}$  or  $\frac{1}{4}$  in measurements. Use decimals instead. For example, 9.5 kg is acceptable,  $9\frac{1}{2}$  kg is not.
- If you are working in a group, always make sure you have a copy of the results before you leave the laboratory.
- Always measure quantities in metric units.

## Activity 6

### Taking measurements

**Aim** To measure various items with a range of measuring devices

**Equipment**

Access to a range of instruments and pieces of equipment that all show different quantities.

**Method**

- 1 Construct a table similar to the one below, in your workbook.
- 2 Write *your* measurement in your table and on a piece of paper next to each piece of equipment.

**Questions**

- 1 **Compare** all the results on the paper from each group and state any differences.
- 2 If you got all different measurements, does this mean that everyone is wrong?
- 3 **Identify** any results that were significantly different from the rest.
- 4 **State** a conclusion for this experiment.
- 5 **Suggest** reasons why scientists may not get *exactly* the same results.

Name of piece of equipment	What is being measured	My measurement	Unit it is measured in

### An important measuring device: the beam balance

A **beam balance** is often used in the school laboratory to measure the **mass** of an object. The mass is a measure of how much **matter** is in an object. It is sometimes incorrectly called weight.

Mass is usually measured in the laboratory in grams, abbreviated as g, or kilograms (kg).

For increased accuracy, an **electronic balance** is sometimes used.

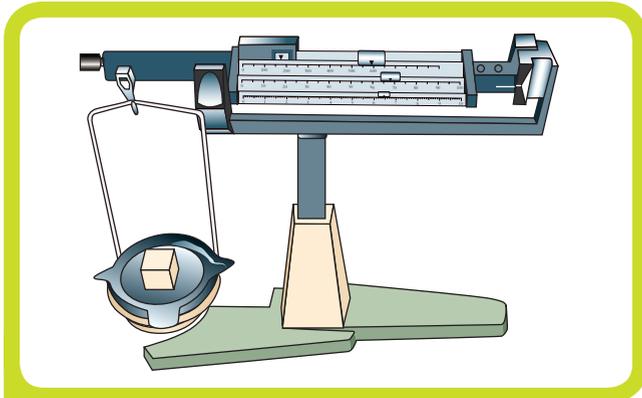
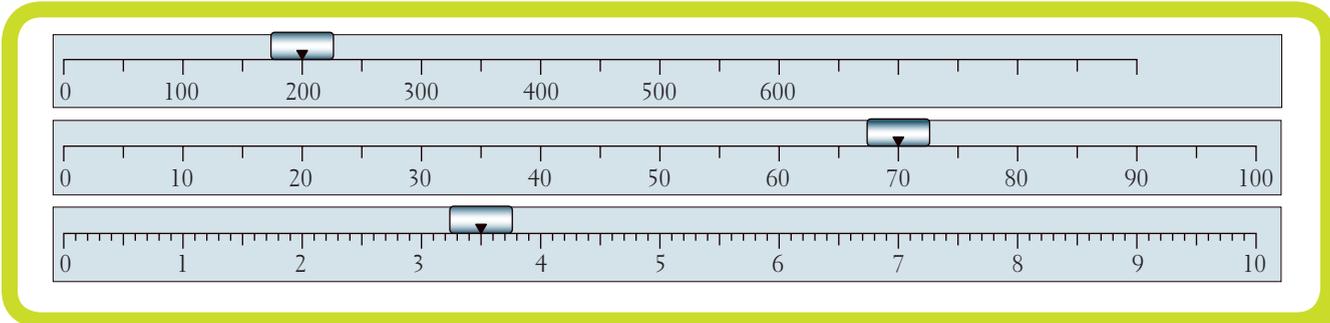


Fig 1.6.5

A laboratory beam balance is used for measuring mass.



A beam balance reading  $200 + 70 + 3.5 = 273.5$  g

Fig 1.6.6



## Activity 7

### How massive?

**Aim** To correctly use a beam balance to find the mass of various objects

#### Equipment

Access to beam balances and objects to weigh, 50g mass

#### Method

- 1 Construct a table in your workbook with the headings 'Object being weighed', 'Mass' and 'Units'.
- 2 At each balance, move all the sliding masses to 0.
- 3 The arm should now be balanced and reading 0. If this does not happen, adjust the balance screw on the edge of the arm.
- 4 Add the object to be measured and slide the heaviest sliding mass until the arm drops below 0. Then pull the sliding mass back one notch.

- 5 Repeat this step for all the sliding masses until you finish with the lightest sliding mass.
- 6 When you have successfully got the pointer at 0, record the measurement in your table and on the paper next to each balance.

#### Questions

- 1 **State** the reading that should be on a beam balance when *nothing* is in its pan.
- 2 **State** the mass that you obtained for the 50 g 'standard' mass.
- 3 **Explain** why a 50 g 'standard' mass might not be *exactly* 50 g in an experiment.
- 4 **Describe** three errors that might be present in these measurements.

## Activity 8

### Observations and predictions

**Aim** To find the mass of various lengths of bush rope

#### Equipment

10 different lengths of bush rope—estimate the lengths between 5 cm and 20 cm

#### Method

- 1 Construct a table in your workbook with headings 'Length' and 'Mass'.
- 2 Select any nine pieces of bush rope and measure their exact lengths and masses. Record their measurements in the table.
- 3 Use the information in your table to plot a graph. Draw a line of best fit through the nine points on the graph.
- 4 Use the graph drawn in step 3 above and estimate the mass of the tenth piece of bush rope.
- 5 Measure the length of the tenth piece of bush rope and record it in the table.

#### Questions

- 1 **Explain** what a line of best fit is.
- 2 For steps 5–8, **compare** your predicted value with the actual value.
- 3 **State** a conclusion about the link between mass and length of bush rope.

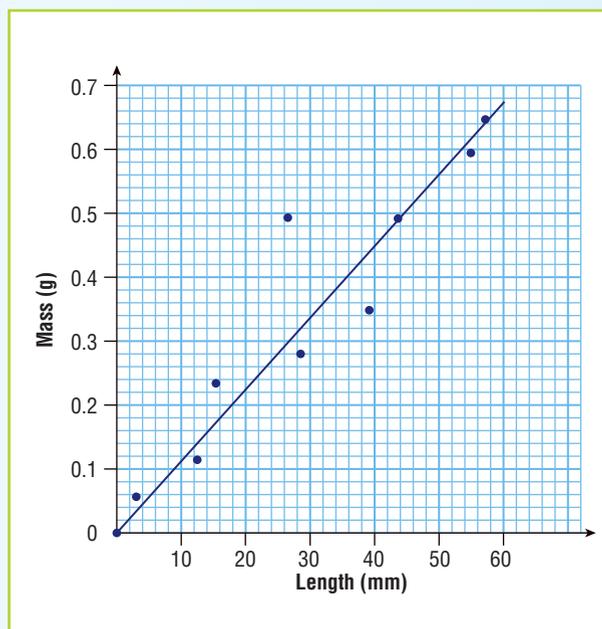


Fig 1.6.7 Line of best fit for mass of bush rope versus length

# 1.6

## [ Questions ]

### Checkpoint

- Copy the following, and **modify** any incorrect statements so they become true.
  - Metric units are never used by scientists for measurements.
  - The kilometre is an example of an imperial unit.
  - Seconds could be used to measure the distance a sprinter runs.
  - There is 375 mL in a Szeba soft drink can (be careful).
  - Mistakes are the same as errors.
- State** the correct metric unit for mass.
- State** two important types of errors. Give examples of each.

### Think

- Select** a unit of **measurement** and a **device** that you would use to measure the following quantities.
  - the temperature of a stream
  - the height of a person
  - the length of a cat
  - the mass of a teaspoon of sugar
  - the volume of a glass of water
- Identify** what is wrong with these measurements.
  - Mass of a mouse = 150¼ g
  - The car was travelling at 100.
  - The wind speed was 10 miles per hour.
  - A full bottle of soft drink contained 1.25 mL.
  - Evan's height = 168 m.
- Natalie took note of the speedometer reading every 5 seconds as her mum's car accelerated. At the start, the speed was 0 km/h. The speed was 20 km/h after 5 seconds, then 30, 50, 60 and 80 km/h every 5 seconds after. Enter these results into a table.
- Identify** which of the abbreviations are correct for each measurement unit.
 

a gram:	gm gms G g
b kilogram:	kilo kg Kg KG
c millimetre:	mms mm Mm mL
d litre:	lt mL lit L
e kilometres per hour:	kph km/h km/hr kil/h
f minutes:	min m mins ms
g degrees Celsius:	deg C deg °C C
h hour:	hr h Hr H
i seconds:	sec secs S s
- Sometimes people use an incorrect term for mass. **Name** this incorrect term.
- Describe** what will happen to the needle of a beam balance if too much sliding mass is added.
- Describe** the difference between an error and a mistake.

### Skills

- Rob's poorly recorded results for an experiment are shown here. Draw up a table and **present** the results as they should look.

Start temperature 15  
 1 minute 18°  
 2            21  
 3            35 degrees  
 •            40  
 •            51  
 •            63  
 70° after 7 min  
 76 = 8 min  
 100 at end

Fig 1.6.8

- Read these measuring devices and **state** their measurements.

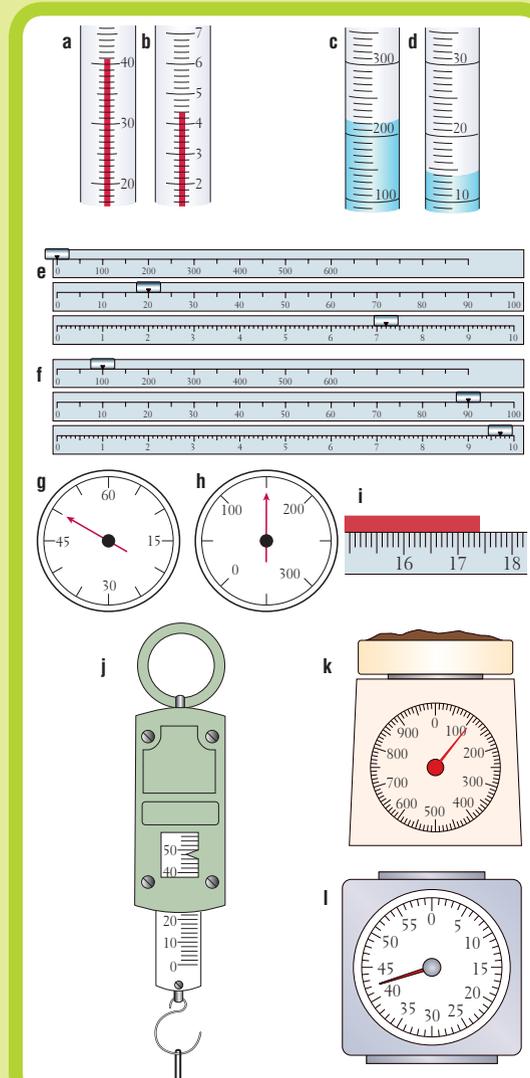


Fig 1.6.9



## [ Extension ]

### Investigate

- 1 Identify** whether NASA made an error or a mistake in its failed 1999 missions to Mars. **Explain** your reasoning.
- 2** Fred measured the mass of some substances that could not be held in the pan of a beam balance. He needed to put the substances in containers instead. **Complete** the table of his results.

### Action

- 3 Describe** how you would find out each of the following. Then use your method to measure them.
  - a** the mass of a packet of Navy biscuits without using any weighing device
  - b** the thickness of a piece of A4 paper with a normal ruler
  - c** the number of your heartbeats in a minute

Type of empty container	Mass of container	Type of substance that was added	Mass of container + substance	Mass of substance
Folded piece of paper	1.2 g	Salt	34.5 g	
Watch-glass	13.7 g	Crystals		18.6 g
Beaker		Water	275.0 g	195.1 g

# UNIT 1.7

## Questions about science

### introduction

Scientists ask **questions** about how the physical and living world around us works. These might be:

- Why does water turn white when it goes down a waterfall?
- How do ants breathe?
- How are rainbows formed?
- What affects the rate at which fruit rots?
- Why are sunsets red?
- Why are dead cockroaches always on their back?

### Science—asking questions

The **answers** to these questions could be found in textbooks, encyclopaedias or on the Internet. Sometimes the questions that scientists ask have never been asked before. That is when scientists need to find the answers themselves by performing experiments. An **experiment** is simply a test on a small part of the world.

Scientists need to be able to use all of their **five senses** to make correct **observations**.

The main sense a scientist uses is **sight**.

They will also use **hearing, smell, taste** and **touch**. However, sometimes it will be too dangerous to use some of these. Tasting is dangerous in science.

In a way, a scientist is like a detective who is trying to solve a puzzling case. Clues must be gathered through careful observation of all the evidence. The various clues can then be linked together until a **conclusion** can be drawn about the case.

In science we don't always get it right the first time. Sometimes more experiments and observations are required.

### The branches of science

Science covers many areas. There are so many, in fact, that it is often easier to split science into branches or disciplines. Some of the important branches are illustrated in Figure 1.7.1.

**Physics** is a branch of science that asks questions about how and why things move and the forces and energy involved.

**Biology** asks questions about living things.

**Chemistry** investigates materials, chemicals and chemical reactions and how they can be used.

**Geology** studies rocks, the Earth, earthquakes, volcanoes and fossils.

**Astronomy** investigates the planets, stars and the universe.

**Ecology** studies how living things affect each other and the environment in which they live.

Physics



Biology



Chemistry



Geology



Astronomy



Ecology



The branches of science

Fig 1.7.1

## Activity 9

## The mysterious case of the stolen sausages

After a beautiful sunny morning, the weather on this fateful day has turned terrible, with torrential downpours of rain and howling wind. You arrive home at 3.17 p.m. and are surprised to notice that the neighbour's lawn has been mowed. You are surprised, since from experience you know that wet grass is very hard to cut.

You enter the house. The sausages that you left defrosting on the kitchen table are gone! You enter the lounge room. The front window has been broken! Pieces of broken glass lie everywhere. There is now nothing hiding

the view of next door's garden and lawn. Mum's favourite vase on the mantelpiece is lying in pieces on the floor. You remember that every time your neighbour dropped in she always said, 'Why don't you get rid of that old vase ... it's so ugly!'.

The curtains are all messed up and the carpet is soaking wet and marked and smudged with mud! Some strands of blond hair are stuck on the windowsill. *But what's this?* A small stone has been placed in the middle of the coffee table ... the calling card of the sausage burglar? Later that night you notice that Fritz, the golden retriever, hasn't touched the food in his bowl.

Your mission is to discover *all* the details of this mysterious case ... who, when, why and how!

### Questions

- 1 State** what you want to know about the case. Scientists call this the 'aim'.
- 2 List** the *observations* you have made.
- 3 Identify** the suspects in this case.
- 4 Explain** what *evidence* there is to link them to the crime scene.
- In *conclusion*, **identify**:
  - a who you think stole the sausages
  - b who or what broke the window
  - c when it probably happened
  - d who or what broke the vase
  - e the order it all happened in.

In the above case, you have used many of the skills a scientist needs. To have successfully solved the case you needed to:

- be clear about what you were trying to find out
- make an educated guess of what you hoped to find out
- make careful observations of what happened
- take careful measurements if possible
- infer reasons about why the investigation went as it did
- draw logical conclusions about what was found out.

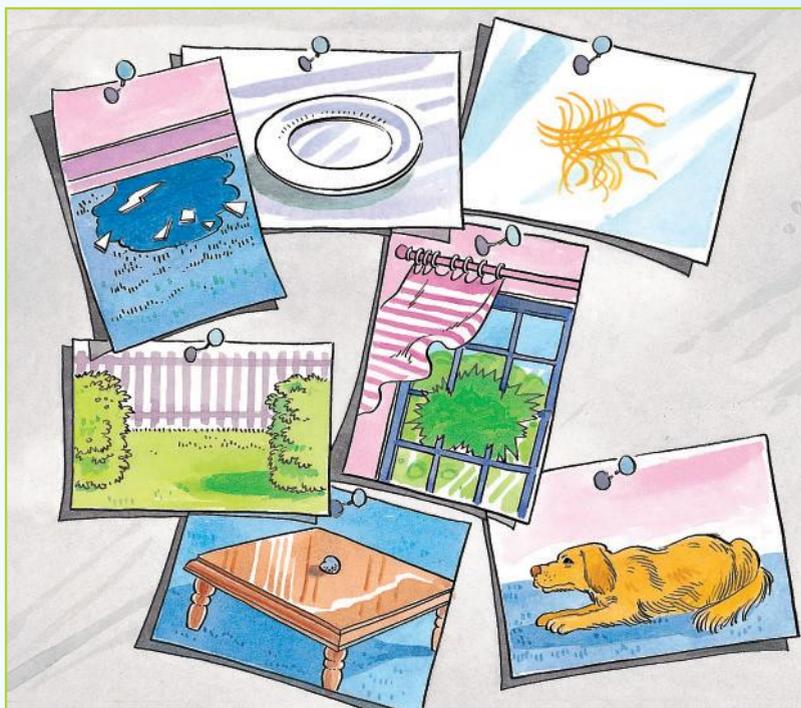


Fig 1.7.2 The clues!



# 1.7

UNIT

## [ Questions ]

### Checkpoint

- 1 **Identify** and name the five senses that we can use to make observations.
- 2 **List** four of the main branches of science.

### Think

- 3 We can use all our senses to make observations but sometimes it is too dangerous to use some of them. Complete the table below.

- 4 **Identify** which branch or discipline of science these scientists would be working in:
  - a Lian is studying the eating habits of a cow.
  - b Robert is developing a new plastic.
  - c Hellen is measuring the growth rate of an apple tree.
  - d Tiaran is studying the movement of the planets.
  - e Janet is studying the crystals embedded in a rock.
- 5 'Scientia' is the Latin word for knowledge. **Describe** at least five kinds of knowledge that scientists research.

Experiment	Senses that you would use	Sense that would give the most information	Senses that you would NOT use
Testing the ability of strong acids to clean a sheet of metal			
Testing how long milk takes to go off			
Testing how long it takes for six tomatoes to ripen			
Studying lava flowing from a volcano			
Testing a new perfume			

## [ Extension ]

### Investigate

- 1 **Research** what these sub-branches of science study.
  - a botany
  - b microbiology
  - c palaeontology
  - d acoustics
  - e seismology
- 2 **Identify** whether these sub-branches of science belong in physics, chemistry, biology, geology or ecology.
  - a optics: the study of light
  - b entomology: the study of insects
  - c vulcanology: the study of volcanoes
  - d zoology: the study of animals

- 3 Scientists use a lot of abbreviations. **Identify** what the following abbreviations stand for.
 

a mL	f HIV+
b CSIRO	g mm
c HAZCHEM	h NASA
d kg	i UNESCO
e $\mu$	j $\pi$

# UNIT 1.8

## Working scientifically

### introduction

The work of scientists rarely starts with an experiment. Normally it starts with observations made in everyday life or even by accident. Their observations lead them to ask questions like 'What caused that?' or 'Why did that happen?'. They then **design** experiments to answer their questions.

Joe noticed that when he washed dishes he sometimes made lots of froth and at other times made almost none. Joe has a problem. Let's see how he solves it scientifically.

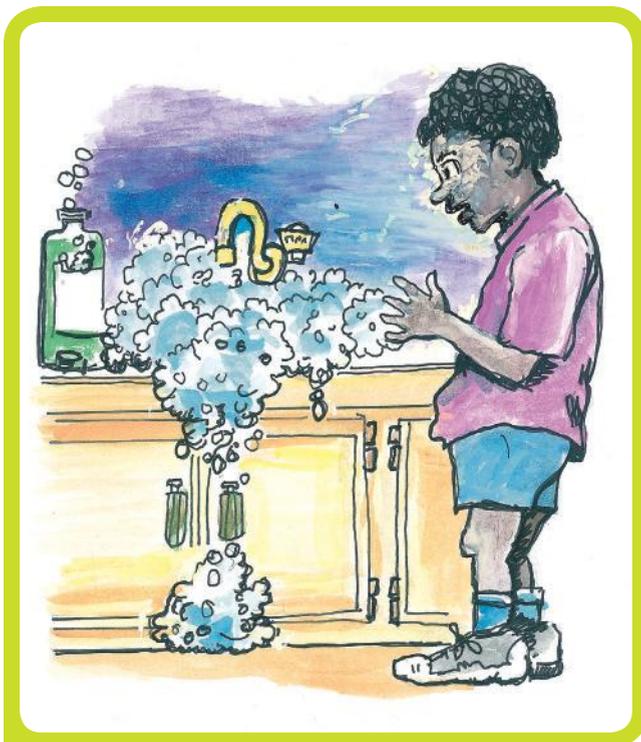


Fig 1.8.1

What affects froth production?

### Be fair!

Things happen due to lots of different factors. But which factor has the biggest effect and which ones don't have any effect at all? Any test that a scientist

carries out must be a fair one. To be fair, we need to only change one factor at a time. These factors are called **variables** and are anything that may affect an experiment.

Joe thought about it carefully and came up with a list of factors that could affect the amount of froth produced:

- the amount of detergent used
- the amount of water in the sink
- the speed of the water coming from the tap
- the temperature of the water.

These were his **variables**.

From their observations, scientists can then make a **hypothesis**. This is a prediction or 'educated guess' about what they may find in an experiment or what might have caused the observations.

Joe had noticed that more froth was produced when faster tap water was added and when more detergent was used. He thought that these variables would have a great effect but didn't think the temperature of the water in the sink would have any effect at all.

This was his **hypothesis**.

Scientists only change *one* factor or variable at a time. Otherwise they would not be able to work out which variable caused the effect. All the other variables must be kept exactly the same or constant.

Joe then designed and ran two experiments that he thought could solve his problem:

- **Experiment 1:** He put 3 drops of detergent in the sink each time. He ran hot water in very slowly at first, then repeated with hot but faster water. He repeated the experiment with very fast but equally hot water. Each time he filled the sink half-way.
- **Experiment 2:** He put 1 drop of detergent in the sink and turned the tap on high until the sink was half full. He then repeated the experiment with 2 drops of detergent, then 3 then 4.

To make sure you design an effective experiment you should know:

- the problem you are trying to solve (the aim)
- exactly what you are going to measure
- what you are going to change

- what you are going to keep the same
- anything else that might affect the experiment but you cannot control, such as air pressure.

## Activity 10

### Froth production

**Aim** To interpret another student's experiment and correctly write a report

#### Equipment

Dishwashing powder with dropper, ruler, access to tap, large beaker/bucket/ice-cream container, thermometer

#### Method

##### PART 1

- 1 Repeat *one* of Joe's experiments.
- 2 Write up the experiment, following the rules for writing a report.

##### PART 2

- 1 Test one of the variables that Joe *did not* test.
- 2 Once again, write up the experiment.

#### Questions

- 1 **State** the variables that Joe tested.
- 2 **Explain** why Joe kept the variables the same in both experiments.
- 3 **List** three other variables that *could* have been tested.
- 4 **Describe** which variable *you* think would have the most effect.

## Activity 11

### Answering a question with an experiment

During the Easter holidays, Rose noticed that when you drop a ball it never bounces back to the height you dropped it from.



Fig 1.8.2 Why didn't the ball come back as high?

Rose asked her sister about this and she replied, 'The ball never gets back as high because it loses some energy. What's more, once you get to a certain height of drop it never bounces any higher'. Rose decided to test her sister's hypothesis.

**Aim** To identify variables and design a simple experiment

#### Equipment

Tennis ball, metre ruler

#### Method

- 1 Identify all the variables that you think will have some effect on the bounce.
- 2 Decide which variable you are going to keep the same.
- 3 Describe, in as much detail as you can, an experiment that would test Rose's sister's statement. You will need to collect at least five different measurements.
- 4 Perform the experiment.
- 5 Construct a table for your results.
- 6 Make suggestions on how you could improve your experiments.

#### Questions

- 1 **Identify** which variables:
  - a affected the bounce height
  - b did not significantly affect the bounce height
- 2 **State** two conditions that would combine to produce:
  - a a high bounce
  - b a low bounce



# 1.8 [ Questions ]

## Checkpoint

- 1 State five points that you should know for an effective experiment. **State** an example of each point.
- 2 **Explain** what is meant by the term 'variable'.
- 3 **Explain** why only one variable should be changed at a time.

## Think

- 4 **List** some variables that may affect:
  - a the number of visitors to a swimming pool
  - b the growth of a plant
  - c the time taken to cook a potato
  - d the number of times you go to the toilet in a day
  - e how long the graduation ceremony will take
  - f your test results for this topic

## Analyse

- 5 **List** Joe's four variables in the above experiment.
- 6 **Identify** the variable that Joe didn't think was important.
- 7 **List** other variables that Joe didn't identify.
- 8 **Explain** whether any of the variables that you listed in question 7 might be important to the experiment.
- 9 Describe a method that Joe could use to measure the froth of the detergent.

## Skills

- 10 For both of Joe's experiments:
  - a **State** an aim.
  - b **List** a detailed method using numbers to set the order.
  - c **Construct** a results table.
- 11 Joe then wanted to test whether the temperature of the water had any effect on the froth. For this new experiment:
  - a **State** Joe's aim.
  - b **State** a list of equipment he would need.
  - c **List** a detailed method.
  - d **Construct** a results table he could use.

## [ Extension ]

### Investigate

- 1 Nikki liked sweet coffee so she always added lots of sugar. She often noticed, however, that a lot of it remained undissolved at the bottom of the cup.
  - a **Describe** three variables that you think would affect the amount of sugar dissolved in a cup of coffee.
  - b **List** the variables in order from the *most* important to the *least* important.
  - c Choose one important variable and **describe** a method to test it.
- 2 George heard an old story that if you want a banana to ripen quickly, you should place it in a box and cover it with banana leaves! He thought this sounded strange and wanted to see if it was true. **Describe** in detail how he could test whether the story was true or not. You may like to perform this experiment to see if your method works.

# UNIT 1.9

## Science in Solomon Islands

### Introduction

In the 21<sup>st</sup> century, Solomon Islanders are no longer isolated from the rest of the world. As we have continued to develop and integrate with the rest of the world, our way of life has significantly changed, because of the introduction and the availability of scientific and technological knowledge in our country. For example, some diseases that could not be cured in the past are no longer a problem because of readily available medications. Today, we can communicate at almost any time from any place with our relatives in the provinces, and even in overseas countries because of telecommunication networks. We can also travel anywhere around the globe in less time in modern jet planes. Finally, with

the technology from satellite dishes in space, we can see changes to weather patterns and predict the formation of cyclones, and make preparations before they strike.



Fig 1.9.1

Satellite dishes, Telekom office, Honiara

### Benefits of science in Solomon Islands

Today, we benefit from some of the achievements that science and technology have brought to our country, especially in the areas of **communication, transportation, medicine, agriculture** and the ability to see how our **natural world works**.

#### Communication

There are currently two companies providing telecommunication networks for communication in our country. They are Our Telekom Company and Be Mobile Company. These two companies have set up satellite dishes in Honiara and in the provinces, and these allow communication to take place. Today we have a good communication system in our country, which enables us to communicate with the outside world or within our own country. The availability of transistor radios, mobile phones, fax machines and the internet have made it easier for us to send messages to anyone at any time. Furthermore, the availability of television networks has also helped us to see what is happening around the world, as it happens.



Fig 1.9.2

Internet cafe in Honiara town



Fig 1.9.3

Mobile phones mean you can communicate no matter where you are.



## Transportation

The different forms of transport available today are far more efficient and faster than the ones our ancestors had. During the days of our ancestors, the fastest way they could travel was probably by paddling their canoe. Today, you can visit your relatives and friends on other islands by plane, by canoe with outboard motor and by ship. You can travel from Honiara to another country on very fast jet planes. In most of our towns, buses, cars and trucks are used to transport people and goods.



Fig 1.9.4 A plane at Henderson Airport, Honiara

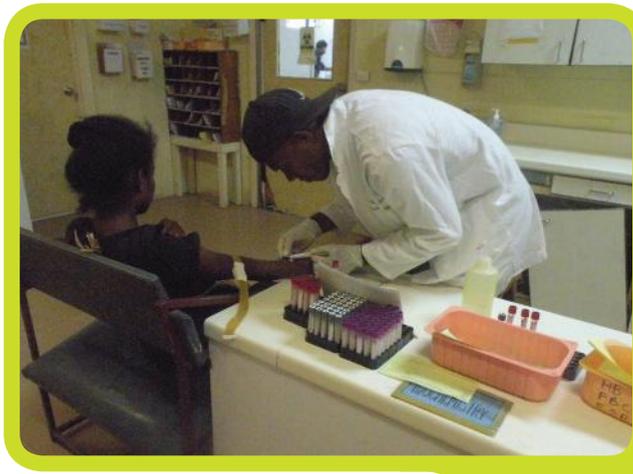


Fig 1.9.5 Local vessels at Honiara Wharf

## Medicine

Using scientific knowledge, scientists have found medicines that can cure diseases such as malaria, tuberculosis and sexually transmitted infections such as gonorrhoea and syphilis. The knowledge doctors have about how our body works and the nutrition in

the food we eat can prevent illnesses such as heart disease. Before the invention of modern medicines, these diseases and many others often killed thousands of people. The availability of modern health services, hospitals and medicines means that we have a much better chance to be healthy and grow up strong.



Lab officer collecting blood samples from a patient, NRH, Honiara Fig 1.9.6



Pregnant women can have ultrasound scans to check the health of their unborn babies. Fig 1.9.7



Fig 1.9.8 Medical supplies at a pharmacy in Honiara

### Agriculture

In 2009, the population of Solomon Islands was about 515 870, and it is increasing at a rate of 2.3 per cent every year. As our population increases, so will the demand for food. Nobody is hungry in Solomon Islands because we are lucky to have enough land to grow crops for ourselves. However, if our population continues to increase at the same rate, it is likely that land for gardening will become scarce in the near future and people will not be able to grow enough food.

Many people in other parts of the world are hungry, and many are undernourished because there is not enough land to grow food or the land has become infertile because it has been overused in an effort to feed the ever-growing population.

To grow more food, farmers today use advanced methods of farming. They use fertilisers that make infertile soil become fertile, providing the nutrients that plants need to produce food for us. Irrigation systems are also used so that there is enough water all year round for the crops. Modern techniques are also used to produce high-yielding crops. Scientists have been responsible for all these developments.



Fig 1.9.9 Rice-farming project in Solomon Islands

### Wonders of the world

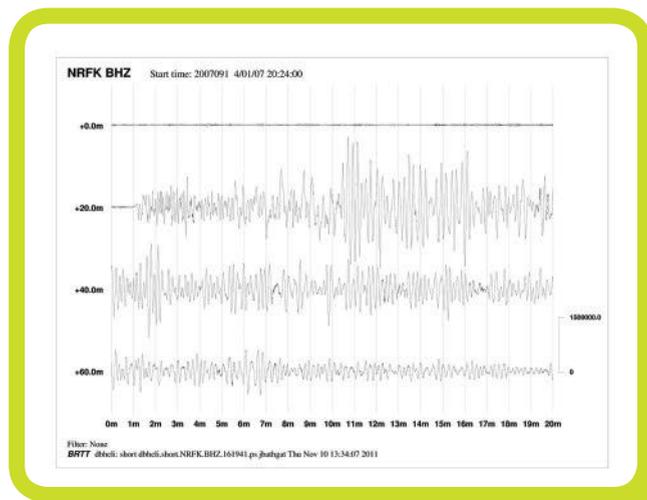
Scientists have also found out how our natural world works. For example, we now know what causes earthquakes and tsunamis and how cyclones develop.

Seismograph stations, such as the one at the Ministry of Geology in Honiara, help seismologists to measure the size of an earthquake and its epicentre or where it occurs. This helps us to predict tsunamis or

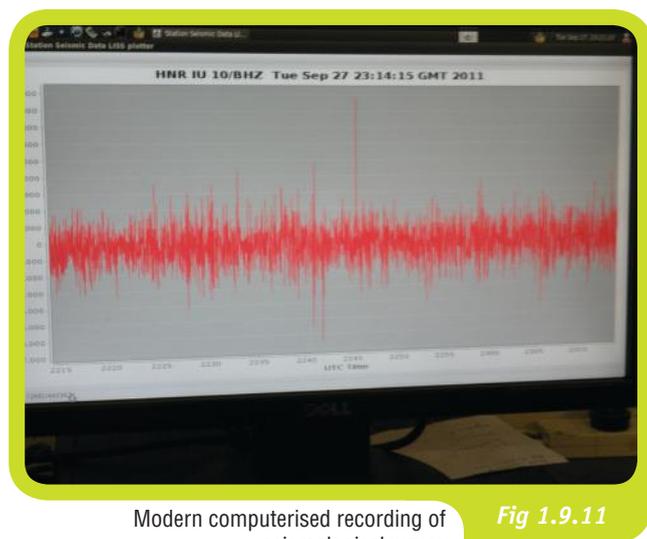
very large tidal waves that are caused by earthquakes that occur under the ocean floor.

Weather stations can now predict what the weather will be like in a couple of days. They can also monitor the path of a cyclone and warn people who are in the path. This enables people to make the necessary preparations before a cyclone hits their area.

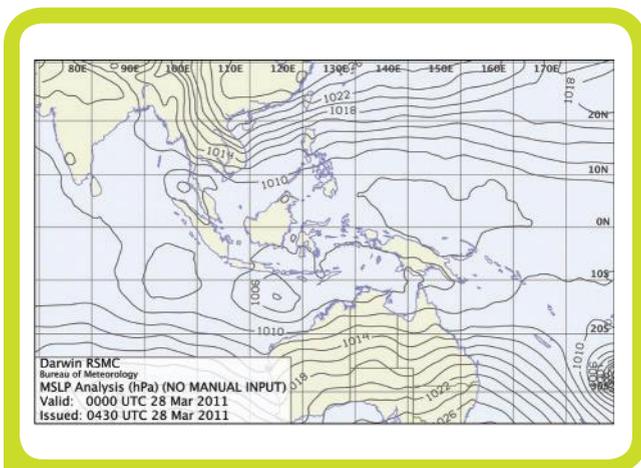
Furthermore, the knowledge of the behaviour of the nuclei of reactive elements is used to produce energy in large nuclear reactors. Many overseas countries use this as an energy source.



Seismological observation, Seismology Division, Geology office, Honiara Fig 1.9.10



Modern computerised recording of seismicological waves Fig 1.9.11



**Fig 1.9.12** Weather maps are used to help predict weather conditions.

## The limits of science

Although science has helped us in many ways, it cannot yet answer all our questions about our natural world or solve all our problems. For example, we are yet to find medicines that can cure diseases such as cancer and AIDS. Medical scientists are still carrying out research, but it may take several years to find medicines that will cure these diseases.

## [ Questions ]

### Checkpoint

- 1 List** five ways that science has changed life in Solomon Islands over the past 50 years, in the areas of communication, transportation, agriculture and medicine.
- 2** What does the word 'technology' mean?
- 3 List** some of the new technologies that have been introduced in your town or village in recent years.
- 4 State** the equipment that is used to track cyclones.
- 5 State** the equipment that is used to track earthquakes.

### Think

- 6** Is technology the same as science? What is the difference between science and technology?
- 7 Explain** what causes tsunamis.
- 8 Explain** why science has limits and in what areas these limits are still evident.

### Analysis

- 9** The knowledge of traditional medicine (for example, medicine produced from the bark of trees) has been passed down through generations of some tribes in Solomon Islands. Do you think we should encourage local people to practise traditional medicine? Give your reasons.
- 10** Some people claim that the life expectancy (the expected length of time people will live) of Solomon Islanders has increased compared to 100 years ago.
  - a** What are the likely reasons for this increase?
  - b Name** at least four diseases that were major causes of death in Solomon Islanders before the introduction of modern medicine and health services.

## Chapter review

### [ Summary questions ]

- Copy the following, and **modify** any incorrect statements so they become true:
  - Spatulas are used for stirring.
  - Goggles do not need to be worn when using chemicals.
  - Measuring cylinders are used to heat water in.
  - A gram is a unit used in the measurement of mass.
  - The air hole should always be shut when lighting a Bunsen burner.
  - The gas should always be turned on before the match is lit.
  - The air hole must be *closed* to produce the yellow flame.
  - Burning paper can be used to safely light a Bunsen burner.
- Identify** the branch or discipline of science in which these scientists would be working.
  - Angela is calculating the fuel needed to launch a rocket.
  - Evon is looking down a microscope at a flu virus.
  - Audrey is watching ants at work.
  - Michael is developing a new plastic.
- Scientists run experiments to obtain information. Apart from experiments, **list** other sources of information that scientists can use.
- State** four observations about:
  - orange juice
  - an ice cube
  - the paper you write on in your workbook
  - dirt
- Name** a piece of equipment you would use to:
  - measure out roughly 100 mL of water
  - heat a small amount of liquid
  - heat strongly a small amount of solid
  - find the mass of a small stone
  - find the boiling point of water
- List** what you need to include in a good experimental report.
- State** the metric units you could use for measurements of:
  - mass (sometimes incorrectly called weight)
  - time
  - length or distance
  - temperature
  - speed
  - volume of a liquid

- Identify** which unit you would select to measure the following quantities.
  - the volume of water in Sydney Harbour
  - the mass of a car
  - the length of a rat
  - the mass of a dog
  - the volume of water in a bathtub
- List** some of the new technologies that have been introduced in your town or village in recent years.

### [ Thinking questions ]

- How observant are you? From memory:
  - Draw the shape of STOP and GIVE WAY traffic signs.
  - Identify** whether your earlobes hang or are attached.
  - Identify** whether the person sitting next to you is right- or left-handed.
  - State** the number of pages in this textbook.
- Collate** the following into observations, inferences and predictions.
  - I've eaten something that was off.  
My stomach is not feeling well.  
I'll vomit soon.
  - The plant required sun and water to grow.  
The plant will grow and fruit.  
The seed has a small leaf shoot breaking it in two.
- Compare** the advantages and disadvantages of using modern forms of transportation such as a boat with an outboard motor, ships, planes and trucks.
- Draw and label the equipment that you would need:
  - to boil 200 mL of water
  - to boil 20 mL of water
  - to evaporate water from sea water
- Graham noticed that his heart was beating fast after a cross-country run. He wanted to know what happened to his heartbeat before, during and after exercise.  
**Design** an experiment to find whether the number of heartbeats increases when you exercise and what it does if exercise stops.



## [ Interpreting questions ]

**15** In the case of the missing sausages, each observation was important in solving the case. The detective needed to *infer* something from each. **Complete** this list of observations in the case and **state** the logical inference that could be made from each.

**16** **Describe** each of the observations in question 15 as qualitative or quantitative.

	Observation	Inference
a	Vase was broken	
b		Window had been broken for a while
c	Blond hair on carpet	
d		Thief is hungry
e	Stone on the table	
f	Next door's lawn was mowed	
g	Fritz was not hungry	
h		Someone entered via the window
i	Curtains were all messed up	

# Classification of living things

By the end of this chapter the learner should be able to:

- Describe the main characteristics of living things: *use energy, use air, produce waste, respond to stimuli and growth.*
- Identify the five main groups of living things as: *animals, plants, fungi, protists, monerans.*
- State levels of classification: *kingdom, phylum, order, family, genus, species.*
- Name a domestic animal using the binomial nomenclature—*genus and species.*
- Use a two-choice key to classify domestic animals and plants.
- Explain what vertebrates are.
- Identify and give examples of vertebrates (mammals, amphibians, reptiles, mammals and fish).
- Identify and give examples of different invertebrates.
- Identify and name a flowering and non-flowering plant.
- Draw the parts of a flower (differentiate male and female parts of flower).
- Identify and give an example of fungi, monera and protista.

- 1 In which section of the village store would you look for washing powder or a tin of food?
- 2 How does a snake warm its body?
- 3 Lots of living things are neither plants nor animals. List some of them.
- 4 What animal uses its whole skin to breathe?
- 5 Is a taxonomist a taxi driver, a taxi agent or a scientist?
- 6 Is a jellyfish really a fish?



# UNIT 2.1

## From kingdom to species

### introduction

Scientists estimate there are 13 to 14 million different types of organisms in the world. So how can we logically organise them? When we are given a large and complicated group of things to organise, the first thing we often do is to sort them into smaller and simpler

groups. Say you were given a basket of fruits and told to put them into two groups. How would you do it? What characteristics would you use? Scientists use the same practice of putting things into groups of related types. This is called **classification**.

### Classification

Examples of classification can be seen all around us. For example, in the village store, goods are organised by type or by the way they are packaged. Waioka tuna will be on one shelf, tomato mackerel fish on another, noodles and biscuits somewhere else. Soap and klin powder are in one place and canned meat and soft drinks in another.

Classification in the village store helps us to find what we want. Let's say you need tomato mackerel fish for dinner. Where does the storekeeper go to look for it? Even if she is new in the store and not yet familiar with it, she knows the tomato mackerel fish is probably in the canned meat corner. If she can't find it, she will be able to find something very similar, because all the similar things are kept together in one part of the store.

Your school library organises its books by subject or author. Books on the same subject are in the same place, and novels by the same author are grouped together.

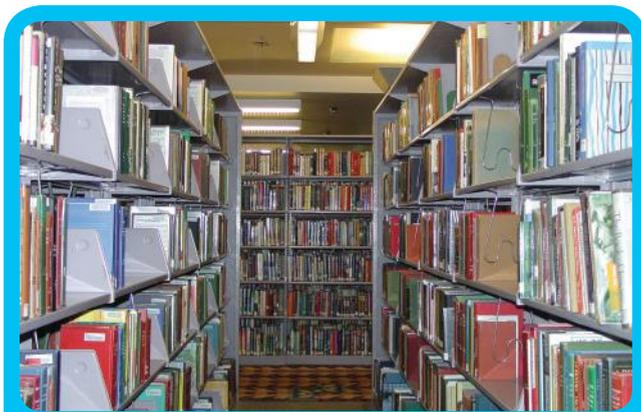


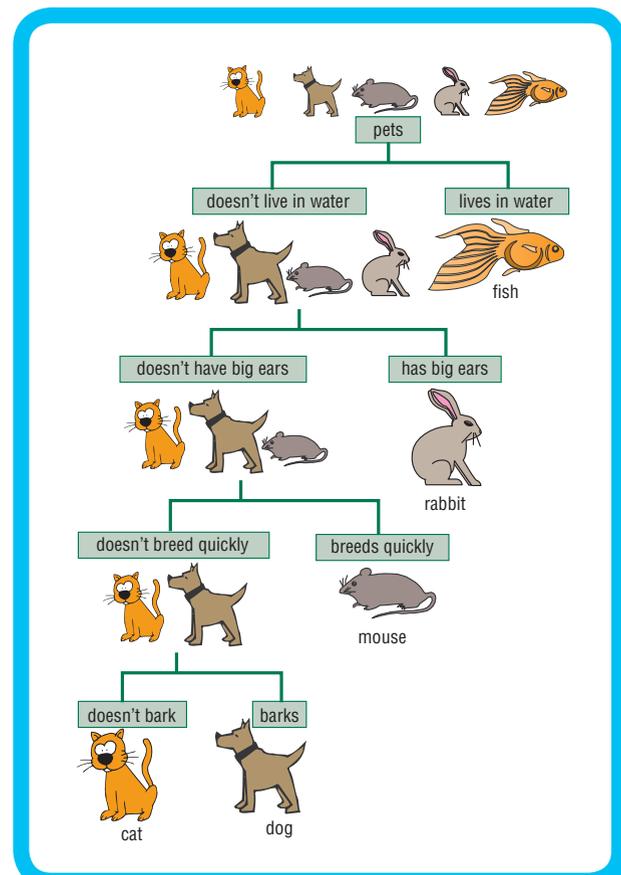
Fig 2.1.1

The books in your school library have been classified—why is this a good idea?

### Introducing keys

To make classifications easier to understand, scientists use a model called a **key**. Keys are simple and easy-to-follow classification systems. They start at the top with one group and slowly subdivide until no more choices are possible. These are most often written as flow charts. Figure 2.1.2 is a key for classifying animals.

The most common type is the **two-choice** key. Two-choice keys have two choices at every point.



Two-choice key classifying five animals

Fig 2.1.2



## Classifying living things

The same thing happens in science when we classify living things. Similar organisms are placed in the same group. All living things in that group are similar. The process that sorts all living things into groups is called **taxonomy**. A person who does this is a **taxonomist**.

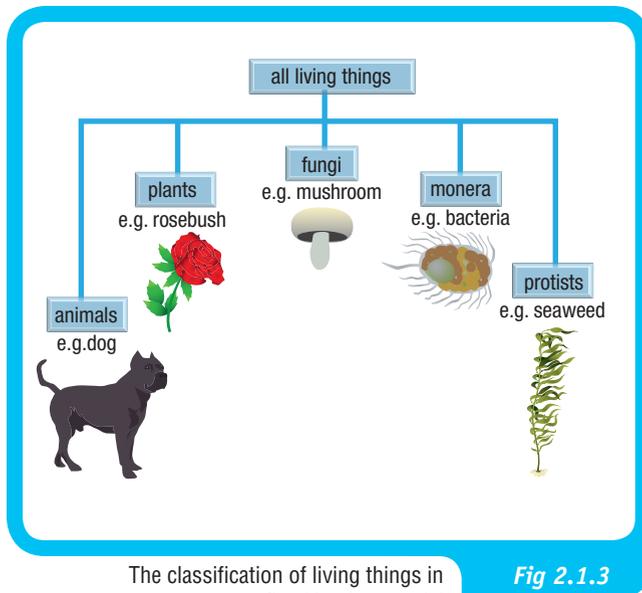
It is easy to classify an organism as either a plant or an animal. However, if we are to make sense of the huge variety of plants and animals we will need to sort them into much smaller groups.

Scientists use a large number of features to sort living things into groups. They use the way that the living thing is 'built' to help them split them into groups. Organisms that have a similar 'body plan' will be in the same group. Organisms with different 'body plans' will be in different groups.

### Groups of living things

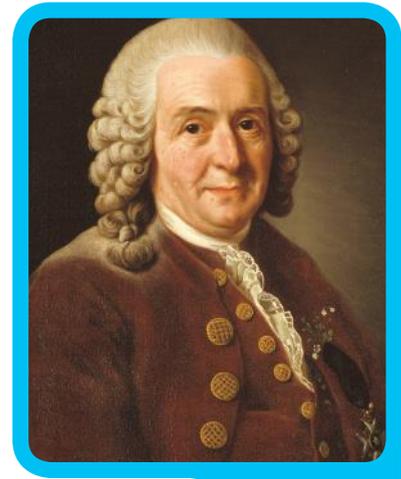
Carolus Linnaeus (a Swedish scientist) proposed a way of grouping and naming living things. He divided all animals into six classes: mammals, birds, amphibians, fishes, insects and other invertebrates. In the 1800s the French scientist Georges Cuvier made a few changes to Linnaeus's system. This set the basis for the classification system we use today.

The largest groups are called **kingdoms**. We will use a five-kingdom classification system: animals, plants, fungi, protists and monera. The microscope has allowed the process of classification to improve the five-kingdom classification.



The classification of living things in a five-kingdom model **Fig 2.1.3**

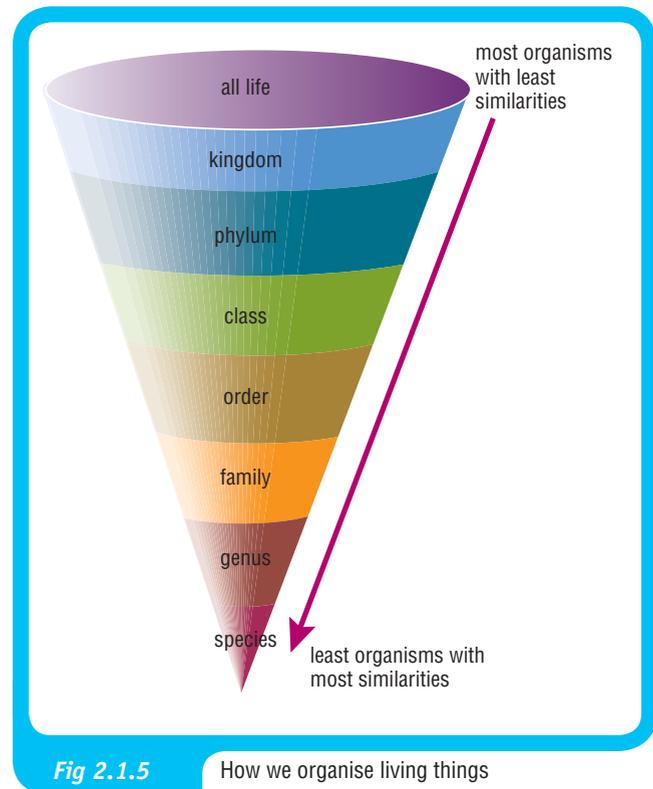
- A kingdom is divided into smaller groups called **phyla** (singular: **phylum**).
- These phyla are then divided into **classes**.
- Classes are divided into **orders**.
- Orders can be divided into **families**.
- Families can be divided into **genera** (singular: **genus**).
- **Genera** are divided into species.



Carolus Linnaeus—Swedish naturalist **Fig 2.1.4**

If all these terms are hard to remember, you might want to think of a *mnemonic*—a silly sentence to help remind you. For example, you can remember:

**Kingdom—Phylum—Class—Order—Family—Genus—Species** by remembering:  
**Kind People Can Often Find Green Shoes**  
 Can you think of a better one?



How we organise living things **Fig 2.1.5**



### What is a species?

As you move down through the five-group classification, the number of living things in each group gets smaller. The things in the group become more similar. They share more features. When you reach the final group it is called a **species**. All members of one species are very similar, but not identical. You only have to look at your classmates to realise that all members of the same species are not identical.

A species is a group of things that can reproduce and create young that can also reproduce. A species is, therefore, a group of similar organisms that can produce fertile young.

For example, a Solomon Islands woman and a Scottish man can have a baby together because they are the same species. They are both human. On the other hand, a snake and a frog cannot mate and produce young. They are different species. Sometimes two different species that look similar can interbreed. For example, a horse and a donkey can interbreed to produce a mule. But a mule cannot reproduce, since it is sterile. This means that the horse and donkey are not of the same species.



Fig 2.1.6

The offspring of a horse and a donkey is called a mule; it is sterile.

### Naming species

Each species of living thing on Earth has its own unique scientific name. The naming system used by scientists throughout the world was established by Linnaeus. The system requires that each species be given a name with two parts—its **binomial name**.

The first part of the scientific name is the **genus**. It is always spelt with a capital letter. The second part is the **species**. It is always spelt with a lower-case letter.

No two living things can have the same scientific name.

An example of classification is this one for dogs. The dog has the following classification:

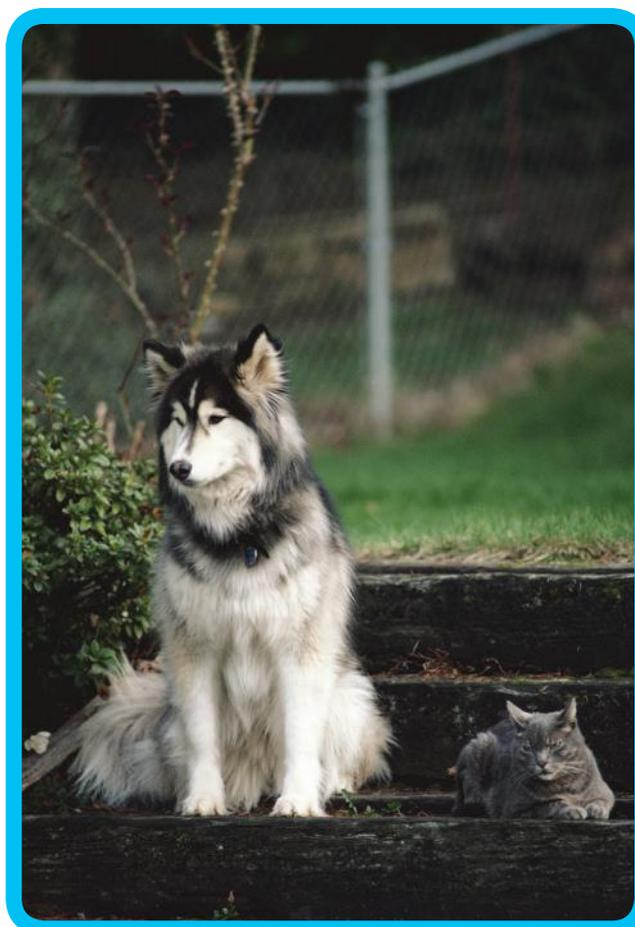
**Kingdom:** Animal

**Phylum:** Chordata

**Class:** Mammalia

**Family:** Canidae

**Genus and species:** *Canis familiaris*.



Can you pick *Canis familiaris* from *Felis catus*?

Fig 2.1.7



Look at the two-choice flow chart in Figure 2.1.8. It is a classification tool for the kingdom 'Animal'.

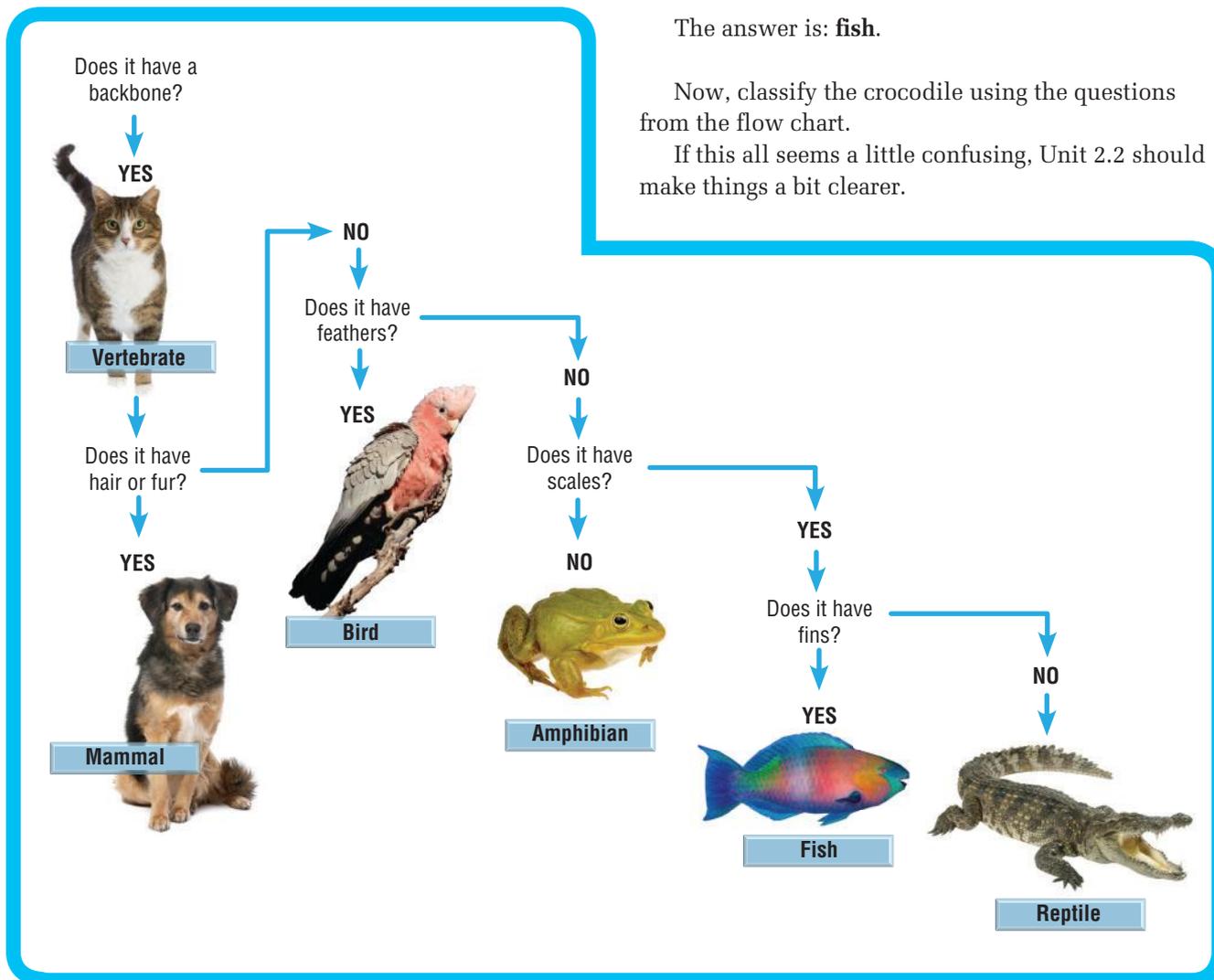
Follow the questions to see how it works. For example, carefully observe the body features of an animal, then ask five questions about the animal:

- Does it have a backbone? Yes
- Does it have hair or fur? No
- Does it have feathers? No
- Does it have scales? Yes
- Does it have fins? Yes

The answer is: **fish**.

Now, classify the crocodile using the questions from the flow chart.

If this all seems a little confusing, Unit 2.2 should make things a bit clearer.



A two-choice flow chart for the classification of vertebrates

Fig 2.1.8

## 2.1 [ Questions ]

UNIT

### Checkpoint

#### Classification

- 1 Define what classification is.
- 2 You are given six common fruits: a coconut, a pineapple, a jack fruit, a banana, an orange and a soursop. List the characteristics you could use to divide them into two groups.

- 3 Apart from the library and supermarket, identify one everyday place where there is a classification system at work.
- 4 Explain why classification systems are useful.



**Classifying living things**

- 5 **Define** the term 'taxonomy'.
- 6 **List** the terms below in order from the group that contains the greatest number of organisms to the group that contains the smallest number of organisms.

Family	Species
Phylum	Kingdom
Genera	Order
Class	

- 7 Explain what a species is.
- 8 **Explain** how we know that a horse and a donkey are different species.
- 9 **Describe** how the unique scientific name for every living thing is created.

**Introducing keys**

- 10 **Explain** what a key is.
- 11 **Explain** what the word 'two-choice' means when used to describe a key.

**Think**

- 12 **Identify** the class that a dog is in.
- 13 If you invented a system for classifying the tools used in a car repair shop, would you base your system on what the tools were made of or what they were used for? **Explain** your answer.
- 14 Think about the cars in a car park. They all have the same function but there are lots of differences between them. **State** the characteristics you could use to classify them.
- 15 A subphylum represents a group smaller than a phylum but bigger than a class. **Explain** what you think a subclass represents.
- 16 There used to be only two kingdoms of organisms—plants and animals. Now there are five.
  - a **Explain** why the number of known kingdoms has changed in the past.
  - b **Explain** why the number of kingdoms may change again in the future.
  - c **Explain** what this says about the way science works.

**Skills**

- 17 **Design** a two-choice key to classify the contents of your pencil case. Make sure you have at least six different items.
- 18 a Write a paragraph to **describe** the contents of your pencil case.  
 b **Explain** which is easier to understand: the key you created in question 17 or the paragraph you just wrote.
- 19 Use the key in Figure 2.1.9 below to **classify** these people. Then name them.

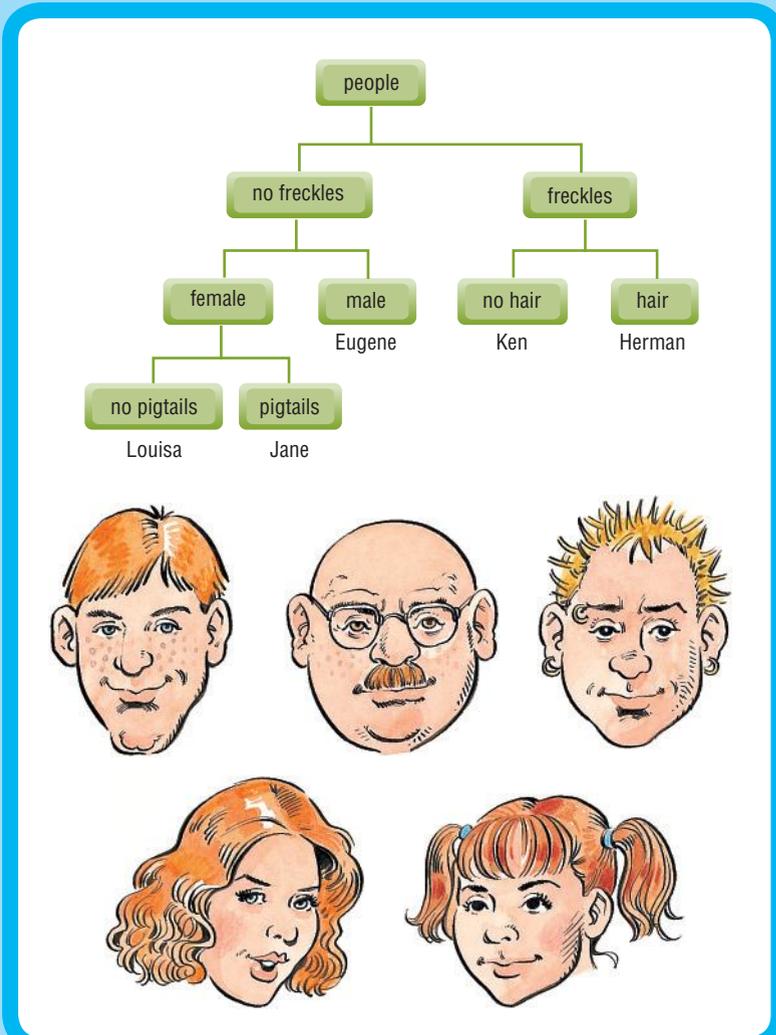


Fig 2.1.9

# UNIT 2.2

## Animal classification

### introduction

Biologists have used the **body structures** or features of animals as the basis for classification. Body structures or features are how animals are physically made up. So animals that are grouped together have body structures or features that are common to all.

### Vertebrates

The main body structure or feature used for classification of animals is whether they have a backbone or not.

**Vertebrates** are animals that have a backbone. They are all members of the phylum Chordata, called chordates. Vertebrates are divided into seven classes—amphibians, reptiles, birds, mammals, bony fish, jawless fish and cartilage fish.

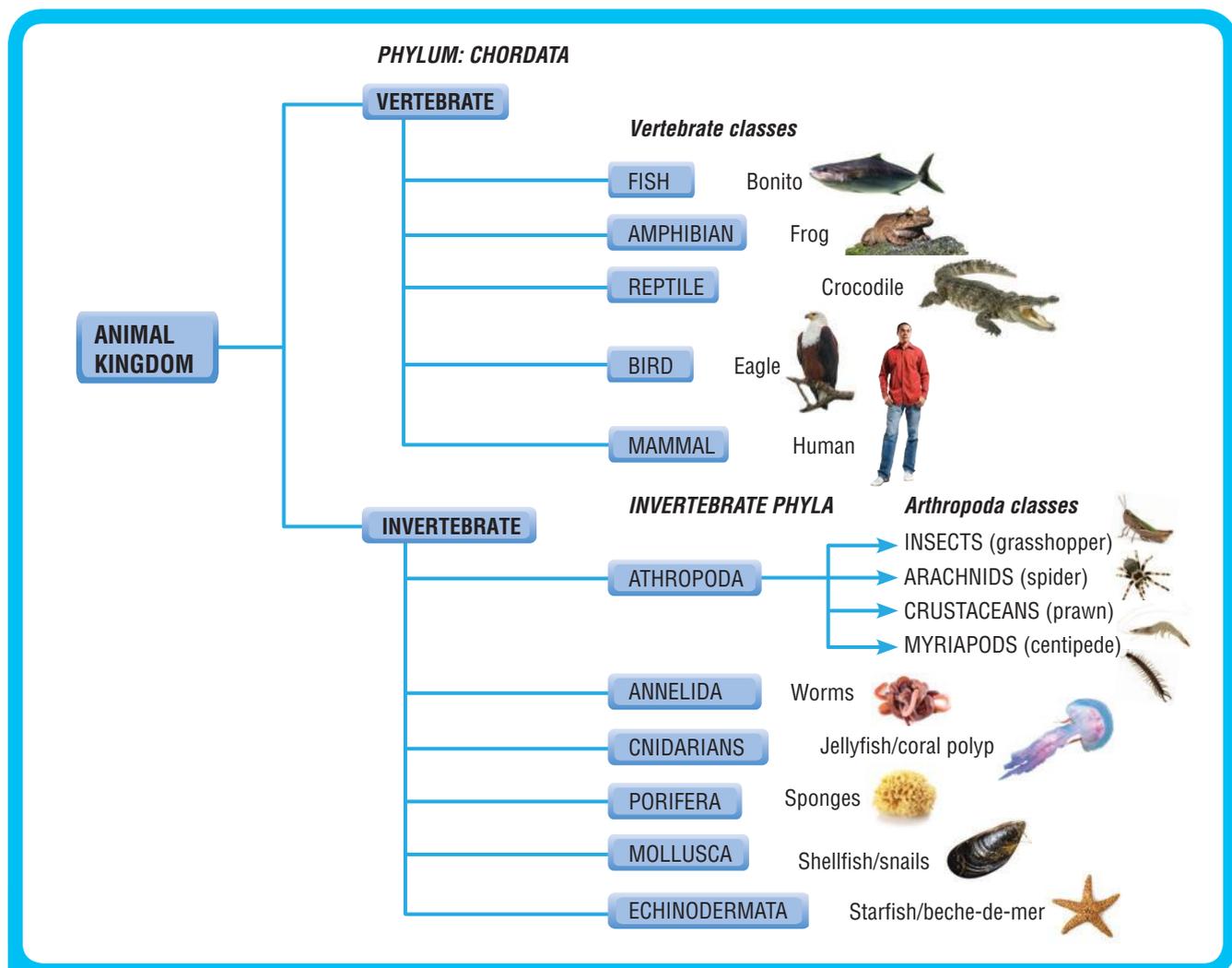


Fig 2.2.1

Major phyla and classes within the animal kingdom

## Amphibians

Amphibians have two stages in their life cycle. In their early life, many live completely under water. In their later life, they live above water. The best known example of this two-stage life cycle is the frog. It starts life as a tadpole with gills. Slowly it changes into an adult frog with lungs.

Amphibians have a thin skin that would dry out if they did not live in a wet area. Amphibians reproduce in water because their eggs do not have a waterproof coat. Amphibians get heat from their surroundings.

All animals that live this two-stage life belong to the class Amphibia, meaning double-life (*amphis* = double, *bios* = life, in Greek).



Fig 2.2.2

From egg to tadpole to frog

## Reptiles

Reptiles form the class Reptilia (*repere* = to creep, in Latin). They have dry scales and lungs, and lay soft, leathery, waterproof eggs. They get heat from their surroundings.

Animals similar to modern-day reptiles were the first animals that could live entirely on land. Reptiles include the snakes, lizards, turtles, tuatara, crocodiles and alligators. Many extinct animals (such as dinosaurs) were reptiles. By lying in the sun, reptiles' body temperature can become as high as humans. However, unlike us, they cannot retain this heat. This is why they are not very active in cold weather.

Some of the world's most dangerous animals are reptiles. In Solomon Islands, some snakes, such as the brown tree snake, can kill very quickly.



Fig 2.2.3

The saltwater crocodile is the most feared reptile in Solomon Islands.



Fig 2.2.4

The poisonous brown tree snake is commonly found in Solomon Islands.

### Birds

All birds have feathers, including the ones that can't fly. They have some scales, but only on their legs and feet. Birds breathe with lungs. They lay hard-shelled eggs. They make their own heat by using energy from their food to keep warm. About ninety-four different species of birds have been seen in Solomon Islands.

Birds form the class Aves (*avis* = bird in Latin).



Fig 2.2.5 Parrots belong to the class Aves.

### Fish

The **bony fishes** have a skeleton of bone. Most fish, including red snapper and reef fish, fall into this class. The **cartilage fishes** have a skeleton of firm, rubber-like cartilage. This is the same material that makes up the soft part of the tip of your nose. They also have paired fins. Sharks and stingrays are cartilage fish. The **jawless fishes** also have a skeleton of cartilage. However, they do not have any paired fins. There are only about forty-five species of this type of fish. One example is the lamprey.



The great white shark is a cartilage fish. Fig 2.2.6

All fish have gills and scales. Most lay eggs. There have been fish in the Earth's water systems for many millions of years.



Fig 2.2.7 The rainbow trout is a bony fish.

### Mammals

All mammals (class Mammalia) are warm-blooded. They feed their young on milk and have hair. Not all hair is the same. Wool and fur are two types of hair. In some mammals such as whales, the hair is not obvious, but it is always present. The mammary glands produce milk. The hair and mammary glands are the features that identify a mammal.

There are three groups of mammals.

- The **placental mammals** give birth to well-developed babies. The babies suckle from their mother's teats. Examples are cows, bats, humans and whales.



The cow is a placental mammal, and produces milk in the udder.

Fig 2.2.8

- The **monotremes** are mammals that lay eggs. The eggs hatch after a few days. Then the babies develop in a pouch.

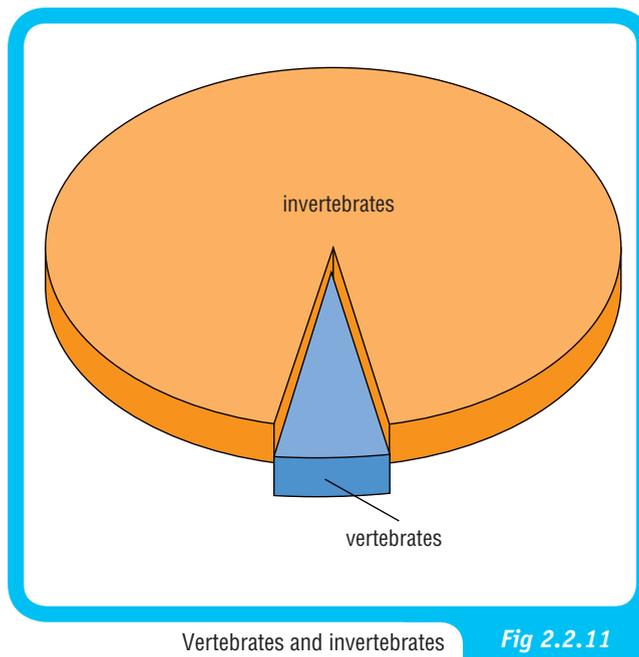
### Invertebrates

Animals without backbones are known as **invertebrates**. As can be seen from the pie graph in Figure 2.2.11, most of the animals in the world are invertebrates. There are six phyla. They are the cnidarians, arthropods, molluscs, worms, echinoderms and sponges.



The opossum is a marsupial mammal with a pouch.

Fig 2.2.9



Vertebrates and invertebrates in the world

Fig 2.2.11

- The **marsupials** give birth to tiny babies. The babies continue to grow in a pouch. The pouch is a pocket of skin on the animal's front. The teats are in the pouch. Examples are wombats, opossums and kangaroos.

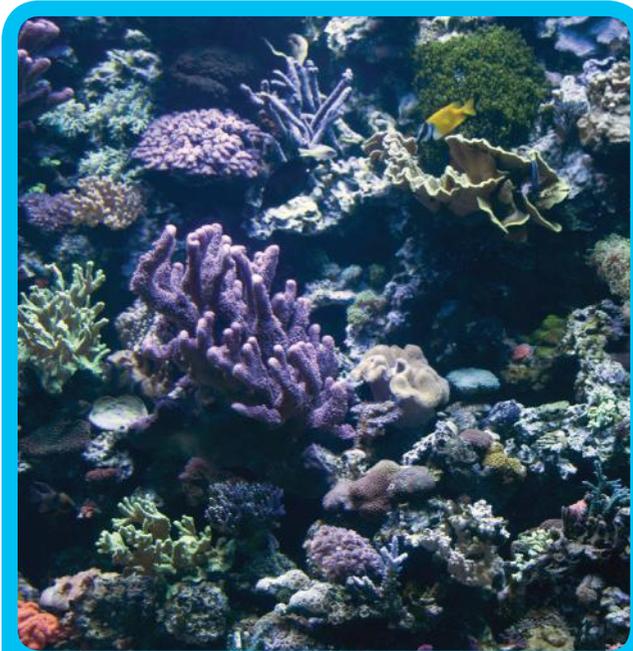


Fig 2.2.10

The echidna is a monotreme—a mammal that lays eggs.

### Cnidarians

So far we know about 10 000 species of cnidarians. All cnidarians have stinging cells and a bag-like body. They have only one opening surrounded by tentacles. Food goes in this opening and wastes go out. Some cnidarians have bodies that attach to something, like a rock. They are called **polyps**. Free-swimming cnidarians are called **medusas**. Cnidarians mostly live in the sea. Some are found in fresh water.



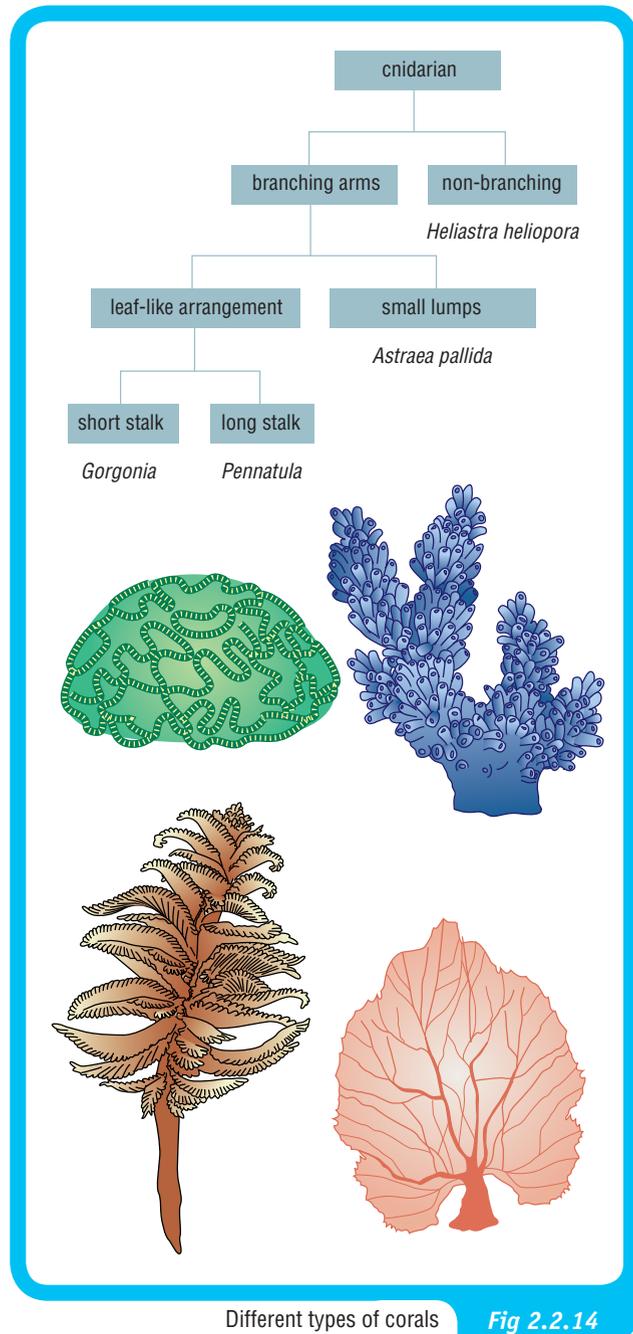
**Fig 2.2.12** A cnidarian—in a coral colony, the bodies of the polyps are joined together

Examples of cnidarians are jellyfish, corals and anemones. Many jellyfish are harmless. Some can kill. Many people have felt the sting of a jellyfish. One treatment for this is to put vinegar on the swollen area to destroy the stinging cells.



A cnidarian—the bluebottle or Portuguese man-of-war **Fig 2.2.13**

Corals are animals, not stones. The living part of coral sits on top of the dead skeleton. Limestone (*calcium carbonate*) skeletons are the remains after the soft part of the coral dies. There are 494 species of corals in Solomon Islands. Coral reefs provide food and hiding places for marine animals, including fish. If there were no coral reefs, there would still be some fish, but not many.



Different types of corals **Fig 2.2.14**

## Arthropods

The arthropods are the largest animal phylum. Arthropods are found everywhere—on land, in the air, and in all water systems. They have segmented bodies, paired jointed legs and an **exoskeleton**. An exoskeleton is a hard outer covering—an external skeleton.

Within the arthropods, the major five are the:

- insects
- centipedes
- millipedes
- arachnids
- crustaceans.

There are about a million different species of known **insects**. Scientists often discover more species. There are more species of insects than any other living thing. Insects have one pair of antennae. Their bodies are divided into three sections—the head, thorax and abdomen. They always have three pairs of legs on their thorax.

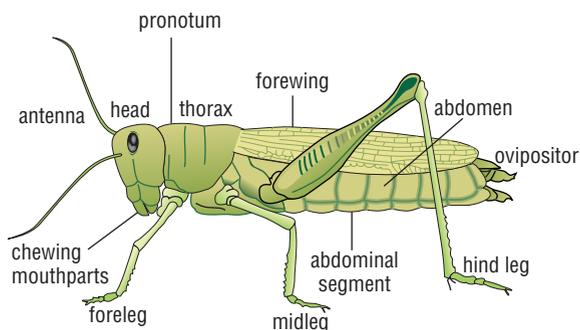


Fig 2.2.15 The parts of an insect—grasshopper



Fig 2.2.16 A cockroach

**Centipedes** live on land and have one long pair of antennae. Their whole body is segmented. They have one pair of legs on each segment. They have jaws on the first segment and their bodies are flat. **Millipedes** also live on land and have one short pair of antennae. Their bodies are also segmented. They are more rounded than centipedes' bodies. Millipedes have two pairs of legs on most segments.



Fig 2.2.17 Millipedes showing two pairs of legs on each segment

Many **arachnids** live on land but some can live in the water. They have no antennae and only a few body segments. They have four pairs of legs. They do not have jaws. Everyone is familiar with spiders, but these are not the only arachnids. Scorpions, mites and ticks also belong to this class.



An arachnid—a rose-haired tarantula Fig 2.2.18

**Crustaceans** mostly live in the water. They have two pairs of antennae and breathe through gills. Examples of crustaceans are crabs, prawns and lobsters.



A crab is a crustacean. **Fig 2.2.19**

### Molluscs

Most **molluscs** live in the water. A few types live only on land. They have soft bodies. The body of some molluscs are covered with a shell. They have internal organs and a large, muscular 'foot' for movement. The molluscs are the second-largest phylum of animals. They include snails, octopuses, slugs and squids.



**Fig 2.2.20** A common garden snail showing the large muscular foot and a shell

### Worms

There are three different phyla of worms. They are the roundworms, the flatworms and the segmented worms. Some live on other organisms, that is, on

other animals and plants. Others are free-living in either water or damp soil. **Roundworms** have long, unsegmented, cylindrical bodies. They also have a digestive tube with a mouth and anus. Examples of roundworms are hookworms and intestinal roundworms.

**Flatworms** are similar to roundworms. Some live in other living things. Others are free-living. They have flat bodies instead of round ones. They have a digestive system, with only one opening. Flukes and tapeworms are examples of flatworms.

**Segmented worms** are found both on land and in the water. They have well-developed body systems and segmented bodies. Examples are leeches and earthworms.



A segmented worm—the different body segments are clearly visible. **Fig 2.2.21**

### Echinoderms

The **echinoderms** are the fifth phylum of invertebrates. Sea stars, sea cucumbers and sea urchins are examples.



A sea star **Fig 2.2.22**

Echinoderms all live in the sea. Many are circular, cylindrical or ball-shaped.

The sea urchin has many sharp spines. Sea urchins are found in holes on the reef. It is easy to see them when you look down from the canoe. Some coastline Solomon Islanders eat them, either raw or cooked.



A sea urchin **Fig 2.2.23**

The sea cucumber is called **beche-de-mer** in Solomon Islands. It is shaped like a sausage. Its body bends easily. People collect them for money.

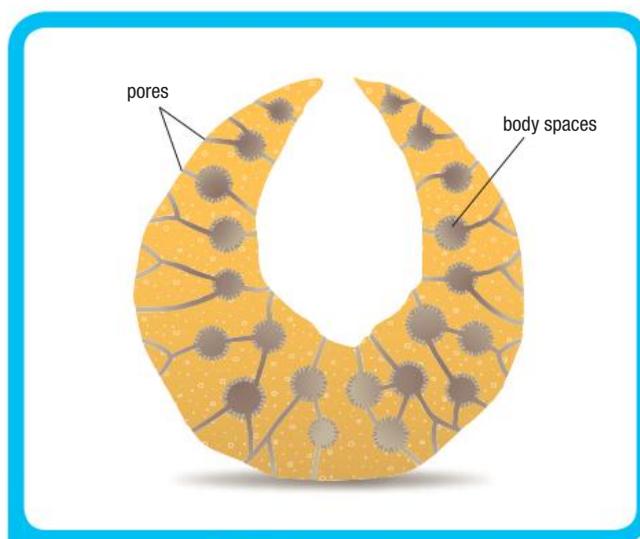


A sea cucumber **Fig 2.2.24**

### Sponges (Porifera)

The sponges are the sixth phylum of invertebrates. The scientific name for the phylum is *porifera*. This means that the animals have pores. The outer layer of the body has holes in it. These pores take in a stream of water. A sponge does not have a head, a mouth or digestive organs. The animal filters its food and oxygen from the water, as the water passes through the sponge.

Figure 2.2.25 shows parts of a sponge. It is magnified to show the pores and the body space. We see sponges on our coral reefs. They look like chunks of foam. Sometimes they wash up on the beach. These pieces are the skeletons of dead sponges.



**Fig 2.2.25** Diagram of sponge



Sponges **Fig 2.2.26**



## 2.2 [ Questions ]

UNIT 2

### Checkpoint

- 1 What is the main thing that biologists have used as a basis for classifying animals?

#### Vertebrates

- 2 **Explain** what a vertebrate is.
- 3 **Identify** the phylum that the vertebrates belong to.
- 4 Copy and complete the following sentences.
- Animals that have a backbone of vertebrae belong to the subphylum \_\_\_\_\_.
  - The five main classes of vertebrates are amphibians, reptiles, birds, \_\_\_\_\_ and \_\_\_\_\_.

#### Invertebrates

- 5 **Explain** the difference between a vertebrate and an invertebrate.
- 6 **List** the main phyla of the invertebrates.

### Think

- 7 **Identify** three characteristics of each of the following classes.
- |              |           |
|--------------|-----------|
| a amphibians | d fish    |
| b reptiles   | e mammals |
| c birds      |           |
- 8 Jimbia are animals with hair that lay eggs. Their young then develop in a pouch. **Classify** the jimbia.
- 9 **Classify** the following animals as vertebrates or invertebrates.
- |            |               |             |
|------------|---------------|-------------|
| a hamster  | d mouse       | g shark     |
| b starfish | e human       | h rabbit    |
| c snail    | f dung beetle | i earthworm |
- 10 **Identify** the two types of cnidarians.
- 11 **Identify** the largest animal phylum.
- 12 **a State** how many species of insects are known.  
**b State** whether you think there are any that are still undiscovered.  
**c Justify** your answer to part b.
- 13 **List** the main differences between centipedes and millipedes.
- 14 **Identify** an example of a mollusc.
- 15 **Clarify** the term 'parasitic'.
- 16 **Identify** an example of an annelid.
- 17 **Identify** two invertebrates that live on land and two that live in the water.

### Analyse

- 18 A new species of living thing is discovered and it is classified into the same group as an animal with six legs and wings. **Identify** the other features you would you expect the new species to have. **Explain** your answer.
- 19 If you discovered a new species of reptile, **list** the features it would have.
- 20 You are watching an animal and it lays an egg.  
**a Identify** the groups it could be in.  
**b Explain** what else you would need to place it in the correct group.

## [ Extension ]

### Investigate

- 1 **Investigate** more about the system used to classify books in the school library and propose what code number would be given to this book if it were in the library.
- 2 Use the information in Unit 2.2 to make a summary showing how animals are classified.  
**a Gather** and include several animal pictures for each group.  
**b Present** your information as a poster or PowerPoint presentation.

# UNIT 2.3

## Plants, fungi, monerans and protists

### introduction

In addition to the animal kingdom, there are four other kingdoms of living things: plants, fungi, monerans and protists. When scientists invented the microscope, they were able to classify these four kingdoms.

### Plants

Plants are classified according to several characteristics—how they feed, their physical features and how they reproduce. The study of plants is called **botany**. Scientists who study plants are called **botanists**.

Vascular plants and bryophytes are the two phyla in the plant kingdom.

### Vascular plants

The vascular plants are a phylum. Vascular plants contain **vascular bundles**. These are cells that transport liquids and nutrients around the plant. Most plants are in this phylum. There are two classes of vascular plants. They are the **flowering** plants (angiosperms) and **non-flowering** plants. Coconuts and mangoes are examples of flowering plants. Conifers, cycads and ferns are examples of non-flowering plants.

### Activity 1

#### Two-choice key for organisms that are not animals

**Aim** Construct a two-choice key for organisms that are not animals

#### Equipment

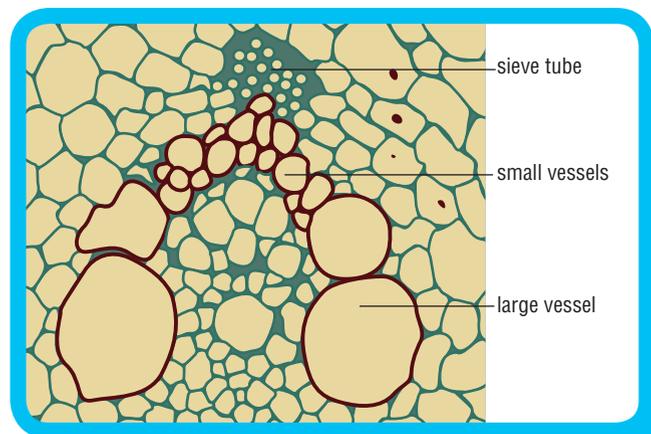
Specimens collected from around the school under teacher's supervision

#### Method

- 1 Examine your specimen carefully. List and discuss some of the characteristics of the specimens. Identify similarities and differences.
- 2 Create a two-choice key to identify the specimens. Use these characteristics to identify the specimen: soft green plants, small trees, cycads, ferns, fungi, mosses and liverworts. Specimens of monerans and protists cannot be found without specific equipment. Include sketches of the specimens. If you don't know their names, you can just call them A, B, C, etc.

#### Questions

- 1 Give your key and samples to a classmate. **Assess** whether they could successfully use your key to identify the plants.
- 2 **Evaluate** your key. How could you improve your key?



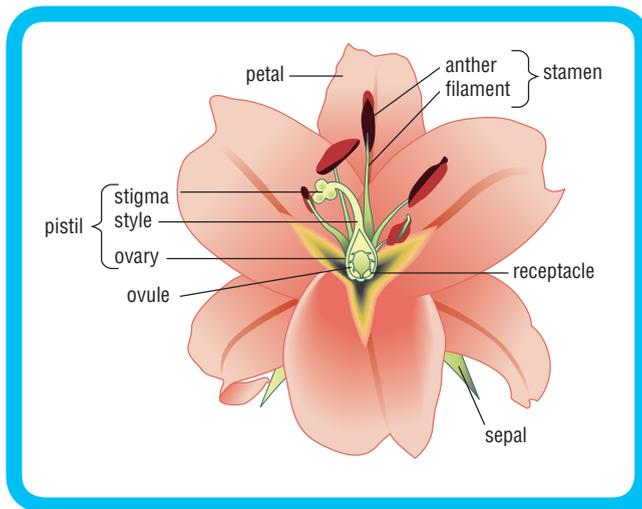
A cross-section of the stem of a vascular plant showing the vascular bundles

Fig 2.3.1

The flowering plants, or angiosperms, are by far the largest class of vascular plants. They always develop seeds inside the flower. The flower later becomes the fruit. The flowers range from large, brightly coloured ones to small, dull-coloured ones. These ones don't really look like flowers at all.



The hibiscus flower is the reproductive part of the plant. **Fig 2.3.2**



The parts of a flower **Fig 2.3.3**

There are vascular plants that do not produce flowers and seeds like angiosperms. Instead they produce seeds on the scales of a cone. Pine trees and cycads are examples.



**Fig 2.3.4** A cycad

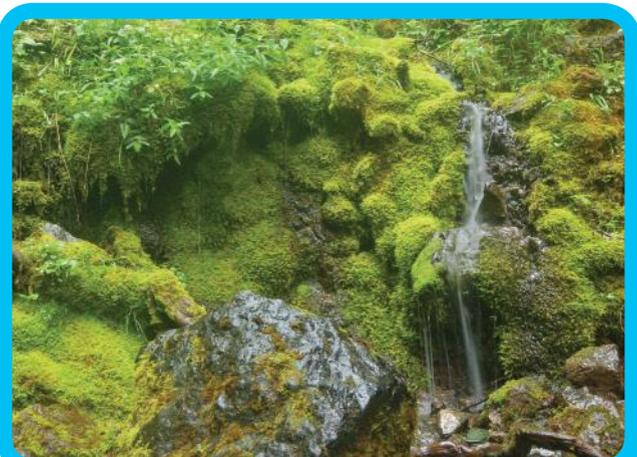
**Ferns** are an example of plants that have no seeds. They reproduce by **spores**. The spores grow on the underside of the leaves.

### Non-vascular plants

This phylum includes the liverworts and mosses. These plants are very small. They don't have a well-developed vascular system or roots. They grow in moist and cooler environments.



**Fig 2.3.5** Liverwort plant



Moss plant **Fig 2.3.6**

### Fungi

This kingdom includes, mushrooms, toadstools and moulds. They cannot make their own food. They must feed on other plants and animals to survive. Fungi reproduce by spores. Some fungi are very useful. The mould *penicillium* gives us the antibiotic medicine penicillin. Some mushrooms can be eaten. Others are poisonous.

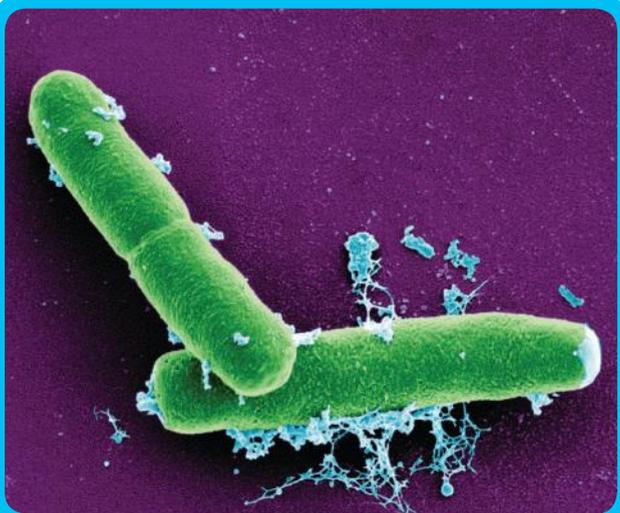


Fig 2.3.7

The death cap mushroom

## Monera

The monera kingdom includes all bacteria and the algae in ponds and oceans. They are living organisms. We can see them only with a microscope. Bacteria are everywhere: in the soil, on your skin and in your intestines. They can be helpful or harmful. The bacteria in your intestines help to digest your food. However, other types of bacteria can cause serious illnesses.



Harmful bacteria—anthrax

Fig 2.3.8

## Protists

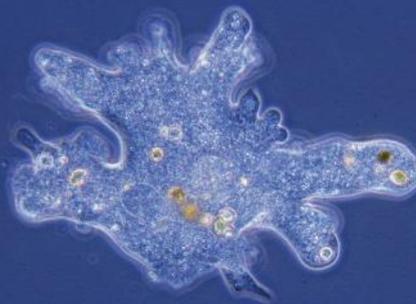
The protist kingdom includes all the things that don't fit in other kingdoms. The algae are plant-like. The protozoa are animal-like. We need a microscope to see algae and protozoa.

All protists live in water. Organisms in this kingdom include seaweeds, slime moulds and amoebas.



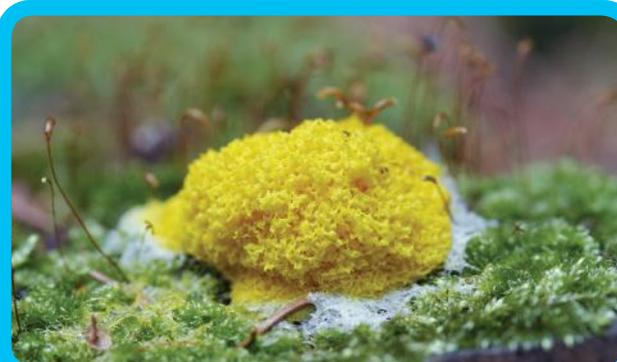
Three different types of seaweed

Fig 2.3.9



Amoeba

Fig 2.3.10

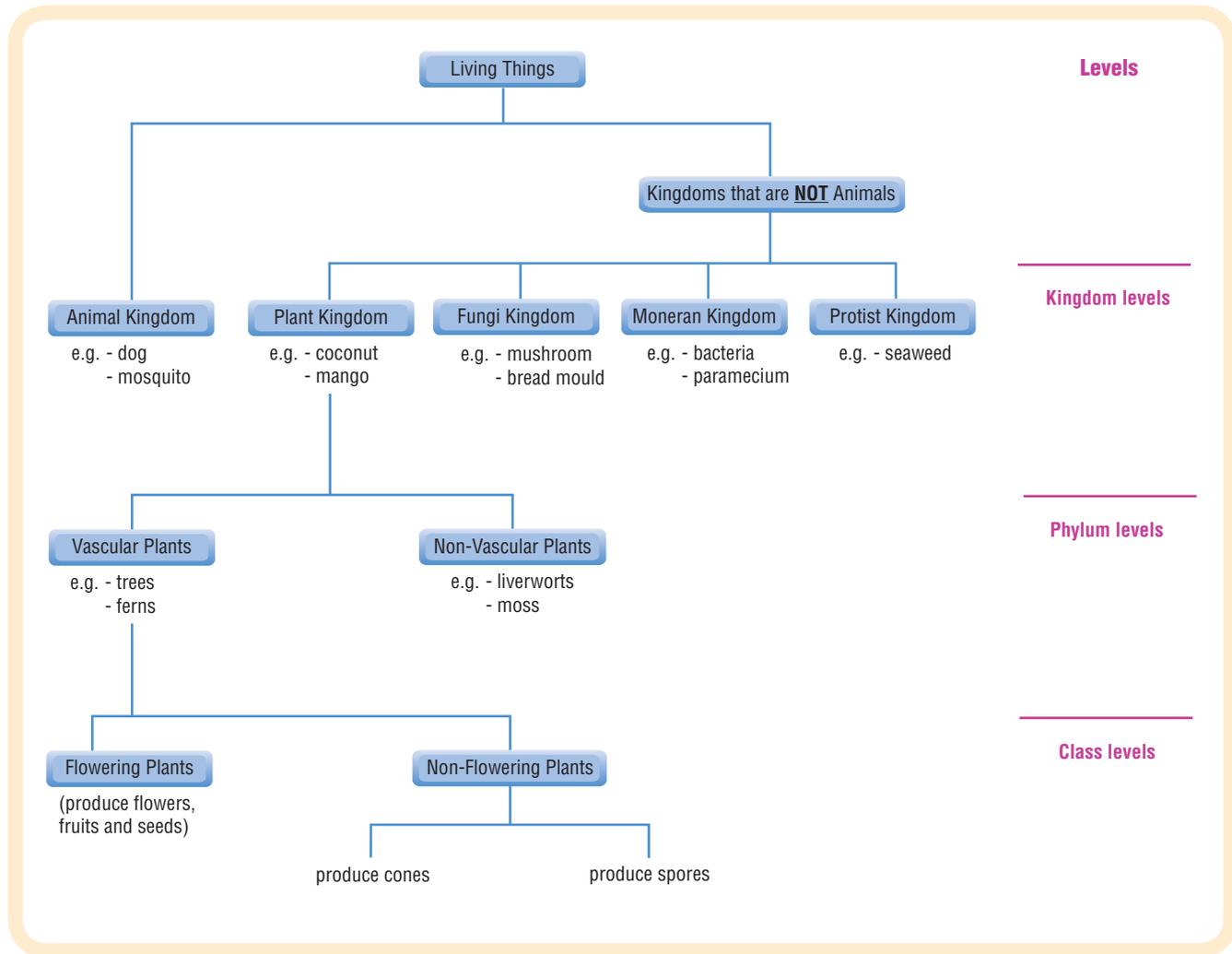


Slime mould

Fig 2.3.11



## Summary: the classification of living things



## 2.3 [ Questions ]

UNIT

### Checkpoint

#### Plants

- 1 **State** what the study of plants is called.
- 2 **Identify** a word for 'major group of plants'.
- 3 **Explain** what is special about angiosperms.
- 4 **Identify** the part of the flower that contains the seeds in an angiosperm.
- 5 **Explain** what sort of seeds conifers produce.

#### Fungi

- 6 **Explain** how fungi are like animals.
- 7 A few fungi are parasitic. **Explain** what this means.

#### Monera

- 8 **Explain** with examples how bacteria can be helpful or harmful.





	Name of class	Examples	Main characteristics
Vascular plants	—		Contain cells that transport water and food around the plant.
Angiosperms	Hydrangeas, eucalypts		
Conifers			
	Cycadopsida		
	Ginkgopsida		
	Filicopsida		No seeds, produce spores on leaves.
Bryophytes	—		
Fungi	—		
Monera	—	Bacteria	
Protists	—		

**Think**

- 9 **Explain** what is so special about protists.
- 10 Copy the following, correcting any incorrect statements so they become true.
  - a A vascular bundle cannot transport anything.
  - b Conifers thrive in hot climates.
  - c Fungi reproduce with seeds.
- 11 **Explain** how ferns reproduce. **Present** your information as a diagram.
- 12 **Identify** three places where bacteria are found.

**[ Extension ]**

**Research** fungal infections of the body such as tinea and ringworm.

**Chapter review**

**[ Summary questions ]**

- 1 Place the following animals in their correct classes:
  - a rat
  - b parrot
  - c bonito
  - d tadpole
  - e gecko.
- 2 Insects and arachnids are classified as arthropods.
  - a **List** two features that are common to both groups.
  - b **List** two features that are different in the two groups.
- 3 What are the reproductive parts of the following?
  - a angiosperms
  - b ferns
  - c fungi.

**[ Thinking questions ]**

- 4 Suggest reasons why dogs and cats are classified as mammals but are different species.
- 5 **Describe** the two stages in the life cycle of amphibians.
- 6 Marsupials are classified as mammals. In what ways are they different from placental mammals and in what ways are they similar?
- 7 Fungi used to be classified as plants. **Explain** the main characteristics of fungi that make them different from plants.
- 8 Justify the creation of a separate kingdom called the protists.

# Solids, liquids and gases

## Specific learning outcomes

7.3.1.1, 7.3.1.2, 7.3.2.1, 7.3.2.2, 7.3.2.3, 7.3.3.1, 7.3.3.1, 7.3.4.1, 7.3.5.1

By the end of this chapter learners should be able to:

- State that matter is substance that has mass and occupies space.
- Use the idea of particle movement to explain the difference between the three states of matter: *solids*, *liquids* and *gases*.
- Investigate the changes caused by heating and cooling of solids, liquids and gases.
- Draw a simple particle diagram to show the change of state from one form to another.
- Use a thermometer to measure the temperature of rain water and boiling water.
- Conduct an experiment to observe that in a physical change the properties of the materials change, but the mass remains unchanged: *melting ice cubes, and water boiling and evaporating*.
- Perform the following to show a chemical change as differentiated from a physical change: *boil an egg, burn wood to charcoal, keep an unripe tomato to ripen, etc.*
- Express in their own words the process that helps to dry wet clothes hanging on the line.

## Challenges

- 1 What's the best way to get out of quicksand?
- 2 What causes the 'fog' on stage and in movies?
- 3 How can a steel ship float when a steel bolt sinks?
- 4 Why is gas, rather than liquid, used in shock absorbers?
- 5 Why does your breath produce 'clouds' on a cold day?
- 6 What is a model used for?
- 7 Does a scientific model always stay the same?



# UNIT 3.1

## Solids, liquids and gases

### introduction

Ice, water and steam or water vapour are substances that we see and use almost every day.

Although they look and act completely differently from each other, they are just different forms of exactly the same thing—water. They contain exactly the same types

of particles—water particles. We cannot see the individual particles of water. We use a model to understand their behaviour.



Fig 3.1.1

Liquid water, solid ice and steam are really the same substances.

### Models in science

We cannot see individual particles of water, but we do know how water (and ice and steam) behaves. In science, a model is an idea that explains certain behaviour. A model might not match exactly what is really going on, but it can be used to help us understand and predict what will happen in other situations. This is similar to a model of a planned building or aircraft that helps designers better understand the real thing.

To better understand different forms of water and other substances, we use the **particle model**.

### The particle model

The word ‘substances’ is used a lot in science. It can be used to describe just about anything without being too specific. For example, if you don’t know what is

made when two chemicals are mixed, you could answer ‘a substance’ and know you are correct!

Instead of ‘substance’, we could try another word that can be used just as generally—**matter**. The annoying thing about substance and matter is their dictionary definitions. Look up ‘matter’, and you will very likely read that ‘matter is what all substances are made of’. Look up ‘substance’, and you get something like ‘anything made of matter’!

One definition of matter is: ‘what everything in the universe is made of’.

Another is: ‘anything that has mass and takes up space’.

Now that the term ‘matter’ has been introduced, we can use it to say that there are three main **states of matter**—**solids**, **liquids** and **gases**. Ice, water and steam are all water, but in different **states**, or **phases**. There are other states as well that occur in special situations.

The particle model of matter explains these states in terms of the packing and movement of the particles in a substance.

### Activity 1

#### States of matter

**Aim** To show the change in matter that occurs when boiling water

**Equipment**  
Kettle, flame (stove, local kitchen)

**Method**  
Heat water in a kettle. Observe what happens when the water begins to boil.

**Question**  
What did you see? Write down your observations.

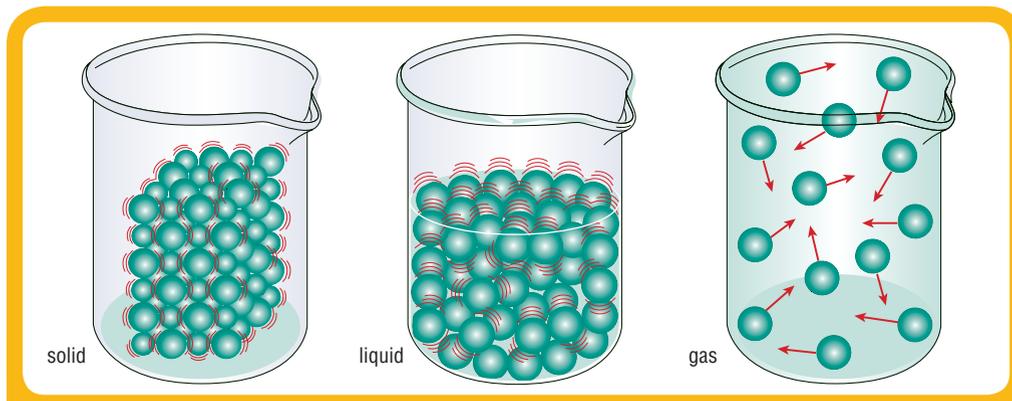


Fig 3.1.2

Particles in solids, liquids and gases vibrate, but those in liquids and gases are able to change position.

## Solids

In a solid, the particles are strongly **bonded** (held together) to each other. The particles in a solid move or vibrate, but not much when compared to liquids and gases. Solids have definite shape, do not flow, and are very difficult (impossible) to compress. Solids expand if heated but less than liquids and gases. The heat energy makes the particles move or vibrate faster.



Fig 3.1.3

What do these objects have in common?

## Liquids

The particles in a liquid are weakly bonded to each other. It doesn't take much to break these bonds (which is just as well when you jump into a swimming pool). The particles in a liquid move around more than those in a solid. Liquids have no definite shape, but can flow to take the shape of the bottom of a container. Like solids, they are very difficult to compress—they are virtually **incompressible**.

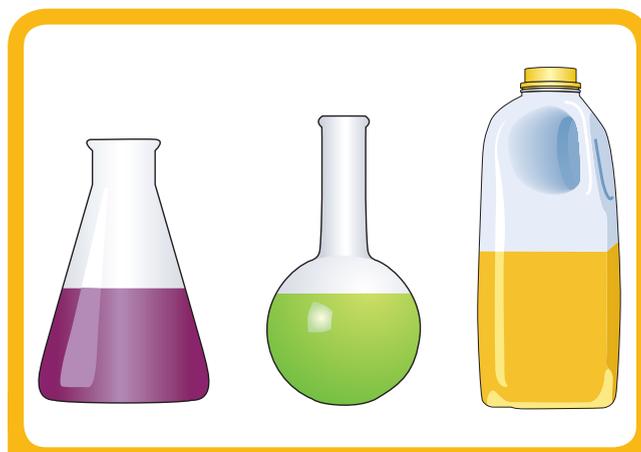


Fig 3.1.4

Liquids take the shape of their containers

## Activity 2

### Solids and liquids

#### Equipment

Bottle

#### Method

- 1 Collect materials (wood or stones) that are bigger than the neck of your bottle. Try to push the materials through the neck of the bottle. Record your observations.
- 2 Pour water through the neck of the bottle. Record your observations.
- 3 Compare the two observations.

## Gases

There are no bonds (links) between the particles in a gas. The particles in a gas have much more energy than those of a solid or liquid. They fly around, bouncing off each other. Gases have no fixed shape.

Even a small amount of gas will spread to completely fill a container. Unlike solids and liquids, gases can be compressed. This is because gases have large amounts of space in between the particles.

### Activity 3

#### Observing gas particles

**Aim** To see moving gas particles

#### Equipment

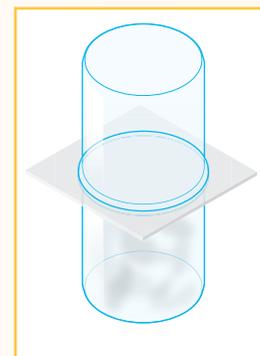
Smoke from fire, two transparent empty jam jars or drinking glasses, piece of plastic

#### Method

- 1 Collect smoke in a transparent empty jam jar or drinking glass and place a piece of plastic over the top. Place another transparent jam jar or drinking glass upside down over the first one on top of the piece of plastic.
- 2 Remove the piece of plastic. Observe what happens.

#### Questions

- 1 What did you see? Write down your observations.
- 2 What did you learn from this activity?



**Fig 3.1.5** Diffusion may be demonstrated by removing the plastic between two jars or glasses.

### Activity 4

#### Compressibility

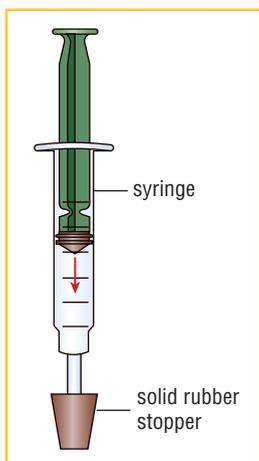
**Aim** To compare the compressibility of a gas with that of a liquid

#### Equipment

A plastic syringe (no needle attached), water, rubber stopper

#### Method

- 1 Draw some air into the syringe.
- 2 Press the opening of the syringe hard against the rubber stopper as shown, and try to compress the air by pushing the plunger.
- 3 Now draw some water into the syringe and repeat step 2.



**Fig 3.1.6**

#### Questions

- 1 **State** which substance you were able to compress.
- 2 Use particle diagrams to **explain** what happened with both substances.

### Activity 5

#### Diffusion of food dye

**Aim** To investigate diffusion in liquids

#### Equipment

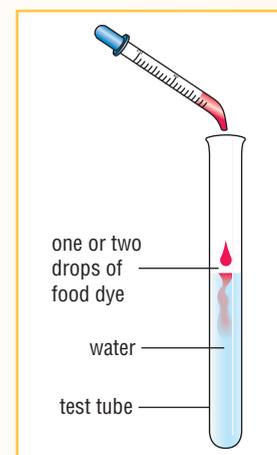
Food dye, eye dropper, test tube or beaker

#### Method

- 1 Almost fill a beaker or test tube with cold water.
- 2 Add a drop of food dye and let the mixture stand for several minutes, sketching what you observe every 30 seconds or so.
- 3 Repeat steps 1 and 2 using hot water.

#### Questions

- 1 **Explain** why the spread of colour cannot be explained by gravity alone.
- 2 **Explain** how temperature affected your experiments.
- 3 **Explain** the process of diffusion in this experiment in terms of particles.



**Fig 3.1.7**

## Evidence of the particle model

### Activity 6

#### Evidence of moving particles

**Aim** To prove that particles move

**Equipment**

Pollen grains, jar of water

**Method**

- 1 Drop some pollen grains into a jar of water.
- 2 Observe what happens.

**Questions**

- 1 What did you see? Write down your observations.
- 2 What did you learn from this activity?

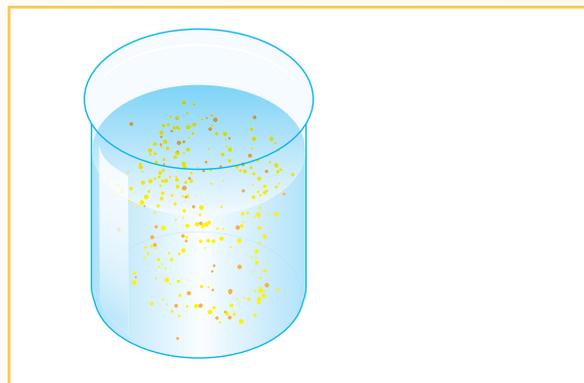


Fig 3.1.8

A scientist called Robert Brown noticed that pollen grains constantly moved in a jar of water. He noticed this when he looked through a microscope. The pollen grains were very small. The water particles bumped against the pollen grains.

This observation by Brown is evidence of the **particle model of matter**. This explanation is called **Brownian motion**, after the scientist's name.

We use the particle model to explain how dissolving happens. When we put sugar in water, it dissolves. The sugar particles fit between the water particles.

Gas particles from car exhaust fumes, perfumes or flowers diffuse through the atmosphere. Our nose detects the small particles. This is how we smell things around us. Particles also diffuse in solids and liquids. An example is milk stains on clothes.

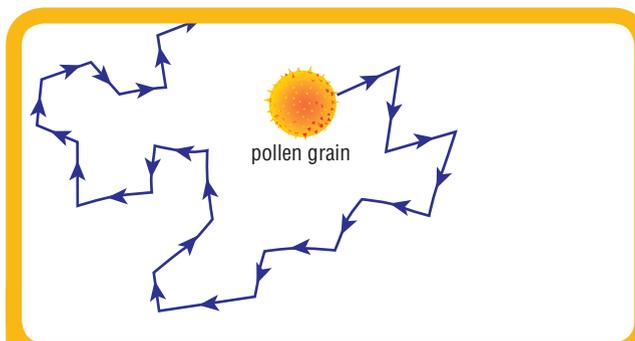
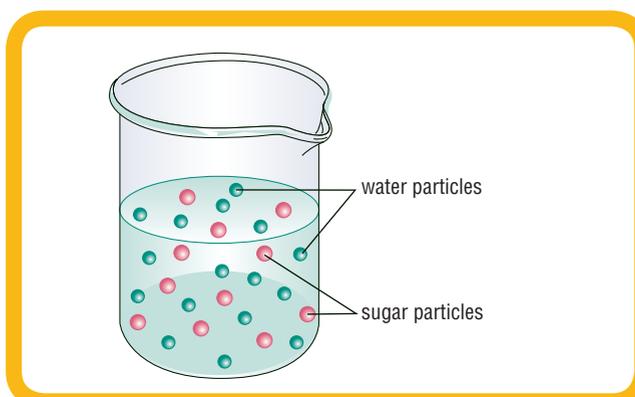


Fig 3.1.9

Individual water molecules can't be seen, but their effect on a pollen grain can be observed.



Dissolving can be explained using the particle model.

Fig 3.1.10

Activity 7

### Plasticine particle models

**Aim** To build a model showing the arrangement of particles in various solids

**Equipment**

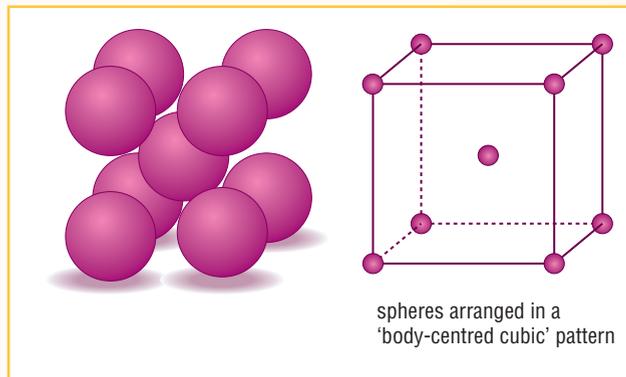
Plasticine

**Method**

- 1 Use the plasticine to make 16 identical balls.
- 2 Investigate the different ways you can pack several of the balls together in regular patterns. One way is shown opposite.
- 3 Sketch the different packing arrangements you come up with.

**Questions**

- 1 How many regular arrangements did you find?
- 2 **State** in which phase of matter you would most likely find regular packing patterns if you could see them.



spheres arranged in a 'body-centred cubic' pattern

Fig 3.1.11

## 3.1 [ Questions ]

**Checkpoint**

*Models in science*

- 1 **Define** the term 'model' as used in science.

*The particle model*

- 2 **State** your own definition of 'matter'.
- 3 **Describe** what is meant by the term 'phase of matter'.

*Solids, liquids and gases*

- 4 **List** five different examples each of a solid, a liquid and a gas.
- 5 Draw a diagram to **compare** the particles in solids, liquids and gases.

*Evidence for the particle model*

- 6 **Explain** how Brownian motion was first discovered.
- 7 **Describe** what happens to the particles in a solid when it dissolves.
- 8 **Explain** why diffusion is evidence for the particle model.

**Think**

- 9 Explain why, when trying to prove a new scientific model, a scientist should repeat their experiments a number of times.
- 10 **Identify** a food or drink that contains:
  - a both solid and liquid material
  - b both a liquid and a gas
  - c only solid
  - d only liquid
- 11 Draw your own version of the particle model. Draw it as three layers, with solid at the bottom, changing into liquid and finally gas at the top.
- 12 The particle model predicts that only gases can be compressed. **Explain** how.
- 13 **Describe** what you think happens to the bonds (attractions) between particles as heat changes a material from solid to liquid to gas.
- 14 People might classify sugar and soft plasticine as liquids because they take the shape of their container. **Clarify** the definition of a solid so that people cannot make this mistake.





- 15 Explain** how the fragrance of a perfume travels throughout a room.
- 16 Describe** Brownian motion.
- 17 Copy and complete** the following table to **summarise** the properties of substances.

Property	Solid	Liquid	Gas
Shape	definite		
Ease of compression	very low		
Bonds between particles		weak	
Movement of particles		medium	

### Analyse

- 18** There must be some bonds or attractions, however weak, between the particles in a liquid. **Explain** why.
- 19 Explain** why foam rubber can be compressed, when solids are supposed to be incompressible.
- 20 Identify** which of the following statements are objective (that is, they are based on evidence).
- If I go outside with wet hair I will catch a cold.
  - I know it is raining outside because I can see the rain.
  - The X-rays showed that I have a broken arm.
  - Many people say that exercise is good for you.

### [ Extension ]

#### Investigate

- 1 Explain** the difference between a fluid and a liquid.
- 2 Research** the viscosity of liquids. Explain how temperature affects the viscosity of honey.
- 3 Explain** what surface tension is and how it enables some insects to walk on water.

# UNIT 3.2

## Changes of state

### introduction

As discussed in Unit 3.1, substances can exist in three different states: solid, liquid and gas. Many of their uses rely on them changing from one state to another. Purifying water relies on a change of state from liquid to gas and back again, as does the formation

of rain. The burning of a candle relies on the wax changing from a solid to a liquid and then to a gas. Understanding how things change from one state to another is very important.

### Applying a model

In this unit we will use the particle model to help explain how substances change from one state to another. An example of this is changing water (liquid) to water vapour (gas) during boiling of water. Using a model to explain how or why something happens is a very important skill.

In each of the following sections, remember to keep thinking about what the particles are doing.

### Change from solid to liquid

To change a solid (like ice) to a liquid (like water), heat energy must be added. This makes the particles move faster. In this way, the substance changes state. This causes the solid to expand. Adding more heat energy results in the breaking of the bonds between the particles, then a liquid is formed. This change is called **melting**. Another example is when a solid wax candle produces pools of liquid wax due to heat energy provided by the flame.

The temperature at which a particular solid changes into a liquid is called the **melting point**.

The melting point of water is  $0^{\circ}\text{C}$ . The melting point of wax is around  $60^{\circ}\text{C}$ .

### Change from liquid to solid

When a liquid changes back to a solid, the change is called **solidification** or **freezing**. This happens when a liquid loses energy and the particles move much slower. This makes the bonds between the particles strong again. The particles return to fixed positions. For example, liquid candle wax loses energy to the surrounding air. It solidifies when its temperature falls below  $60^{\circ}\text{C}$ . Water will not freeze until it reaches  $0^{\circ}\text{C}$ .



Liquid water can be changed to a solid (ice) by freezing. If the ice is heated, the solid will change back to a liquid (water).

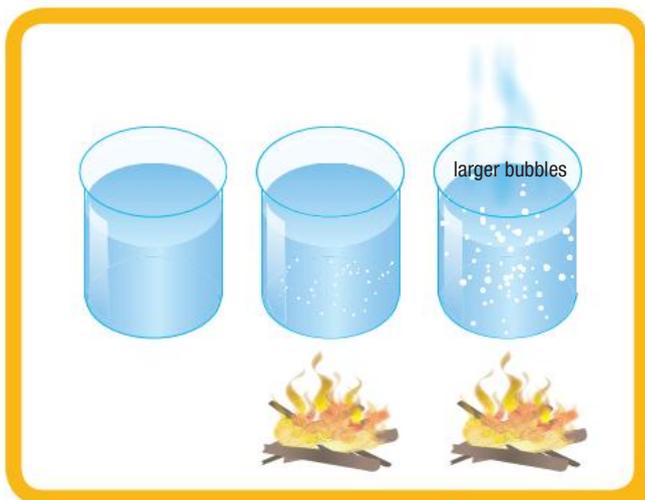


## Change from liquid to gas

To change a liquid into a gas, heat must be added to completely break the bonds between particles. When heat is added to a liquid, small bubbles of gas will form inside the liquid. When enough heat is added, these gas bubbles become large enough to float to the surface and **boiling** takes place. When a liquid boils, bubbles of gas or steam escape into the air. This is called **evaporation** or **vaporisation**. The temperature at which a liquid boils is called the **boiling point**.

The boiling point of water is 100°C.

A liquid does not have to boil in order for evaporation to occur—boiling just speeds up the process. A small pool of water will all evaporate on a dry day as particles at the surface absorb enough energy from the air to escape the liquid.



Boiling occurs when bubbles of gas escape from the liquid.

Fig 3.2.2

## Change from gas to liquid

The opposite of evaporation is **condensation**. Condensation occurs when gas particles lose energy and turn into liquid. When you breathe out on a very cold day, the water vapour in your breath (which is a gas) condenses to form tiny droplets of water which float in air and appear like a fog. A similar thing happens when you breathe on a window and water droplets condense on the glass.



Fig 3.2.3

Condensation

## Change from solid to gas

A much less common change is when a solid absorbs heat and changes directly to a gas without melting and going through the liquid stage.

This is called **sublimation**. An example of sublimation is when dry ice of carbon dioxide sublimates to form carbon dioxide gas. Dry ice is used on stage and in movies to produce the effect of fog.

The word 'sublimation' may also be used to describe the action of a gas changing directly into a solid.



Sublimation in action

Fig 3.2.4



## Activity 8

### Ice to water to steam temperature graph

**Aim** To investigate what happens to the temperature of water as it changes state

#### Equipment

Ice cubes, heat-proof mat, water, gauze mat, beaker (250 mL), measuring cylinder (100 mL), thermometer (0°C to 110°C), Bunsen burner, tripod

#### Method

- 1 Mix several ice cubes with 100 mL of water.
- 2 Place the thermometer in the ice/water mixture and record the temperature once every minute for 3 minutes.
- 3 Light the Bunsen burner and keep the air hole opening in the same position throughout the experiment.
- 4 Heat the ice/water mixture, and continue to record the temperature at 1-minute intervals until the water boils. Measure the temperature for 3 more minutes after boiling starts, but stop boiling if the water level falls below 50 mL.
- 5 Record your measurements in a table.

#### Questions

- 1 **Present** the results in a graph showing temperature on the vertical axis and time in minutes on the horizontal axis.
- 2 **Explain** why you had to keep the air hole opening fixed during the experiment.

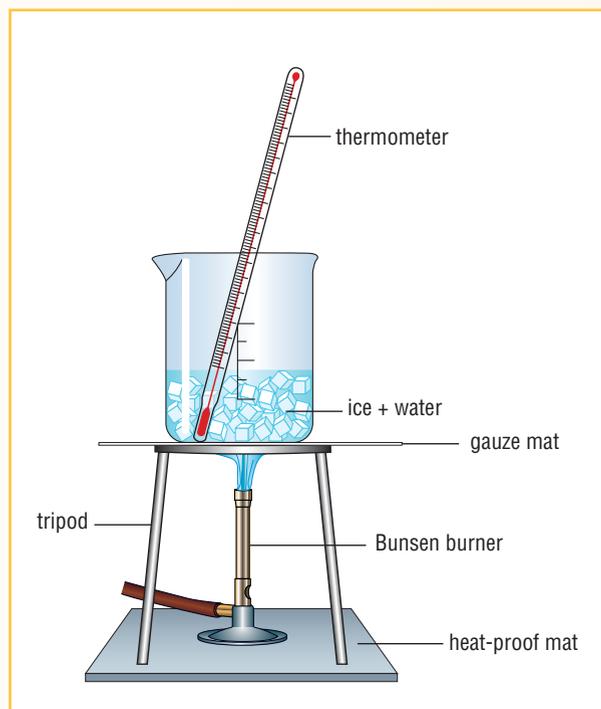


Fig 3.2.5

- 3 **Explain** why your graph did not quite start at 0°C.
- 4 **Identify** any level sections in your graph. Explain why level sections may occur.
- 5 Imagine you were able to capture the steam produced when all the water has evaporated and measure its temperature as you continued to heat it. **Describe** the temperature graph that would be observed.



### Teacher demonstration

#### Iodine sublimation

Iodine is an example of a substance that sublimates. It is a purple solid, in the form of crystals. When iodine crystals are heated on a piece of mesh, the solid crystals change directly into a deep purple coloured gas. It is easy to see. However, iodine gas is very poisonous.

**CAUTION:** Iodine gas is poisonous—exercise caution and use a fume cupboard. Check the MSDS. Safety glasses must be used. Seal the test tube with a rubber stopper after heating and leave inside the fume cupboard.

**WARNING:** DO NOT carry out this demonstration for your students if your science laboratory does not have a fume cupboard.

Watch your teacher gently heat the test tube in a fume cupboard until a small amount of purple gas is produced.

Observe what happens as the iodine cools.

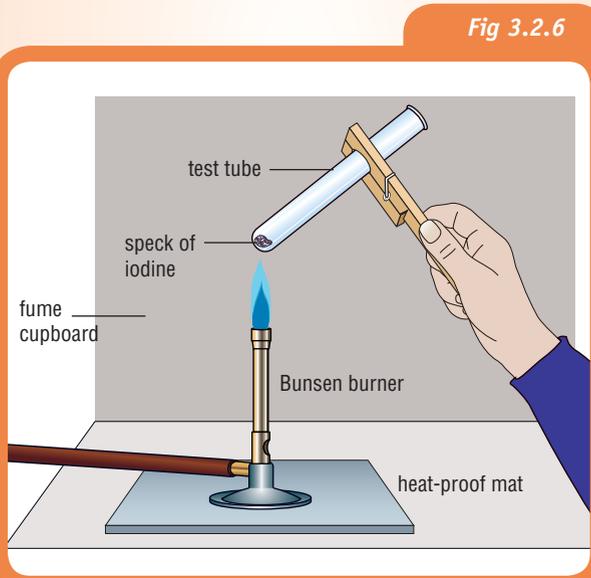


Fig 3.2.6

#### Questions

- 1 **Describe** the iodine at the start of this demonstration and any changes in state that occurred.
- 2 **Identify** whether any liquid iodine formed.
- 3 **Describe** the coating on the side of the test tube as the contents cooled.
- 4 **Explain** how you know that the purple substance produced after heating was a gas.



Fig 3.2.7 Sublimation of iodine

### Summary of changes of state

Figure 3.2.8 summarises the different changes of state.

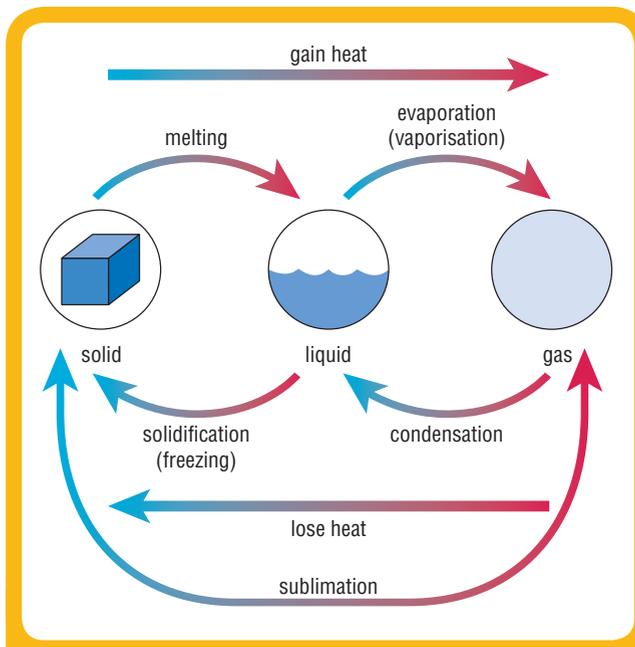


Fig 3.2.8 Changes of state

# 3.2 [ Questions ]

## Checkpoint

### Solid to liquid

- 1 **Identify** which change of state the term 'melting' refers to.
- 2 **Describe** what is meant by 'melting point'.
- 3 **Describe** what happens at the melting point of water and identify at what temperature it happens.

### Liquid to solid

- 4 **Identify** the two names given to a change of state from liquid to solid.
- 5 **Identify** the freezing point of wax.

### Liquid to gas

- 6 **Define** the terms 'boiling' and 'evaporation'.
- 7 **Describe** what happens to the particles when water boils.

### Gas to liquid

- 8 **Explain** what is occurring in Figure 3.2.3.

### Solid to gas

- 9 **Explain** why it is not usual to find substances that undergo sublimation.
- 10 **Identify** two substances that sublime.

## Think

- 11 **State** the scientific term used to describe when:
  - a liquid changes into a gas
  - a gas changes into a liquid
  - a solid changes directly into a gas
- 12 **Identify** which of the following is likely to be closest to the melting point of a steel rod.
  - 0°C
  - 60°C
  - 100°C
  - 1500°C
- 13 **Identify** which of the following is likely to be closest to the melting point of oxygen.
  - 200°C
  - 0°C
  - 20°C
  - 100°C
- 14 **Explain** what would happen to an unlit wax candle on a 40°C day.
- 15 **State** another term for 'evaporation'.
- 16 **State** the opposite term to:
  - melting
  - condensation

- 17 **Describe** three changes of state that may occur in the home.
- 18 **Explain** how heat is transferred when a solid sublimates.
- 19 **List** the advantages of dry ice compared with water ice when producing fog for a stage effect.

## Analyse

- 20 Draw a change of state diagram based on a triangle with solid, liquid and gas at the corners. On each side of the triangle, indicate the name of the process of the change in state, in each direction (e.g. melting).
- 21 Kevin notices that when his swimming pool is heated to 27°C, the water level falls by about 10 cm each week.
  - a **Explain** how this can happen when 27°C is a lot lower than the boiling point of water, 100°C.
  - b **Predict** what would happen if the swimming pool was:
    - i not heated
    - ii heated to a higher temperature, say 30°C

## [ Extension ]

### Investigate

- 1 Prepare a **list** of melting points and boiling points for several substances.
- 2 **Investigate** the history of the thermometer, and the three different temperature scales (Celsius, Fahrenheit, Kelvin).
- 3 **Describe** 'snap freezing' and 'freeze-drying'.

## [ Student activities ]

- 1
  - a **Describe** what a model is.
  - b **Describe** an example of how the particle model can be used to predict the behaviour of each state of matter when a solid is heated.
  - c **Investigate** and **explain** what these other scientific terms mean, and when they are used: inference, hypothesis, prediction, theory, law, observation.
- 2
  - a **Outline** the features of a good scientific model that can lead to it becoming accepted without anybody seeing the thing that the model suggests is there.
  - b **Discuss** this in a group and create a final list of the most important features of a good scientific model.
  - c **Present** your findings to the class.

# UNIT 3.3

## Physical and chemical change

### introduction

Changes are happening to substances around us all the time. These changes may be as simple as a change in shape, for example, when an empty soft drink can is squashed. Another simple change is when a substance is broken into smaller pieces, like glass in a window being smashed with a stone, or sugar being dissolved in hot coffee. In some cases, changes produce new substances. For

example, petrol explodes or burns to form different gases; an iron nail rusts, producing an orange-red material or substance covering the nail. These are examples of complex changes. Changes can be classified as physical or chemical.

### Activity 9

#### Observing changes

- 1 Light a candle. Let the wax melt and allow it to drop on the floor. Observe and record what you see. Is this a physical or chemical change? Give a reason for your answer.

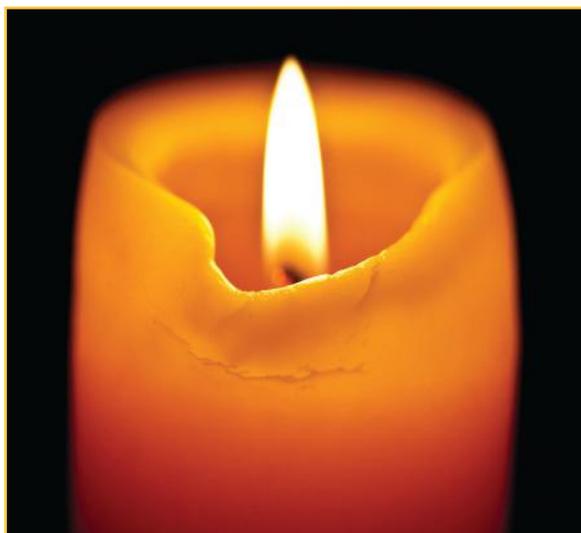


Fig 3.3.1

- 2 Burn some paper until it is ash. Observe and record what you see. Is this a physical or chemical change? Give a reason for your answer.

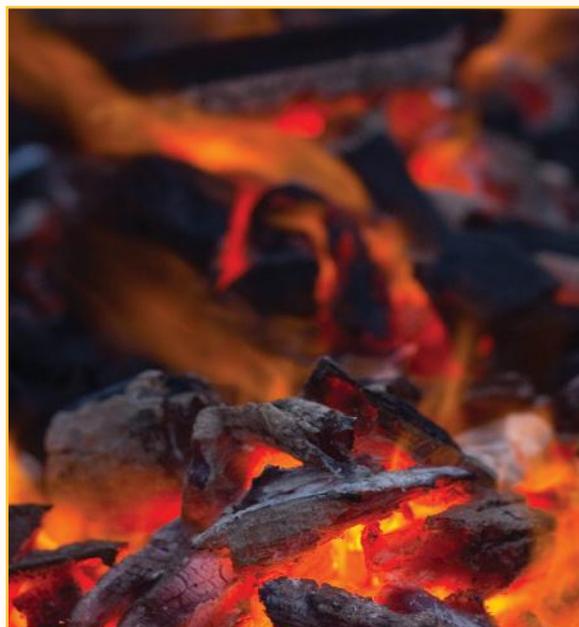


Fig 3.3.2



Exploding fireworks involve physical and chemical changes.

Fig 3.3.3

## Physical change

A **physical change** occurs when a substance changes, but no new substance is formed.

Physical changes occur when the state of a substance changes (e.g. melting, evaporation, freezing, condensing) or a substance is crushed, ground or cut into smaller pieces.

The following are examples of physical change.

- A plate is dropped and shatters.
- Ice melts.
- Water boils.
- Milo dissolves in hot milk.
- Grass is cut.
- Branches of a tree are cut into small pieces.
- A metal knife is sharpened.
- Finger nails are filed down.
- A piece of bread is soft and wet when put in a cup of Milo or coffee.



Fig 3.3.4

Frozen carbon dioxide in water undergoes a physical change from solid to gas.



## Chemical change

A **chemical change** occurs whenever a new substance forms. When a substance forms that looks different or acts very differently from what was there before, then the chemical change is easy to see. Sometimes, however, the change is not easy to observe. The only indication may be a change in colour, the production of heat or light or a drop in the temperature of the material.

The following are examples of chemical changes.

- Wood burns to form charcoal (carbon).
- A green tomato ripens and turns red.
- An egg is cooked to become a white and yellow solid.
- Vegetable scraps in the compost bin decompose to produce a rich soil.
- A dead rat stuck in the wall of a house begins to smell awful.
- A metal panel on a car rusts.
- Fireworks explode.
- Concrete hardens.

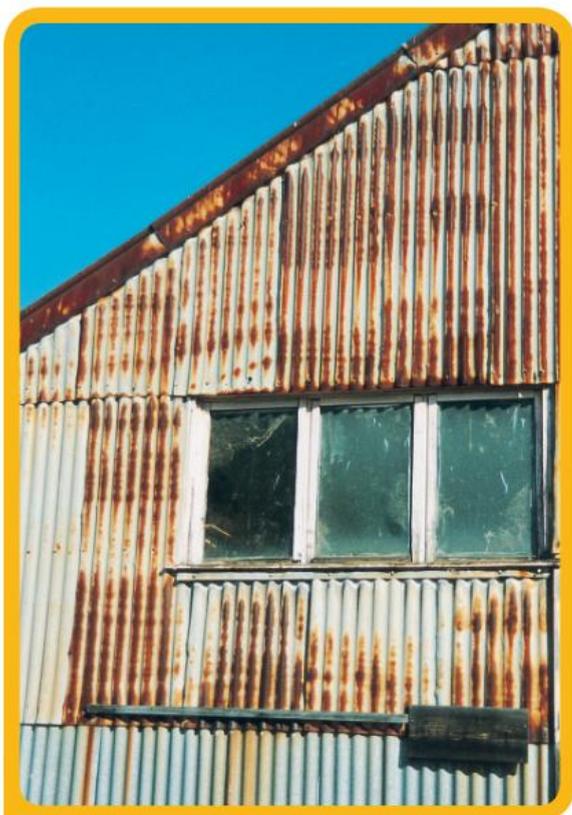


Fig 3.3.5 Rusting is a chemical change.

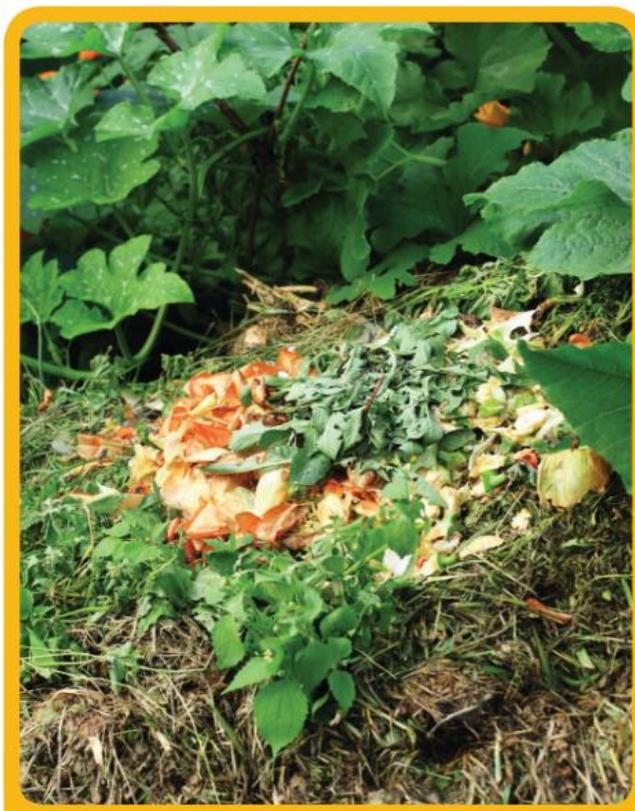


Fig 3.3.6 Vegetable scraps decompose to produce rich soil. This is a chemical change.

## UNIT 3.3 [ Questions ]

### Checkpoint

#### Physical change

- 1 Describe what is meant by 'physical change'.
- 2 Give two examples of a physical change.

#### Chemical change

- 3 Describe what a 'chemical change' is.
- 4 Chemical change is not always easy to observe. Give some features of a chemical change.
- 5 Give two examples of a chemical change.

### Think

- 6 Identify seven physical changes you have encountered in everyday life.
- 7 Identify and list the physical and chemical changes that occur during the burning of the candle.

# Chapter review

## [ Summary questions ]

- 1 State** the three phases of matter.
- 2 Describe** a household example of each of the states of matter.
- 3 Copy and complete:** Matter is something that takes up \_\_\_\_\_ and has \_\_\_\_\_.
- 4 Complete the table below, summarising** the different possible changes of state.

From \ To	Solid	Liquid	Gas
Solid		melting	
Liquid			
Gas			

- 5 Identify** all the changes of state involved when a container of frozen soup is thawed out and boiled.
- 6 Identify** a substance that sublimates.
- 7 Explain** what a model is and why they are used in science.
- 8 Identify** two phenomena in this chapter that can be explained by the particle model.

## [ Thinking questions ]

- 9 Identify** three other models that are used in science to help us better understand a phenomenon.
- 10 Compare** the bonds between particles in a solid with those in a liquid.
- 11 List** which states of matter are compressible.
- 12 Describe** one piece of evidence that supports the particle model.
- 13** Substance A has a melting point of 10°C. Identify its state at normal room temperature.

## [ Interpreting questions ]

- 14 Identify** at which of the following temperatures water is the most dense. Give a reason for your answer.
  - a 0°C
  - b 1°C
  - c 3°C
  - d 5°C
- 15 Explain** how a thermometer works.
- 16 Explain** what causes gas to exert pressure when placed in a container.
- 17** Using your knowledge of the particle model, draw diagrams to **demonstrate** the arrangement and motion of particles in a solid, a liquid and a gas.

# Energy forms

CHAPTER

# 4

By the end of this chapter learners should be able to:

- Demonstrate that energy is used when work is done by: *boiling an egg, lifting a book, digging a hole*, etc.
- Identify and describe different forms of energy: *heat, sound, elastic, electrical*, etc.
- Demonstrate energy transformation in the following situations: *falling coconut, moving car/canoe, kicking a soccer ball, writing in a book, brushing your hair*, etc.
- Identify the form of energy in: *music coming from the radio, stretching a rubber band, boiling water using firewood, heating water using an electric jug*.
- Identify and describe renewable and non-renewable energy sources.
- State the law of conservation of energy: *Energy cannot be created nor destroyed, but can be changed from one form to another.*

- 1 Give three examples of energy.
- 2 Why do you feel cold when you jump into a pool that is at the same temperature as the surrounding air?
- 3 How does a thermos keep your boiled water hot all day long?
- 4 Describe three devices or pieces of equipment that use energy.
- 5 Draw a diagram to show how a periscope works.
- 6 When is a sound dangerous?





# UNIT 4.1

## Energy forms

### introduction

On 16 July 1945, scientists exploded the first atom bomb. For the first time the atom was split in a nuclear reaction that released a huge amount of energy very quickly. This enormous explosion was seen 400 kilometres away. The shock wave was felt 80 kilometres away.

The energy released was made up of different forms including heat, light and sound. This single event changed our lives forever. So what is this thing called energy?

### What is energy?

Every activity we engage in needs energy. However, it is difficult to describe what energy is, as there is no simple piece of energy a scientist can collect and study. Let us not worry so much about what energy is, but what it can do. When energy is used, some work is done. Scientists say that **energy is the ability to do work**. But what is work?

Work is getting things done. Carrying a bag of copra, or hoeing mounts for planting potato vines, or grating coconut, or cutting sago palm leaves, requires hard work and uses a lot of energy.

There are two main types of energy: potential energy and kinetic energy. But these can take many different forms.

**Potential energy** is stored energy. The energy in food, a stretched rubber band, petrol or a battery is stored inside the material. Anything that is held above the ground has potential energy because gravity is trying to pull it down. When we release stored or potential energy it is often changed into kinetic energy.

**Kinetic energy** is energy of motion. All moving things have kinetic energy.

We are using kinetic energy every time we play soccer, train for netball and athletics or even just sit around talking.

All energy is measured with the same unit. This unit is called the **joule** and has the symbol 'J'. The symbol is commonly seen on food packaging where the units are in kJ, which represents kilojoules or 1000 joules.



A compressed spring

Fig 4.1.1

## Activity 1

## Energy in food

**Aim** To measure the energy stored in some foods

**Equipment**

Test tube; retort stand, boss head and clamp; tripod and gauze mat; Bunsen burner; balance; measuring cylinder (50 mL); aluminium tray; thermometer (–10 to 110°C); small amounts of three different food types, such as peanuts, bread, chips, breakfast cereal, butter, meat, cheese (1 g of each)

**Method**

- Copy the table below into your notebook.
- Set up the apparatus as shown in Figure 4.1.2. Make sure the test tube is just above the gauze mat.
- Measure 10 mL of water into the test tube.
- Measure the temperature of the water and record it in your results table.
- Measure 1 g of one of the foods and put it on the gauze mat. If it is a fatty or runny food like butter, you may need to put it on an aluminum tray.
- Light the food, then place the test tube above it and take the temperature of the water with a thermometer. Watch for when the temperature stops rising - this is the final temperature; record it in the results table. Repeat with other pieces of food.

**Questions**

- Which food, when burnt, heats the water to its highest temperature?
- What does the highest temperature change tell us about the energy in the food?

Food (1 g)	Starting temperature of the water (°C)	Highest temperature the water reached (°C)	Amount of temperature (°C)

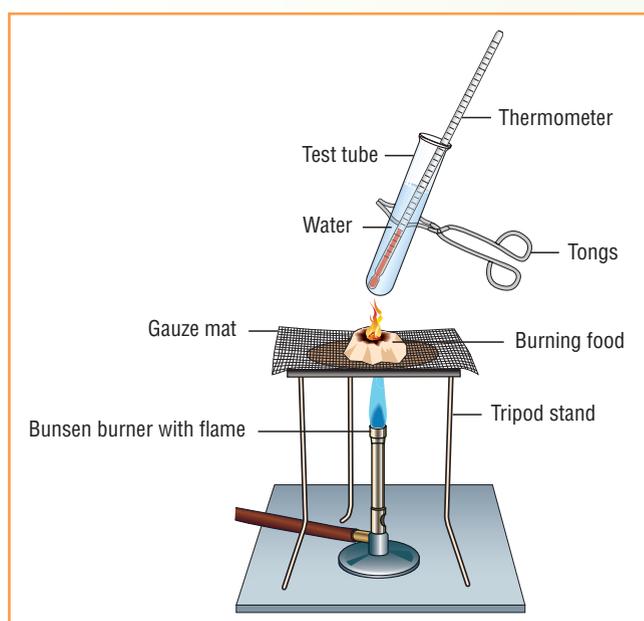


Fig 4.1.2



## Forms of energy

Potential and kinetic energy can exist in many different forms, as shown in Figure 4.1.3.



a. Electrical



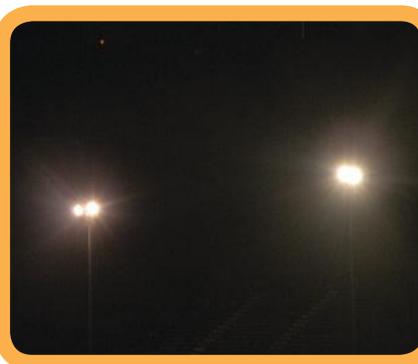
b. Gravitational



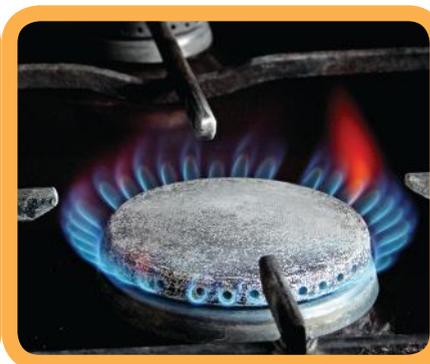
c. Elastic



d. Nuclear



e. Light



f. Heat



g. Chemical



h. Sound



i. Kinetic

Forms of energy

Fig 4.1.3

## Energy transformations

Energy can be changed or **transformed** from one kind of energy to another. Most machines and appliances operate because they are able to change energy into another type, and then use this energy to do work.

Some examples of energy changes or transformations are shown in Figure 4.1.3.

The lighting of a match is one example of an action that involves many energy changes. First, moving our hand to strike the match involves kinetic

energy. This is turned into heat and sound energy caused by the friction of the moving match head against the side of the box. The heat energy from the friction causes a chemical reaction to begin. This releases the chemical potential energy stored in the match head and wood as light and heat energy.

## Activity 2

### Popcorn

**Aim** To use heat energy to change the stored energy in corn into sound and motion

#### Equipment

Popping corn, small saucepan with lid, Bunsen burner, cooking oil

#### Method

- 1 Place a small amount of cooking oil in the saucepan.
- 2 Cover the bottom of the pan with popping corn.
- 3 Heat the saucepan slowly, constantly moving it in the flame.
- 4 Continue heating, noting any changes that occur.

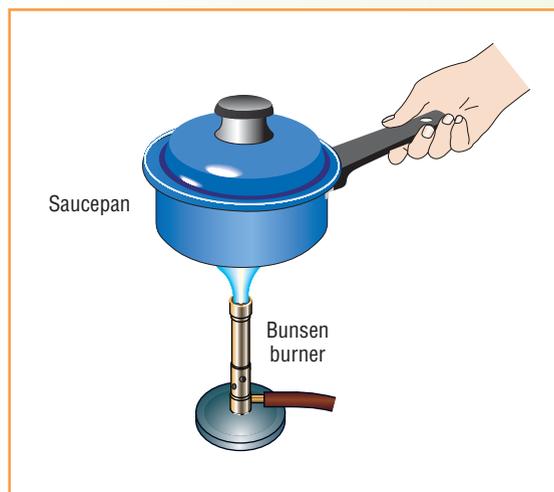


Fig 4.1.4

#### Questions

- 1 **List** the energy changes that occurred during the heating of the corn.
- 2 **Compare** the unpopped corn to the popped corn and suggest what happened to the grains.



Fig 4.1.5

In most everyday actions, energy changes from one form to another.

## Activity 3

### Chemical energy

**Aim** To perform an energy transformation

#### Equipment

Test tubes, test tube rack, 100 mL measuring cylinder, sodium hydrogen carbonate (bicarb soda), hydrochloric acid (2 M), acetic acid (vinegar) (2 M)

#### Method

- 1 Place a spatula of sodium hydrogen carbonate into a test tube.
- 2 Place the test tube in a test tube rack.
- 3 Measure 20 mL of the hydrochloric acid in a measuring cylinder.
- 4 Carefully but quickly pour the acid into the test tube.
- 5 Observe any energy released during the reaction. There may be more than one type of energy released, so use your senses of sight and hearing to examine the reaction carefully.
- 6 Repeat steps 1 to 5 using the acetic acid.

#### Questions

- 1 **Describe** the energy transformations that took place in this reaction.
- 2 **Describe** any difference in the amount of bubbles formed by each acid.
- 3 **Identify** the acid that released energy the fastest. **Explain** how you could tell.
- 4 **Identify** the acid that released the most energy. **Explain** how you could tell.
- 5 **Identify** the acid that had more chemical potential energy stored in it.



## The source of all energy

Where did all the energy on Earth come from? All the energy on Earth comes from the Sun. Plants trap the Sun's energy and turn it into chemical potential energy as they grow. Animals eat the plants and use this energy for many purposes. The energy absorbed by plants ends up in many places such as: fossil fuel products (oil, diesel, petrol, kerosene, gas and aero-fuel), forests, shrubs, garden crops and vegetables.

This energy is then released when:

- Fossil fuel products are burnt in a car engine.
- Food crops and vegetables are eaten and digested by animals.
- Gas and wood are burnt in cooking fires.

Sunlight is absorbed by non-living objects such as rocks and later released as heat. Without the Sun's light energy we would always be in the dark.

## Alternative sources of energy

### The Sun

We know that plants trap or capture light from the Sun and turn it into chemical potential energy in fuels (oil, diesel, petrol, kerosene and firewood.) Solar cells or panels can also turn the Sun's light energy directly into electricity. Solar cells are very useful in rural Solomon Islands villages because they require no fuel except sunlight, which is plentiful and free.



Fig 4.1.6 Solar cells on a roof

### Water

The term 'hydro' means 'water'. Moving or falling water has energy. In a hydroelectric power station, the energy of moving water is changed into electricity. The water is stored in dams and allowed to fall at certain heights

onto water turbines. When the turbines are turned, electricity is produced. Electricity produced in this way is called hydroelectricity. The amount of electricity can be increased by either making a small volume of water fall from a very high point, or by making a large volume fall from a lower height. Although this would be a very expensive project to build, water is plentiful everywhere in Solomon Islands.

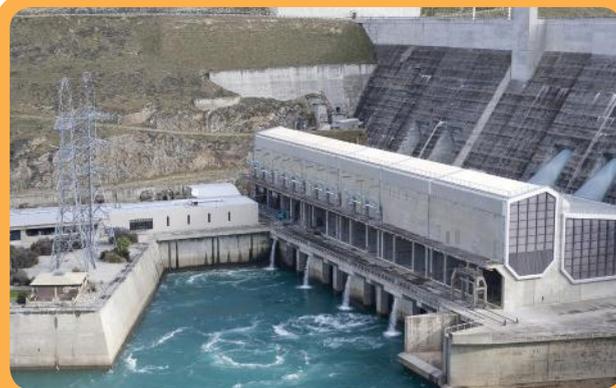


Fig 4.1.7 A hydroelectric power station

### Wind

When hot air rises over the equatorial region, a space is created. Cooler air from the North and South Poles moves in to fill this space. This movement of air is called wind. Wind has energy. Sailing boats and windmills have used wind energy for thousands of years. Wind turbine generators convert wind energy into electricity. Although this is a potential project for anywhere in Solomon Islands, it would be very costly to build.



Fig 4.1.8 Wind has energy to move things.

## Waves

The energy of waves can be used by forcing the waves into a narrow pipe. This causes the air above them to rise and fall. This movement of air passes through a turbine, producing electricity. Sea waves are plentiful, but, again, this would be a very expensive project to build for Solomon Islands.

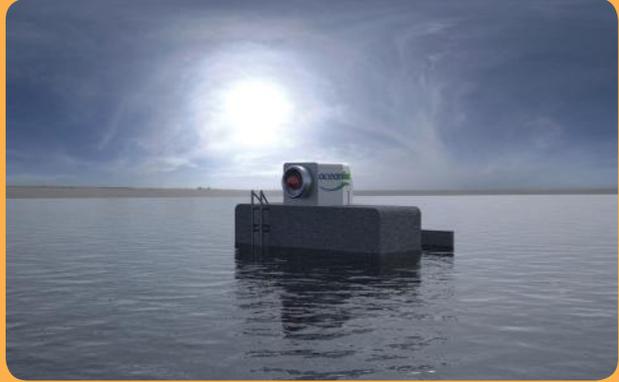


Fig 4.1.9 Waves are a source of energy.

## Heat from the Earth

The Earth's crust prevents heat from the Earth's molten interior from destroying life on the ground surface. New Zealand has hot molten rocks (magma) very close to the surface because it is situated on fault lines in the Earth's crust. New Zealand is able to use this geothermal energy to produce electricity.

In geothermal power stations, water is pumped down into the Earth, reaching the hot molten rocks. It is heated by these hot rocks until it boils, producing steam. Steam is then collected in the power station and turns the turbines, producing electricity. This project would be possible in locations similar to New Zealand.



Fig 4.1.10 Geothermal power station

## Uranium

The first atomic bombs destroyed the Japanese cities of Nagasaki and Hiroshima in 1945. This ended World War II. The great destruction was caused by the huge amounts of heat energy produced in the nucleus of the uranium atoms in the bombs.

Nowadays, this energy is used in nuclear power stations, where the nuclear reactions are controlled. In nuclear power stations, the heat energy produced during a nuclear reaction is used to boil water, producing steam. The steam turns the turbines that drive electrical generators and produce electrical energy.

While nuclear power can provide large amounts of heat energy and electricity needs, it can also cause enormous destruction if used as a nuclear weapon.



Fig 4.1.11 A nuclear power station

## Renewable and non-renewable energy

There are two types of energy: renewable and non-renewable energy. They are different from each other because they come from different energy sources.

**Renewable energy** comes from renewable energy sources. There are unlimited (or plentiful) supplies of renewable energy sources. The energy in these sources will never run out. It can always be replaced or renewed. Some examples of renewable energy sources are:

- Sun or solar
- water
- wind
- waves
- heat from the Earth.



The advantages of renewable energy sources are:

- they are readily available in rural villages in Solomon Islands
- they have low running costs
- they cause little environmental pollution
- they provide efficient heating.

Disadvantages of renewable energy sources are:

- in the case of the Sun, wind and waves, they depend on natural conditions
- they need large collectors
- the site of the energy source is not accessible for other use
- if a dam breaks, it may pose risks to people's lives.

**Non-renewable energy** comes from non-renewable energy sources. There are limited supplies of non-renewable energy sources. The energy in these sources will run out. It cannot be replaced or renewed. Some examples of renewable energy sources are:

- fossil fuels and their products (oil, diesel, petrol, kerosene and aero-fuel)
- wood
- uranium atoms.

Advantages of non-renewable energy sources:

- they have many uses
- there are still reserves in many countries
- they are easily mined
- they are easily transported.

Disadvantages of non-renewable energy sources:

- some, especially fossil fuels, have caused environmental pollution
- most countries have limited supplies
- in the case of nuclear energy, there are problems with the disposal of radioactive waste.

## Energy conservation

For all energy, there is a chain of energy changes, like the process described for the match. In fact, energy can never be created or destroyed. It can only be changed from one form to another. This is the **law of conservation of energy**. Sometimes it appears that the energy has 'gone' into other forms, such as sound, heat or light. Some energy changes are shown in Figure 4.1.12:

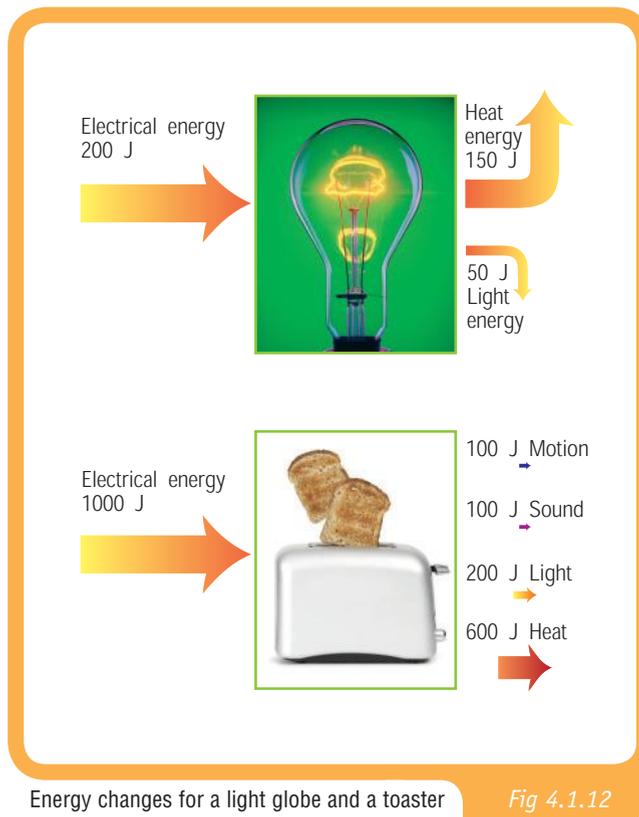
- electrical energy changes to heat energy and light energy
- electrical energy changes to heat energy, sound energy, kinetic energy and light energy.

It is important to conserve energy—for every joule of energy we do not use, there is one less joule of energy to be produced. If every person were to use less energy, all our energy requirements would be reduced. This would mean our current sources of energy would last longer, and there would be less pollution and destruction to our environment.

To help us conserve our non-renewable resources and the protect our environment, we should all try to adopt the **Three Rs Solution**:

- **R1: Reduce.** If you don't really need something, don't buy it or use it. For example, turn off the lights if you leave the room.
- **R2: Reuse.** If you are about to throw a plastic bag in the rubbish bin, try to think of another way to use it. For example, you may use it to store your perfume, hairpins and brushes.
- **R3: Recycle.** Pass items on to someone who may be able to use them. For example, after you finish your soft drink, pass on the empty aluminium soft drink can to the tin collector.

If each individual makes an effort, our communities and the entire planet will be healthier for longer. What steps can you take today?



Energy changes for a light globe and a toaster

Fig 4.1.12

# 4.1 [ Questions ]

UNIT

## Checkpoint

### What is energy?

- 1 **Clarify** what is meant by the term 'energy'.
- 2 **Identify** the two main types of energy.
- 3 **Explain** the two types of energy in your answer to question 2, giving an example of each.

### Forms of energy

- 4 **List** all the forms of energy shown in Figure 4.1.3.
- 5 **Identify** an example of each energy form you have listed.

### Energy transformations

- 6 **Clarify** what is meant by the term 'energy transformation'.
- 7 **Construct** a flow chart to **summarise** the energy changes when a match is lit.

### The source of all energy

- 8 **Identify** what is said to be the source of all energy on Earth.
- 9 **Identify** an example of how humans use the Sun's energy directly.
- 10 A herbivorous animal eats only plants. Give an example of this type of animal and **explain** how it gets energy from the Sun through its food.
- 11 Carnivorous animals only eat other animals or insects and do not eat plants directly. Give an example of a carnivorous animal and **explain** how their energy also can be traced back to the Sun.

### Energy conservation

- 12 **State** the law of conservation of energy.
- 13 **Clarify** what we really mean when we say that energy is 'lost'.
- 14 We burn petrol in a car engine to get the car moving. A lot of energy, however, is wasted. **Identify** two forms of energy into which this 'lost' energy is converted.

## Think

- 15 **Describe** the energy transformations that take place when an atomic bomb explodes.

- 16 **Describe** the energy transformations that take place in the following situations. Remember, the energy may be transformed more than once, and to more than one type or form of energy.

- a bread toaster
- b light globe
- c radio
- d car engine
- e a person parachuting out of an aeroplane
- f a person doing a bungee jump (jumping from a high place—a bridge or cliff—with a long elastic rope tied to the feet)
- g a student riding a bicycle, starting from rest

- 17 Solar panels capture the Sun's energy and turn it into electricity. **Explain** why solar panels are similar to plants.

## Analyse

- 18 For each of the energy transformations listed in the table, **identify** and match which situation it belongs to.

	Energy transformation	Situation
a	Chemical potential → heat and light	Crane lifting an old car
b	Light → heat	Turning on a torch
c	Chemical potential → electrical → light and heat	Running car
d	Chemical potential → kinetic and heat	Dragging a box of books on the ground
e	Gravitational potential → kinetic → sound (and heat)	Burning wood in a fire
f	Chemical potential → kinetic → gravitational potential	Mango falling and landing on a roof
g	Chemical potential → kinetic, sound and heat	Light bulb
h	Kinetic → heat and sound	Swinging object

>>



- 19** The following energy transformations occur in a hydro power station. Study each stage of the process and answer the questions that follow.

Water stored in dam high up in mountains (gravitational potential)



Water falls down pipes (kinetic)



Water turns turbine (kinetic)



Turbine produces electricity (electrical)

- a** Not all the energy that is stored in the water at the start is turned into electricity at the end. Some people could say that energy is 'lost' in each stage of making electricity. **Explain** where this lost energy may go at each stage of the process above.
- b Identify** a better term to replace the word 'lost'.
- c Describe** the energy changes that could occur as you turn on the television and use the electrical energy.

### Create

- 20 Construct** a model of a simple device that transforms energy from one type to another. Present your model to the class and explain the energy transformations involved.

## [ Extension ]

### Investigate

- 1 Investigate** the energy changes that occur in a coal power station. Draw a flow chart to present your information.
- 2 Identify** five devices in your home that transform energy and write down the energy transformations for each.
- 3 Investigate** renewable and non-renewable energy sources that we use to make energy for everyday living.
- a Construct** a table to show the advantages and disadvantages of each energy source.
- b Evaluate** each energy source and decide whether it is suitable to use in the future. Give reasons to support your decisions.

## Chapter review

### [ Summary questions ]

- 1** What are the two main types of energy?
- 2 List** three alternative sources of energy that have already been used in Solomon Islands.
- 3** What are some of the non-renewable energy sources that are commonly used in the villages in Solomon Islands?
- 4** What is the energy transformation involved when you rub your hands together?
- 5** The three Rs solution has been tried to reduce our use of non-renewable resources. What do the three Rs stand for?

### [ Thinking questions ]

- 6 Explain** briefly explain how a solar system works.
- 7 Explain** why the Sun is said to be the source of energy.
- 8** When energy is applied, work is said to be done. **Explain** what it means to say that work is done.

7.5.1.1, 7.5.2.1, 7.5.3.1, 7.5.4.1, 7.5.5.1, 7.5.6.1, 7.5.7.1, 7.5.8.1, 7.5.9.1, 7.5.10.1, 7.5.10.2, 7.5.10.3, 7.5.11.1, 7.5.12.1

# Our planet Earth

CHAPTER

# 5

**By the end of this chapter learners should be able to:**

- Draw the layers of the Earth in the correct order: *crust, mantle, liquid layer, core.*
- Describe the various layers of the Earth in terms of their material state.
- Model the different layers of the Earth using a boiled egg or germinating coconut fruit.
- State that volcanic activities and earthquakes are caused by the movements of the Earth's plates.
- Identify signs/indicators of these natural processes to help us prepare to avoid or minimise disastrous consequences when they occur.
- State that minerals are the building blocks of all rocks.
- Identify some common rocks and describe the minerals contained in them.
- Use Mohs scale of hardness to identify common minerals.
- Identify the valuable minerals, e.g. gold, diamond, nickel.
- Identify and describe the three types of rocks: *igneous, sedimentary, metamorphic.*
- Illustrate the process of the rock cycle using a schematic diagram.
- Give examples of rock weathering and erosion processes.
- List and explain types of weathering.
- Identify the different human activities that cause weathering and erosion.

- 1 If we dug to the centre of the Earth, list some of the things we would see.
- 2 What causes volcanoes and earthquakes?
- 3 What are rocks made up of?
- 4 What is acid rain and what damage can it cause?



# UNIT 5.1

## Our Earth

### introduction

In 1872, Jules Verne wrote a best-selling novel called *A Journey to the Centre of the Earth*, in which dinosaurs fought to the death deep inside a hollow Earth. Today geologists are still trying to find out what actually goes on inside our Earth. Geologists ask us to imagine the Earth as a cracked hard-boiled egg.

### Activity 1

#### Modelling the Earth's interior

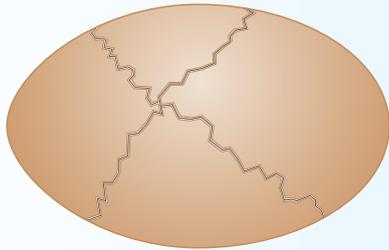
**Aim** To observe a model of the Earth's interior

#### Equipment

Fresh hard-boiled egg, one per group

#### Method

- 1 Cut the fresh hard-boiled egg into two halves.
- 2 Observe and record different layers of the egg.



**Fig 5.1.1** A cracked hard-boiled egg has similar layers to the planet Earth.

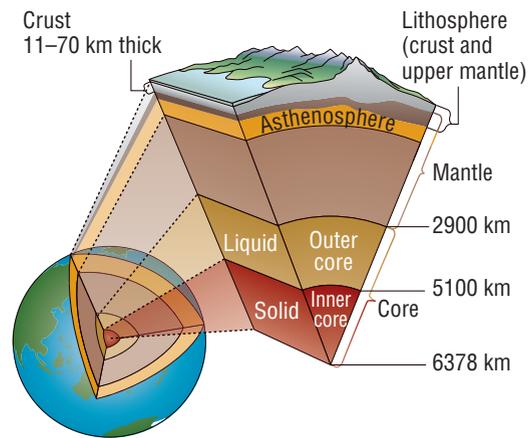
#### Questions

- 1 Draw the cross-section of the boiled egg.
- 2 Write a description of each of the layers you observe from the boiled egg.
- 3 Explain how each layer of the egg relate to the layers of the Earth.

The thin, crushed shell of the hard-boiled egg is the crust and is divided into plates; within the shell is the mantle of firm but slippery egg white, and the core is the solid yolk.

As you move the pieces of shell around, some mantle is exposed. The same thing happens on Earth, but this movement creates mountains, earthquakes and volcanoes.

### Different layers of the Earth



This cutaway view of the Earth shows the different layers.

**Fig 5.1.2**

#### The crust

The **crust** is the layer of Earth on which we live. It contains the land and seas. In the crust, the first thing we would come across is a thin layer of soil and sand. This is followed by a layer composed mostly of solid rock. Just like the shell of an egg, it is brittle and can easily break. On Earth there are 12 major 'pieces' or **plates**. The crust is thickest under the continents (about 70 km thick) and thinnest under the sea (about 11 km thick). The crust is extremely thin when compared to the diameter of the Earth.

The temperature of the crust increases from an average of 20°C at the Earth's surface, to about 500°C at its maximum depth.

#### The mantle

The mantle is about 2900 km thick, with temperatures of 500°C near the crust and 3000°C nearer the core. The **upper mantle** is solid. The upper mantle and crust form a rigid layer of rock called the **lithosphere** (from *lithos*, Greek for 'stone').

Geologists believe that below the lithosphere is a narrow layer of semi-molten rock called the **asthenosphere** (from *asthenes*, Greek for 'weak'). Below this is the **lower mantle**, which is solid due to the extreme pressure from the material above.

#### The core

At the centre of the Earth is the **core**. The core is made up of two parts, a 2200 km thick liquid outer core and a 1280 km thick solid inner core.

The **outer core** is made of moving molten (or melted) metal (iron and nickel). This metal gives the Earth its north and south poles and its **magnetic field**. The magnetic field protects the Earth from some of the Sun's harmful rays. The temperature of the outer core varies from 4000 to 6000°C.

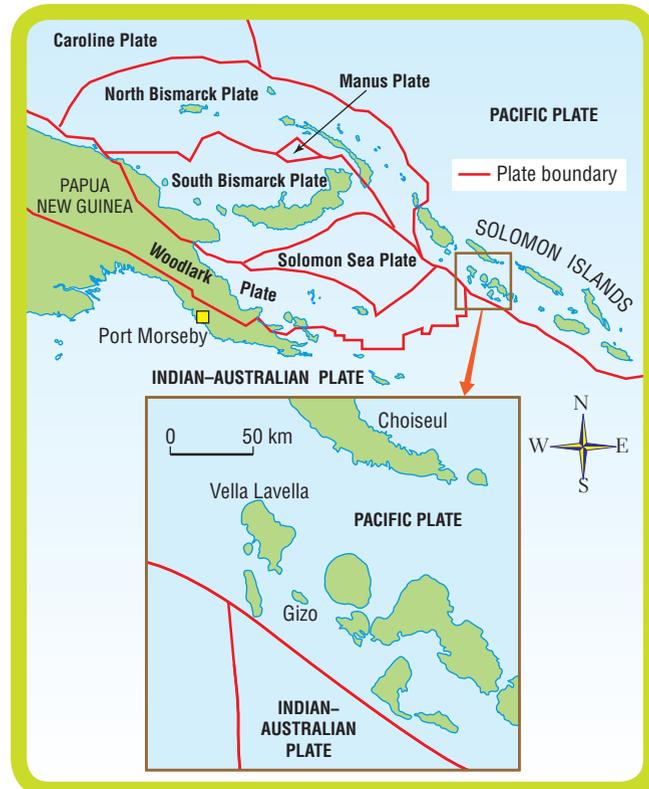
The remaining 1280 km is the **inner core**, where temperatures range from 4000°C to 7000°C. At these temperatures the iron and nickel that make up the inner core should be molten, but the high pressures from the layers above keep these metals solid.

### Crashing plates

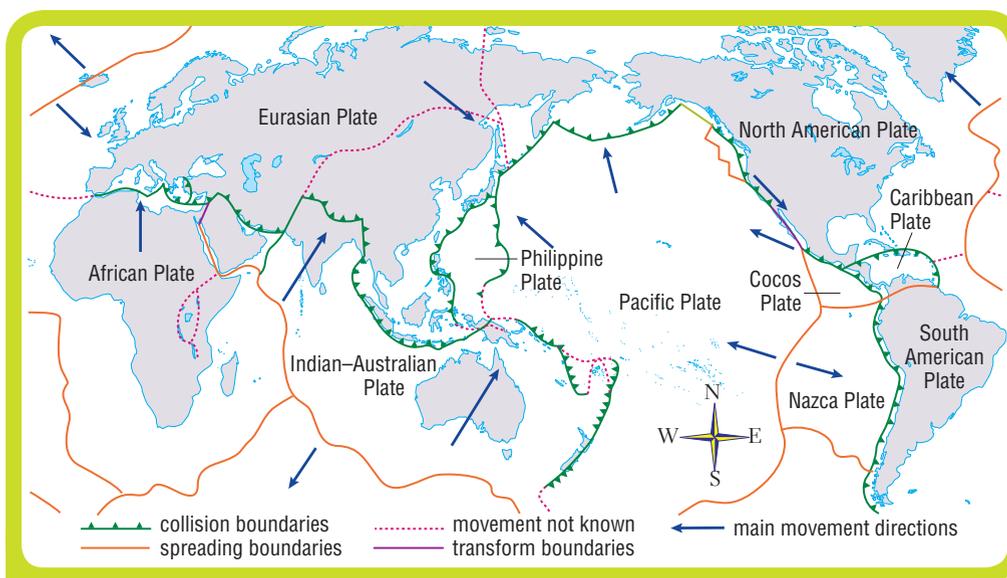
The surface of the Earth looks as if it could never move, but bits of it are actually moving all the time. The lithosphere is broken into huge slabs of rock called **plates**. These plates 'float' on the semi-molten rock of the asthenosphere. Currents, called **convection currents**, in the asthenosphere slowly move the semi-molten rock and also carry the plates along with it, making the plates move from time to time. The idea that the Earth's lithosphere is made up of shifting plates was first introduced in 1969 and is called the **theory of plate tectonics**. The plates move until they eventually crash into one another, break away from each other or slip along or under each other. This is the source of **volcanic activity** and **earthquakes**.

This sliding is not smooth, it causes the rocks to stick and jam together. Pressure builds until the rocks

can take no more. There is a sudden explosive slippage and an earthquake happens. The damage is most severe at the edges of the plate.



The plate system in Solomon Islands (top). The location of the 2007 earthquake in Solomon Islands (bottom). **Fig 5.1.4**



**Fig 5.1.3** Earth's plates move in different directions as they split, bang and scrape together.

An example of this is the earthquake in Solomon Islands on 1 April 2007. The earthquake happened on the line where the Pacific Plate and the Indian-Australian Plate collide.

This earthquake was very severe. It caused a huge wave that hit Gizo, Vella Lavella and Choiseul islands. A huge wave like this is called a tsunami. The tsunami drowned over 60 people and destroyed many villages and buildings.



**Fig 5.1.5** The edge of a tectonic plate: the San Andreas fault causes up to five tremors a day through California.

- 5** Draw a cut-open diagram of planet Earth and label:
- a the crust
  - b the outer and inner core
  - c the outer and inner mantle
  - d the lithosphere and asthenosphere

**Crashing plates**

- 6** Copy and complete:  
The \_\_\_\_\_ is broken into huge slabs of rock called \_\_\_\_\_. These \_\_\_\_\_ 'float' on the continually moving molten rock of the \_\_\_\_\_.
- 7** **Identify** two events that are caused by the plates of the Earth crashing into each other or moving apart.
- 8** **Describe** how an earthquake may be caused.

**Think**

- 9** **List** the types of places where a geologist may work.
- 10** **Describe** two tasks that a geologist would do as part of their work.
- 11** **Describe** what skills you would need to have if you were to be a good geologist.
- 12** **Explain** why a geologist would need to check the land and rock that a skyscraper is to be built on.
- 13** Copy the following and **modify** any incorrect statements so they become true.
- a The inner core of the Earth is solid.
  - b The iron and nickel in the crust gives the Earth its magnetic field.
  - c The crust is very thick compared to the total volume of the Earth.
  - d Mines are often deep enough to go into the mantle.
- 14** **Describe** how life on Earth would be affected if there were no magnetic field.

**Skills**

- 15** **Use** the information in the table to plot a line graph showing the temperature for every kilometre as we dig into the crust.

Depth (km)	0	2	4	6	8
Temperature (°C)	20	87	153	220	286

- 16** **Use** your graph from question 15 to estimate the temperature at the following depths:
- a 1 km
  - b 5 km
  - c 10 km
  - d 20 km

5.1 [ Questions ]

**Checkpoint**

*Journey to the centre of the Earth*

- 1** **Explain** what is meant by 'the crust of the Earth'.
- 2** **Identify** where the crust is:
- a thickest
  - b thinnest
- 3** **List** the layers of the Earth from inside to out.
- 4** **Identify** which of the layers of the Earth is:
- a the thickest
  - b the hottest
  - c mainly made of iron and nickel
  - d liquid
  - e solid

# UNIT 5.2

## Rocks and minerals

### introduction

The study of rocks, minerals and the Earth's surface is called **geology**. A person who studies these things is therefore called a geologist. To understand everything about rocks and minerals, let us first define the terms 'rocks' and 'minerals'.

### Activity 2

#### Identifying rocks and minerals

**Aim** To describe samples and determine whether they are rocks or minerals

#### Equipment

Samples of rocks and minerals

#### Method

Your teacher may provide you with physical samples of rocks or minerals to study, or ask you to study samples A, B, C and D in the photos below. Record your results in the table below.



Fig 5.2.1 (A) feldspar (B) basalt (C) mica (D) granite

#### Results

Specimen	Description	Is it a rock or a mineral?	Name of rock or mineral
A			
B			
C			
D			

### Activity 3

#### Studying minerals

**Aim** To study and describe a sample of a mineral

#### Equipment

Sample of quartz, hand lens

#### Method

- 1 You have already identified a mineral in Activity 2. In this activity you will study another mineral, quartz.
- 2 Your teacher will either provide a sample of the mineral, or ask you to study the photo below instead.
- 3 Observe the mineral and answer the questions in the table below.



Fig 5.2.2 Quartz

#### Results

Questions	Observations
1 What is the chemical composition of quartz?	
2 Is quartz the same mineral throughout?	
3 Describe some features of quartz (e.g. shape, colour and hardness) that you can identify.	

### Minerals

Minerals are the building blocks of all rocks. They are natural substances in which the particles are arranged in patterns. Minerals often occur in beautiful shapes called crystals. Metals, gems and industrial materials of many kinds are made from minerals. Examples of minerals are quartz, mica and feldspar as seen in Figures 5.2.1 and 5.2.2.

Ninety-nine per cent of all minerals are made up of only eight elements—oxygen, silicon, aluminium, iron, calcium, sodium, potassium and magnesium. For example, quartz is made up of silicon and oxygen—these are the two most common elements that make up the Earth.

Some minerals are made up of only one metal element, such as gold, silver or platinum, and are called **native metals**.

### Characteristics of minerals

Minerals have different properties and characteristics as described below.

**Hardness** is an important property of minerals. A mineral is harder than another if it can scratch it, without getting scratched itself. In 1812, an Austrian mineralogist, Frederic Mohs, invented a scale of hardness for minerals. The scale has points from one (1) to ten (10). Ten (10) on the scale is the hardest, and one (1) on the scale is the softest. If a mineral is higher on the Mohs than another, it can scratch the one that is lower. Here is the Mohs scale (left) and how some common objects rate on the scale (right):

Mohs scale of hardness	
1	Talc
2	Gypsum
3	Calcite
4	Fluorite
5	Apatite
6	Orthoclase
7	Quartz
8	Topaz
9	Corundum
10	Diamond

Hardness of common objects	
Fingernail	2.5
Copper coin	3.5
Iron nail	4.5
Glass	5.5
Steel knife	6.5
Emery board	9.5

Although a mineral may have a specific **colour**, this is not a reliable enough property to identify it. A better method is to crush it into a powder.

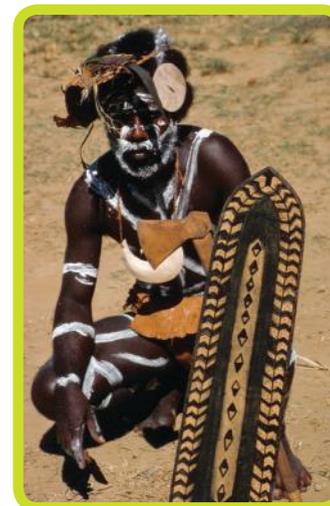
The colour of a powdered mineral is called its **streak**. This can be seen by rubbing a mineral on a white tile. Some minerals do not produce a streak, while other powdered minerals have a different-coloured streak than the mineral itself.

Many groups of people worldwide use powdered minerals as decorations and for painting materials. In Solomon Islands, people use powder from sandstone and charcoal for decoration when performing cultural dances. The powder is mixed with water and applied to dancers' bodies and faces.

The table below shows colours found in some common rocks:

Name of coloured rock	Colour of streak	Where coloured rock is collected
Haematite	Red	Found as pebbles
Kaolin	White	In creek or river beds
Charcoal	Black	Produced in fires

Different colours in minerals are caused by the different chemicals in them. The red colour of haematite is caused by lots of iron oxide (also known as rust). These coloured rocks can mix to form other colours. Charcoal is commonly mixed with kaolin to make grey. The powders are also mixed with egg, juice or blood to make a paste that can then be painted onto rocks or the body.



Body painting using powder from sandstone in Solomon Islands

### Activity 4

#### Identifying minerals using 'hardness of scale'

**Aim** To put four samples of rock in order of hardness

**Equipment**

Mineral samples (magnetite, quartz, calcite, azunite), iron nail, glass, steel knife

**Method**

- This is a scratching activity. Do it in groups. The table of common objects above shows that a steel knife has a hardness of 6.5. Scratch the mineral samples using the knife. Be careful when handling the knife.
- Does the knife scratch all the samples?
- Use the iron nail, glass and your fingernail to scratch all four samples. Use the results to put the samples in order of hardness.
- Record the hardness order in the table. Write your description of each sample in the correct space in the table.

#### Results

Sample	Mineral samples	Description of the mineral	Hardness scale
A	Magnetite		
B	Quartz		
C	Calcite		
D	Azunite		

### Crystals

Many minerals have a specific **crystal structure**. The word ‘crystal’ comes from the Greek word *kyros*, meaning ‘icy cold’. In ancient times it was believed that quartz crystals were composed of water that had frozen so solid that it could never melt.

Because each mineral has a different crystal structure and colour, they reflect light differently. **Lustre** is a term that refers to the way a mineral reflects light.

Some crystals have an internal structure that causes them to break apart more easily in particular directions. These are called **cleavage planes**.



Several cleavage planes can be seen in this crystal. **Fig 5.2.4**

### Rocks

#### Activity 5

#### Studying granite rock

**Aim** To study the properties and formation of granite

**Equipment**

Granite rock, hand lens

**Method**

You have already identified a rock in Activity 2. Your teacher will either provide you with a sample of granite for this activity, or refer you to Figure 5.2.5. Observe the granite and answer the questions in the table below.

**Results**

Questions	Observations
1 Which minerals make up granite?	
2 How does granite form?	
3 Describe some physical properties of granite (e.g. shape, colour and hardness) that you are able to identify.	

**Petrology** is the study of rocks. A petrologist is a person who studies rocks. A petrologist is usually employed by a mining company. His or her work is to collect rock samples, look at their properties and work out which minerals they contain.

**Rocks** are made up of minerals. Granite is a rock made from three minerals—quartz, mica and feldspar—whereas limestone contains just one mineral—calcium carbonate. You may be surprised to learn that clay and sand are types of rock.



Granite is made up of the minerals quartz, mica and feldspar. **Fig 5.2.5**

### Ores

**Ores** are rocks or minerals containing elements that can be extracted. For example, iron is extracted from an ore called haematite, and aluminium from the ore bauxite.

This is a table of some economically important minerals in Solomon Islands and Australia:

Mineral	Source	Use
Bauxite	Rennell Island, Weipa (Australia)	Aluminium window frames, beams, etc.
Chalcopyrite	Mt Isa (Australia), Makira, Guadalcanal, Isabel, Choiseul	Copper ore (mineral from which copper is derived)
Gold	Gold Ridge, Guadalcanal. Found in alluvial and placer deposits, and hydrothermal veins or porphyries	Jewellery, circuits, ornaments, watches, etc.
Magnetite	Metasomatic deposits at Biggenden (Australia). Beach sand deposits on Guadalcanal, Isabel and Choiseul	Material for coal-washing plants
Muscovite (mica)	Metamorphic schists on Guadalcanal and Makira	Toaster elements, insulators



Haematite (iron ore) occurs in several forms, including so-called kidney ore.

Fig 5.2.6

Some countries, including Australia, have large mines for removing important materials such as aluminium, iron, uranium and many other elements from rocks. Some examples of ores are listed in the table below.

Ore	Element that may be extracted
Azurite	Copper
Bauxite	Aluminium
Carnotite	Uranium
Cassiterite	Tin
Chalcopyrite	Copper
Galena	Lead
Haematite	Iron

## Questions

### Checkpoint

#### Minerals

- 1 Describe the work geologists do.
- 2 Explain what minerals are.
- 3 List four examples of minerals
- 4 List four characteristics of minerals.
- 5 a Explain what Mohs hardness scale is used for.  
b Frederick Mohs was a scientist. Identify what type of scientist he was.

#### Rocks

- 6 Describe the work petrologists do.
- 7 Explain the term 'ore'.
- 8 Identify three examples of rocks.

#### Ores

- 9 Is an ore a rock, a mineral or could it be either?
- 10 Clarify the term 'ore'.
- 11 Identify the ore that contains:  
a iron                      b aluminium
- 12 Identify two ore types that contain the same element.

### Think

- 13 Explain the difference between geology and petrology.
- 14 Explain how a native mineral is different from most other minerals.
- 15 Identify how ancient or current-day people use pigments from minerals.
- 16 Describe what ochre is and who uses it.

- 17 Identify three ochres and their colour.
- 18 Explain how an ochre is prepared before being used for painting.
- 19 The following statements are incorrect. **Modify** each so it becomes correct.
  - a A mineral is any substance found in the ground.
  - b The two most common elements that make up the Earth are oxygen and aluminium.
  - c Gold and silver are metals, not minerals.
  - d Mineralogy is the study of minerals.
- 20 Silicates are types of minerals containing silicon and oxygen. **Explain** why silicates are very common.
- 21 True or false?
  - a Clay is a type of rock.
  - b A rock may contain only one type of mineral.
  - c Ore is a type of mineral.

### Analyse

- 22 a **Construct** a line representing Mohs scale of hardness.  
b **Predict** where each of the following would go on the line and mark them on it.  
i fingernail      ii copper      iii iron nail
- 23 **List** the following minerals in order from softest to hardest: apatite, calcite, talc, quartz, diamond.
- 24 **Predict** whether:
  - a orthoclase would scratch gypsum
  - b quartz would scratch topaz
  - c calcite would scratch your fingernail
  - d diamond would scratch glass
- 25 Gneiss contains feldspar, quartz, mica and hornblende. **Identify** which of these:
  - a are minerals
  - b is a rock

# UNIT 5.3

## Types of rocks

### introduction

Have you noticed that some rocks are different to others? There are so many different rocks that geologists have found it hard to classify them. To make identification of rocks easier, geologists classify rocks according to how they were formed. This results in three main types of rocks: igneous, sedimentary and metamorphic.

### Activity 6

#### Identifying igneous rocks

**Aim** To study and identify two samples of igneous rock

#### Equipment

Two samples of igneous rocks, hand lens

#### Method

- 1 Your teacher will either provide two samples of igneous rocks for this activity, or will refer you to the photos below.
- 2 Study the samples of igneous rock. Record your observations in the table below.



Fig 5.3.1 (A) obsidian (B) basalt

#### Results

Samples of igneous rock	Description	Where would you find this type of igneous rock?	What is the local name given to this igneous rock?
A			
B			

### Igneous rocks

**Igneous rocks** are formed when molten (or melted) material from within the Earth cools and becomes solid. Igneous comes from the Latin word *ignis*, meaning 'fire'.

Molten (or melted) material is called **magma** when it is below the Earth's surface, and **lava** when it is above the Earth's surface. Magma reaches the Earth's surface when volcanoes erupt.

When magma cools slowly below the Earth's surface, **intrusive igneous** rocks containing large crystals are formed. Intrusive means 'forced in'. This is a good explanation of how intrusive igneous rocks have squeezed between other rock layers.

Granite is an example of a slow-cooling igneous rock in which large crystals are easy to see.

Lava cools more quickly on the Earth's surface than underground magma, and the crystals formed are smaller or non-existent. This results in **extrusive igneous** rocks. Extrusive means 'pushed out'. Basalt is an example of an extrusive igneous rock containing tiny crystals and is the main rock forming the Earth's crust.

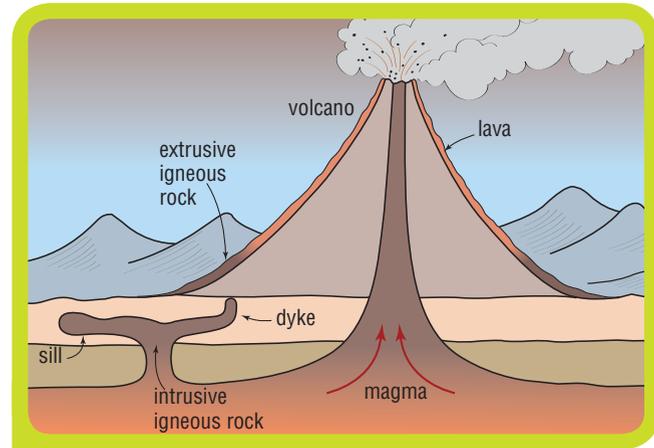


Fig 5.3.2 How extrusive and intrusive igneous rocks are formed



Lava solidifying to form extrusive igneous rock

Fig 5.3.3

## Uses of igneous rocks

Because they are hard, igneous rocks like granite and basalt are useful building materials.

The table below shows how they can be used.

Uses of granite	Uses of basalt
Bridges	Bridges
Buildings	Buildings
Kitchen benchtops	Crushed and placed under railway sleepers
Gravestones	Crushed and covered with tar to make bitumen roads

## Ancient tools

In the past, Solomon Islanders had a great knowledge of rocks in Solomon Islands. Rocks are important in the making of tools, weapons and ochres. Different rocks were identified for different purposes depending on their hardness, ability to flake and form sharp edges, ability to be ground or worn down, and their colours. Very hard igneous rocks were suitable for making tools such as axe heads. For example, volcanic greenstone had the hardness, toughness and fine grain needed to make heavy-duty axes with a sharpened edge. Axes made from igneous rocks have been found on different islands in Solomon Islands.



A Solomon Islands axe head made from igneous rock **Fig 5.3.4**

## Sedimentary rocks

**Sedimentary rocks** get their name from the Latin words *sedimentum*, meaning 'settling', and *sedere*, meaning 'to sit down'. They are made from **sediment**—small, broken-down bits of other rocks, or animal or plant remains. This material has been squeezed and stuck together in a process known as **lithification**. There are two main stages in lithification. First, sediment builds up in a layer (for example, at the bottom of a river bed or the sea). The pressure of material above it squeezes the sediment at the bottom of the layer. This pressure reduces the air gaps and the particles stack or stick together. Second, water passes through the squeezed sediment, carrying with it minerals that cement the sediment particles together even more strongly.

This table shows what sedimentary rocks are made from.

Sedimentary rock	Made from
Sandstone	Sand
Mudstone	Mud
Conglomerate	Particles of different sizes
Limestone	Remains of sea organisms (e.g. fish, corals)
Chalk	Skeletons of tiny sea animals
Coal	Compressed plant material

## Activity 7

### Identifying sedimentary rocks

#### Aim

To study and identify two sedimentary rocks

#### Equipment

Two samples of sedimentary rocks (labelled A and B), hand lens

#### Method

- 1 Study samples of two sedimentary rocks or the photos below.
- 2 Record your observations in the table below.



**Fig 5.3.5** (A) sandstone (B) siltstone

#### Results

Samples of sedimentary rock	Description	Where would you find this type of sedimentary rock?	What is the local name given to this sedimentary rock?
A			
B			

Here are examples of other sedimentary rocks that are found in other countries.



*Fig 5.3.6*

The Three Sisters in the Blue Mountains National Park in Australia—note the horizontal sedimentary rock layers



*Fig 5.3.8*

These stalactites are chemical sedimentary rocks.



*Fig 5.3.7*

The white cliffs of Dover, England

The white cliffs of Dover in England are made of powdery chalk composed of the tiny skeletons of sea creatures over 70 million years old.

Sedimentary rocks are easy to split because of their layered structure. Sandstone comes in a variety of colours, and blocks of it are used to make bridges and buildings. Limestone may be ground to make cement, which in turn is a key ingredient in concrete, one of the most important building materials of all. Coal is burnt to provide power for electricity generation and heating.



*Fig 5.3.9*

Kata Tjuta in Australia, meaning 'many heads' in the indigenous Anangu language

## Metamorphic rocks **Activity 8**

### Identifying metamorphic rocks

**Aim** To study and identify samples of metamorphic rock

**Equipment**

Two samples of metamorphic rocks, hand lens

**Method**

- 1 Your teacher will either provide samples of two metamorphic rocks for this activity, or refer you to the photos below. Study the samples of metamorphic rocks.
- 2 Record your observations in the table below.

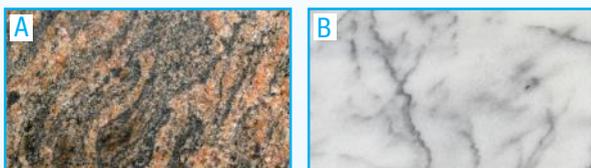


Fig 5.3.10 (A) granite (B) marble

**Results**

Samples of metamorphic rocks	Description	Where would you find this type of metamorphic rock?	What is the local name given to this metamorphic rock?
A			
B			

High pressure conditions deep in the Earth's crust can change rocks into new types of rocks. The word 'metamorphic' comes from the Greek words *meta* (meaning 'change') and *morphe* (meaning 'form'), therefore a **metamorphic rock** is one that has changed form.

Sedimentary, igneous or even metamorphic rocks may be changed by heat, pressure or a combination of both within the Earth. A rock made this way is stronger than the original material, because its particles are joined together. This table shows how rocks can be changed.

Original	Original	Changed by	Metamorphic
Limestone	Sedimentary	Heat	Marble
Granite	Igneous	Heat, pressure	Gneiss
Shale	Sedimentary	Pressure	Slate
Slate	Metamorphic	Heat, pressure	Schist
Schist	Metamorphic	Heat, pressure	Gneiss

Gneiss is an example of a metamorphic rock that frequently contains bands of different minerals. The bends indicate where high pressure has folded the rock.



Fig 5.3.11 Gneiss (pronounced 'nice') is a metamorphic rock.

### Career profile

#### Palaeontologist

A palaeontologist (a person who studies fossils) examines, classifies and describes animal and plant fossils found in sedimentary rocks. This helps us understand the history of life on Earth, which is particularly important in oil exploration.



A palaeontologist with a fossilised dinosaur skull

Fig 5.3.12

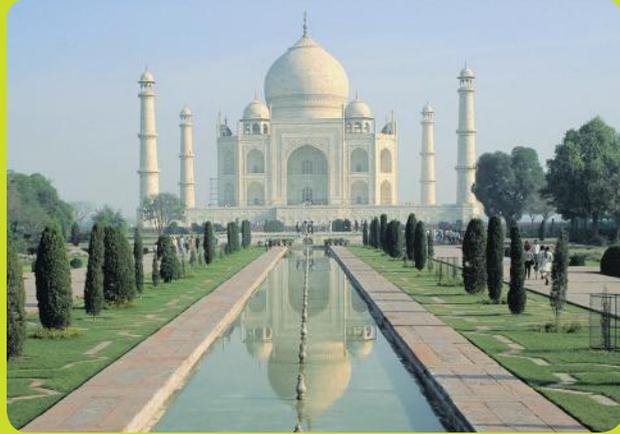
**Palaeontologists can be involved in:**

- locating sites where fossils may be found
- carefully digging fossils out of the rocks in which they are found
- preparing fossils for display or storage
- dating fossils to work out their age
- using information about fossils to study other things such as oil exploration or the history of life on the Earth.

**A good palaeontologist will:**

- be able to work safely as a team member or alone
- be able to work very carefully and patiently as it can take years to remove fossils from rocks
- have a good eye for detail
- love fossils.

The Taj Mahal in India is built from marble, a metamorphic rock, inlaid with gemstones. Slate is used for roofing tiles, floor tiles and billiard tabletops.

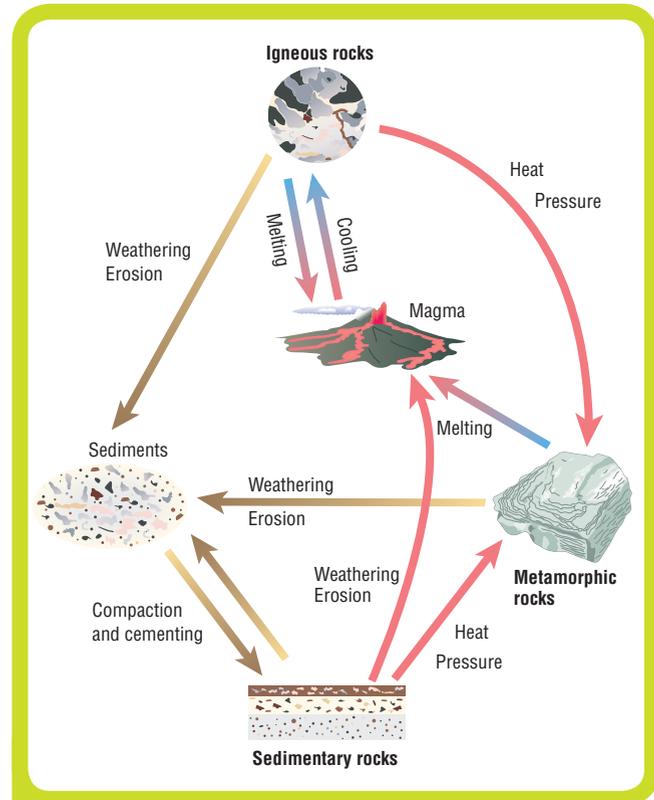


**Fig 5.3.13** The Taj Mahal in India is made of white marble and was built by the emperor Shah Jahan as a tomb for his wife, Mumtaz.

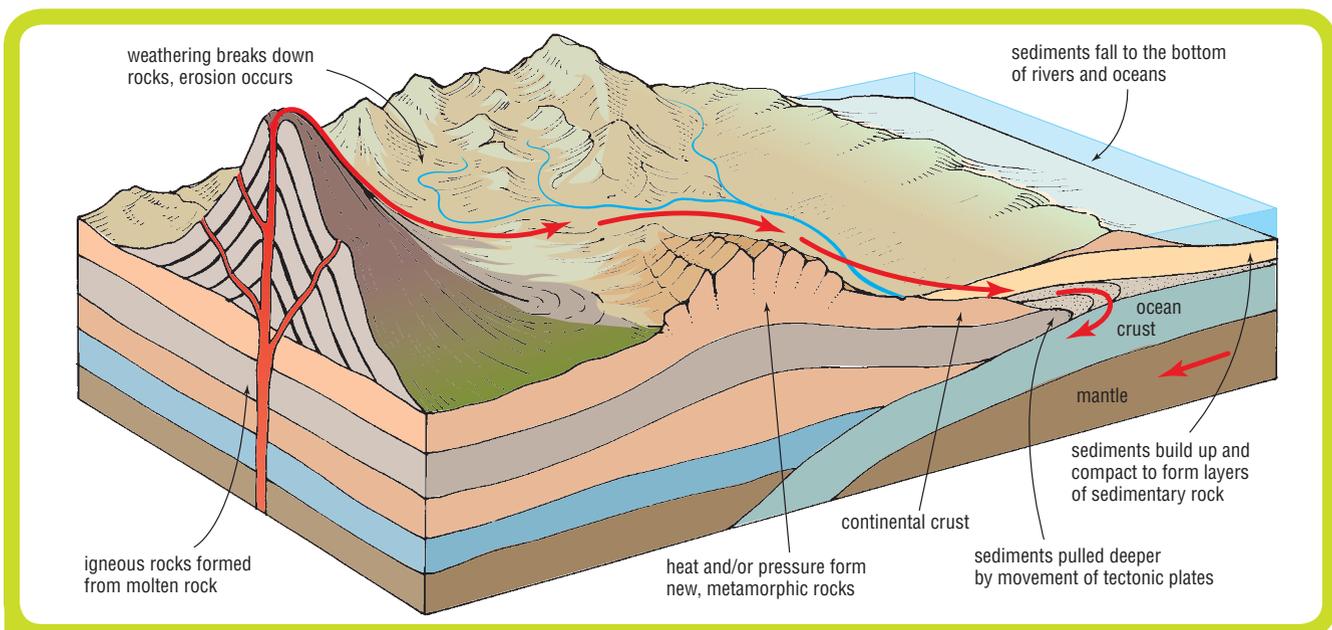
### The rock cycle

If sedimentary and igneous rocks have been changed continually into metamorphic rocks during Earth's history, shouldn't rocks today be mostly metamorphic ones? The answer is no, because rocks, including metamorphic ones, change back into other types because of other influences such as **weathering**,

**erosion** or melting, in what is known as the **rock cycle**. The diagrams on this page show the processes within the rock cycle.



**Fig 5.3.15** The processes in the rock cycle



**Fig 5.3.14** The rock cycle

## Career profile

### Geologist

Geologists study the composition and structure of the Earth. This allows them to locate materials and minerals. Geologists work in laboratories and in the field, usually as part of a team. Fieldwork can involve spending time in remote deserts, or in tropical or Antarctic areas.



Geologists studying sedimentary rock layers in the field

Fig 5.3.16

#### Geologists can be involved in:

- advising on suitable locations for tunnels and bridges
- examining rock samples using electron microscopes
- studying the nature and effects of natural events like weathering, erosion, earthquakes and volcanoes
- taking rock samples for analysis
- finding the age of rocks and fossils.

#### A good geologist will be able to:

- work as a team member or alone
- keep accurate records and prepare reports
- work safely in a number of different environments.

**3** The rate of cooling of molten rock affects crystal formation. **Explain** how this occurs and **identify** whether fast or slow cooling forms the biggest crystals.

**4** **Identify** two types of igneous rocks.

**5** **Describe** a use for a particular igneous rock.

#### Sedimentary rocks

**6** **Identify** two types of sedimentary rocks and describe what they are made from.

**7** The particles in a sedimentary rock have to stick together. **Explain** two ways in which this can occur.

#### Metamorphic rocks

**8** **Identify** two things that may affect rocks in the Earth's crust.

**9** **Identify** two types of metamorphic rocks and name their 'parent' rocks.

**10** Marble is sometimes used to make food-cutting boards. **Propose** a reason why marble is used for this purpose.

#### Rock cycle

**11** Copy and complete Figure 5.3.17, which is a schematic diagram summarising the rock cycle.

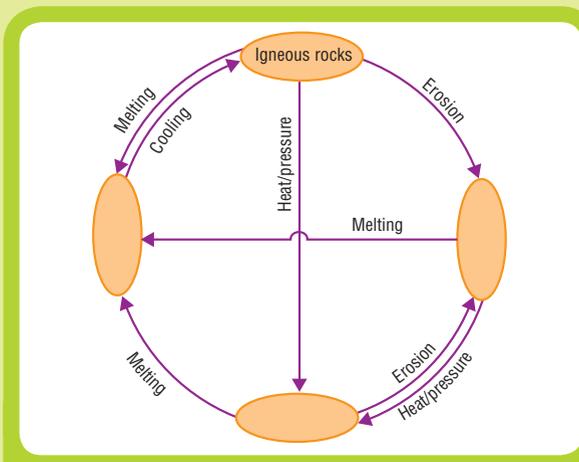


Fig 5.3.17 Schematic diagram of the rock cycle

#### Think

**12** Copy and complete: Rocks are classified according to ...

**13** Granite is formed underground, yet granite boulders are often seen above ground in many volcanic areas. **Explain** how this could happen.

**14** **Clarify** the meaning of these terms:

- a sediment
- b lithification

**15** Although coal is made from plant material, a lump of coal burns much longer than a similar-sized piece of dry plant. **Explain** why.

**16** Write a one-sentence **summary** of each of the three main rock types.

## Questions

### Checkpoint

#### Igneous rocks

- 1** **Explain** the meaning of the Latin word *ignis*.
- 2** **Compare** and differentiate the following:
  - a magma and lava
  - b intrusive and extrusive rocks
  - c a dyke and a sill

**Analyse**

- 17 Classify** the following types of rocks using their descriptions and name each rock.
- Commonly known as bluestone, this rock has small crystals and is found where volcanoes used to be.
  - Used for tiling floors, this rock easily breaks into layers.
  - This rock is white and made up of the remains of millions of sea creatures.
  - Formed inside the Earth by heat and pressure, this rock has layers of minerals that are visible.
  - This rock forms where muddy rivers flow into lakes.
  - This rock has large, easily seen crystals and forms inside volcanoes.
  - This rock is used for making axe heads.

**[ Extension ]****Investigate**

**Investigate** the properties of artificial sedimentary rocks made from various combinations of sand, dry clay, small stones, plaster mix and water.

**Activity 9****Observing cooling rates of crystals**

**Aim** To observe the effect of cooling rates on crystal size

**Equipment**

Copper sulfate, two 100 mL beakers, two 500 mL beakers, one 250 mL beaker, stirring rod, Bunsen burner, tripod, gauze mat, heat-proof mat, safety glasses

**Improved equipment**

Two transparent plastic cups, two 1 L ice-cream containers, 375 mL Milo tin, kerosene/gas stove

**Method**

- One-quarter fill the 250 mL beaker with cold water and dissolve as much copper sulfate in it as possible.
- Heat the solution and add more copper sulfate in small amounts until no more will dissolve. You now have a saturated copper sulfate solution.
- Carefully place half of the solution in each of the 100 mL beakers.
- Place one 100 mL beaker in a 500 mL beaker with some cold water as shown in Figure 5.3.18.



- Place the other 100 mL beaker in an empty 500 mL beaker.
- Allow each to stand overnight and pour off any excess solution from the 100 mL beakers.
- Observe any crystals formed.

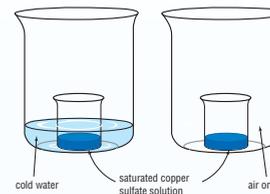


Fig 5.3.18

**Questions**

- Describe** and sketch any crystals formed in the small beakers.
- Compare** the contents of the beakers to see if there are any key differences between them. If so, **describe** them.
- Explain** what caused larger crystals to form.

**Activity 10****Making concrete**

Concrete is made from a combination of two or more of the following: cement, sand, crushed rock, water.

**Aim** To make various types of concrete

**Equipment**

Cement (dry, powdered), sand, finely crushed rock, plastic teaspoon, paper or plastic cups, water

**Method**

- In one cup, place 3 teaspoons of sand and 3 teaspoons of cement. Label this cup 3S, 3C.
- In another cup, place 4 teaspoons of sand and 2 teaspoons of cement. Label this cup 4S, 2C.
- In another cup, place 2 teaspoons of sand and 4 teaspoons of cement. Label this cup 2S, 4C.
- In another cup, place 3 teaspoons of finely crushed rock, 2 teaspoons of sand and 1 teaspoon of cement. Label this cup 3R, 2S, 1C.
- Now gradually add a small amount of water to the first cup and mix until you get a thick, even paste. Repeat for the other cups.
- Leave each cup to dry overnight.
- Devise a test for the strength of each concrete sample.

**Questions**

- Explain** why it was important to have the same total amount of ingredients in each case.
- Identify** which sample was strongest.
- Identify** whether you think concrete setting is a physical or chemical change. **Explain** why.

# UNIT 5.4

## Weathering and erosion

### Introduction

Have you ever wondered where soil, sand, pebbles and boulders came from? When you look very closely at them you will see that they are simply rocks that have been broken down into smaller particles. This natural process is caused by wind, water, temperature and other factors. Humans can also speed up this change through their actions, some of which can have negative effects on the environment.

### Activity 11

#### Erosion and its effects

**Aim** To identify which type of erosion is occurring and its effects and prevention

#### Method

Study the picture on the right. Answer the following questions.

- 1 Describe what you saw in the picture.
- 2 What is your conclusion of the causes of what you saw in the picture. What are the effects it had on the people and the natural environment?
- 3 What are some of the measures that you can recommend to the government to avoid this happening in your local area or environment?
- 4 Are there traditional practices that you can apply to stop or minimise weathering in your area?

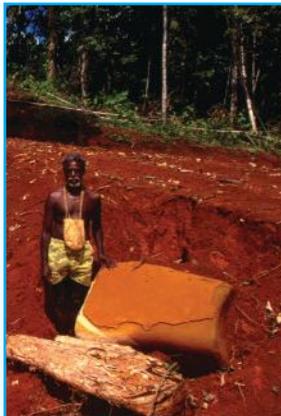


Fig 5.4.1 Erosion

This movement is called **erosion**. The material that is washed away is called **sediment** and is the first step in making sedimentary rocks.

#### Types of weathering

**Physical weathering** is when rocks break into smaller pieces. Waves crashing on rocky shores break down our coasts. Dramatic changes in temperature break rock into small flakes: water expands when it freezes and can split rocks in two.

The small particles of soil and sand that are carried away by wind and water have an abrasive action. They can act like sandpaper on other rocks that they scrape across. Farming and drought loosen the soil and can speed up erosion by the wind.

Some rocks are changed into new substances by chemical reactions with water or the gases of the air. This is called **chemical weathering**.

Burning fossil fuels and other industrial activity adds harmful pollutants to the air. Some of these

pollutants are acidic, and they can dissolve in rainwater to form acid rain. **Acid rain** is a product of pollution that can speed up the process of chemical weathering. It can also have many effects on the environment, including:

- dissolving statues and buildings made of certain rocks such as marble
- killing fish and animals in rivers and lakes
- killing forests, leading to erosion
- making soils too acidic for plants and crops to grow.

Other weathering can be caused by animals. Animals break rocks apart as they look for food, and when they build burrows. Seeds can settle and grow in small cracks in rocks, and the roots of trees can cause cracks as they grow. Any weathering due to living things is called **biological weathering**.



Fig 5.4.2 Chemical weathering

#### Break it down

Rocks seem tough, but can be broken down in a variety of ways. The process of breaking down rocks into smaller pieces is called **weathering**. These smaller pieces of weathered materials can be moved away by:

- wind
- creeks and rivers
- water from rain
- ice and glaciers.

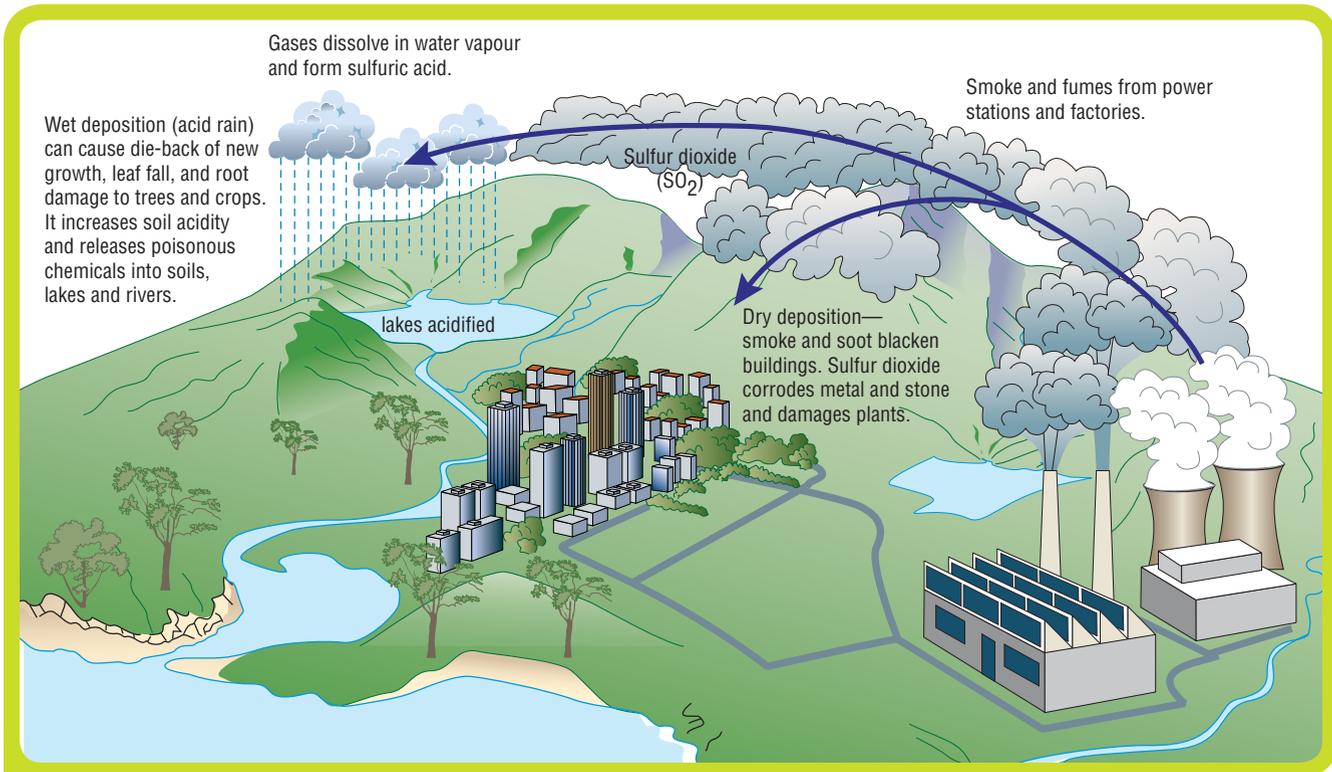


Fig 5.4.3

Sulfur dioxide in pollution causes acid rain, which will increase chemical weathering.

## People and erosion

Science has produced many inventions built and fuelled from materials found in the Earth's crust. Humans have changed the surface of the Earth dramatically, particularly in the past 200 years since the Industrial Revolution.

We have seen rocks being broken down by mining them, by using explosives, and by building roads, houses and cities.

Exhaust gases from cars and factories have added destructive gases to the air. These can slowly weather away rock on mountainsides and the rock used for city buildings.

Building houses and roads, and digging on farms, all change how water and wind flow. Without careful planning, these changes can increase the amount of soil and sand that is washed away. The roots of trees and plant cover help to keep soil bound together and make it less likely to be eroded. Forest clearing can remove grass and plant cover, allowing the wind and water to remove the soil.



Erosion in Solomon Islands Fig 5.4.4

## Career profile

### Environmental scientist

Science has had a large impact on our society and especially on the environment. Environmental scientists have the important job of measuring, recording and finding methods to control the harmful effects of human activity on our environment.



Environmental scientist taking a water sample to check pollution levels

Fig 5.4.5

#### Environmental scientists can be involved in:

- investigating the effects of chemical spills and accidents on the environment
- assisting farmers, industry and others in methods to reduce their negative effect on the environment
- testing pollution in water, soil and air
- assessing the environmental impact of new housing estates and industrial developments
- upholding anti-pollution laws.

#### A good environmental scientist will be able to:

- work as part of a large team
- communicate by writing clear, accurate reports
- apply the scientific method to an investigation
- be passionate about environmental issues.

## What can we do?

Some of the advances that science has given us can speed up erosion and weathering, so there is now a need to bring this environmental damage under control. We all need to help protect the environment.

Encouraging subsistence farming and carefully planning drainage systems in commercial farming help reduce soil erosion. Reforestation programs in logged areas help reduce wind speed and erosion.

Choosing to walk or ride a bicycle, or paddle a canoe instead of driving a car means that you are producing fewer harmful gases that cause acid rain. The use of alternative fuels reduces the amount of pollution, for example, bio-fuel such as coconut oil, corn oil, cassava oil and sugar-cane oil.



Fig 5.4.6

Riding a bicycle or paddling a canoe can help reduce air pollution and, therefore, reduce environmental damage.



# UNIT 5.4

## [ Questions ]

### Checkpoint

#### Break it down

- 1 Explain** the meanings of the following terms:
  - a soil
  - b decomposition
  - c weathering
  - d sediment
- 2 Explain** the difference between erosion and weathering.
- 3 Describe** what happens to water when it freezes.
- 4 Identify** three causes of:
  - a mechanical weathering
  - b biological weathering
- 5 Identify** three different ways in which rocks are weathered.
- 6 Identify** four ways in which weathered material can be moved.

#### People and erosion

- 7 Explain** two ways in which humans and science have accelerated weathering.
- 8 Identify** the chemical released into the air that speeds up chemical weathering.
- 9 Explain** how this chemical gets into the air.
- 10 Describe** how acid rain speeds up chemical weathering.

#### What can we do?

- 11 Describe** whose responsibility it is to stop the weathering caused by humans.
- 12 Identify** two things that you can personally do that will help stop or slow weathering and erosion.

### Think

- 13 Compare** the similarities and differences between sand and boulders.
- 14** It is dangerous to leave a filled glass bottle in the freezer. **Explain** why.
- 15** Many ancient statues in cities have changed shape in the past 50 years. **Propose** a reason why.
- 16 Identify** which parts of a statue are most likely to be weathered and **explain** why.

- 17** Chemical weathering is more likely in the city than the country. **Explain** why.
- 18** In your own words, **summarise** what an environmental scientist does.
- 19 Construct** an argument as to why you think humans have or have not sped up erosion and weathering.

## [ Extension ]

### Investigate

- 1 a Investigate** ways of minimising erosion in *one* of the following situations:
  - in rivers
  - on beaches
  - on farms
  - around building or road construction sites
- b Use** this information to go out and find examples of these methods. Take some photographs or draw diagrams of them.
- c Produce** a poster with your photos or diagrams to show how these methods work.
- 2 Describe** what these geographical features are and how they form.
  - a river deltas
  - b sandbanks and sandbars in rivers
- 3 Produce** a crossword about weathering and erosion.



## Chapter review

### [ Summary questions ]

- 1 Draw a cut-open diagram of the Earth. Briefly describe the following parts: the crust, outer mantle, inner mantle, outer core and inner core.
- 2 Draw a simplified diagram to demonstrate the rock cycle and acid rain.
- 3 Briefly explain the differences between weathering and erosion.
- 4 List any traditional practices or methods that can be applied to stop or minimise erosion in your local area.

### [ Thinking and interpreting questions ]

- 5 Briefly explain Alfred Wegener's theory of continental drift.
- 6 Briefly explain why we have earthquakes, cyclones and volcanic activity in Solomon Islands.
- 7 Compare the following terms: rocks and minerals, crystals and minerals, pigments and streaks, rock and ore.

- 8 Describe the following types of rocks: igneous, sedimentary and metamorphic.
- 9 Copy and complete the following table to summarise the science careers covered in this chapter.

Job title	Main tasks	Skills required
Geologist		
Palaeontologist		
Environmental scientist		

### [ Extension question ]

Conduct research on some of the mineral resources in Solomon Islands that are available for extraction. Find out their location and the potential for extracting them. Discuss the economic and social benefits of extracting the minerals at the community, provincial and national levels.

# Solutions, solutes and solvents

By the end of this chapter learners should be able to:

- 1 Identify some examples of the three types of mixtures: *solutions (salt and water)*, *suspensions (sand and water)* and *colloids (milk in water)*.
- 2 Produce a solution by dissolving solute in solvent: *sugar (solute) in water (solvent)*, *salt (solute) in water (solvent)*, *klin powder (solute) in water (solvent)*, etc.
- 3 Select appropriate methods to separate substances from mixtures—insoluble substances: *decanting, sieving, filtering, gravity separation, centrifugation, magnetizing*; soluble substances: *evaporation, distillation, chromatography, centrifugation*.
- 4 Identify common solutions and solvents around them that are hazardous.
- 5 Select sources of clean drinking water for human use: *in the school, at home, in the community/village*, etc.
- 6 Use local water purification methods: *settling, decanting, coconut fibre filtering*.
- 7 Identify methods of sewage treatment.
- 8 Explain why treatment is important before disposing of waste water into a stream or the sea.

- 1 What is a mixture?
- 2 What happens when oil and water are mixed?
- 3 Is sea water a pure substance or a mixture of substances?
- 4 How would you separate a mixture of sand and salt?
- 5 Where does all the waste water in your house end up?



# UNIT 6.1

## Types of mixtures

### introduction

There are many types of mixtures. Soft drinks, peanut butter, coffee, milk, sea water, hair gel and air are mixtures that we see every day. A **mixture** contains two or more chemically pure substances. They may be separated using a physical process such as sieving/straining (the use of a strainer) or filtering. When a mixture is made, no new substances are formed. The

particles of each substance are spread between the particles of the other substance. Look around your home and you will be surprised at the number of different mixtures that we use every day.

### Solutions

**Solutions** are the most common type of mixture. A solution is formed when one substance (called the **solute**) dissolves in another (called the **solvent**). For example, when sugar is mixed with water, the solute is the sugar and the solvent is the water. We say that a sugar solution has been formed. One characteristic of solutions is that they are transparent (though they may be coloured)—no particles of the solute can be seen as they are too small and are spread evenly throughout the solvent.

When a solution is made, the solute does not disappear. All of the solute added is still in the solution even though you can't see it. The total mass of a solution is always equal to the mass of the solvent plus the mass of the solute. This is shown in Figure 6.1.1.

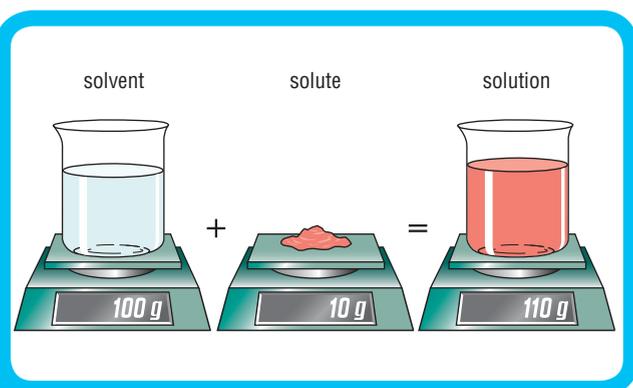


Fig 6.1.1

Mass stays the same in solutions. We say that the mass is preserved.

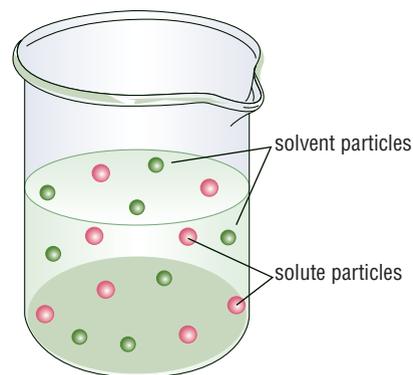


Fig 6.1.2

A solution showing the distribution of solvent and solute particles



Soft drink is a solution of sugar, flavourings and gas in water.

Fig 6.1.3



Solutions can also be made by dissolving a liquid in a liquid, or a gas in a liquid. The table below gives some examples of solutions.

Solute	Solvent	Solution
Carbon dioxide gas	Water	Soda water
Detergent	Water	Washing up water
Oil	Petrol	Two-stroke motor mower fuel
Germ-killing chemicals	Water	Disinfectant
Nail polish	Acetone (nail polish remover)	No common name
Pen ink stains	Methylated spirits	No common name

If one substance can dissolve in another, we say that the substance is **soluble**. A substance that will not dissolve is called **insoluble**—for example, sand is insoluble in water.

## Activity 1

### Testing solubility in water

**Aim** To test the solubility of various substances in water

#### Equipment

Salt, sugar, ground-up coloured chalk, copper sulfate, flour, soil, household and other substances as provided by your teacher, test tubes, test tube holder, water, rubber stopper(s), spatula(s), safety glasses

#### Method

- 1 Use a spatula to place a *very small* amount of a substance into a test tube.
- 2 Half fill the test tube with water.

- 3 Place a rubber stopper in the top of the test tube and shake it in an attempt to dissolve the substance.
- 4 Return the shaken test tube to the test tube rack and observe it.
- 5 Repeat steps 1 to 4 for the other substances, recording your observations.

#### Questions

- 1 **Classify** all the substances tested as soluble or insoluble.
- 2 **Explain** why was it important to use a very small amount of each substance.
- 3 **Identify** which substance appeared to be:
  - a most soluble
  - b least soluble

## Activity 2

## Temperature and solubility

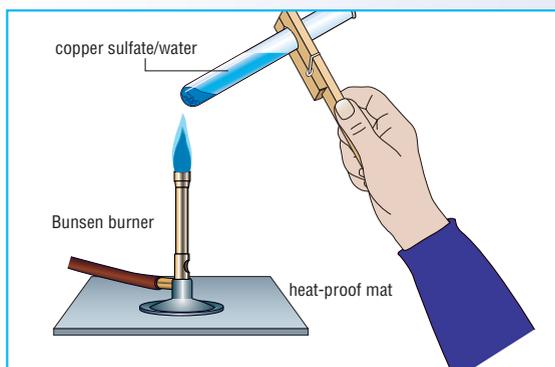
**Aim** To find out how temperature affects the solubility of two different chemicals

**Equipment**

Test tubes, test tube holder and rack, sodium chloride (table salt), glucose (sugar), spatula, safety glasses

**Method**

- 1 Fill the test tubes with cold water to a depth of 5 cm.
- 2 Use the spatula to add a tiny amount of sodium chloride to a test tube, and gently swirl the test tube to dissolve the chemical.
- 3 Continue adding more chemical until a small amount remains undissolved in the test tube.
- 4 Gently heat the solution for about 10–20 seconds. Do not boil it.



**Fig 6.1.4** When heating a solution in a test tube, turn the opening of the test tube away from your body.

- 5 Again swirl the test tube and try to dissolve more chemical.
- 6 Place the test tube in the rack and leave it to cool. Observe what happens as it cools.
- 7 Repeat steps 1 to 6 using glucose.

**Questions**

- 1 **Describe** the effect (if any) of heat on solubility.
- 2 **Explain** the difference in solubility between sodium chloride and glucose.
- 3 Glucose and air have similar solubilities. Use this information to **explain** the bubbles that are seen as water is first heated.
- 4 **Describe** what happens as a saturated solution cools. (You may have to leave your test tube of sodium chloride solution overnight before answering this.)

## Activity 3

## Surface area and solubility

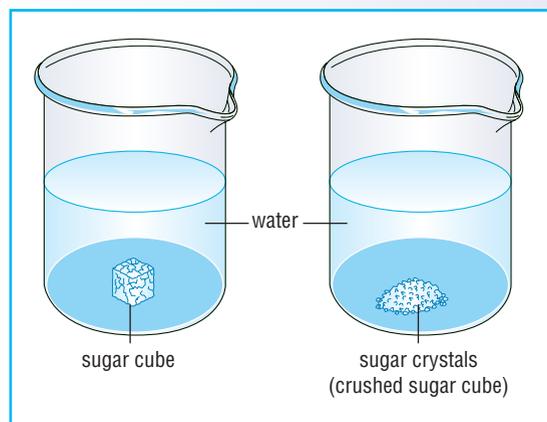
**Aim** To examine whether surface area has any effect on the rate of dissolving

**Equipment**

Two sugar cubes, two beakers, water

**Method**

- 1 Place an equal amount of water (e.g. to a depth of 5 cm) at the same temperature in each beaker.
- 2 Crush one of the sugar cubes into separate crystals.
- 3 Place the whole cube in one beaker and the crushed cube in the other.



**Fig 6.1.5** Comparison between cube and crushed sugar

- 4 Swirl both beakers for 10 seconds in an attempt to dissolve as much of the sugar as possible.

**Questions**

- 1 The crushed cube has greater surface area (imagine it spread over the bottom of the beaker). **Describe** what effect increasing the surface area of a solute has on the rate of dissolving.
- 2 **Describe** why all of the crushed cube is used rather than some of it.
- 3 **State** reasons for keeping water level and temperature the same in both experiments.

## Concentration

When a solvent (e.g. water) contains a large amount of solute (e.g. salt), the solution is said to be **concentrated**. The opposite of concentrated is **dilute**. Adding more solvent will dilute a concentrated solution. Adding more solute will make the solution even more concentrated.

If more and more solute is added to a solvent, a point is reached where no more will dissolve. When a solution reaches this point, it is said to be **saturated**.

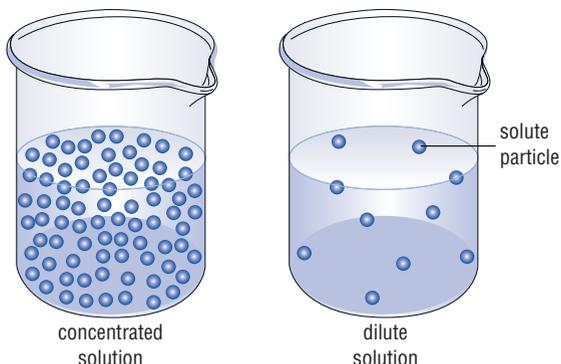


Fig 6.1.6

A concentrated and a dilute solution. Note the increased number of solute particles in the concentrated solution.

## Suspensions

A mixture of water and sand is not a solution, but is called a **suspension**.

In a solution, the sizes of the solute and solvent particles are similar. In a suspension, the particles being mixed are bigger than those in the solution and initially they appear suspended. However, they will settle to the bottom of the container if left long enough. Some medicines and some types of paint are suspensions: they separate into different layers and therefore need to be re-mixed before use.

The substance that settles out of a suspension is called the **sediment**. Sediment can be filtered out of a suspension, unlike the solute in a solution, which would pass through the filter.

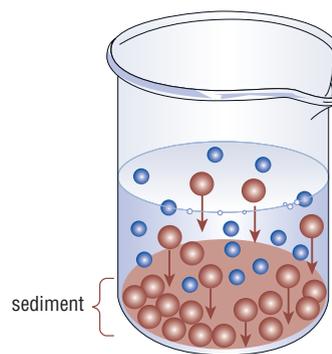


Fig 6.1.7

A suspension showing the larger particles separating out by gravity

## Colloids

A **colloid** is in between a solution and a suspension. The particles in a colloid are bigger than those in a solution, but smaller than those of a suspension. They do not settle out as quickly.

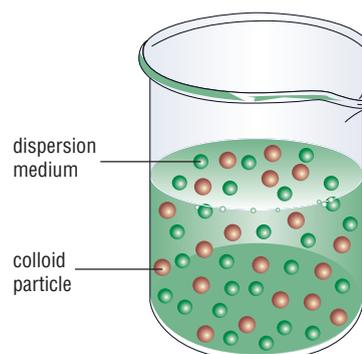


Fig 6.1.8

A colloid showing the relative particle sizes



Some paints are colloids, others are suspensions.

Fig 6.1.9



How then can we tell the difference between a solution and a colloid? The main difference is that a solution is clear, but a colloid is 'cloudy' due to light reflecting off the larger particles.

The substance in which the particles are being spread is called the dispersion medium. It may be a solid, a liquid or a gas. This results in several possible colloid combinations, which are described below.

### Sols

A **sol** is an emulsion where particles of a solid are spread throughout a liquid. Unlike a solution, a sol is not transparent. Blood plasma is a sol in which solid blood proteins are spread throughout water. Blood is made up of blood plasma and blood cells.

### Emulsions

An **emulsion** is a colloid in which particles of a liquid are spread throughout another liquid.

Milk is an emulsion of liquid fat spread throughout water. Medicinal ointments are other examples of emulsions. Normally oil and water will not mix, but if detergent is added, it helps break up fat and oil drops into small particles that allow an oil/water emulsion to form. A chemical that helps fats form an emulsion is called an **emulsifier**. Detergent helps emulsify fats, as does bile in our intestines, making fats easier to digest.

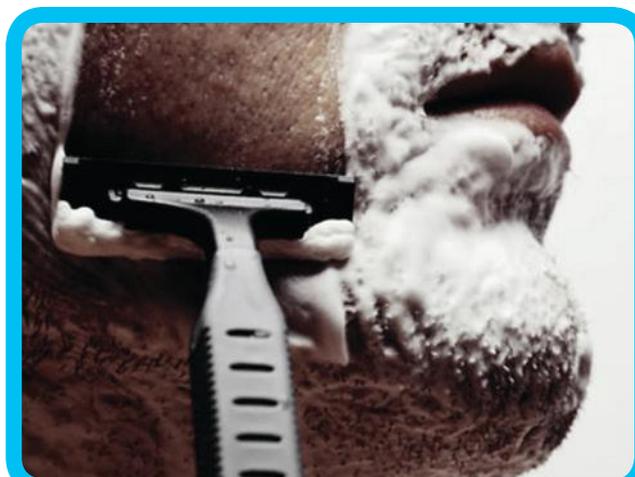


Fig 6.1.10

Milk is an emulsion.

### Foams

A **foam** is a colloid made up of a gas mixed with a liquid. Shaving foam and fire extinguisher foam are examples.



Shaving foam is an example of a foam.

Fig 6.1.11

### Gels

A **gel** is a colloid in which liquid particles (e.g. water) are held between the particles of a solid (e.g. gelatine). Jelly is a well-known example of a gel. Gels melt easily when heated.



Jelly is a colloid.

Fig 6.1.12

**Smoke**

Smoke is an example of a colloid formed when a solid (carbon) is spread throughout a gas (air).



Smoke is a colloid. **Fig 6.1.13**

**Mist**

A liquid spread throughout a gas may form a colloidal **mist**. Fog is a common example.



Fog is a colloid. **Fig 6.1.14**

**6.1****UNIT****[ Questions ]****Checkpoint****Solutions**

- 1 Explain** what is meant by the terms 'solution', 'solute' and 'solvent'.
- 2 Choose** the correct answer:  
When coffee powder is mixed with hot water, the water is the:
  - a solute
  - b solvent
  - c solution
- 3 In** a solution, the particles of the solute cannot be seen because:
  - a they are spread too thinly throughout the solvent
  - b they have been destroyed by the solvent
  - c they have been converted to solvent particles
- 4 True or false?**
  - a In a solution, the solvent is always water.
  - b A solute is always a solid.
  - c A substance that is insoluble must be a solid.
  - d When a mixture is made, new substances are not formed.

**Concentration**

- 5 Compare** a concentrated and a dilute solution by listing their differences and similarities in a table.
- 6 Draw** two diagrams showing a concentrated and a dilute solution, labelling the solute and solvent.

**Suspensions**

- 7 Explain** why the particles in a suspension sink.
- 8 Identify** the substance that settles out of a suspension in the following examples:
  - a a mixture of chalk and water
  - b muddy water
  - c used engine oil that contains bits of worn metal
- 9 State** two examples of suspensions.

**Colloids**

- 10 Explain** why a colloid is said to be in between a solution and a suspension.

**Think**

- 11 Graffiti** (unnecessary writing on walls, desks etc.) remover product is used to wash paint from a wall. **Classify** the paint as solvent, solute or solution.
- 12 Identify** two examples of common substances that are:
  - a soluble in water
  - b insoluble in water





- 13** Which of the following is *not* a solution?
- a Coke
  - b salt water
  - c sand in water
- 14 Describe** how a dilute solution is formed.
- 15** Name a solution in which there are many solute particles and few solvent particles. Define the type of mixture that this represents.
- 16 Design** an experiment to determine whether cordial is a suspension or a solution. In your experiment, you should:
- a outline a clear aim for the experiment
  - b identify conditions (variables) that will change or should be kept constant
  - c suggest ways of reducing any wastes that might be made in the experiment
- 17 Explain** why some medicines need to be shaken before using them.

### Analyse

- 18** Copy and complete the following table after referring to Figure 6.1.1.

Mass of solvent (g)	Mass of solute (g)	Mass of solution (g)
100	12	
60		90
	65	180

## [ Extension ]

### Investigate

- 1 a Define** an alloy.
- b Explain** why an alloy is a mixture.
- c Identify** some alloys that may be found around the home.
- d Relate** the use of each alloy to its properties, such as lightness or resistance to rust.

### Action

- 2 Determine** whether equal amounts of washing powder will dissolve in cold and hot water.
- a Design** a test involving stained material to compare the results of washing in both types of water.
- b Identify** any steps in your method that might be dangerous, e.g. working with hot water, spilling washing powder onto skin. Describe how you could perform these steps safely.
- c** Carry out your test and report on your results.

# Separating insoluble substances

## introduction

The separation of mixtures can give us pure substances. To obtain pure substances, we often need to remove insoluble substances from a mixture. Since each part of a mixture keeps its own properties we can use several methods. This is important as it is used in industry to

purify metals, and in other activities, like panning to separate gold from river sand.

## Decanting

**Decanting** is a simple method of separation that may be used with suspensions. The mixture is left long enough for most of the sediment to collect at the bottom of a container. The liquid above the sediment is carefully poured into another container.

## Sieving

**Sieving** is useful when there are different-sized particles in a mixture. If you are making bricks, you could sieve the sand mixture so that the finer sand particles pass through the sieve while the larger sand and gravel particles are collected on the sieve. Crushed metal ore may be sieved to collect pieces that require further crushing before extraction of metals.

Another common use for sieving is in fishing nets with different-sized holes to catch the size of fish you want.

## Filtration

Filtration is just a very fine sieving process. Instead of a sieve, a special filter is used. One type of filter used in the laboratory is **filter** paper. It contains millions of tiny holes that allow particles in a solution, including water, to pass through, but not the larger particles. Tea bags, dust masks, vacuum cleaners, car fuel systems, spa and swimming pool filters are all filters. The substance that is trapped by the filter is called the **residue**, and what passes through is called the **filtrate**.



A sieve in action

Fig 6.2.1

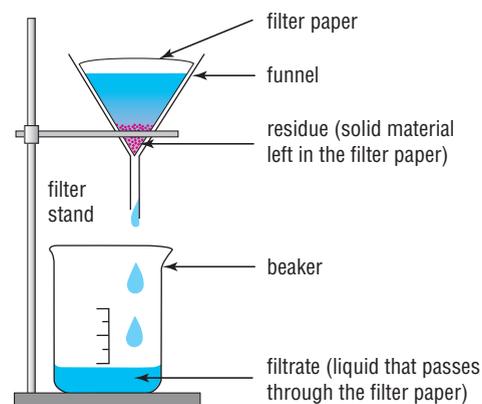


Fig 6.2.2

The filtering process is used to separate solids from liquids in the science laboratory.

## Activity 4

### Filtration

**Aim** To filter a mixture to obtain a filtrate and a residue

#### Equipment

Crushed (powdered) coloured chalk and copper sulfate mixture, conical flask, beaker (100 mL), funnel, filter paper, stirring rod, safety glasses

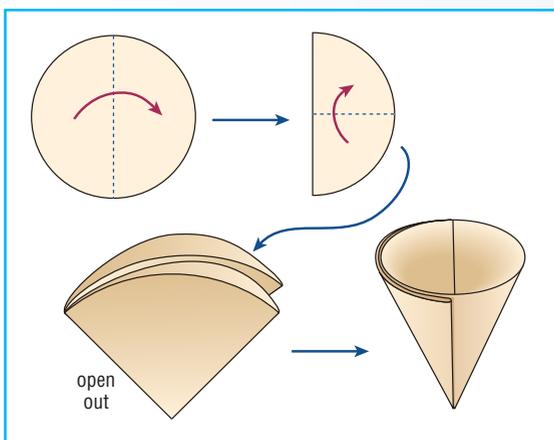


Fig 6.2.3 Method for correctly folding a filter paper

#### Method

- 1 Place the powdered mixture into the beaker, and add about 50 mL of water.
- 2 Use the stirring rod to mix the water and powder as best you can.
- 3 Fold the filter paper as shown in Figure 6.2.3 and place it in the funnel. Then place the funnel in the conical flask.
- 4 Tip the water/powder mixture into the filter paper.

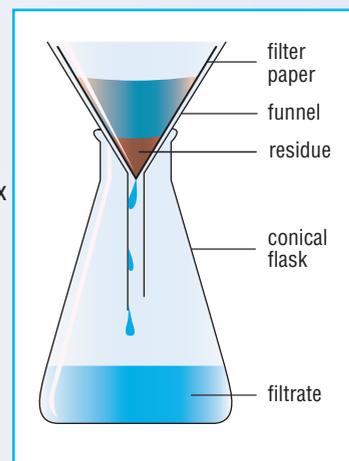


Fig 6.2.4 Assembled filtering apparatus

#### Questions

- 1 **Contrast** the size of the copper sulfate particles with that of the chalk particles. **Explain** your observation.
- 2 **Produce** a magnified diagram explaining how the filtrate is trapped by the filter paper. Use different symbols for the solute and solvent particles.
- 3 **Recommend** a method that might recover the copper sulfate powder from the filtrate.

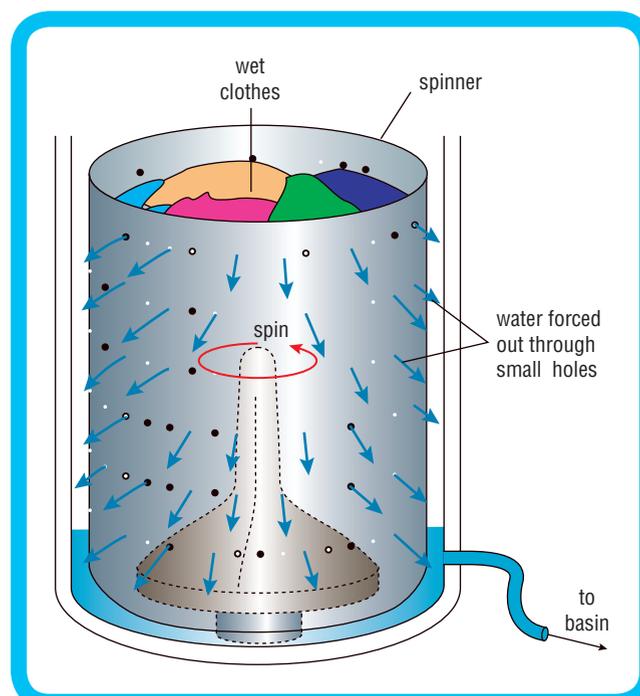
### Gravity separation

If a mixture containing water and particles of different weights is stirred or shaken, the heavier particles will tend to move towards the bottom of the container. This is how **panning** for gold works—tiny (but heavier) specks of gold sink to the bottom of the pan, so they remain when the lighter gravel is washed off.

### Centrifuging

Another method involving the movement of particles is centrifuging. The spin drier in a washing machine is a type of **centrifuge**. When the spin cycle activates, the drum rotates rapidly, forcing the clothes and water against the drum wall. The walls contain small holes that allow water to pass through them and be pumped out, leaving the clothes 'spun dry'.

Similarly, a medical laboratory centrifuge holds special test tubes at an angle so that the heavier particles in a liquid are forced to the bottom of the tubes. Blood can be separated using a centrifuge. Milk and its cream can be separated this way too.



A washing machine spin dries clothes using a centrifuge action.

Fig 6.2.5

## Magnetic separation

Scrap iron may be separated from non-magnetic materials using a powerful electromagnet suspended over a conveyer belt. The electromagnet may be turned on and off to release the collected iron.

### Activity 5

#### Magnetic separation

**Aim** To separate a mixture using a magnet

**Equipment**

A mixture of sand and iron filings, a sheet of newspaper, a magnet in a plastic bag, empty container for iron filings, a sheet of paper

**Method**

- 1 Place the sheet of newspaper on a bench, then place a small pile of the sand/iron filings mixture on top.
- 2 Spread the mixture into a flat pile and place a sheet of paper on top.
- 3 Use the magnet in the plastic bag to carefully separate the mixture, placing the separated iron filings in a clean container as you go.

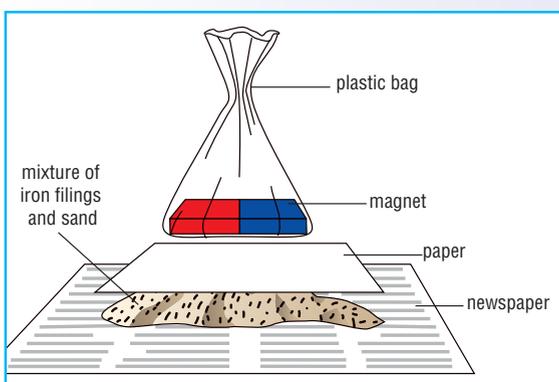


Fig 6.2.6 Magnetic separation

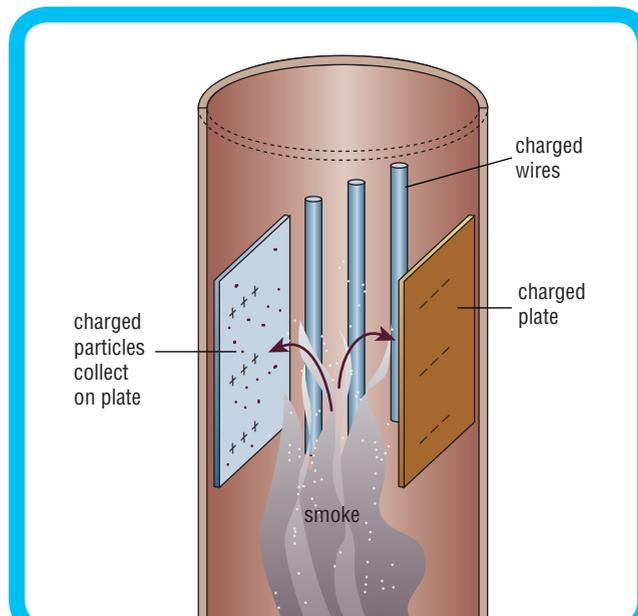
**Questions**

- 1 **Explain** why the sheet of paper was placed on top of the mixture.
- 2 **Explain** why the magnet was placed in a plastic bag.
- 3 **Propose** how a similar technique could be used in industries.



## Electrostatic separation

Industrial chimneys may contain **electrostatic precipitators**, which remove waste products by charging particles as they move up a chimney. The particles, once charged, are attracted to metal plates (also charged) and are prevented from being released into the atmosphere.

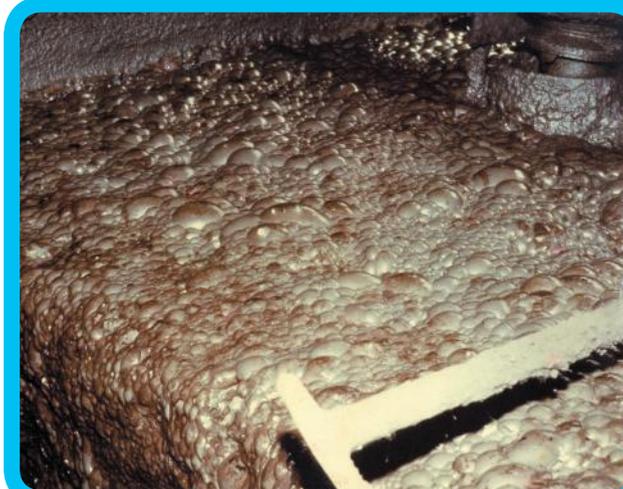


An electrostatic precipitator

Fig 6.2.8

## Froth flotation

**Froth** flotation is used in the processing of minerals. During copper production, rocks containing grains of copper are crushed and ground to a fine powder. This is called **liberation**. Once liberation has occurred, the powder is mixed with water and special chemicals in flotation cells. Air is then blown into the mixture to produce bubbles of froth. Chemicals in the mixture stop the bubbles bursting, and help the copper stick to the bubbles. The unwanted part of the powdered rock, called **gangue**, falls to the bottom of the flotation cells. Copper **ore**, containing a high proportion of copper, may then be skimmed from the top of the flotation cells.



Froth flotation of copper ore

Fig 6.2.9

## Questions

### Checkpoint

#### Decanting

- 1 Draw a diagram to **explain** how you could decant water from a sand/water mixture.

#### Sieving

- 2 **Explain** a use of sieving and how this process works.

#### Filtration

- 3 True or false?
  - a Filtration may be used to separate a solute from a solution.
  - b Filtrate is what passes through a filter.
- 4 **Explain** what the residue is in filtration.

#### Centrifuge

- 5 **Describe** how the spinning of a centrifuge causes separation.

### Think

- 6 **Identify** and **explain** two uses of filtration in your home.
- 7 **Draw** a cross-section diagram of the filtration method used in the laboratory.
- 8 A quarry produces a mixture of small and large crushed rock pieces. **Explain** the basic method that may be used to separate the small and large pieces.
- 9 **Specify** a separation method to assist with the following problems:
  - a A container of small metal nuts and bolts is spilt on the grass near a workshop.

- b A fisherman wishes to catch legal-sized fish for market.
  - c A child mistakenly pours salt on fine sand.
  - d A hunter thirsts for a drink in a hot summer day and has only muddy water available.
- 10 **Explain** why salt can't be separated from salt water by using filter paper. **Clarify** your answer using diagrams showing the sizes of water and salt particles.

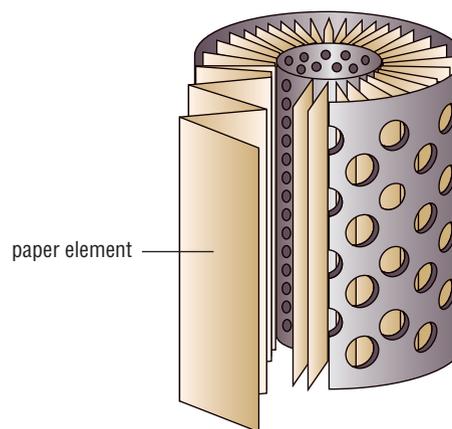


Fig 6.2.10

The inside of a car's oil filter

# UNIT 6.3

## Separating soluble substances

### introduction

Soluble substances are more difficult to separate out of mixtures than insoluble substances. The methods used rely on the basic properties of matter, and are used in many industrial applications. These include making salt from sea water, purifying water for drinking, and even in forensics for working out who committed a crime.

### Evaporation and crystallisation

A filter cannot separate the solute particles in a solution, but crystals of the solute will remain behind if the solvent is left to evaporate. Boiling the solution can speed up the evaporation process. In large-scale salt production, giant **salt pans** allow **evaporation** using the heat energy from the Sun.



Fig 6.3.1

Large-scale salt production in a salt pan

### Separation by evaporation

**Aim** To collect the dissolved substances from soft drink using evaporation

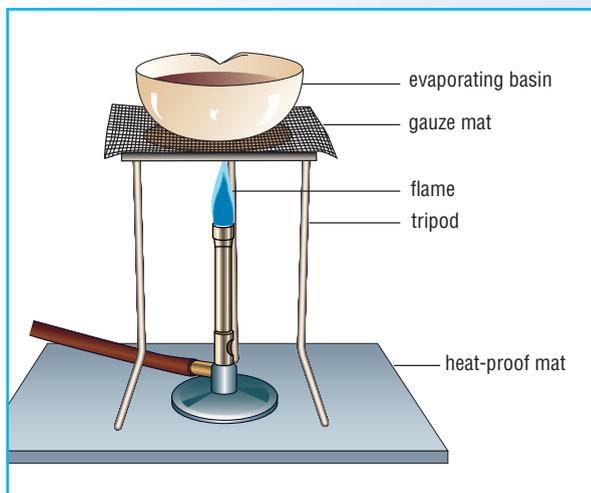


Fig 6.3.2 Evaporation separates the dissolved substances from the solvent.

### Activity 6

#### Equipment

Bunsen burner, salt solution or soft drink, heat-proof mat, evaporating basin, tripod, gauze mat, safety glasses

#### Method

- 1 Place a small amount of solution in the evaporating basin (half to one-third full) and place it on the gauze mat as shown here.
- 2 Heat the solution, but turn off the Bunsen burner just before the last drop of water disappears (the heat remaining in the basin will be more than enough to finish evaporating the water).
- 3 Allow the crystals to cool. You may wish to stick a sample in your book under a piece of contact adhesive.

#### Questions

- 1 **Describe** what you saw as the water evaporated.
- 2 **Explain** why it is important to stop heating when the water is just about gone.
- 3 **Predict** where the water went.

## Distillation

Distillation also involves evaporation, but this time the evaporated liquid, called the **distillate**, is collected. Again, what remains in the original container is called the residue.

Tap water contains several other substances, and so strictly speaking is not pure. **Distillation** is used to obtain pure or distilled water. A laboratory distillation apparatus is shown in Figure 6.3.3.

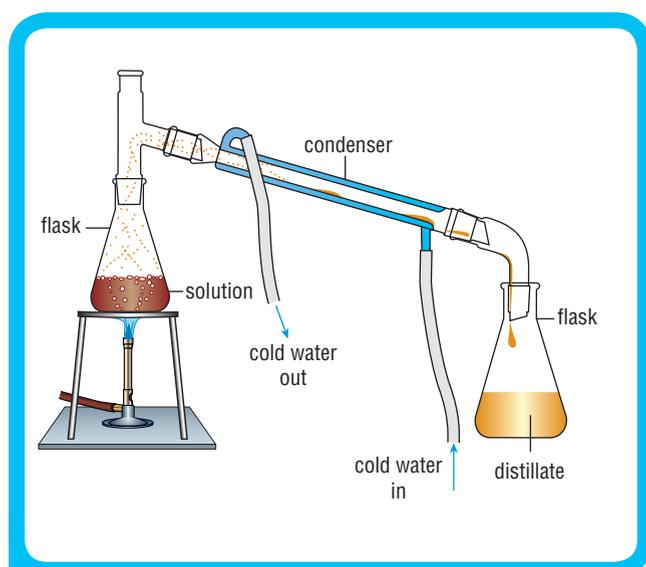


Fig 6.3.3 A laboratory distillation apparatus

A desert survival technique involves the collection of distillate using a sheet of plastic to trap water distilled from the ground or plants.

Distillation is also used in the production of whisky (hence the term 'distillery') and perfume.

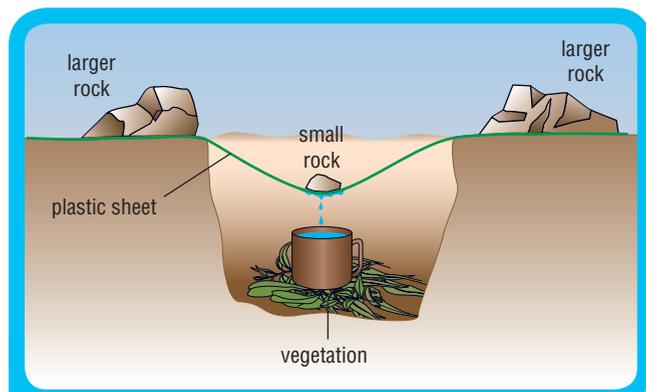


Fig 6.3.4 Life-saving distillation in the desert

## Activity 7

### A simple distillation

**Aim** To collect a sample of pure water using distillation

#### Equipment

Bunsen burner, gauze mat, heat-proof mat, conical flask, tripod, watch-glass, wooden test tube holder, salt solution, beaker, 3 paperclips, water, safety glasses

#### Method

##### PART A The distillation

- 1 Assemble the apparatus as shown in Figure 6.3.5.

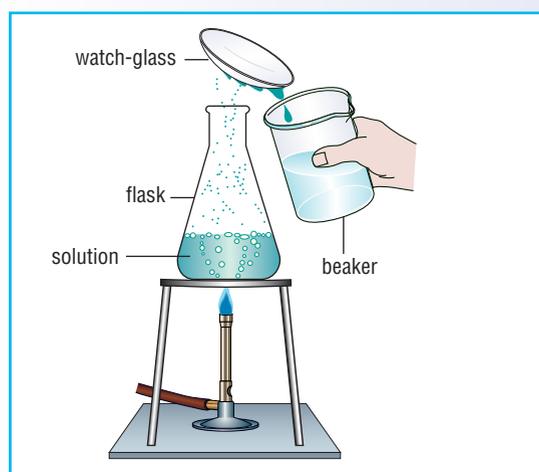


Fig 6.3.5 Pure water can be collected from simple distillation.

- 2 Use the watch-glass and beaker to collect distilled water. Save some of the salt solution for Part B of this activity.

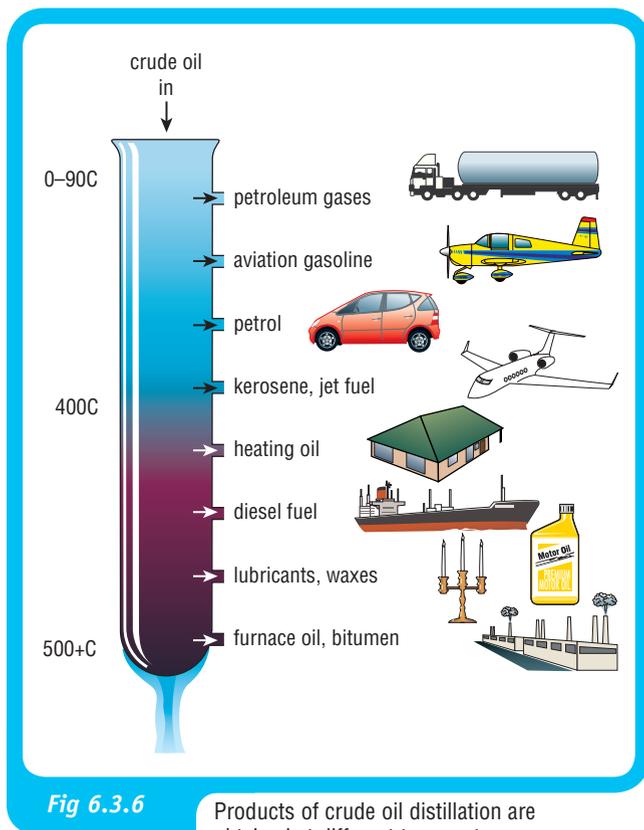
##### PART B Testing the distillate

- 1 Unfold the paperclips.
- 2 Dip one paperclip in the salt solution and then hold the dipped end of the paperclip in the blue flame of a Bunsen burner. What colour flame is produced?
- 3 Dip another paperclip in plain water and repeat the 'flame test'.
- 4 Dip a third paperclip in your distillate and repeat the 'flame test'.

#### Questions

- 1 **Explain** what the flame tests tell you about the distillate.
- 2 **Present** a reason for not using the same paperclip for all three flame tests.

Many different substances (called **fractions**) exist in crude oil. **Fractional distillation** uses the fact that these substances boil at different temperatures. This allows them to be separated into petrol and other substances as shown in Figure 6.3.6.



**Fig 6.3.6** Products of crude oil distillation are obtained at different temperatures.

## Absorption

**Absorption** occurs when a material is ‘taken in’ or ‘swallowed’ by another. A kitchen sponge absorbs water. Special chemicals may be used to absorb particular substances from a mixture.

Charcoal contains many fine pores that allow it to absorb many dangerous gases, and so is used in gas masks and breathing filters.

Packages of food that must be kept free of moisture contain small packets of silica gel, which can absorb nearly half their weight in water.

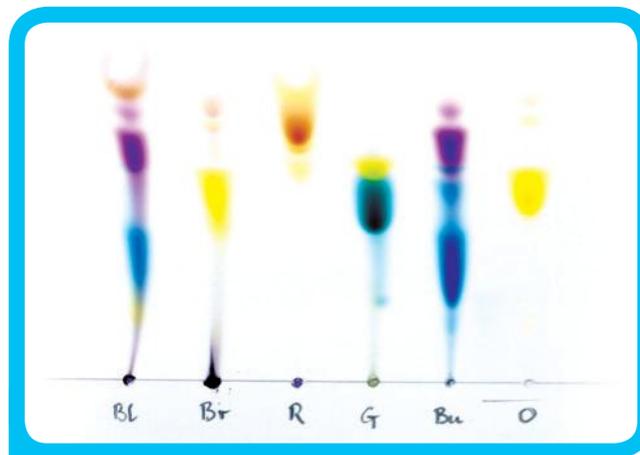


Silica gel separates water from materials by absorbing the moisture.

**Fig 6.3.7**

## Chromatography

**Chromatography** is a technique that may be used to separate colours in inks, food dyes and other mixtures of colours. A **medium** such as blotting or filter paper containing a spot of the mixture is placed in contact with a solvent (e.g. water). Because different colours move at different rates through the medium, they separate along the medium.



**Fig 6.3.8**

Paper chromatography can be used to separate the colours in ink.

## Activity 8

## Chromatography of colours

**Aim** To separate the colours in ink

### Equipment

Water-based Texta pens, eye dropper, water, beaker, filter paper

### Method

- 1 Using a water-based Texta pen, make a dot in the centre of a piece of filter paper.
- 2 Place the filter paper on top of the beaker.
- 3 Using the eye dropper, place a drop of water on the dot of ink.

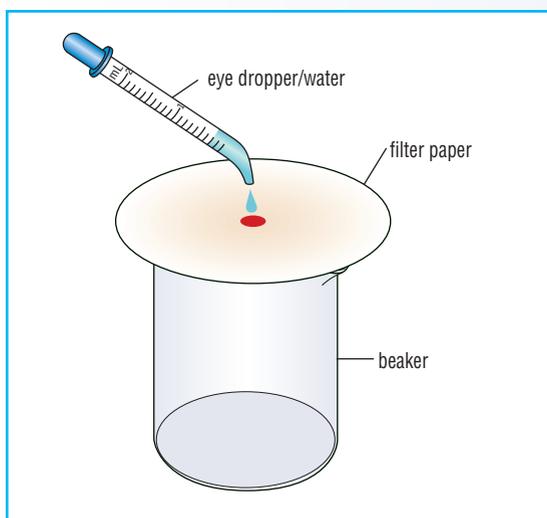


Fig 6.3.9 The process of chromatography

- 4 Repeat step 3 if necessary to spread rings of colour from the dot. Be patient.
- 5 Try different-coloured dots.
- 6 Compare results for different brands of pens.

### Questions

- 1 **Present** a list of the colours in each Texta pen you tested.
- 2 **Explain** why different colours spread at different rates.

# 6.3 [ Questions ]

UNIT

## Checkpoint

### Evaporation and crystallisation

- 1 Copy and complete: When a solution evaporates, c\_\_\_\_\_ of solute may be left behind.
- 2 Describe what a salt pan is and what it is used for.

### Distillation

- 3 Describe how distillation is different to evaporation.
- 4 Name the different stages in distillation and explain what happens at each stage.
- 5 Identify three examples where distillation is used.
- 6 Define a *fraction* in distillation.
- 7 Identify three different fractions and their uses from Figure 6.3.6.

### Absorption

- 8 Identify an example of something that absorbs a:
  - a liquid
  - b gas

### Chromatography

- 9 Clarify the types of mixtures that chromatography is used to separate.
- 10 Explain how different colours move in chromatography.

## Think

- 11 Copy and complete the table below to summarise the separation methods in this unit.

Separation method	Brief description	Example
Evaporating	The mixture is boiled so that the solvent evaporates. This will leave behind the solute.	Salt from sea water

- 12 Explain why salt is obtained from salt pans, rather than from boiling sea water.

- 13 The small silica gel packets inside various products carry a notice saying: DO NOT EAT. **Propose** why this warning is present.
- 14 **Plan** a sequence of steps for producing fresh water from sea water.
- 15 **Identify** a separation technique for each of the following situations.
  - a A teacher has smelly feet.
  - b Joe was cooking and dropped a bag of salt into a bowl of water. He wants to get the salt back, but not the water.
  - c Mary wants to recycle water from her washing machine to make drinking water.
  - d The police have three pens and want to find out which one was used to write an anonymous letter.
  - e James want to breathe clean air, not paint fumes, while painting his house.
- 16 **Explain** why each of the separation techniques identified in question 15 would work.



# UNIT 6.4

## Water supply and sewage

### introduction

Our water supplies and waste water are two mixtures that need to be treated very carefully. Removing unwanted impurities from drinking water is important to our health. Removing impurities from waste water is important to the health of the environment.

### Water supply

You may be surprised to learn that rainwater is a mixture, and is by no means a pure substance. Rain is produced when water evaporates from oceans, lakes and other bodies of water and even from plants and soil. Because it has been in contact with substances that dissolve in it, rainwater is a dilute mixture. It must be treated before being supplied to our homes.

Water from domestic rainwater tanks is generally not treated, as the chance of contamination is low. The rainwater that we normally drink must be treated. This is to ensure it does not contain harmful levels of chemicals or bacteria. Treatment may involve the dissolving of the following substances in the supply.

#### Chlorine

**Chlorine** is added in liquid or gas form to kill germs that can cause diseases.

#### Fluoride

**Fluoride** is added to help prevent tooth decay in consumers of the treated water.

#### Lime and soda ash

The chemicals **lime** and **soda ash** may be used to ensure the water is at a neutral pH, like a 'water-balanced' swimming pool. You will learn more about acidity and pH levels when you study acids and bases later in Science.

### Activity 9

#### Water purification

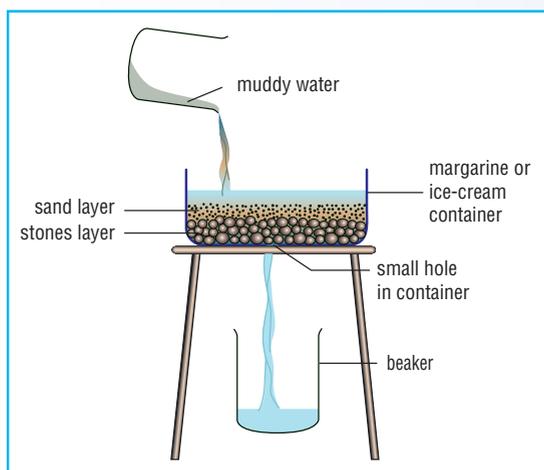
**Aim** To purify some dirty water for drinking

#### Equipment

Ice-cream or margarine container, sand, stones, muddy water, beakers (2 x 250 mL), tripod, stirring rod

#### Method

- 1 Prepare the container containing sand and stones as shown in Figure 6.4.1.



**Fig 6.4.1** Separating clean water from muddy water by using layers of sand and stone

- 2 Pour half of your muddy water into the container, and keep half for later comparison.

- 3 Allow the filtrate to drain into the clean beaker long enough to collect a good sample of 'purified water'.

#### Questions

- 1 **Describe** the effectiveness of the sand/stones filtration.
- 2 **Design** a method that could improve the purification (e.g. by adding stages to the basic method).

## Electrolytes

**Electrolytes** trap suspended particles by causing them to clump together and fall to the bottom of the tank as sediment. These clumps are called **floc**, and the process is called **flocculation**.

Figure 6.4.3 shows the basic stages of water supply. The service reservoir is a water tank that stores water for use during peak demand times. The stand pipe is used to provide increased pressure to high service areas.

## Activity 10

### Testing flocculation chemicals

**Aim** To identify some chemicals that cause flocculation

#### Equipment

A 250 mL beaker of muddy water, filter paper, conical flask, funnel, stirring rod, some of the following: copper sulfate, iron(II) chloride, copper chloride, sodium carbonate, sodium bicarbonate, ammonium sulfate, magnesium sulfate, calcium sulfate, safety glasses

#### Method

- 1 Let the muddy water stand for a few minutes to separate out some sediment.
- 2 Decant some of the water into a filtering apparatus.
- 3 Take the filtrate and add a few drops of one of the chemicals to be tested, stirring briefly. Note whether any flocculation occurs.
- 4 Test the other chemicals in this way.

#### Questions

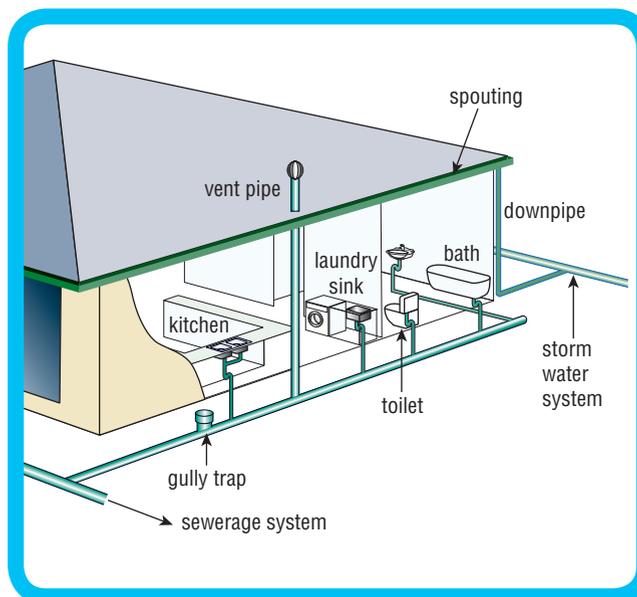
- 1 **Identify** which chemical produced the most flocculation.
- 2 **State** which type of particles you think the chemicals that caused flocculation reacted with—those in suspension or those in solution. **Explain** why.
- 3 The ‘clumped chemicals’ are referred to as the flocculent. **Explain** how you could remove the flocculent.

## Sewage

Many people get the terms ‘sewage’ and ‘sewerage’ mixed up. **Sewage** is the waste and water mixture that humans put down sinks, drains and toilets in their homes and in industrial processes.

**Sewerage** is the word used to describe the network of pipes into which sewage passes.

Most homes in Solomon Islands urban centres are connected to a **septic tank**. Sewage is broken down in the septic tank by bacteria and is released into the soil. A thick solid waste material is left in the tank and must be removed from time to time. Because a septic tank depends on bacteria, chemicals that may kill bacteria should not be allowed to pass into the tank. Most houses in Honiara city and provincial urban centres are connected to the sewerage network without going through a treatment plant. The sewage ends up in the ocean eventually.



Household connections to the sewerage system

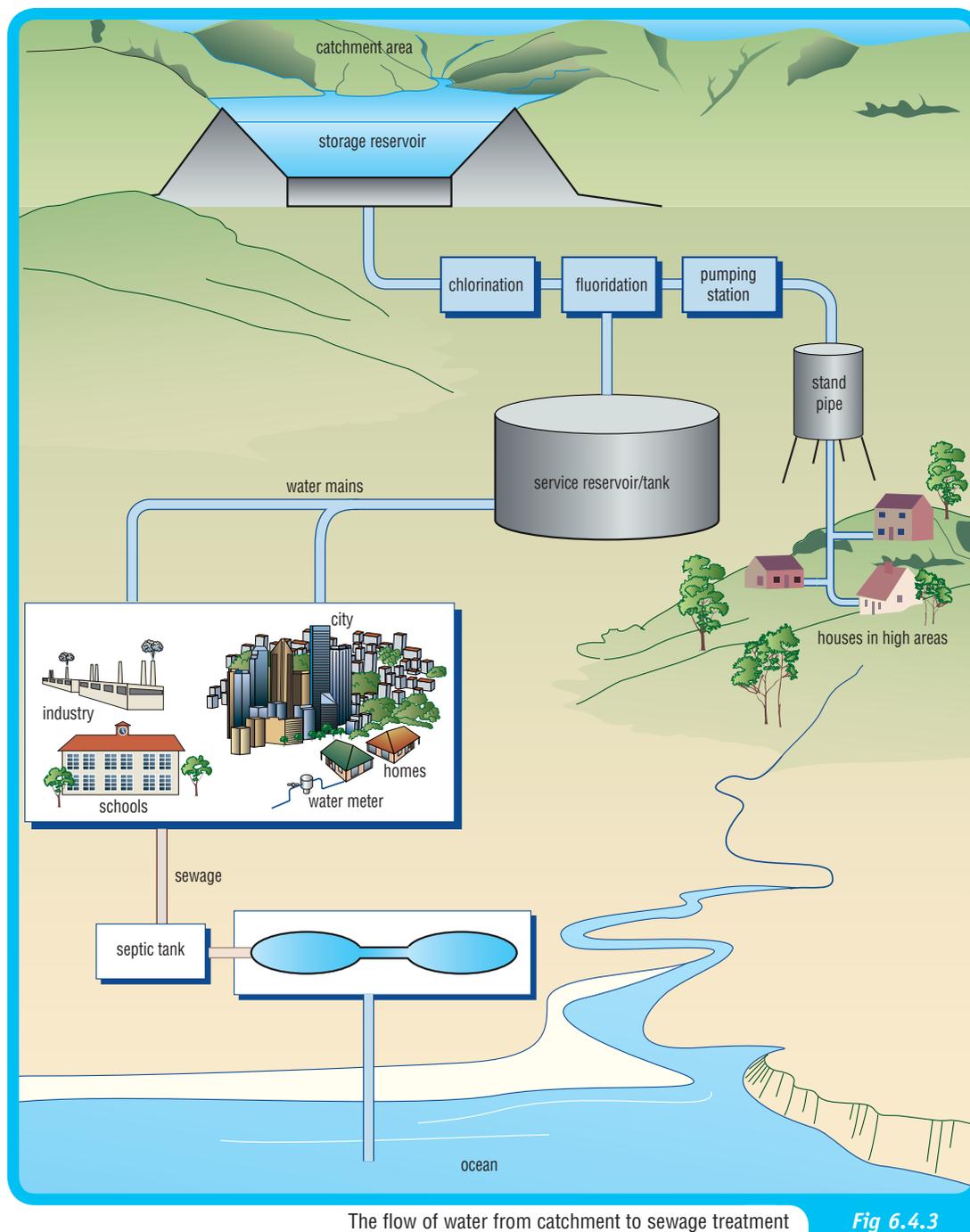
Fig 6.4.2

## Sewage treatment

Sewage treatment is the way that contaminants are removed from waste water and household sewage, both runoff and domestic. It includes physical, chemical and biological processes to remove physical, chemical and biological contaminants (wastes). Its objective is to produce an environmentally safe fluid waste stream (or treated effluent) and a solid waste (or treated sludge) suitable for disposal or reuse. Using advanced technology it is now possible to re-use sewage effluent for drinking water. Sewage includes household waste liquid from toilets, baths, showers, kitchens and sinks that is disposed of through sewers. In many areas, sewage also includes liquid waste from industry and commerce.

Although not done in Solomon Islands, all waste fluids must be channelled to a waste treatment plant or collected from septic tanks and carried to the treatment plant. In the basic treatment or primary treatment, sewage is collected and allowed to rest so that heavy solids can sink to the bottom, while grease and oil or lighter solids float to the surface. The settled and floating materials are removed and the liquid that remains can be discharged. This liquid is

considered to be quite safe. Alternatively, the liquid can be subjected to secondary treatment in which micro-organisms from the water are removed before discharging the liquid. For waste liquid to be very safe, it is important that it is disinfected by adding chemical to the waste liquid before discharging it to the sea or streams. This is called the tertiary treatment. This waste water is considered safe and does not pose risk to the environment.



The flow of water from catchment to sewage treatment

Fig 6.4.3

## 6.4

## UNIT

## [ Questions ]

## Checkpoint

## Water supply

- 1 Rainwater is evaporated water. **Identify** some places where this water has been evaporated from.
- 2 **Classify** rainwater as either a mixture or a pure substance.
- 3 **Account** for how rainwater picks up impurities.
- 4 When treating water, which chemical is added to:
  - a kill germs?
  - b prevent tooth decay?
- 5 **Explain** the term 'flocculation'.

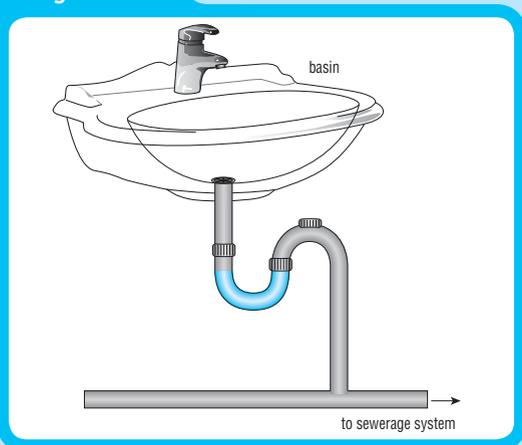
## Sewerage

- 6 **Distinguish** between *sewage* and *sewerage*.
- 7 **Identify** three items connected to the sewerage system in your house.
- 8 **Explain** what breaks down sewage in a septic tank.
- 9 **Explain** how the septic tank helps separate sewage.

## Think

- 10 **Explain** why more chlorine is required per litre in swimming pools than in our drinking water.
- 11 The catchment of a reservoir is the hills, creeks and rivers around the reservoir. **Propose** why it is important to look after the catchment of a water supply.
- 12 The forest in a catchment is often said to be like a natural filter. **Explain** what you think this means.
- 13 **Justify** why it is better to wash a car on your lawn than on the road.
- 14 **Predict** what could happen if untreated sewage was released into rivers or the ocean.
- 15 **Propose** a reason why basins around the house have 'S bends'.

Fig 6.4.4 Why does this basin have an 'S' bend?



## [ Extension ]

## Create

- 1 **Design** a house that would assist people in country areas to use their house roofs to collect and use rainwater.
- 2 Why should people save water? **Design** and **present** a poster to promote reducing water waste in your home.

## Investigate

- 3 **Research** and **compare** the amount of water used in various industrial processes (e.g. making paper, soft drinks, recycling). Present the data as both a table and a column graph.
- 4 **Research** the history of the sewerage system and its effects on public health.
- 5 **Research** the composting toilet and produce an advertisement to sell this product. In your advertisement you must:
  - a **Outline** how the composting toilet works.
  - b **Discuss** its advantages and benefits.
- 6 a **Define** the term 'acid rain'.  
b **Describe** regions of the world where acid rain is a problem.

## Action

- 7 Organise a representative from a local water-treatment facility to visit your class and talk about the importance of clean water.

# Chapter review

## [ Summary questions ]

- 1 Identify** four mixtures found in the home.
- Paint is removed from a brush using turpentine. **Identify:**  
a the solvent                      b the solute
- 3 Describe** how a solution and a suspension are different.
- Copy and complete: A substance that will not dissolve is said to be \_\_\_\_\_.
- Give the correct scientific term for a:  
a weak solution                      b strong solution
- 6 Outline** the process of:  
a sieving                              b filtration
- 7 Explain** how crude oil is separated into several types of chemicals.
- 8 Identify** three substances obtained from crude oil and **specify** two uses for each substance.
- 9 Identify** the separation method used in gold panning.
- 10 Identify** three uses for a centrifuge.
- 11 Identify** the separation method in which charcoal is used. **Describe** how this technique works.
- 12 Define** and **explain** chromatography. **Identify** how it is used in forensic science.
- 13 Explain** how rainwater can be used to pick up contamination.
- 14 Explain** why fluoride is added to our water supply.
- 15 Explain** why water in reservoirs is stored for several years before further treatment.
- 16 Define** 'floc'.

## [ Thinking questions ]

- 17 Explain** what happens to a soluble solid when it dissolves in a liquid.
- Water is a solvent for many substances. **Identify** suitable solvents for:  
a oil paint                      b grease                      c nail polish
- 19 Predict** which would dissolve faster in water—a gram of cube sugar or a gram of castor sugar. **Explain** your answer. If you were performing an experiment to test this prediction, describe which factors must be kept constant.
- 20** If you suspected that the contents of a bucket contained sand, clay and salt all mixed with water, **explain** how you would:  
a remove all impurities in one attempt  
b remove only the sand  
c remove both the clay and the sand

## [ Interpreting questions ]

- 21** Study the following data and answer the questions that follow.

Volume of water used = 100 mL

Temperature of water (°C)	0	20	40	60	80	100
Maximum amount of copper sulfate that would dissolve (grams)	18	22	29	38	50	78

- a Identify** the solvent and solute.
- b Clarify** what happens to the solubility as the temperature is increased.
- c Account** for your observation in part **b**.
- d** If the volume of water was doubled, **predict** what would happen to the amount of solute that could dissolve at 20°C. **Explain** your answer.
- e Identify** the type of graph that would best represent these results.
- f** Draw a diagram to **illustrate** the experimental set-up you would use to collect the salt.

# Introduction to cells

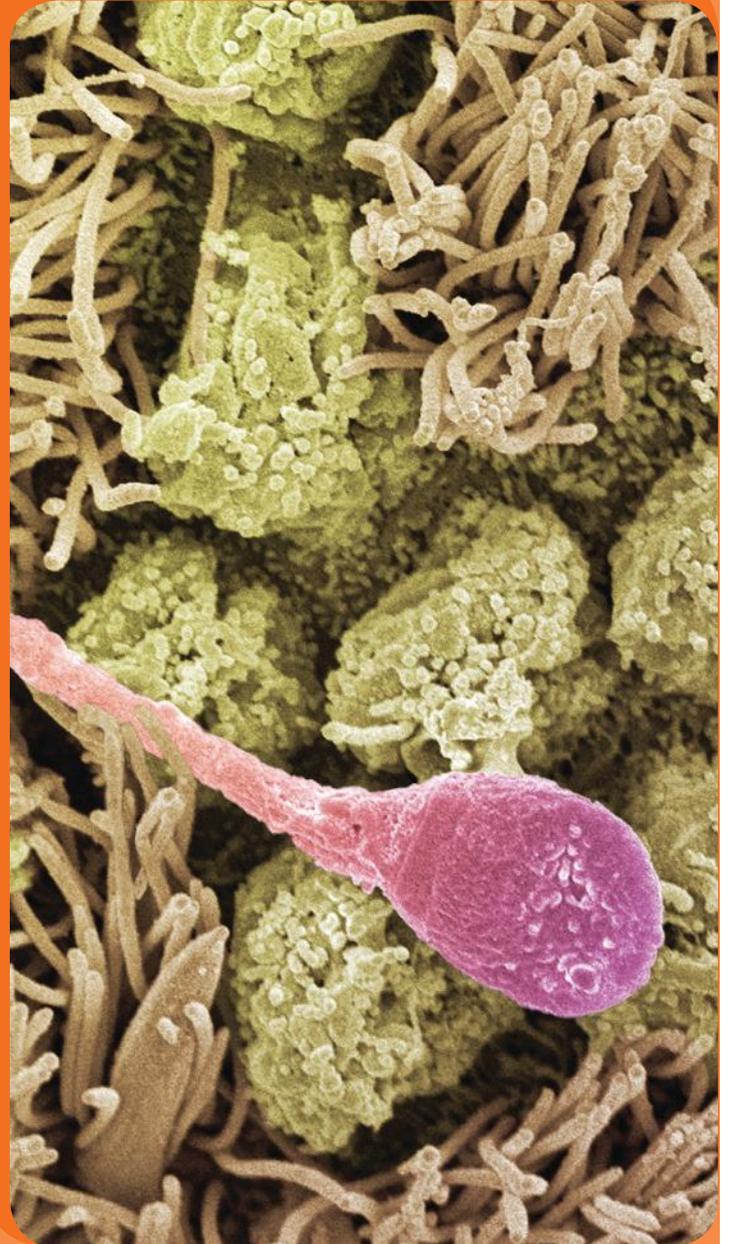
## CHAPTER

## 7

By the end of this chapter learners should be able to:

- Identify the parts of the microscope and explain their uses: *eyepiece, objective lens* and *stage*.
- Perform steps for the correct use of the microscope.
- Prepare a simple specimen using onion skins and observe.
- Explain that a cell is the smallest (basic) unit of all living things.
- Identify the basic parts of a living *animal* and *plant* cell.
- Identify parts present in a plant cell, but absent in an animal cell.
- State the function of each part of a cell: *nucleus, chloroplast, cell wall, cell membrane, cytoplasm*.
- State that: *a group of cells make a tissue, a group of tissues make an organ, a group of organs make a system*.
- Identify examples of different living: tissues (*muscle, skin, bone*), organs (*lung, heart, liver*) and systems (*reproductive, digestive*).
- Identify specialised cells in animals and plants and state their functions.
- Identify and recognise different types of single-celled organisms.
- Use a diagram to show the developmental stages from cells to organ.
- Identify examples of different systems that are found in animals and plants, and list the organs that make up each system.

- 1 The photograph on this page shows the developmental stages from cells to organs. How are photographs like this obtained?
- 2 What do you think the word 'cell' means?
- 3 What do humans and plants have common?
- 4 What type of creatures can you find lots of in a drop of water?
- 5 What body systems do we have?



# UNIT 7.1

## The microscope

### introduction

Humans have always wondered what things are made up of. We pull apart pens and calculators to see what is inside. We try to look closer and closer to find out what tiny parts are inside larger objects. The microscope was invented to allow scientists to view extremely small things that are normally not able to be seen.

Without the microscope, scientists and students would not be able to study the tiny building blocks of life that we call cells. Knowledge about cells and their structure has allowed scientists to make important advances in science and medicine. ‘Microscopic’ is a term that means an object is small, so small that the only clear way of seeing it is by using a microscope.

### The light microscope

A **microscope** is an instrument used to obtain magnified images of small objects. A magnifying glass is what we call a **simple microscope**, as it contains just one lens. A **compound microscope**, commonly



Hooke's microscope

Fig 7.1.1

used in schools today, contains two or more lenses. The compound microscope was invented by Hans Janssen and his son Zacharias and separately by Hans Lippershey in 1609, though some history books suggest that Janssen's invention may date back to 1590. In 1665, Robert Hooke designed a prototype (shown in Figure 7.1.1) of the modern compound light microscope.

The light microscopes of today are used to magnify specimens by as much as 1500 times.

### Parts of the microscope

A **monocular microscope** is a type of compound microscope and has a single eyepiece, like the one shown in Figure 7.1.2.



Fig 7.1.2

A monocular compound light microscope

A **stereo microscope** is one that has two eyepieces. These are more expensive than single-eyepiece microscopes, but provide a clearer and more three-dimensional image.



A student using a stereo microscope to observe a bacterial slide

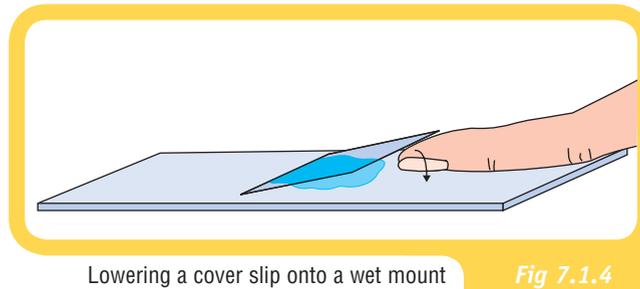
Fig 7.1.3

## Using a microscope

Correct use of microscopes can help students to see very clear images that scientists may see.

What you place under a microscope is called a **specimen**. What you see when you look through the eyepiece is called the **image**. To obtain a good image, we sometimes need to prepare the specimen first, by doing the following:

- Obtain a thin section by scraping, peeling or slicing the object. This allows more light to pass through the specimen into the microscope and to your eye.
- Place the specimen onto a glass microscope slide. Stain the specimen to make it darker and easier to see.
- Secure the specimen so it doesn't move easily. One way of making a good specimen is by using a **wet mount**. A wet mount is made by placing the specimen on a glass microscope slide with a drop of water. Gently lower a thin glass cover slip onto the specimen and water by placing one edge of the cover slip down first. Use a piece of filter paper to soak up any excess water.



Lowering a cover slip onto a wet mount

Fig 7.1.4

**Note:** Air bubbles may become trapped under the cover slip and appear as circles. **DO NOT** confuse air bubbles with images that you try to observe.

Once the specimen has been prepared, you are ready to look at its image using a microscope.

### Steps for correct use of a microscope

To protect both the microscope and the slides from damage and to obtain a clear image, you must follow these steps:

- 1 Place the prepared slide on the stage and secure it using the clips.
- 2 If your microscope has a built-in lamp, switch it on, or adjust the mirror to project light through the stage to the specimen.
- 3 Select the objective lens with the *lowest* magnification and rotate it into place. (It is easier to start viewing with low magnification.)
- 4 While looking from the *side* (*not* through the eyepiece), adjust the coarse focusing knob so the objective lens is just above the specimen. Take note of which way you must turn the knob to move the objective lens away from the specimen.
- 5 Look through the eyepiece and further adjust the mirror to obtain an adequate amount of light through the specimen. Turn the coarse focusing knob so the objective lens moves away from the specimen (remember the direction to turn from step 4) until you obtain as clear an image as possible.
- 6 Try to improve the sharpness of the image by turning the fine focusing knob.

To obtain higher magnification, swap the eyepiece with another one or rotate an objective lens of higher magnification into place. Then repeat steps 4 to 6. The total magnification is obtained by multiplying the magnification of the eyepiece by the magnification of the objective lens being used. For example, if the eyepiece is labelled 'x 10', and the objective lens is labelled 'x 20', then the total magnification is 'x 200'.



An ant, magnified 125 times

Fig 7.1.5

## Activity 1

### Focus on the news

**Aim** To make a wet mount and view it using a light microscope

#### Equipment

Microscope, microscope lamp, a section of newspaper containing small print, eye dropper, glass microscope slide, cover slip

#### Method

- 1 Cut out a small section of newspaper filled with small print.
- 2 Prepare a wet mount containing the newsprint using the procedure described on page 128 and set the microscope to the lowest magnification.
- 3 Obtain a focused image of the newsprint. Sketch what you see. Record the magnification used. Count how many letters fit in the field of view.
- 4 Slowly move the slide containing the newsprint to the left, and note which way the image appears to move. Then note how the image moves when the slide is moved right, away from and towards you.
- 5 Repeat steps 3 and 4 but with a higher magnification.

#### Questions

- 1 **State** how many letters fitted into the field of view at each magnification.
- 2 **Compare** the movement of the image to that of the actual specimen.

## Sketching microscope images

The area that can be seen through the eyepiece of a microscope is called the **field of view**.

When making a sketch of an image from the microscope, it is a good idea to do a simplified drawing of one or more objects within it. Don't worry too much about shading—concentrate on the main lines and features. It is essential to record the magnification used for each image and good practice to add a brief written description. An actual view of material taken from the inside of a human cheek is shown in Figure 7.1.6 with a sketch of its main features in Figure 7.1.7.

## Activity 2

### Observing everyday objects using a microscope

**Aim** To observe common objects at various magnifications

#### Equipment

Microscope, microscope lamp, glass microscope slides, cover slips, eye dropper, small samples suitable for viewing under a microscope, such as a sugar crystal (both plain and caster), salt, copper sulfate, hair, clothing fibres, leaf, insect, writing sample (in ballpoint pen ink), mini grid (optional)

#### Method

- 1 Observe a small specimen of each item under a microscope using the steps described on page 128. Specimens may not require wet mount preparation.
- 2 Sketch what you see in each case and record the magnification used to obtain the clearest image.
- 3 If you do not see an image, try shining the microscope lamp onto the surface of the object. Notice that this works very well with solid objects.

#### Questions

- 1 **Describe** in words how each specimen appeared.
- 2 **Explain** any observations that you did not expect.
- 3 **Describe** two ways in which a microscope could be used to solve crimes.

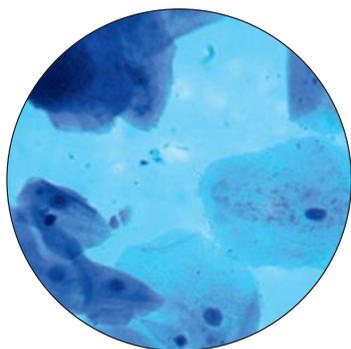


Fig 7.1.6 Human cheek cells magnified 100 times

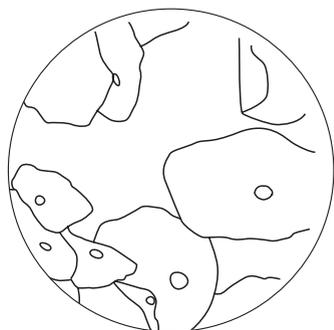


Fig 7.1.7 A sketch of the cheek cells shown in Figure 7.1.6

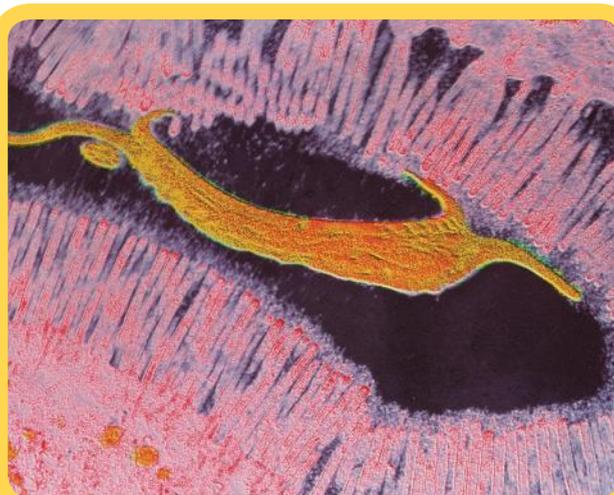


Fig 7.1.8 A transmission electron microscope or TEM

## The electron microscope

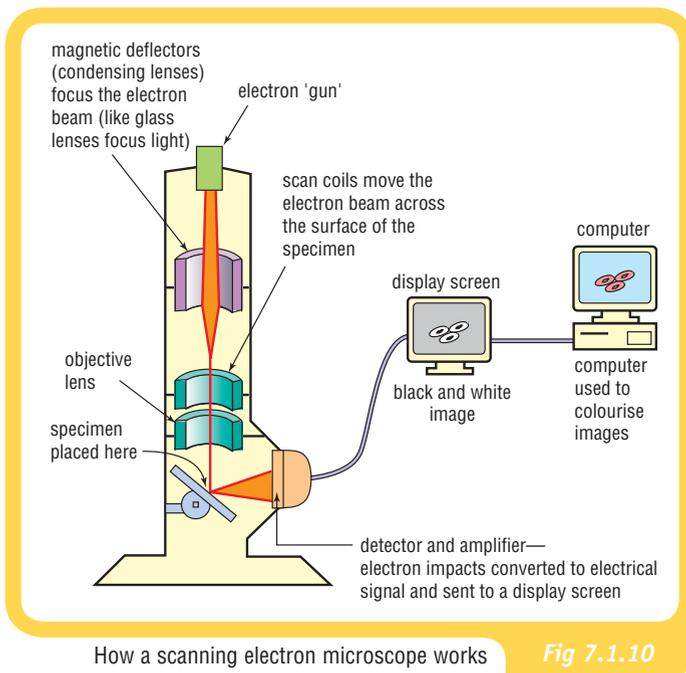
The **transmission electron microscope** (TEM) was invented in 1930 by Ernst Ruska and made commercially in 1938 to aid in the study of metals. Instead of using light, this type of microscope uses a beam of tiny negatively charged particles called **electrons** that are transmitted through a thinly sliced specimen. An image is then produced and projected onto a screen for viewing. When it was found that the beam of electrons did not destroy specimens from plants and animals, biologists were able to use the electron microscope to gather more details than ever before.

The transmission electron microscope can magnify up to around a million times, so it can reveal the delicate internal structure of cells and other specimens. See Figure 7.1.9 for an example of a transmission electron microscope (TEM) image.



TEM image of *Giardia protozoa*, a nasty bacterium found in contaminated water (magnified 1200 times)

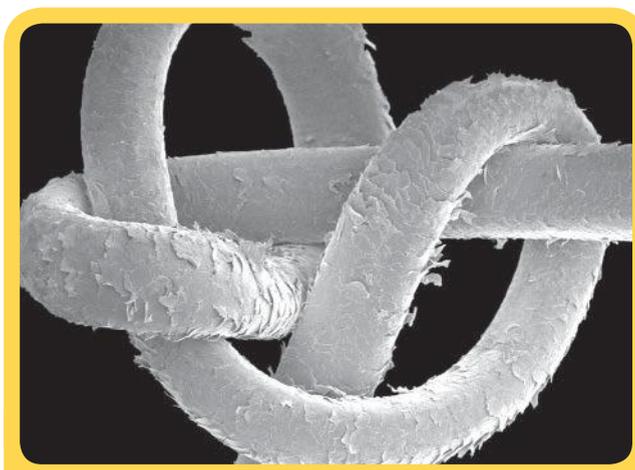
Fig 7.1.9



How a scanning electron microscope works **Fig 7.1.10**

A more recent development is the **scanning electron microscope**, or SEM, which moves a beam of electrons across the surface of the specimen and reconstructs an image, showing surface detail. Although first invented in 1942, the SEM did not become available commercially until 1965 due to problems with the electron beam. Specimens viewed with an SEM require less preparation but the images are not as detailed. Compare the images displayed in Figures 7.1.9 and 7.1.12.

Many of the impressive ‘super-magnified’ images seen in science magazines are obtained using an SEM. Although an SEM produces only black and white images (Figure 7.1.11), a computer may be used to add colour and so make more features obvious. Colour SEM pictures obtained this way are called ‘false colour’ images (Figure 7.1.12).



**Fig 7.1.11** A scanning electron microscope image of a knotted human hair



SEM image of *Giardia* in a human intestine (magnified 1100 times) **Fig 7.1.12**

## 7.1 [ Questions ]

### Checkpoint

#### The light microscope

- 1 Define the following:
  - a microscope
  - b microscopic

- 2 **Produce** a diagram showing the main parts of a microscope.
- 3 **Identify** another name for the eyepiece.
- 4 **Identify** who invented the microscope and in what year was it invented.

#### Using the microscope

- 5 **Summarise** the six steps for using a microscope by drawing a series of cartoons for its use.
- 6 **Produce** two rules concerning the safe handling of microscopes.

#### The electron microscope

- 7 **Explain** what electron microscopes were originally used for.

>>



- 8 Explain** how the electron beam travels in an electron microscope to produce an image.
- 9 State** what SEM stands for.

**Think**

- 10** Name two types of compound light microscope. **Identify** which of the microscopes would give a finer, more detailed image of the specimen.
- 11 State** the total magnification of the following microscopes.
- The eyepiece has a magnification of  $\times 20$  and the objective lens is labelled  $\times 40$ .
  - Both the objective lens and the eyepiece have  $\times 10$  on them.
  - The objective lens magnifies 100 times and the eyepiece magnifies 5 times.
  - Complete the table by calculating the magnification.

Eyepiece magnification	Objective lens magnification	Total magnification
$\times 10$		$\times 200$
	$\times 20$	$\times 300$
$\times 5$	$\times 20$	
	$\times 100$	$\times 1000$
$\times 30$		$\times 600$

- 12 State** the approximate maximum magnification of:
- a light microscope
  - an electron microscope

**Skills**

- 13** An image of a specimen obtained using a magnification of  $\times 50$  is shown below. Accurately sketch the image that would be obtained with a magnification of  $\times 200$ .

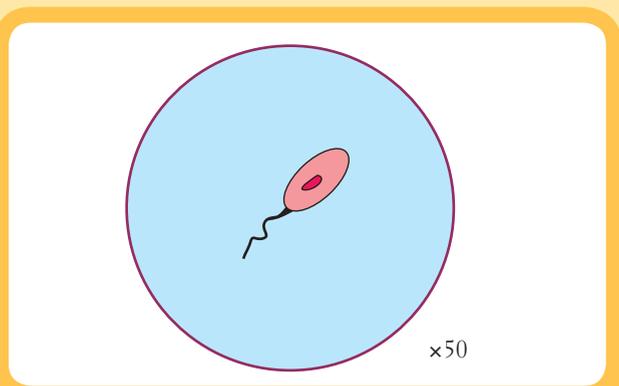


Fig 7.1.13

- 14** Sketch the following microscope specimen using the correct drawing technique.

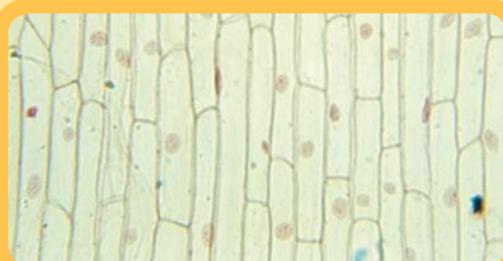


Fig 7.1.14 Onion cells

- 15** A specimen is 0.2 mm long. **Calculate** how long it appears if it is magnified by 1000 times.

**Analyse**

- 17 Explain** some advantages of the SEM over a transmission electron microscope.
- 18 Compare** an SEM and a light microscope by listing their similarities and differences in a table.

[ **Extension** ]

**Investigate**

- Create** a poster to teach other students how to use the microscope.
- Research** some other key people involved in the use and development of early microscopes, and give a brief presentation about their achievements. Choose from the following people: Galileo Galilei, Antoni van Leeuwenhoek, Giovanni Amici, Robert Brown, Matthias Schleiden and Theodor Schwann.
- A micrometer is an instrument that measures extremely small objects. **Describe** how it is used.
- Millimetre and micrometre are units often used when measuring small lengths. **Identify** what their symbols are.
- Describe** how specimens are prepared for viewing by an electron microscope. **Present** your findings in a flow chart.

# UNIT 7.2

## Plant and animal cells

### introduction

In 1663, the English scientist Robert Hooke discovered cells in cork. This is a special bark that is often used as a stopper for wine bottles and is similar to, but thicker than, the paper-like bark that you often find on trees in the park or school grounds.

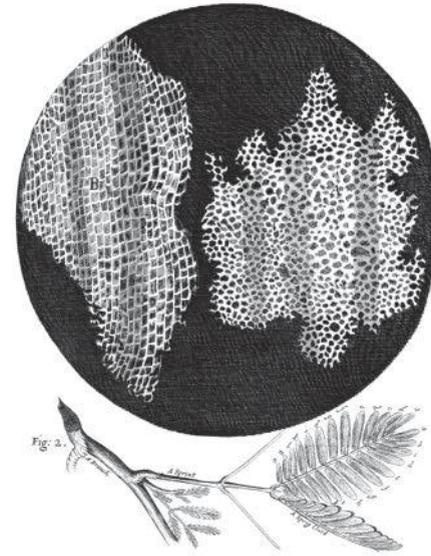
### Discovering cells

Using an early microscope, Hooke studied many different objects including feathers, the stinger of a bee and the foot of a fly. When he placed a thin strip of cork under his microscope he saw empty box-like shapes that looked like the small rooms, or **cells**, occupied by monks of the time. It was logical then to call these box-like shapes cells too.

It was not until nearly 200 years later, in 1839, that German biologists Theodor Schwann and Matthias Schleiden proposed the **cell theory** of life. This theory states:

- 1 All living things, or **organisms**, are made up of cells.
- 2 New cells are created by old cells dividing in two.
- 3 All cells are similar to each other, but not identical.

Cells may be thought of as the building blocks of life, and they come in a variety of types and sizes.



Hooke's first sketch showing 'cells' in cork

Fig 7.2.1

Skin, muscles, blood and plants are all made up of different types of cells. Most cells are so small that hundreds would fit on a full stop. Our bodies contain over a hundred million, million cells. An example of a very large cell is a hen's egg.

### Activity 3

#### A bird's egg — a single large cell

Birds' eggs are single large cells. Use the library or a science textbook to check if this is correct. If a bird's egg is available, break open the egg in a cup or container or a petri dish. Notice the yellow yolk and the clear albumen (the 'white'). Look at the yolk carefully and you should see a tiny white patch. If this egg has an embryo forming, you will observe the 'ropes' in the albumen.

Draw the egg and label the parts, then answer the questions.

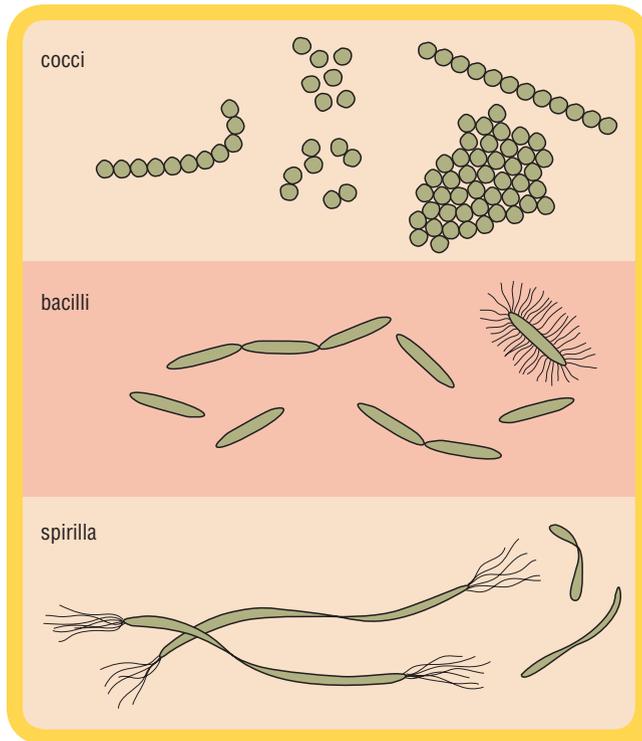
#### Questions

- 1 What does the tiny white patch in the yolk represent?
- 2 **Identify** the part of the egg that contains the cytoplasm.
- 3 Which part of the egg will develop into a young chicken?
- 4 What do you think the ropes in the albumen are for?

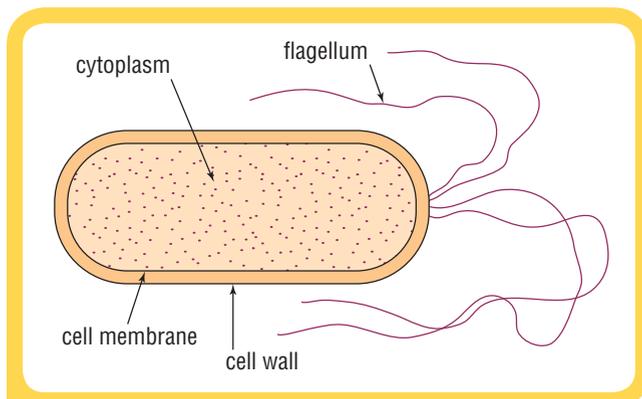


The simplest type of cell is a bacterial cell.

**Bacteria** (sometimes called **germs**) are tiny cells that can have either good or bad effects. There are different types of bacteria (see Figure 7.2.2) that help us digest food, break down dead plants and animals in soil, and cause disease.



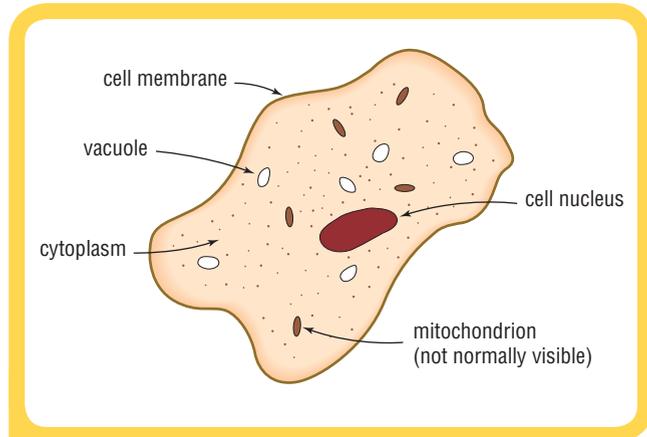
The three different types of bacteria **Fig 7.2.2**



**Fig 7.2.3** A diagram of a bacterium showing its main features

There are two main types of cells—animal and plant cells. Each cell is made up of parts called **organelles**. Each organelle does a separate job inside the cell.

## Animal cells



**Fig 7.2.4** A diagram of an animal cell showing the main organelles

Cells from animals such as humans, pigs or frogs have several organelles in common.

- 1 **Cell membrane**—this is a thin, flexible outer layer that surrounds the cell and controls what goes in or comes out.
- 2 **Cytoplasm**—this jelly-like liquid fills most of the cell and contains hundreds of different chemicals. The cytoplasm is the chemical factory of the cell.
- 3 **Vacuoles**—these are storage areas that may contain air, water, wastes and food particles. Animal cells often contain several small vacuoles.
- 4 **Cell nucleus**—this is the ‘control room’ of the cell. It contains genes. Each gene contains information for the production of chemicals. The nucleus controls all chemical reactions in a cell. It also controls how the cell develops and functions. The nucleus also contains instructions for building new cells.
- 5 **Mitochondria**—these small objects are the power house of the cells. Each mitochondrion uses sugar and oxygen in a series of chemical reactions to release energy. Mitochondria are so small that they cannot be seen using a light microscope. Mitochondria were first described in muscle cells by Rudolph von Kolliker, a Swiss anatomist and physiologist, in 1857.

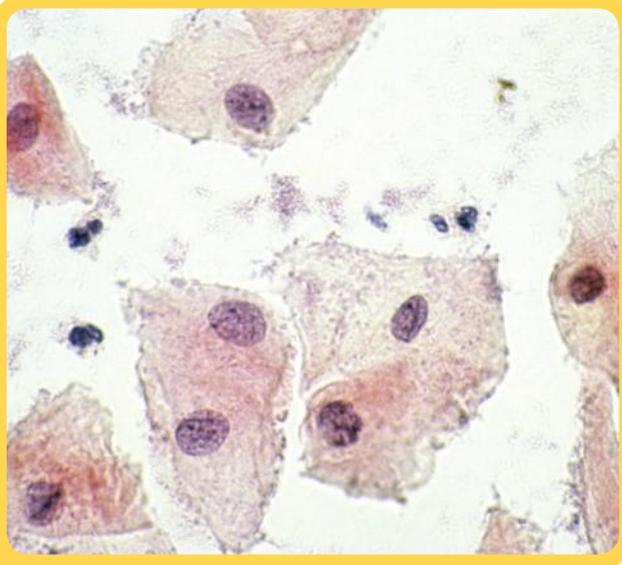


Fig 7.2.5 Stained human cheek cells

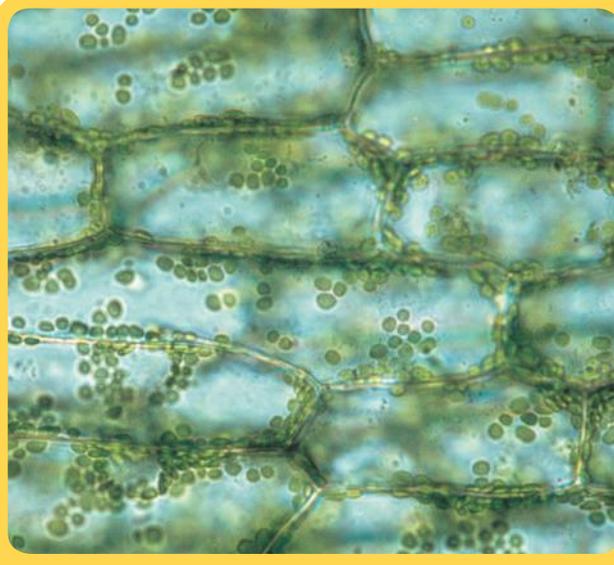
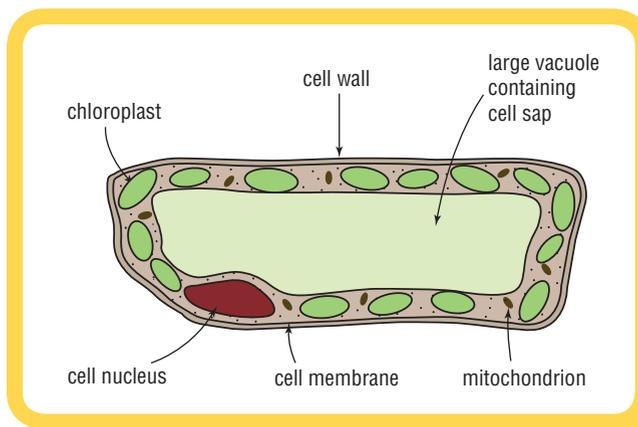


Fig 7.2.7 Plant cells

## Plant cells

As stated in the cell theory, all cells are similar but not identical. Plant cells have several features in common with animal cells, but there are also some differences.

Unlike animals, plants need to make their own food with the help of sunlight, carbon dioxide and water. They do this in a process known as **photosynthesis**. Photosynthesis occurs in organelles called **chloroplasts** inside leaf cells. Chloroplasts may be seen using a light microscope. Chloroplasts contain a green chemical, **chlorophyll**, which traps the light energy plants need for photosynthesis. The **cell wall** contains a tough fibrous material called cellulose and provides the support needed by the plant cell. Plant cells contain a single large vacuole filled with **cell sap**.



A plant cell showing the main organelles Fig 7.2.6

## Activity 4

### Comparing animal and plant cells

Study the animal and plant cell diagrams (Figures 7.2.4 and 7.2.6). Indicate in the table the similarities and differences between the two types of cells.

- 1 Put a tick (✓) in the space where the feature is present and a cross (x) where the feature is absent.
- 2 Write the differences between the two types of cells.
- 3 Muscle cells contain large number of mitochondria. Explain this observation.

Features	Animal cell	Plant cell
Cell nucleus		
Cell wall		
Cell membrane		
Cytoplasm		
Vacuole		
Chloroplast		
Mitochondria		

## Activity 5

### Onion and banana cells

**Aim** To observe and draw plant cells

**Equipment**

A microscope, potassium iodide stain, lamp, filter paper, glass microscope slide, eye dropper, water, cover slip, onion skin, banana sample, wooden spatula (an icy pole stick is ideal)

**Method**

- 1 Obtain a thin (one cell thick) layer of onion skin. Your teacher will show you how to do this.
- 2 Place a small sample of the onion skin onto a glass microscope slide.
- 3 Place a drop of water on the sample.
- 4 Carefully place a cover slip on top of the onion skin and water.
- 5 Observe at two different magnifications using the microscope.
- 6 Draw your field of view at the two different magnifications.
- 7 Smear a thin layer of banana onto a clean glass microscope slide.

- 8 Place a drop of iodine stain on the sample.
- 9 Carefully place a cover slip on top of the banana and stain.
- 10 Obtain a clear image using the microscope and draw what you see.

**Questions**

- 1 **Explain** why the stain was recommended when viewing banana cells, but not for onion cells.
- 2 **Identify** which cells were easier to observe.
- 3 **Describe** some of the similarities and differences you observed between banana and onion cells.

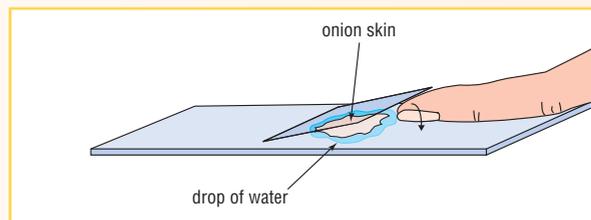


Fig 7.2.8 Lowering the cover slip

## 7.2 [ Questions ]

UNIT

**Checkpoint**

**Discovering cells**

- 1 **Identify** who first used the term 'cell' to describe the small structures in a slice of cork.
- 2 **State** when Schwann and Schleiden proposed the cell theory.
- 3 Write three points to briefly **describe** the cell theory.
- 4 **Identify** the simplest type of cell.

**Animal cells**

- 5 **Identify** the part of a cell that could be called:
  - a the 'control room'      b the 'chemical factory'
  - c the 'gatekeeper'      d the 'powerhouse'
  - e the 'walls'
- 6 **Identify** three types of body cells.

**Plant cells**

- 7 **Identify** the green substance in plant cells and **state** its function.
- 8 **Clarify** the following terms related to plant cells:
  - a photosynthesis      b cell wall      c cellulose
- 9 **Identify** three differences between plant and animal cells.

**Think**

- 10 **Compare** an organelle in a cell to an organ in the human body. How similar are they in what they do?
- 11 **Clarify** the term 'organism'.
- 12 **Identify** how big cells are.
- 13 **State** how many cells our bodies are thought to contain.
- 14 Draw a diagram of an animal cell and a plant cell side by side. **Compare** the cells by labelling the parts that are common to both with one label.
- 15 Muscle cells contain large numbers of mitochondria. **Explain** this observation.
- 16 **Identify** the contents of a vacuole if it is in a:
  - a plant cell      b animal cell

**Analyse**

- 17 **Construct** a table like the one shown here to **compare** animal and plant cells. Make sure you include some similarities and some differences.

Feature	Animal cell	Plant cell

- 18 Plant cells need to have thicker walls than animal cells. **Explain** why.
- 19 **Explain** why there are fewer types of plant cells than animal cells.

# UNIT 7.3

## Specialised cells

### introduction

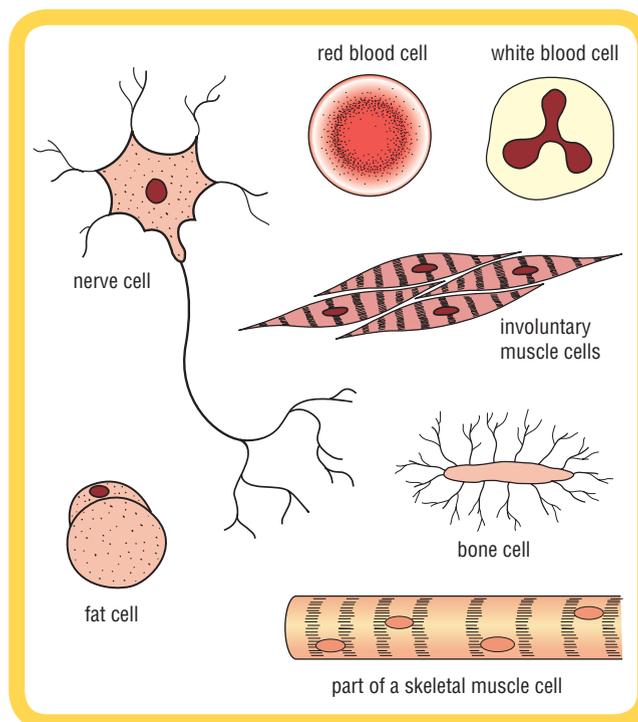
The first cells on Earth were very similar to the simplest cells we find on Earth today, the bacteria cells. Each bacteria is made up of only one cell. Each bacterial cell does everything needed to keep the bacterium alive. In more complicated organisms, cells live together in groups or colonies. In these colonies the cells are **specialised**. Specialised cells in colonies do particular jobs which could not be done by single cells living alone. Some cells, for example, specialise in swimming and others in feeding.

The larger a plant or animal is, the more specialised cells it contains. The human body is an example of a multicellular organism. It is made up of millions of cells. There are about 200 different types of specialised cells. These cells carry out several jobs or functions.

### Different types of human cells

Animals and plants that are made up of lots of cells working together are called **multicellular**, meaning 'many cells'. The human body must carry out several different jobs or functions, and it requires many different types of cells to do so. Having different types of cells makes doing these jobs more efficient, as cells can focus on one main thing at a time.

Blood cells carry food and oxygen around the body, muscle cells assist movement, nerve cells send messages from the brain to the muscles, skin cells cover our bodies and keep out infection, bone cells help support the body and protect the internal organs, fat cells insulate the body and store energy, while sperm and eggs cells can combine to produce a new human being.



Various types of human cells, each specialised for a different purpose

Fig 7.3.1

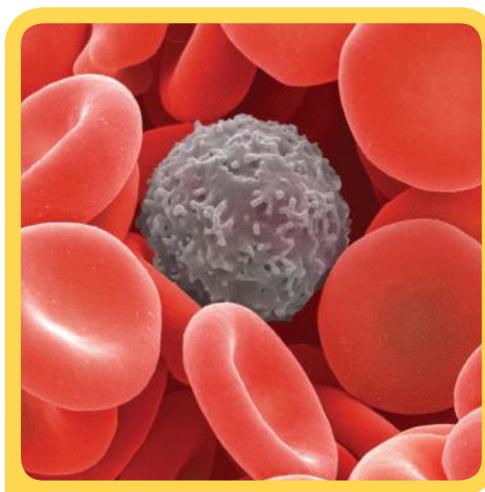


Fig 7.3.2

A coloured SEM image, magnified 3000 times, of red and white blood cells

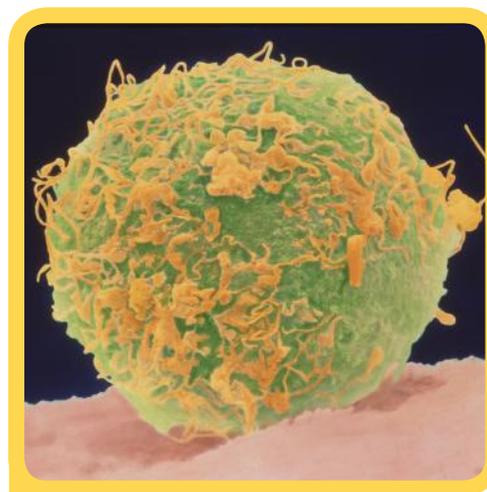


Fig 7.3.3

SEM image of sperm cells and an egg cell

## Plant cells

Plants also contain different types of cells that perform different functions. Several types of specialised plant cells are shown in Figures 7.3.4 to 7.3.8.

A layer of cells near the top of a leaf does most of the **photosynthesis**. Chloroplasts in the cell use energy from the Sun to convert carbon dioxide and water into glucose. This is then used as food for the plant. Oxygen is made as a waste material.

Special **conducting cells** form tubes or pipes that transport water and nutrients to all parts of the plant.

When plants take in carbon dioxide they give out oxygen and also lose a little water from their leaves. Special **guard cells** on the underside of a leaf open and close small openings called **stomata** to reduce this water loss. Stoma is the term for a single stomata.

Water is absorbed from soil by **root hair cells**.

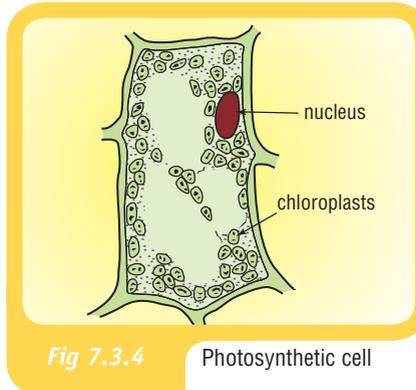


Fig 7.3.4 Photosynthetic cell

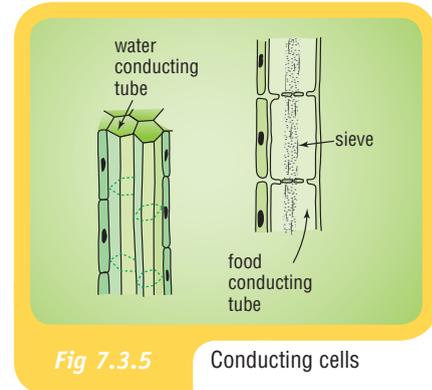


Fig 7.3.5 Conducting cells

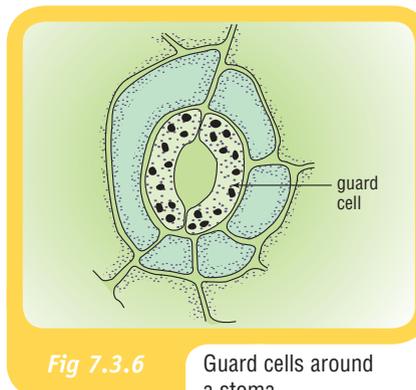


Fig 7.3.6 Guard cells around a stoma



Fig 7.3.7 SEM image showing the guard cells around an open stoma

## Activity 6

### Viewing prepared slides

**Aim** To observe prepared microscope slides of specialised plant and animal cells

#### Equipment

Prepared slides of various specialised plant and animal cells, microscope, lamp

#### Method

- 1 Observe a prepared slide using a microscope.
- 2 Sketch the image and label your sketch. Include the name from the slide and the magnification used.
- 3 Repeat with several different slides of plant and animal cells.

#### Questions

- 1 **Compare** the slides, looking for any similarities and differences.
- 2 **Explain** the advantages of using prepared slides rather than obtaining your own specimens.
- 3 **Describe** the features within the cells that you were able to observe.

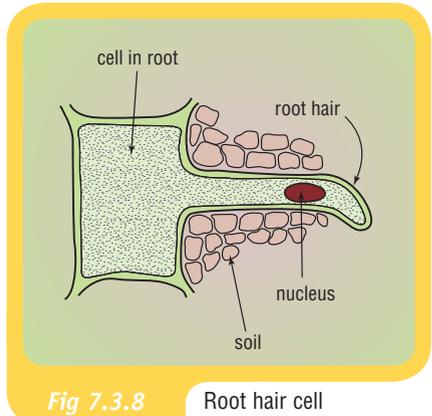


Fig 7.3.8 Root hair cell

## Single-celled organisms

While humans contain more than 200 different types of cell, there are some simple forms of life that are made up of only a single cell. These organisms are called **unicellular**, meaning 'one cell'. This cell carries out all the required functions such as food intake and movement.

You can usually find unicellular organisms in a drop of pond water viewed under a microscope.

Because some single-celled organisms show both plant and animal characteristics, they are often classified not as plants or animals, but as **protists**. Different types of protist include:

- 1 **flagellates**—these have a long, whip-like tail or flagellum that helps them move, e.g. *Chlamydomonas* and *Euglena*
- 2 **ciliates**—they move due to a wave-like beating of tiny hairs (or cilia), e.g. *Paramecium*
- 3 **amoebas**—they have no definite shape but flow rather than swim
- 4 **sporozoans**—they generally don't move themselves, but exist and move with other cells. The potentially deadly disease malaria is caused by a sporozoan that lives in blood cells. This sporozoan is the plasmodium. The plasmodium can move from person to person when a mosquito passes on infected blood to a new victim.

Not all unicellular organisms cause disease—many are important parts of the food chain.

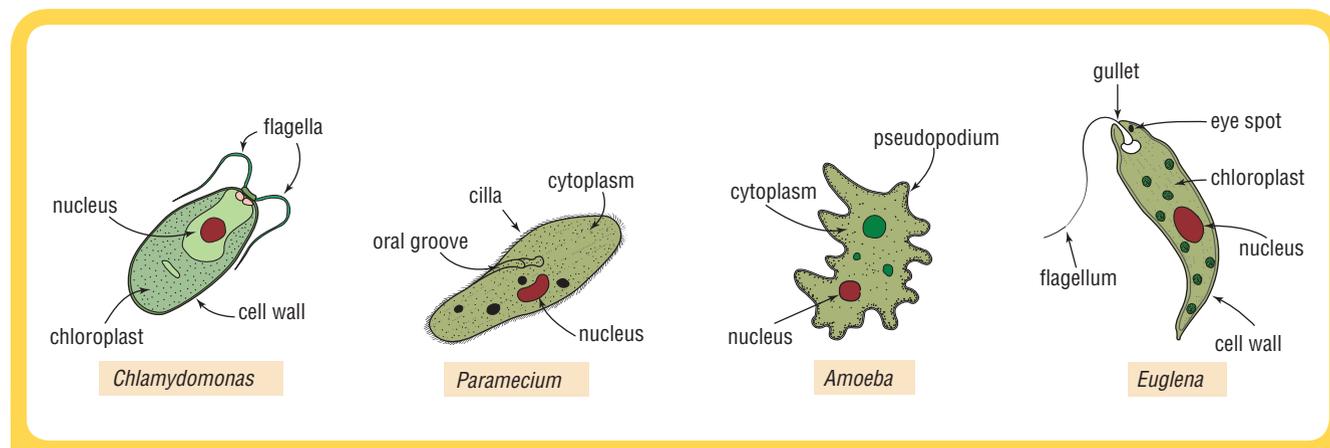


Fig 7.3.9 Single-celled organisms commonly found in pond water

## Activity 7

### Life in a drop of water

**Aim** To observe and draw single-celled organisms in pond water

#### Equipment

Some pond water, or other water containing single-celled organisms (e.g. a hay infusion), microscope, lamp, glass microscope slide, cover slip, eye dropper

#### Method

- 1 Place a drop of pond water onto the glass microscope slide and cover it with a cover slip.
- 2 Use a microscope to obtain a view of the life within the drop of water.
- 3 Sketch as many different organisms as you can.

#### Questions

- 1 **State** how many different organisms you saw.
- 2 **Explain** how they appeared to move.
- 3 If possible, **identify** and **name** each type of organism.



## 7.3

## UNIT

## [ Questions ]

**Checkpoint***Different types of human cells*

- 1 **State** the type of human cells that:
  - a help keep out infection
  - b send messages from brain to muscle
  - c carry oxygen
  - d assist with movement
- 2 Draw two different types of human cell and **state** their function.
- 3 **State** approximately how many different types of specialised cells there are in the human body.

*Plant cells*

- 4 **Identify** four types of specialised plant cells.
- 5 **Describe** what would happen to a plant without guard cells.
- 6 The cells on a leaf that specialise in photosynthesis are found only on the upper surface. **Explain** why.

*Single-celled organisms*

- 7 **State** another name for a single-celled organism.
- 8 **Identify** four types of unicellular organism.
- 9 **Identify** a disease caused by a unicellular organism.

**Think**

- 10 Construct a diagram to **explain** how an amoeba reproduces.
- 11 Draw labelled diagrams of two different protists to **clarify** their structures.
- 12 **Describe** a flagellum.
- 13 **Identify** which type of protist moves by beating many hair-like structures.

**Analyse**

- 14 Two types of conducting cells form vessels that are grouped together in a plant. **Explain** why this is a good idea.
- 15 One type of protist has something in common with plants. **Identify** which protist it is and what it has in common.

[ **Extension** ]**Investigate**

Many diseases are caused by protozoa, including malaria. **Construct** a brochure to be placed in a doctor's clinic to teach others about malaria. Your information should include:

- a the cause of the disease
- b the signs and symptoms of the disease
- c who is most likely to get the disease
- d methods to prevent infection
- e possible cures or treatments.

## Groups of cells

## introduction

People in a group can perform more complex tasks than one person alone. Like people, the different specialised cells in our bodies are organised into groups to help them work more effectively.

## Cells, tissues and organs

A human being develops from a single fertilised cell called a zygote. The zygote forms by joining a male sperm cell and a female egg cell (see Figure 7.3.3). This cell then divides to form two new cells. The two new cells then divide to form four cells and so on and so on, until millions of cells are present.

Groups of similar cells are called **tissue**. Tissues in turn may be grouped together to form an **organ**. For example, heart cells form heart tissue, which makes up the heart, the organ specialised for pumping blood around the human body. Skin cells form skin tissue that makes up another organ—the skin.

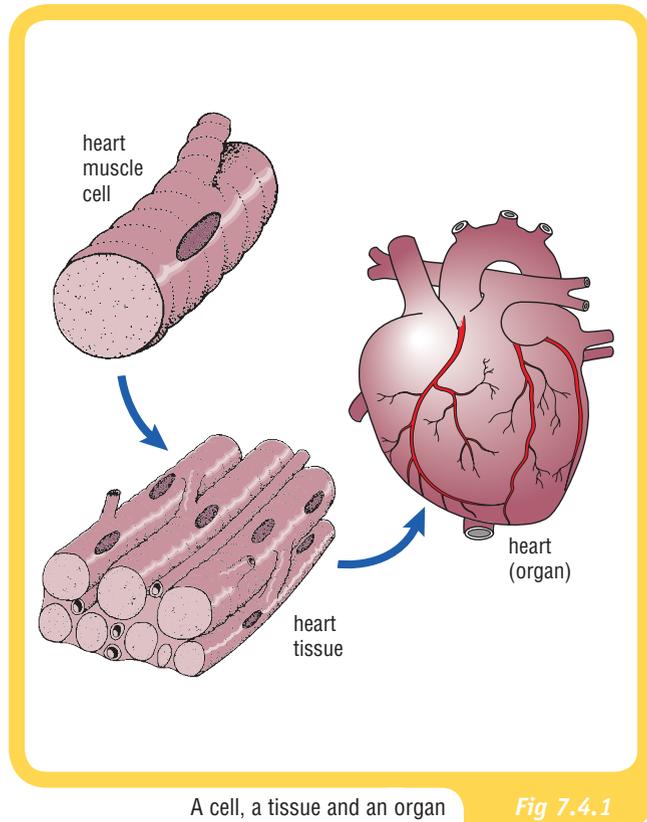
Some other human organs made from specialist tissue and cells are the brain, intestines, liver, kidneys and eyes.

Animals and plants may contain several different organs.

## Activity 8

## Body systems

- 1 a What is a system?  
b What is a body system made up of?
- 2 Name some other systems in the human body. Name some of the organs in each system.
- 3 Describe the differences between a tissue and an organ in a body system.



A cell, a tissue and an organ

Fig 7.4.1

## Systems

A group of organs that work together is called a **system**. For example, in humans and animals, groups of muscles work together to form the muscular system. Some other human body systems are described briefly here and will be studied in more detail later.

Several systems together form an **organism**, or living thing, such as a human.

In humans, the **nervous system** includes the brain, spinal cord and nerves. The brain and spinal cord are referred to as the **central nervous system**; they send and receive messages that are carried by the nerves as a series of electrical signals and chemical changes.

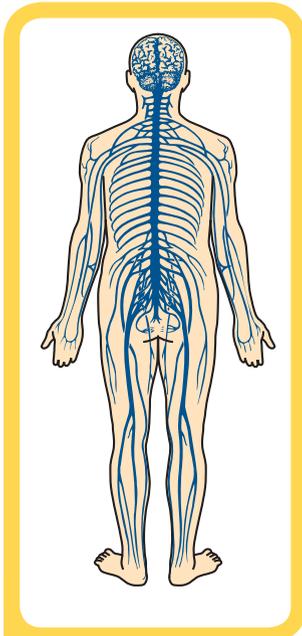


Fig 7.4.2 The nervous system

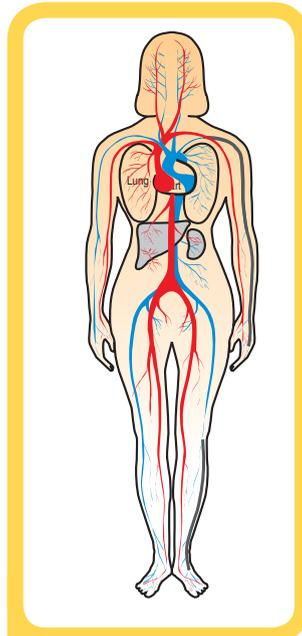


Fig 7.4.3 The circulatory system

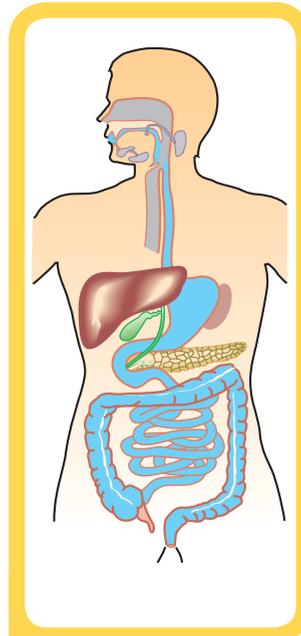


Fig 7.4.4 The digestive system

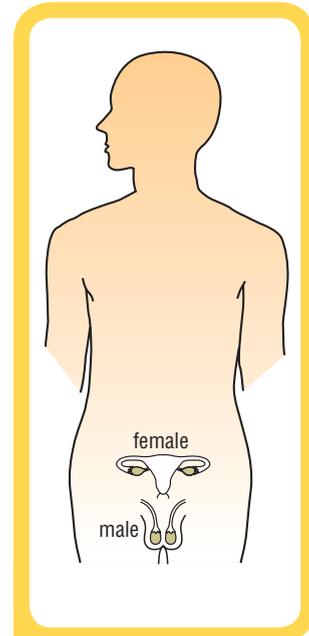


Fig 7.4.5 The reproductive system

The **circulatory system** consists of the heart and blood vessels that carry food and oxygen to cells. Waste materials in the blood are transported to other organs for separation before being removed from the body.

The **digestive system** includes the stomach and intestines and breaks down food into substances small enough to be absorbed into the bloodstream. Some separation of waste materials also occurs here.

The **reproductive system** produces sex cells and contains the organs required for sexual reproduction. In a woman, this includes the uterus (sometimes called the womb), where a baby develops.

The **respiratory system** includes the trachea (or windpipe), lungs and diaphragm. The respiratory system is where oxygen is transferred to the blood for circulation to other parts of the body. Carbon dioxide is expelled from the lungs when we breathe out.

Excretion is the removal of waste from the body. The lungs expel carbon dioxide and the skin excretes sweat, but the main body system involved in excretion is the **urinary system**. Here, the kidneys filter out wastes from the blood and control the amount and contents of body fluids, producing urine in the process.

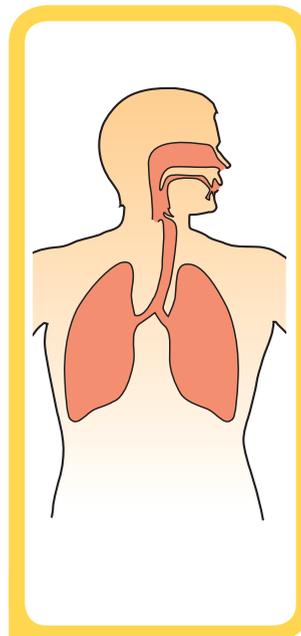


Fig 7.4.6 The respiratory system

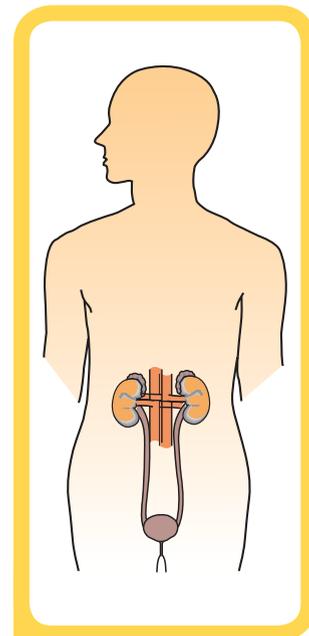
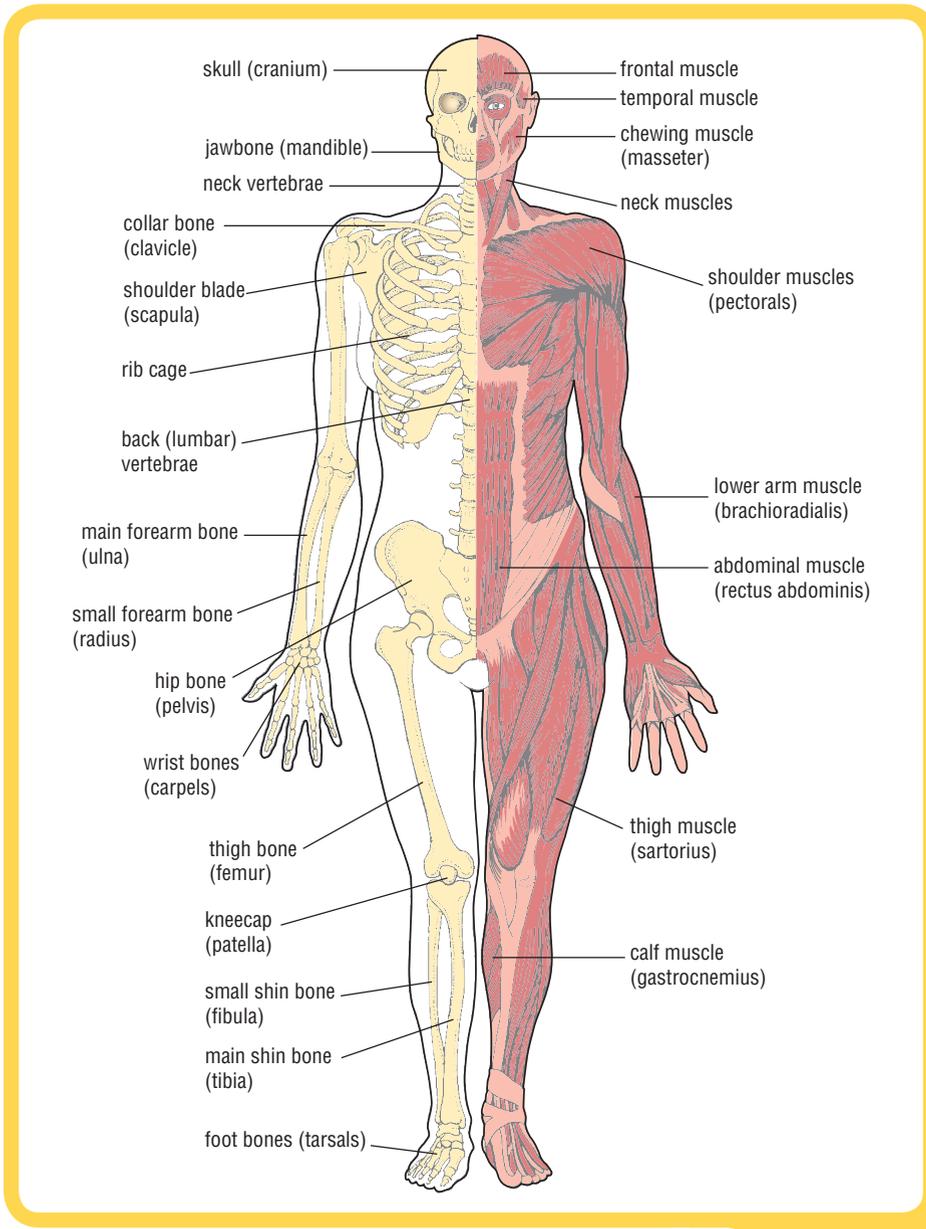


Fig 7.4.7 The urinary system

The **skeletal** and **muscular systems** work together to provide protection, movement and support for the body.



The major parts of the skeletal and muscular systems **Fig 7.4.8**

## Plant systems

Plants are also made of cells which group together to form organs and systems.

Leaf cells group to form a leaf, which is an organ of the plant. Several leaves form a food-making system for the plant. Other plant systems may include:

- a reproductive system consisting of the parts of a flower
- a food and water transport system consisting of a network of veins
- a food-storage system in the form of a bulb
- a root system for securing the plant in the ground and obtaining water and nutrients from the soil.

These plant systems are studied in more detail later.

**3 State** the names of four different organs.

### Systems

**4 Describe** what is meant by the term 'body system'.

**5 Copy and complete** the table below to **summarise** the six body systems.

Body system	List of its parts	Brief description of what it does

>>

## Questions

### Checkpoint

#### Cells, tissues and organs

- 1 Clarify** what the word 'zygote' means.
- 2 Copy and complete**, using the words *tissue*, *organ* and *cells* (one word is used twice): Many \_\_\_\_\_ form \_\_\_\_\_. Groups of \_\_\_\_\_ make up an \_\_\_\_\_.



**Think**

**6** In Figure 7.4.9, if a cell is represented by a circle (shown in diagram A), **select** the diagram (from B, C, D or E) that best represents:

- a tissue
- b an organ
- c a body system

Note that each answer is different.

**7 Identify** which body system is the main one involved in each of the following situations.

- a Your face goes red after you run for a kilometre.
- b Your leg moves up after you are tapped on the knee.
- c You need to go to the toilet.
- d You feel 'full' after a meal.
- e You gasp for air after swimming under water.

**8** Look at each body system on page 142 and **name** at least one organ in each system.

**9** Where in the human skeleton would you expect to find an example of each of the joints shown in Figures 7.4.10, 7.4.11 and 7.4.12?

**10** Study the plant diagram in Figure 7.4.13 and **state** which part contains each of the following systems.

- a reproductive system
- b food-making system
- c food and water transport system
- d water absorption and anchoring system
- e food-storage system

**11 Describe** what you think the term 'locomotion system in humans' means.

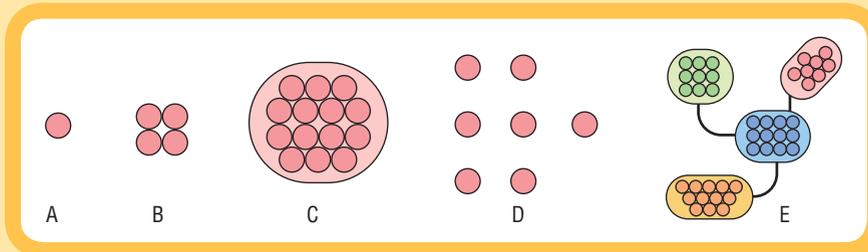


Fig 7.4.9

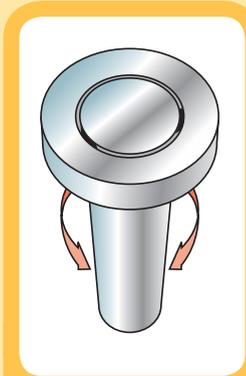


Fig 7.4.10 Pivot joint

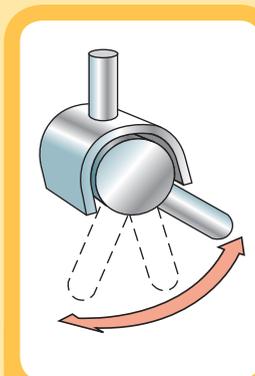


Fig 7.4.11 Hinge joint



Fig 7.4.12 Ball and socket joint

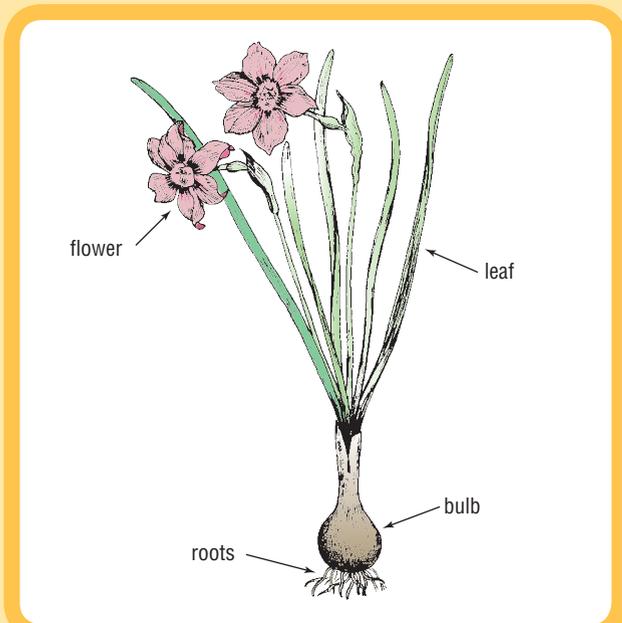


Fig 7.4.13

# Chapter review

## [ Summary questions ]

- 1 What is a compound microscope?
- 2 **State** two rules you should remember when using a microscope.
- 3 **List** the main parts of the microscope from its top to its base.
- 4 **State** the type of material Robert Hooke was looking at when he coined the term 'cells'.
- 5 **Sketch** a bacterium, showing its main parts.
- 6 **Sketch** an animal cell and label its parts.
- 7 **Sketch** a plant cell. Label its parts.
- 8 **Explain** the function of each of the following cell organelles.
  - a cell membrane
  - b cell wall
  - c cytoplasm
  - d vacuole
  - e cell nucleus
  - f chloroplasts
- 9 **Explain** what a specialised cell is.
- 10 **Name** three types of human cells and state what job each does.
- 11 **Name** two specific protists and state which type of protist each one is.
- 12 **Identify** whether a protist is a multicellular or unicellular organism.
- 13 **Describe** two different types of plant cell, and what each does.

## [ Thinking questions ]

- 14 **Calculate** the overall magnification for a microscope with a 20 x eyepiece and a 50 x objective lens.
- 15 **Explain** why it is important to develop different types of microscopes.
- 16 **State** the names of two different types of microscopes and **explain** the benefits of each to society.

- 17 **Identify** two features that plant and animal cells have in common.
- 18 Copy and complete the following table to **summarise** the history of cells. Include as many scientists as you can find throughout this chapter.

Date	Scientist	Discovery
1609	Hans Janssen and his son	Invented the compound microscope

## [ Interpreting questions ]

- 19
  - a Use examples to **distinguish** between unicellular and multicellular organisms.
  - b **List** the advantages and disadvantages of an organism being multicellular.
  - c **List** the advantages and disadvantages of an organism being unicellular.
  - d **Evaluate** whether unicellular or multicellular organisms have a greater advantage in terms of survival.
  - e Are humans unicellular or multicellular? **Explain** your answer.
- 20 **Identify** which of the words below involves:
  - a the most cells
  - b the least cells*tissue, body system, organ*
- 21 Choose two body systems and **describe** them briefly. Include a simple diagram that shows the main parts of the systems.

# Light and colours

## CHAPTER

## 8

By the end of this chapter learners should be able to:

- Identify luminous and non-luminous objects.
- Describe different uses of some important luminous objects in our everyday life, e.g. *kerosene lamps, light bulbs, torch light, Sun, fireflies.*
- Use simple experiments to demonstrate that light travels in a straight line: *casting shadows using sunlight or torch light, see through straight and bent pipe.*
- Demonstrate bending of light rays by passing the rays through glass or water.
- Conduct simple experiments to show the reflection of light on plane and curved surfaces.
- Draw the different types of lenses and show the light rays as they move away from the lenses.
- Demonstrate the use of curved mirrors and lenses: *rear view mirrors as safety mirrors in vehicles; security mirrors in shops and supermarkets; in telescopes, binoculars and microscopes.*
- Demonstrate that dark surfaces absorb light and white surfaces reflect light, e.g. *pass light through black and white surfaces.*
- Recognise the rainbow as the natural spectrum of colour.
- Use a prism (or water trough and mirror) to observe the spectrum.

- 1 Why do reflectors on a bike appear bright only when lights shine on them?
- 2 Why does there often appear to be water lying on bitumen roads on hot days?
- 3 Why do cameras, microscopes and our eyes need lenses?
- 4 Why do shops often have curved mirrors high up on the wall?
- 5 Unless you are under water, it is very difficult to spear a fish. Why?
- 6 Why is the sky blue?
- 7 When mixed, yellow and blue make green. True or false?





# UNIT 8.1

## Light

### Introduction

You see it every day and use it every night. Without it you cannot see. What is it? It's light! Light is the fastest form of energy known. It travels at 300 000 kilometres per second and does not need a material to travel through. (Just as well, as it has to travel through empty space.) At this speed, light only takes about eight and a half minutes to travel 150 million kilometres from the Sun to the Earth.

### Luminous and non-luminous

We see objects because they either give out their own light (such objects are called **luminous**) or they reflect the light coming from something else (**non-luminous**). Most objects that we see are non-luminous. We see them only because they reflect sunlight or artificial light (e.g. from a light bulb) to our eyes.

Figures 8.1.1 to 8.1.4 show some examples of luminous and non-luminous objects.

The Sun and a light bulb are examples of **incandescent** objects. These are objects that give out both heat and light. A firefly and an angler fish are examples of **bioluminescent** creatures—living things that give out light without heat.

### Shadows

Shadows are formed when an object blocks the light aimed at a surface. We can predict the position and type of shadow (sharp or unclear) using the fact that light travels in a straight line. The term **umbra** is used to describe a full or sharp shadow. When a larger light source is used, the shadow formed consists of a small umbra and a much larger partial shadow called the **penumbra**. The effect of the size of the light source on the shadow produced is shown in Figures 8.1.6 and 8.1.7.

#### Luminous



Fig 8.1.1 The Sun

#### Non-luminous



Fig 8.1.2 The Moon



Fig 8.1.3 A red traffic light

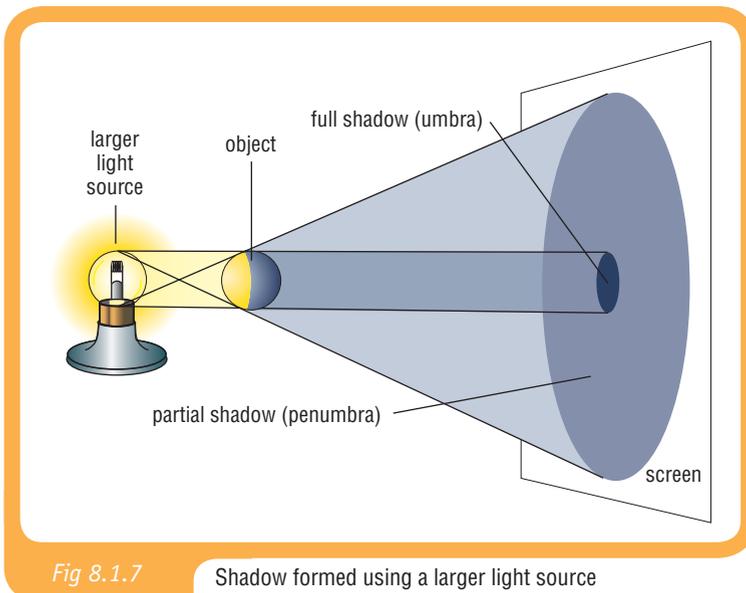
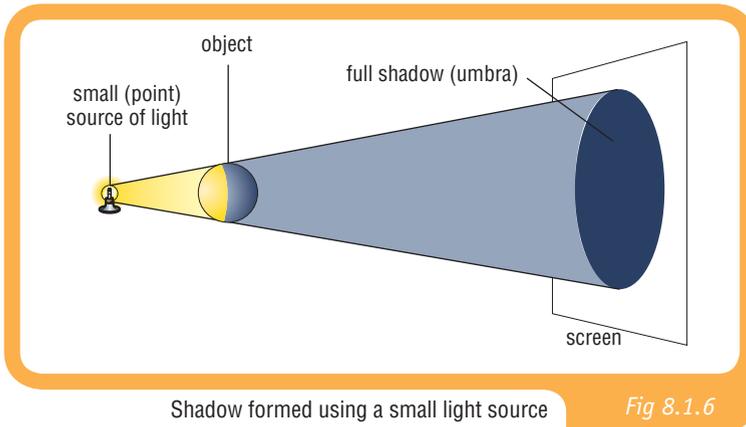


Fig 8.1.4 A tennis ball



The angler fish uses bioluminescence to attract prey.

Fig 8.1.5

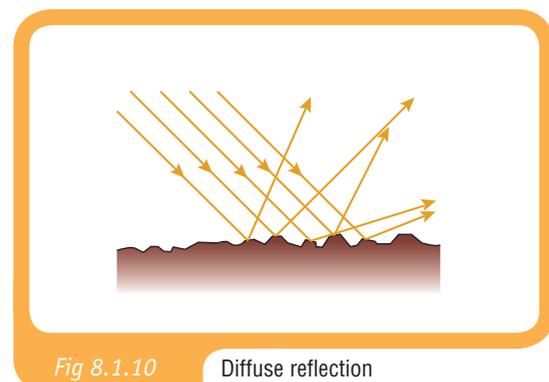
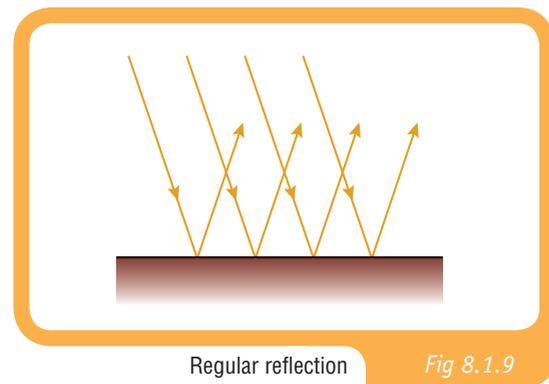
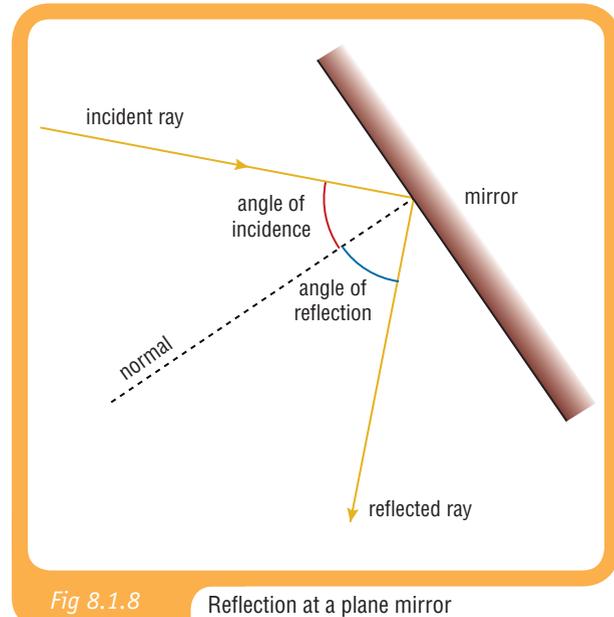


## Reflection

**Reflection** occurs when light rays 'bounce' off a surface. There are two main types of reflection: regular and diffuse. **Regular reflection** occurs at a very smooth surface, such as a mirror or polished metal, and forms a clear image in it. If we cannot see a clear image, then **diffuse reflection** has occurred. For example, light may reflect from a tabletop, but not well enough to form a clear image. Even though it appears smooth, a tabletop surface is quite rough compared to a mirror.

Both types of reflection obey the **law of reflection**. This law states that the angle of the incoming ray is always equal to the angle of the reflected ray.

We measure these angles between the rays and a line called the **normal**, which is drawn at right angles to the surface.





## Activity 1

### The pinhole camera

**Aim** To show that light travels in a straight line

#### Equipment

A small cardboard box (e.g. a taiyo box), aluminium foil, tracing paper, masking tape, a candle, scissors

#### Method

- 1 Remove a section from each end of the box, and replace it with foil at one end and tracing paper at the other. Seal all gaps with masking tape.
- 2 Make a small hole in the centre of the foil using a compass point or similar small point.
- 3 Place a lit candle about 30 cm in front of the pinhole/foil end of the box.
- 4 Make sure the room is as dark as possible. Observe the image formed at the tracing paper end of the box.
- 5 Investigate the effect of moving the candle to different distances from the pinhole.
- 6 Investigate the effect of increasing the size of the pinhole.

#### Questions

- 1 **Compare** the pinhole camera with a real camera. What section represents the film?
- 2 Copy and complete Figure 8.1.12. Which way up is the image?
- 3 **Explain** what happens to the image when:
  - a the candle is moved further away from the camera.
  - b the hole is made larger.

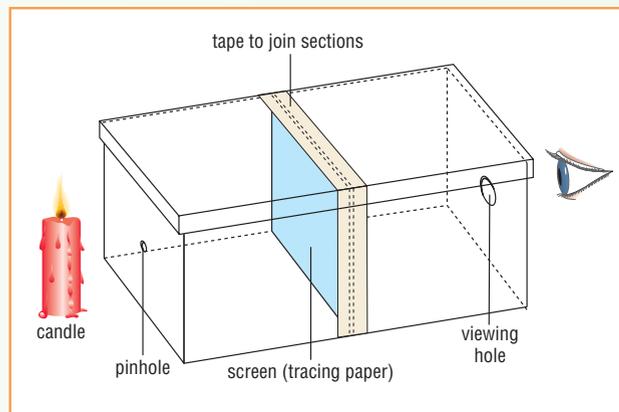


Fig 8.1.11 Pinhole camera

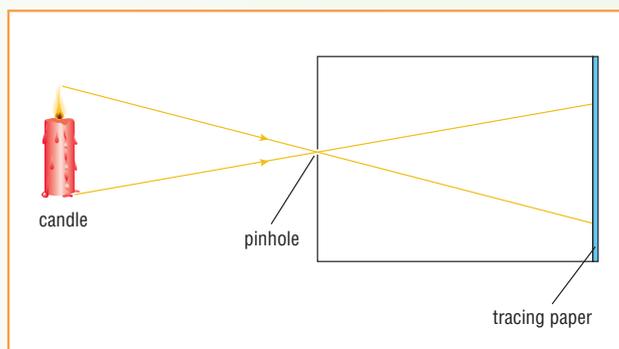


Fig 8.1.12

### Images and ray tracing

When you look into a flat or plane mirror, you see an image of yourself the same distance behind the mirror, yet you know there is actually no one there. Such an image is called a **virtual image**. Virtual images can be identified when it is known that the light does not actually come from the image (in this case, light does not come from behind the mirror). The law of reflection explains how virtual images are formed.

Figure 8.1.13 shows a diagram of an object (a candle) placed in front of a mirror. The lines indicate a single ray of light. Note that the image is the same distance as the object in front of the mirror.

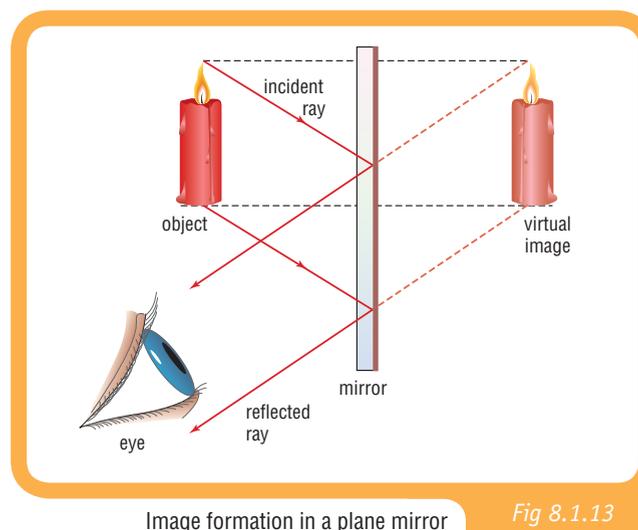
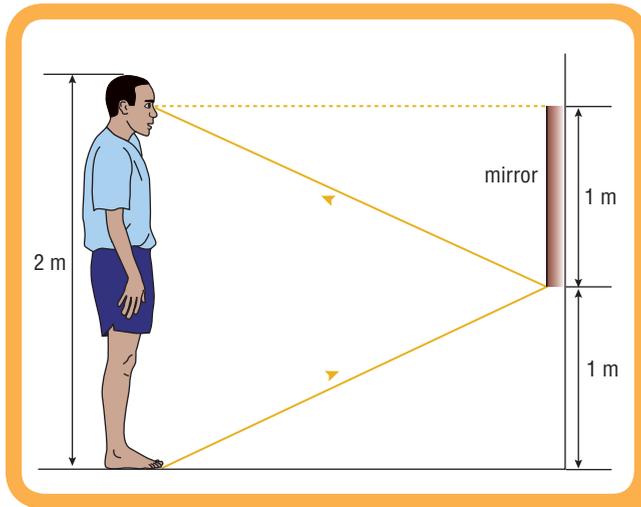


Image formation in a plane mirror

Fig 8.1.13

## Uses of plane mirrors

Mirrors are used in many clothes shops for obvious reasons. Figure 8.1.14 shows that in order to see your whole body in a plane mirror, a mirror only half your height is needed if it is placed at the right level.



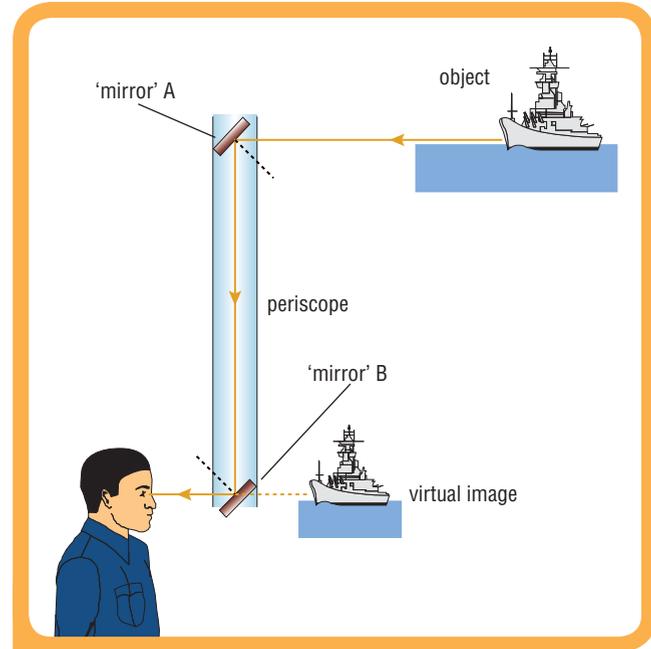
You do not need a mirror the same size as yourself to see your whole body. *Fig 8.1.14*

Have you noticed how the image of writing appears the wrong way around in a mirror? This effect is known as **lateral inversion**. Emergency vehicles such as ambulances and fire engines often have their names written back to front so they are easily read in rear-view mirrors.

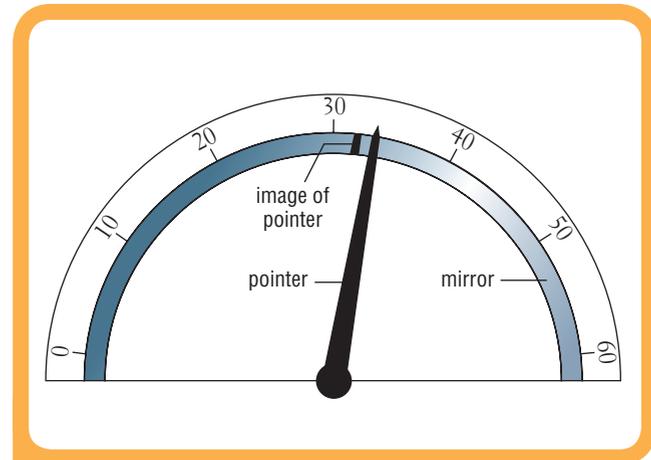


The back-to-front writing will appear the correct way around when seen in a rear-view mirror. *Fig 8.1.15*

A periscope makes use of reflection to allow the user to view an image of something at a higher level. Note how the image is at the same level as the user's eye.



*Fig 8.1.16* In a periscope, two parallel mirrors produce a virtual image.



*Fig 8.1.17* An accurate reading is obtained when the pointer covers its image.



## Activity 2

### The law of reflection

**Aim** To investigate the law of reflection

#### Equipment

A light box and power supply, ruler, mirror, protractor or Mathomat, plain paper

#### Method

- 1 Assemble the equipment as shown here, marking the position of the back of the mirror and the normal.
- 2 Mark the position of the incident and reflected rays.
- 3 Measure the angle of incidence and angle of reflection and record your results in a table.
- 4 Repeat steps 1 to 3 for several different angles of incidence.

#### Questions

- 1 **Explain** why the back of the mirror is marked and not the front.

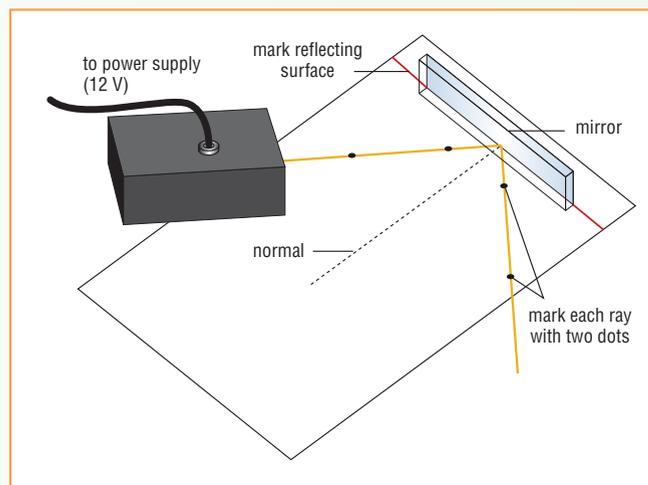


Fig 8.1.18

- 2 **Draw** a conclusion about the angles for each pair of rays.
- 3 **Describe** some examples of reflection in real life.

## Activity 3

### Image location

**Aim** To locate an image in a plane mirror

#### Equipment

A mirror, plain paper, ruler, a pin or small object (e.g. a nail in a small block of wood)

#### Method

- 1 Place the mirror on the paper and mark its position.
- 2 Place the object in front of the mirror and mark its position with a small cross.
- 3 Look at the image 'in the mirror' and rule a line of sight on the paper towards the front of the mirror as shown.
- 4 Place the ruler in a different position and rule another line of sight.
- 5 Repeat step 3.
- 6 Remove the mirror from the paper and continue the lines of sight until they cross each other.

#### Questions

- 1 **Identify** where the lines of sight cross each other.
- 2 **Copy** the sentence and complete it by choosing one of the words in brackets: The lines of sight represent \_\_\_\_\_ (reflected/incident) rays.

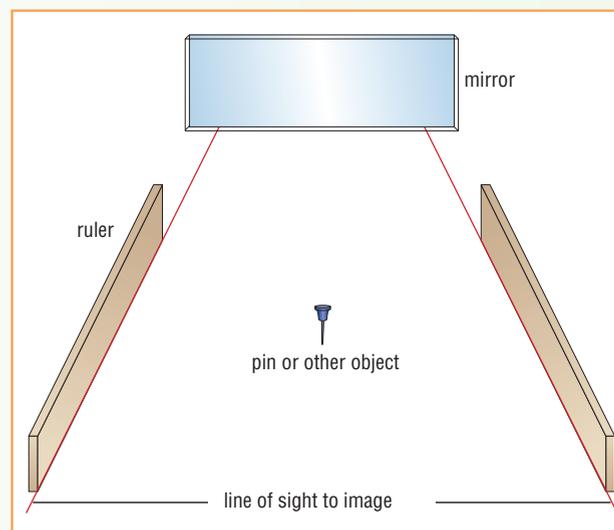


Fig 8.1.19

- 3 Rule a line from the cross that marked the pin's position to where the lines of sight met. **State** the angle this new line makes with the mirror's surface.
- 4 **State** how far in front of the mirror the pin was.
- 5 **State** how far behind the mirror the image was.

## Activity 4

## The periscope

**Aim** To apply the law of reflection of light by constructing a working periscope

**Equipment**

Cardboard sheet, sticky tape, two mirrors (each approximately 5 x 7 cm, though smaller will do), scissors

**Method**

- 1 Draw the plan in Figure 8.1.20 onto your sheet of cardboard.
- 2 Score the lines firmly with a pen to aid folding later.
- 3 Attach mirrors where indicated.
- 4 Fold the periscope together so that the lines indicated form 'valley folds', and the mirrors end up on the inside. Use tape to join the edges together.
- 5 Try your new periscope!

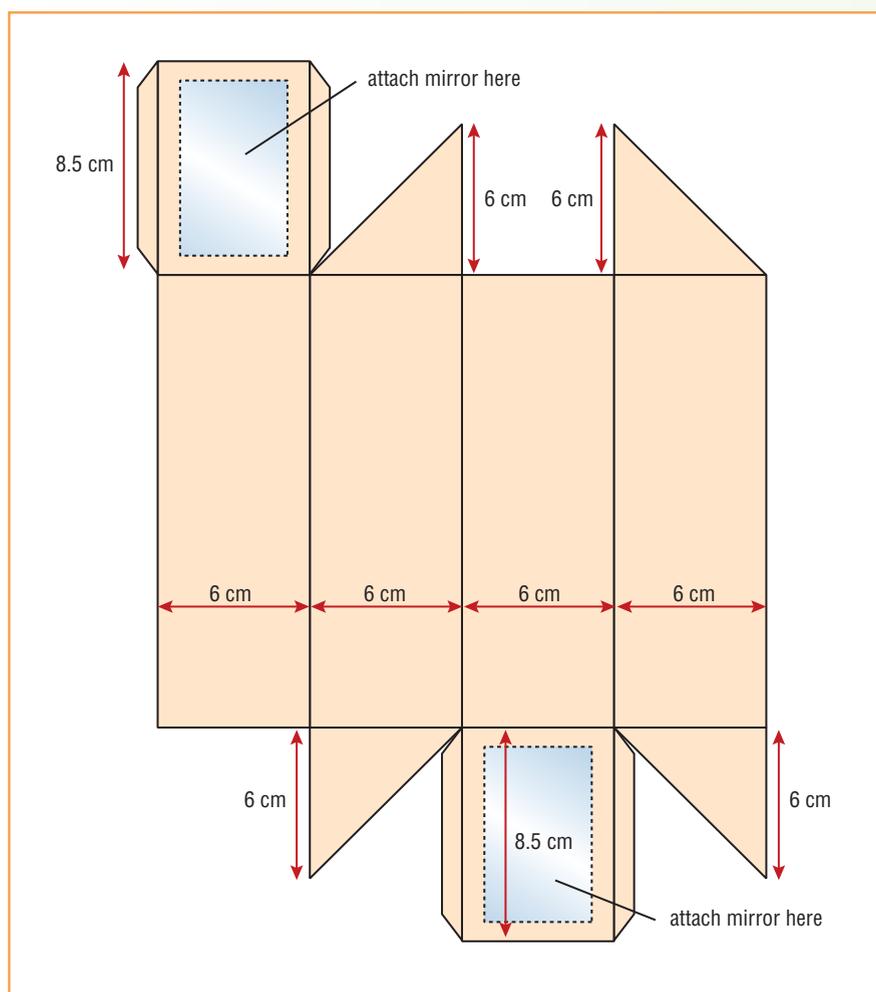


Fig 8.1.20

**Questions**

- 1 **State** the size of the angle at which the light strikes the top of the mirror when the periscope is upright and aimed directly at an object.
- 2 How could the periscope be made twice as long? **Draw** a new plan for such a periscope.
- 3 **Propose** some uses for periscopes.



# 8.1 [ Questions ]

UNIT

## Checkpoint

### Luminous and non-luminous

- 1 **Explain** how we can see a basketball even though it does not produce its own light.
- 2 **Identify** five examples of:
  - a luminous objects
  - b non-luminous objects
- 3 **Identify** three incandescent objects.
- 4 Copy and complete: A glow-worm is an example of a \_\_\_\_\_ luminescent creature.

### Shadows

- 5 **Explain** how a shadow is formed.
- 6 **Clarify** the meaning of the term 'penumbra'.
- 7 **Describe** how a shadow changes when an object moves towards a screen. Assume the light source is small.

### Reflection

- 8 **Clarify** the terms below by writing a definition for each.
  - a reflection
  - b diffuse reflection
  - c law of reflection
  - d normal
- 9 **Identify** another example (besides a tabletop) of a surface that would most likely produce diffuse reflection.
- 10 Copy and complete Figure 8.1.21, labelling the angle of incidence, angle of reflection, incident ray, reflected ray and normal.

### Uses of plane mirrors

- 11 Describe two uses of plane mirrors.

## Think

- 12 **Explain** the evidence that suggests that light does not need a material to travel through.
- 13 Copy Figure 8.1.7, which shows a large light source, an object and its shadow on a screen. Underneath, draw a similar diagram, but make the object closer to the screen.
- 14 The Sun is a very large and wide source of light. If instead it was a tiny but bright point source of light, **explain** how the shadows on Earth would be different.
- 15 Write the word EMERGENCY VEHICLE so that it would appear correctly when viewed in a mirror.
- 16 When a periscope is used, **identify** where the following are normally located.
  - a the object
  - b the image
- 17 Other than those examples used in this unit, **identify** two other situations where plane mirrors are used.
- 18 **a Identify** four devices that use light to perform a task.  
**b Evaluate** the importance of each device to society.

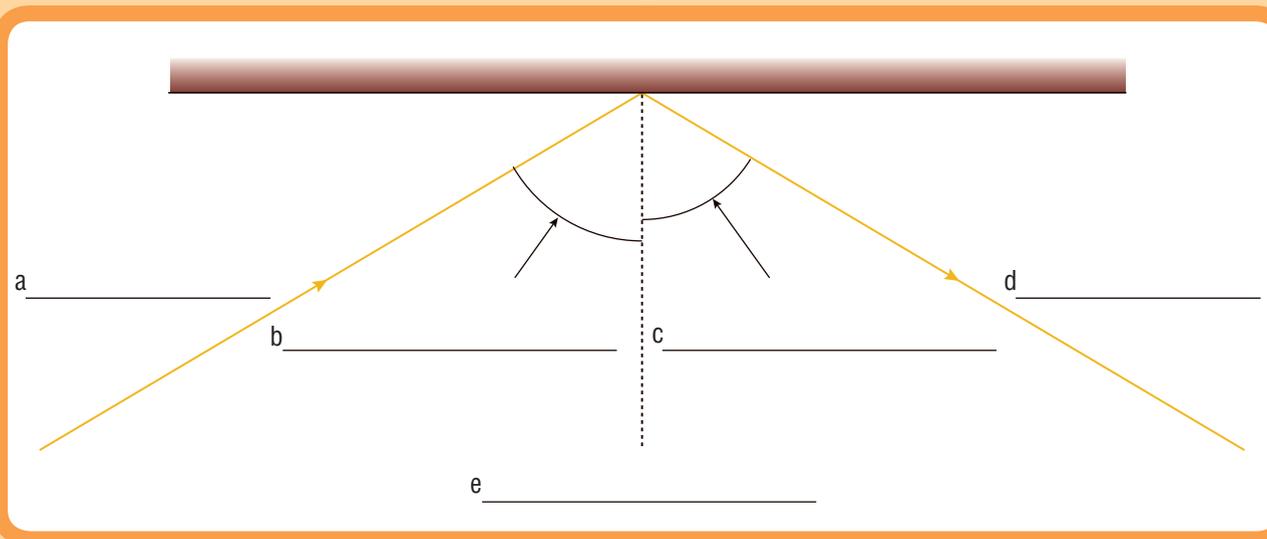


Fig 8.1.21



**Analyse**

- 19** Copy Figure 8.1.22 and draw the reflected ray for each incident ray.

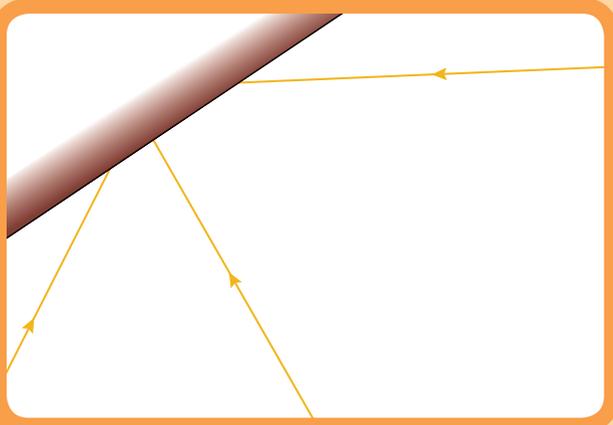


Fig 8.1.22

- 20** Copy and complete Figure 8.1.23, showing how the image is formed.

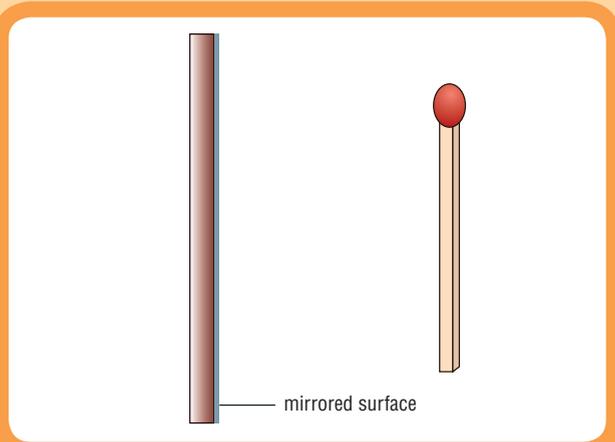


Fig 8.1.23

- 21** In a clothes shop, a plane mirror is needed that allows people up to 180 cm tall to see themselves in it from head to foot. **Calculate** what length the mirror should be.
- 22** Redraw Figure 8.1.14 but place the person further from the mirror. Use rays to **demonstrate** that they can still see themselves from head to foot.

**[ Extension ]****Investigate**

- 1 Research** what is meant by both a solar and a lunar eclipse. Draw diagrams to explain the differences.
- 2** Find out how a kaleidoscope works.
- 3 Research** what an *aurora* is and make a presentation to the class about this.



# UNIT 8.2

## Bending light

### Introduction

When light from an object enters our eyes, an image is formed on the retina. This allows us to see that object. Light can reach the eye in many ways. Light travels directly to our eye if we look straight at a **luminous** object like a light bulb. If we look away from the bulb, light will still reach our eyes by **reflecting** from the bulb in the room. Sometimes the light enters our eye after it has passed through a transparent

substance such as water or glass. Light is bent as it passes through different substances. This bending of light is called **refraction**. Refraction is responsible for making a pond look shallower than it really is. It also makes objects look bigger in water.

### Activity 5

#### Measuring angle of incidence and angle of refraction

**Aim** To investigate the relationship between the angle of incidence and the angle of refraction

#### Equipment

A light box and single slit slide, 12 volt power source, sheet of paper, ruler, polar graph paper (or protractor), semicircular slab of Perspex

#### Method

- 1 Put together the apparatus as shown in Figure 8.2.1.
- 2 Ensure an initial angle of incidence of  $10^\circ$ . Use two dots or crosses to mark each part of the light path and measure the angle of refraction.

Record your results in a table like the one shown here, including your results for the following angles of incidence:  $10^\circ$ ,  $20^\circ$ ,  $30^\circ$ ,  $40^\circ$ ,  $50^\circ$ ,  $60^\circ$ ,  $70^\circ$ ,  $80^\circ$ .

Angle of incidence	Angle of refraction	Amount of bending
$0^\circ$	$0^\circ$	$0^\circ$

- 3 If time allows, replace the Perspex slab with a semicircular, water-filled dish and repeat the experiment.

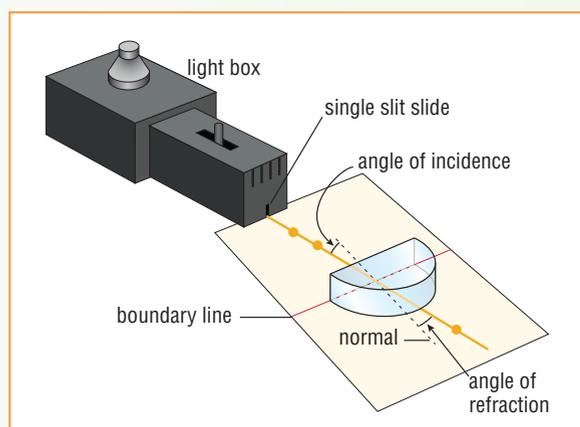


Fig 8.2.1 Comparing angles of incidence and refraction

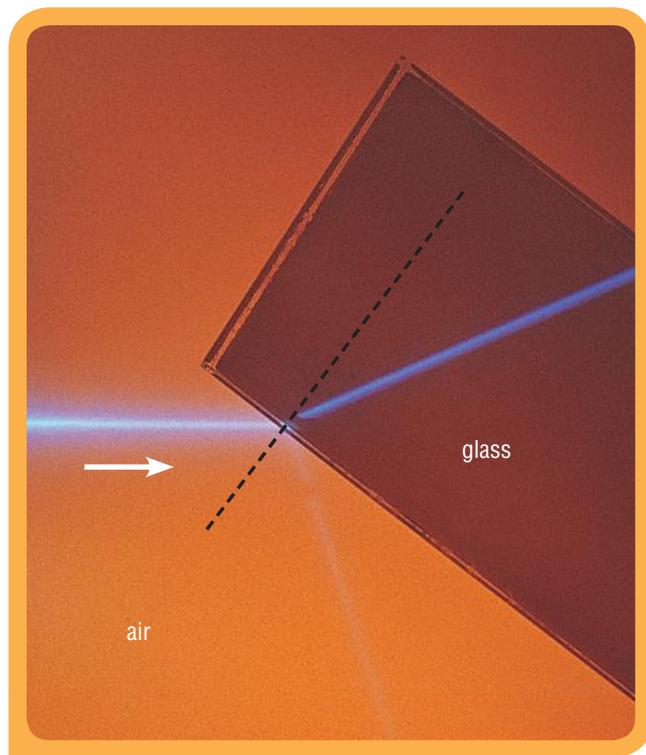
#### Questions

- 1 **Explain** why the semicircular slab is a better shape to use.
- 2 **Analyse** how the angle of incidence affects the degree of bending of light.
- 3 **Draw** a graph of angle of incidence versus angle of refraction for Perspex (and water if this was also tested).
- 4 **Show** how the graph would be different if a semicircular diamond was used instead. Diamond is more optically dense than Perspex.

## Refraction

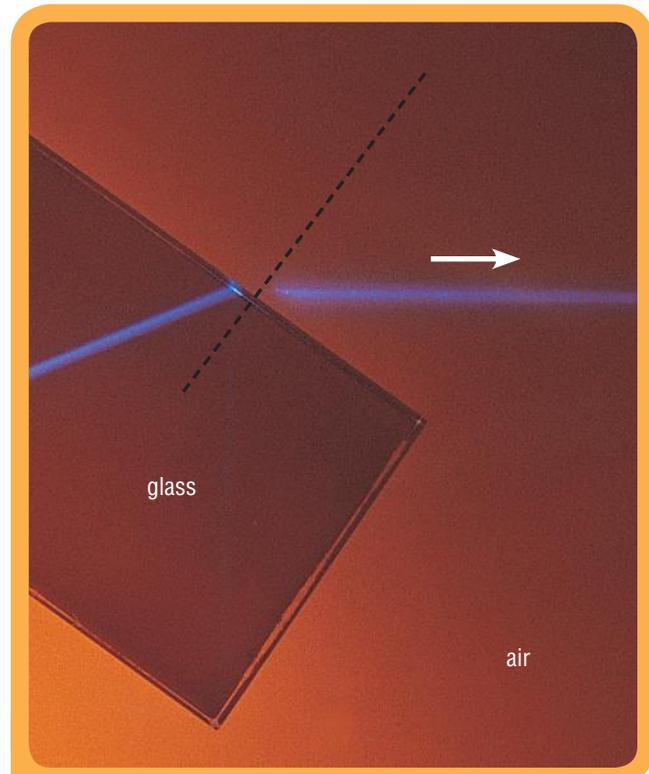
**Refraction** is the bending of a light ray as it passes into a different substance. Figures 8.2.2 and 8.2.3 show how a light ray is bent as it travels through a glass block. A dotted line has been drawn on each photo. Each dotted line is called a **normal**. A normal is a line drawn perpendicular (at  $90^\circ$ ) to the boundary between the two substances. The light ray bends towards the normal on entering the glass, and away from the normal on leaving it.

Experiments have shown that light slows down as it passes from air into glass. It also bends towards the normal. Glass is an example of a substance that has a higher **refractive index** than air. We also say that glass has a higher optical density than air. Other substances with optical densities higher than air are water, clear perspex and diamond.



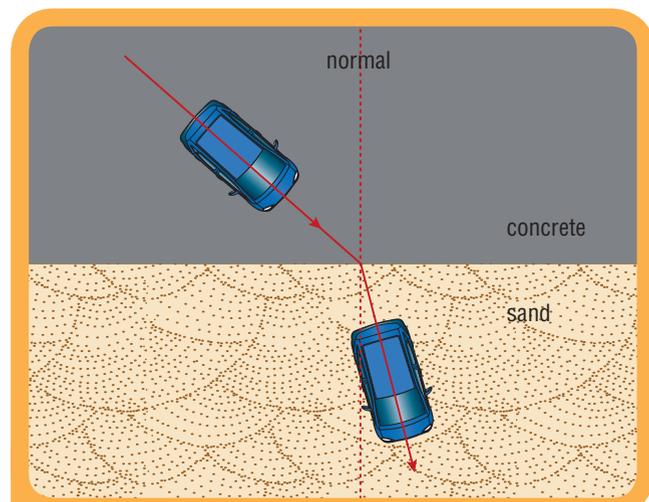
**Fig 8.2.2** Refraction in a glass block. The refracted light bends away from the normal. Note that a dotted line called a normal has been superimposed on the picture.

When light travels from one substance into another of lower **optical density** (e.g. from glass to air), it speeds up and bends away from the normal.



**Fig 8.2.3** This diagram shows light travelling from a denser medium (glass) to a less dense medium (air), resulting in light bending away from the normal.

Light travelling from one substance into another of greater optical density may be compared to a car passing from a region that allows fast travel (such as a concrete surface) to one that slows the vehicle down (such as sand).



**Fig 8.2.4** A car slows down and its path bends towards the normal as it drives into sand from concrete.



Refraction explains why when objects are put into water, they appear bent when seen from air.

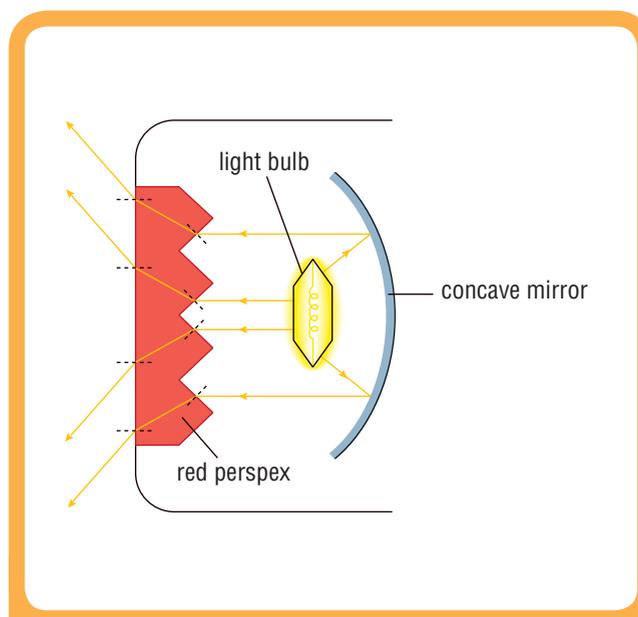


Refraction causes the 'bending' of the ruler. **Fig 8.2.5**

You may be wondering why the ruler in Figure 8.2.5 is bent away from the normal instead of towards the normal like the ray in Figure 8.2.2. This is because light from the lower part of the ruler is travelling into a region of low optical density (air), causing it to bend away from the normal. The image in the water

is actually an **illusion**. This is an image our brain works out based on where light from the lower part of the ruler appears to come from. It assumes that the light travelled in a perfectly straight line, even though it didn't.

The back lenses that make up a car's stoplights use refraction. This is to ensure light is bent up or down to avoid a strong beam of direct light reaching the eyes of other motorists.



**Fig 8.2.6** A car stoplight in action. Notice how light is refracted towards the normal on entering the perspex, and away from the normal on leaving it.

## 8.2

### [ Questions ]

#### Checkpoint

##### Refraction

- 1 **Define** the term 'refraction'.
- 2 **Identify** an example of where refraction occurs.
- 3 The refractive index of a substance can be used to predict which way a light ray will refract and by how much. **Identify** another term that can also be used to predict the bending of light by a substance.

#### Think

- 4 **Explain** how a bike reflector can reflect light if it doesn't contain a mirror.
- 5 **Describe** what happens when a light ray that is travelling through glass gets to the end of the glass and strikes the air at an angle:
  - a less than the critical angle
  - b greater than the critical angle

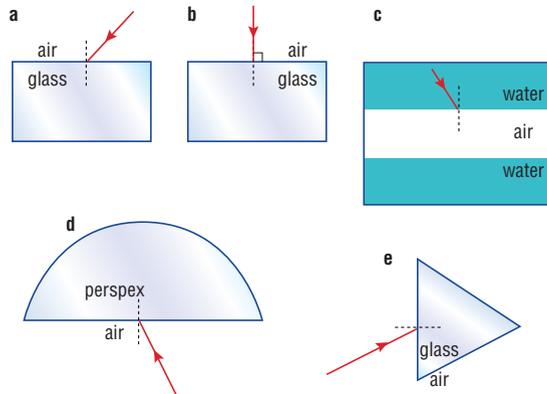




**Analyse**

- 6 a Copy the diagrams in Figure 8.2.7 into your workbook.
- b Draw a normal wherever the light rays enter a new substance.
- c **Demonstrate** what will happen to the rays as they enter and leave the substances by continuing the ray through the shape and out the other side.

Fig 8.2.7



[ **Extension** ]

**Investigate**

As shown in Figure 8.2.8, place a coin in a dish and have a glass of water within reach. Look at the coin and move your head until it just moves out of view. Slowly add water to the bowl and observe the coin. **Describe** and **explain** your observations.

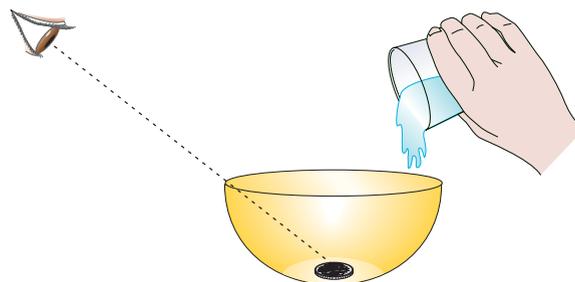


Fig 8.2.8



# UNIT 8.3

## Lenses and curved mirrors

### introduction

Light rays often need to be controlled and focused to produce images in instruments such as microscopes, cameras and binoculars. Controlling light rays is also important to change the focus for people wearing contact lenses or glasses. We can control and focus light by using **lenses** and **curved mirrors**.

Lenses are some of the best-known applications of refraction and are commonly used in optical instruments. Our eyes have lenses and they too use refraction to focus the light, allowing us to see an image.

Mirrors do not refract light but reflect it instead. We look in the mirror every morning to see ourselves. Other smooth surfaces can do this too. Some very strange images, however, can be formed if we look instead into curved mirrors like those found at amusement parks.

### Types of lenses

There are two main types of lenses:

- **convex lenses**—these curve outwards and are thicker in the middle
- **concave lenses**—these curve inwards (a little like a cave) and are thinner in the middle.

When describing lenses and drawing rays of light through the lenses, scientists use special rules which are shown in Figure 8.3.2.

The main rules featured in Figure 8.3.2 are:

- In a convex lens, an incoming ray parallel to the principal axis is refracted through the **principal focus (F)**.
- In a concave lens, an incoming ray parallel to the principal axis is refracted so that it *appears* to come from the principal focus (F).
- The distance from the plane of the lens (centre line of the lens) to F is called the **focal length** of the lens.

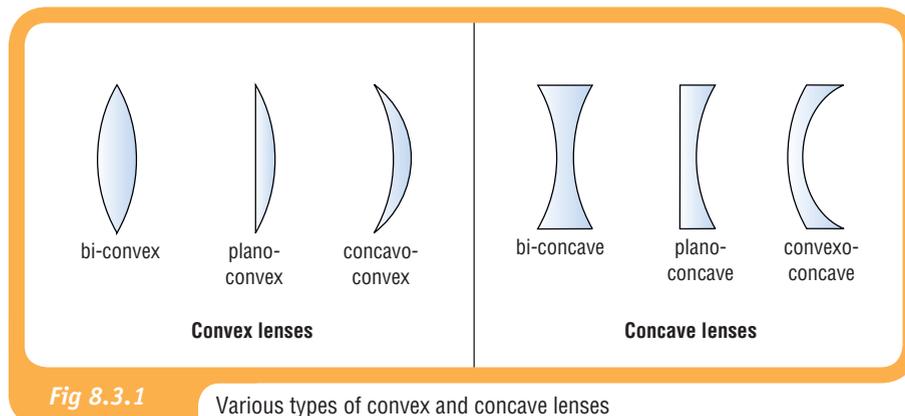
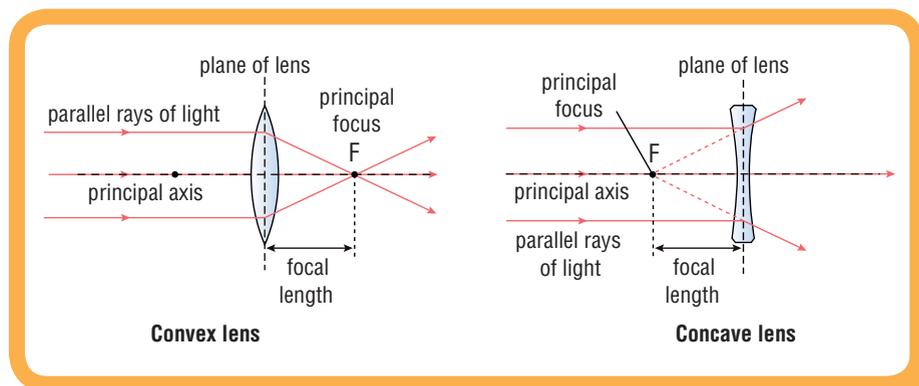


Fig 8.3.1

Various types of convex and concave lenses



Key features of lenses

Fig 8.3.2

- A ray passing through the centre of either type of lens is unaffected.
- As with all images, rays of light that come from a part of the object come together again at that same part of the image.
- The greater the curvature of a lens, the more it bends light and hence the shorter the focal length.

## Optical instruments

Lenses are the key components in several optical instruments.

### Telescopes

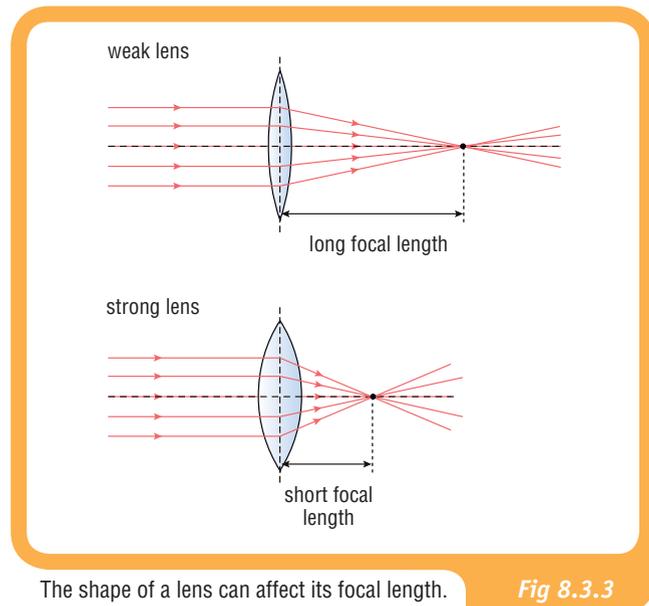
Telescopes make small, far-away objects appear larger. A single lens will only produce smaller images of objects a long way away. The stars and the Moon would appear even smaller! In order to produce a magnified image of such objects, two lenses are used.

The objective lens in a telescope produces a real, inverted image just inside the focus of a second lens, called the eyepiece lens. The image produced by the first lens now acts as the object for the second lens. Because the first image is inside the focus of the second lens, the second image (the one seen by the telescope user) is virtual and enlarged compared to the first one (see Figure 8.3.4).

The thinner the first lens (objective lens), the larger the first image. But thin lenses have longer focal lengths—this is why telescopes are long instruments. A telescope is focused by adjusting the distance between the two lenses. The image produced by a simple telescope is upside down, but this is usually not important when viewing objects such as planets and stars.

### Binoculars

Binoculars do the same job as a telescope, although here we need the image to be the right way up. This is important—for example, can you imagine viewing sports where everything was upside down?



The shape of a lens can affect its focal length.

Fig 8.3.3

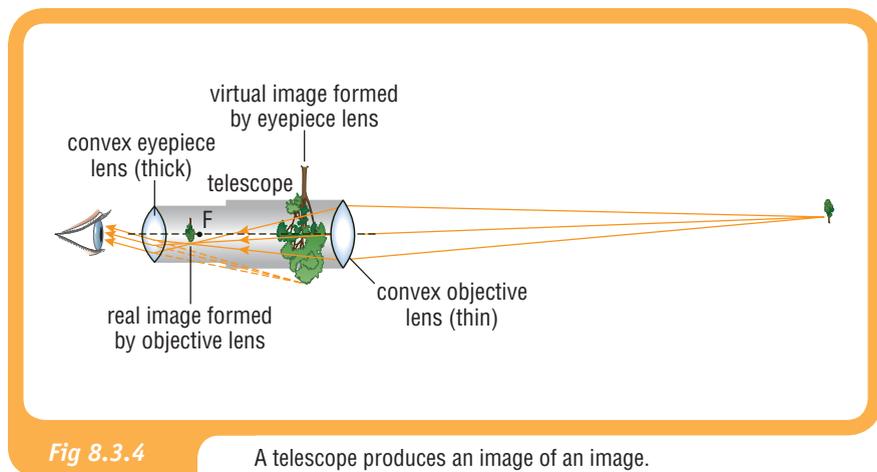


Fig 8.3.4

A telescope produces an image of an image.

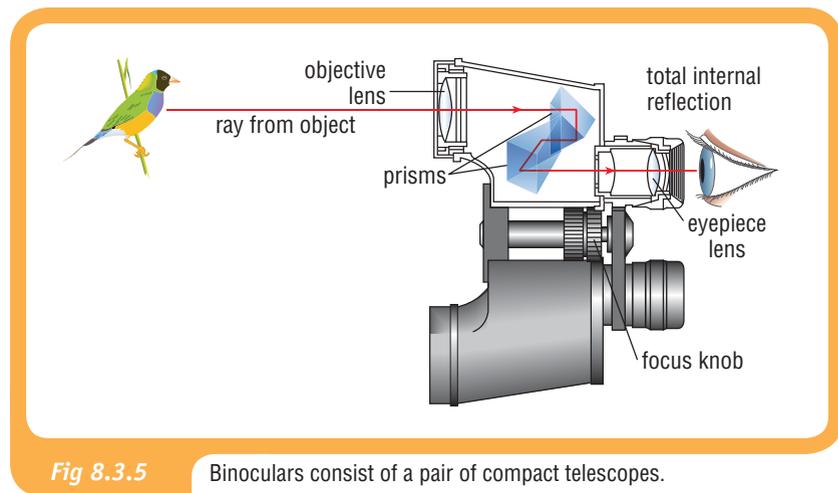


Fig 8.3.5

Binoculars consist of a pair of compact telescopes.



Binoculars consist of two telescopes but they use triangular prisms to redirect light and ensure images are upright.

The 'bouncing' of the light path is due to total internal reflection and has the added advantage of having an instrument shorter than a conventional telescope.

### Microscopes

Microscopes make small objects appear much larger. A microscope, like a telescope, produces images in several stages. Light may be reflected from a mirror through a condenser. If a condenser is present it sits below the stage and directs focused light through the specimen. The light then passes through an objective lens to form a real image inside the focal length of an eyepiece lens. The eyepiece lens then magnifies the first image to produce a final virtual image.



A compound microscope **Fig 8.3.6**

### Curved mirrors

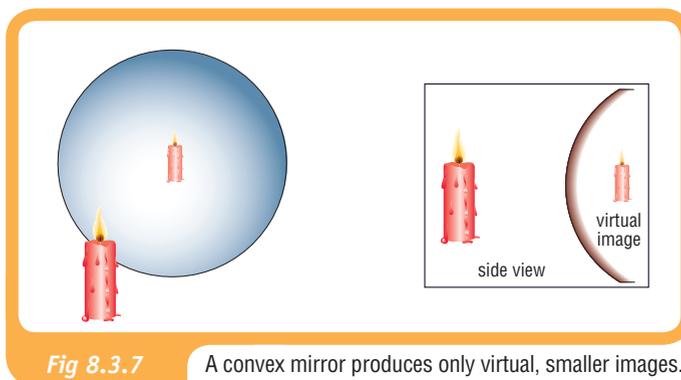
Previously, we looked at plane mirrors and how reflections occurred. Curved mirrors can also reflect light. There are two main types of curved mirrors: concave and convex.

### Concave mirrors

**Concave mirrors** produce an enlarged (magnified) virtual image of an object placed close to the mirror. They are very useful when shaving or applying makeup or when dentists need a close-up view of tooth decay.

### Convex mirrors

**Convex mirrors** gather rays of light from a wide area to produce a smaller virtual image behind the mirror. See Figure 8.3.7. Convex mirrors are useful when a wide view is needed. They are used in shops for security across the whole store at corners where the shopkeeper cannot see. Also, some car mirrors give a wider view of what is behind the car. See Figure 8.3.8.



**Fig 8.3.7** A convex mirror produces only virtual, smaller images.



A convex mirror produces a wider view than a flat mirror. **Fig 8.3.8**

## Activity 6

### Images in a convex lens

**Aim** To investigate the image formed by different convex lenses

#### Equipment

A convex lens, white card or screen, plasticine or lens holder, metre ruler, candle or small globe with power supply

#### Method

- 1 Determine the focal length of your lens by using it to form an image of a window 5 metres or more away on your card/screen. Measure the distance of the image/screen from the lens—this is the focal length.
- 2 Use your apparatus to obtain the clearest possible image on the screen with the candle or lamp more than two focal lengths from the lens. A darkened room will help.
- 3 Copy the table below, and record your measurements.
- 4 Repeat for the other positions in the table.

#### Questions

- 1 **Describe** what happened as the object was brought closer to the lens.
- 2 **Summarise** the situations in which:
  - a a real image (on a screen) is obtained
  - a virtual image (one that cannot be 'caught' on a screen) is obtained
  - c no image is obtained
- 3 If time permits, repeat for a convex lens of different focal length.

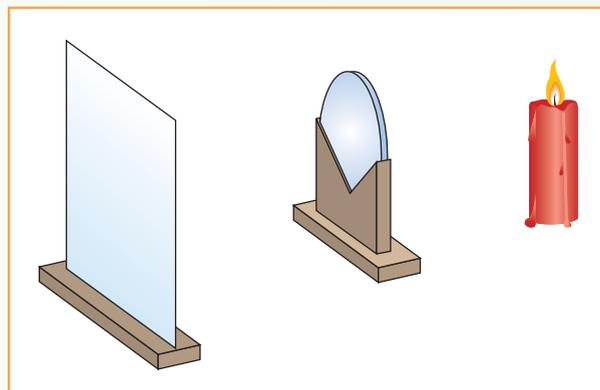


Fig 8.3.9

## Activity 7

### Images in a concave lens

**Aim** To investigate the image formed by different concave lenses

#### Equipment

A concave lens, card or screen, candle or light globe and power source

#### Method

- 1 Using the equipment provided, attempt to capture an image produced by a concave lens on a screen.
- 2 Study the effect of moving the object closer to the lens, then away from the lens.

#### Questions

- 1 **Assess** whether it is possible to form a real image (one that may be 'caught' on a screen) using a concave lens.
- 2 **Explain** how the image changes as the object-to-lens distance is varied.



## Activity 8

### Telescopes and microscopes

**Aim** To investigate how telescopes and microscopes form images

#### Equipment

Two convex lenses—one thin (e.g. focal length 25 cm) and one thick (e.g. focal length 5 cm), cardboard, scissors, tracing paper or other transparent material (e.g. thin plastic from a shopping bag), lamp, small object to view

#### Method

##### Part A: The telescope

- 1 Construct and assemble the apparatus as shown in Figure 8.3.10.
- 2 Place the object a large distance (say, 1 metre) from the objective lens, and move the eyepiece lens and screen to obtain the clearest possible image looking through the eyepiece lens. Note the size of the image compared with the object.
- 3 While looking through the eyepiece lens and observing the image, remove the screen. You should still see the image! Think about why.

##### Part B: The microscope

- 1 Now move the object close to the lens (but not closer than the focal length).
- 2 Adjust the position of the lenses to obtain an image that is larger than the object.

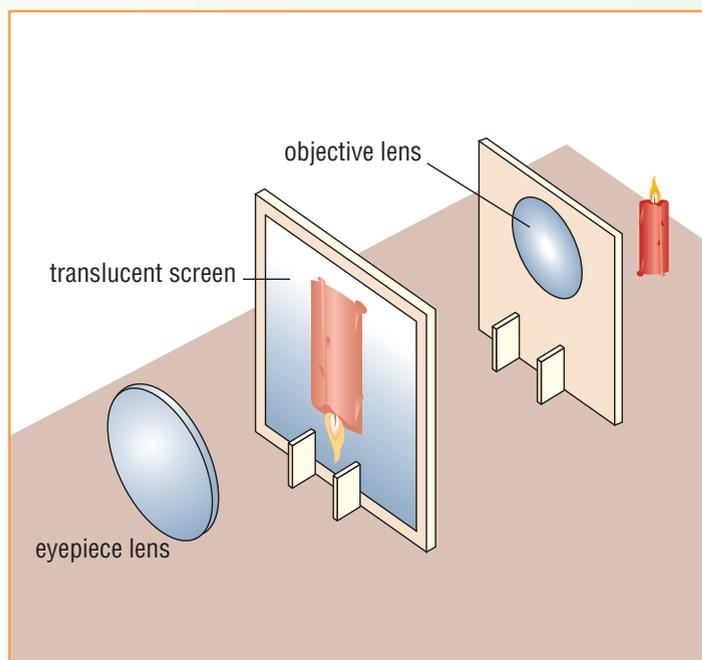


Fig 8.3.10

#### Questions

- 1 **Distinguish** between a telescope and a microscope.
- 2 **Describe** how the removal of the screen changes the image in part A (step 3) above.

## Activity 9

### Constructing a field telescope

Construct a portable telescope using cardboard tubes. Use it to focus on various objects. Investigate by placing a concave lens inside the cardboard tube and focusing on various objects.

## Curved mirrors

**Aim** To investigate the images formed by convex and concave mirrors

### Equipment

A convex and a concave mirror, a candle, a screen

### Method

#### PART A: Concave mirror

- 1 Arrange the apparatus as shown in Figure 8.3.11.
- 2 Move the screen until you obtain a clear image of the candle.
- 3 Investigate the different images produced with the candle at different distances from the mirror. Is there a position where it is impossible to obtain an image on the screen? Can you see a virtual image in the mirror?

#### PART B: Convex mirror

- 1 Hold the mirror at arm's length and look at your image.
- 2 Gradually move the mirror towards you, noting any changes in the image as you do so.

### Questions

- 1 **Explain** what happens to the image as an object is brought closer to:
  - a a concave mirror
  - a convex mirror
- 2 **Identify** which type(s) of image are possible in each type of mirror.

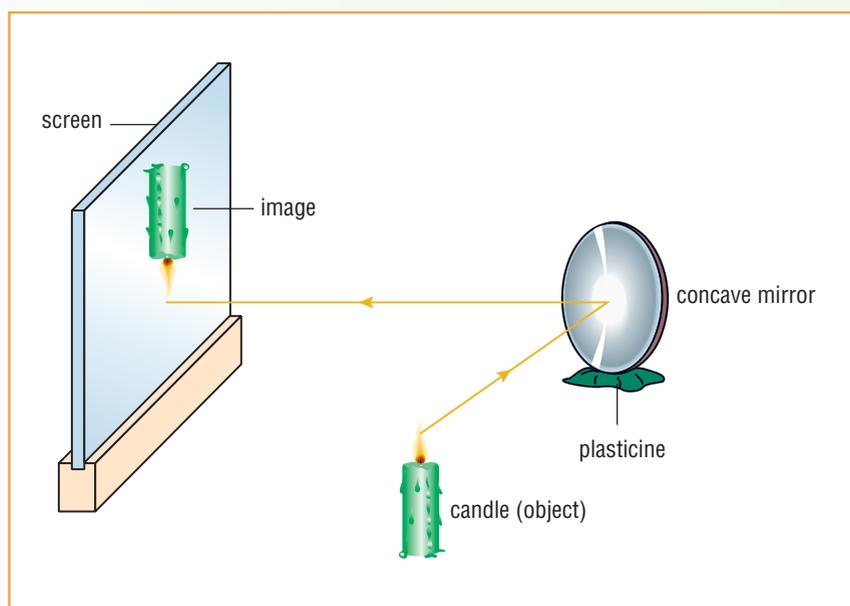


Fig 8.3.11



### Activity 11

## Lenses and a light box

**Aim** To investigate the refraction of light through various lenses

### Equipment

A light box, multiple-slit slide, 12-volt power supply, light box lenses set, sheet of paper.

### Method

- 1 Adjust the light box (using the knob on top) to produce a wide beam of light with parallel edges on a piece of paper.
- 2 Direct a wide beam of light through a lens shape with no slide inserted in the light box.
- 3 Now use the slide with multiple slits to direct several parallel beams of light through the lens. Use a pencil to mark parts of the light paths.
- 4 Remove the lens and light box from the paper and rule the complete light paths.
- 5 Repeat steps 1 to 4 for concave lenses. (Use a new piece of paper in each case.)

### Questions

- 1 **Describe** in words the effect of:
  - a a convex lens
  - a concave lens
- 2 **Compare** the light path through a wide convex lens **with** that through a thin one.
- 3 **Identify** whether there are any individual light rays that are not bent by the lens in each case.
- 4 What were the focal lengths of the lenses you used? **Construct** a trace or sketch of each lens and write the focal length under each one.

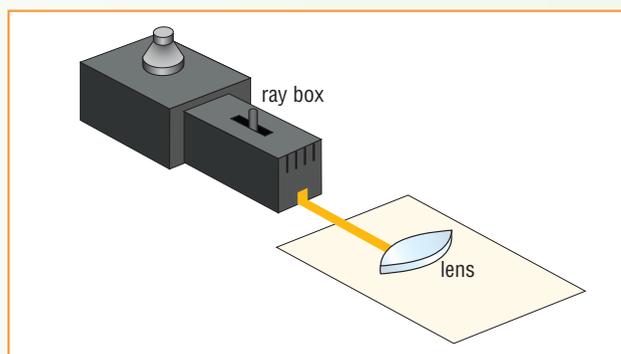


Fig 8.3.12

## [ Questions ]

### Checkpoint

#### Types of lenses

- 1 Copy the lenses in Figure 8.3.13 and **identify** each as concave or convex by labelling them.
- 2 The terms 'diverging' (moving apart) and 'converging' (coming together) may be used to describe lenses. **Identify** which term applies to:
  - a a convex lens
  - a concave lens

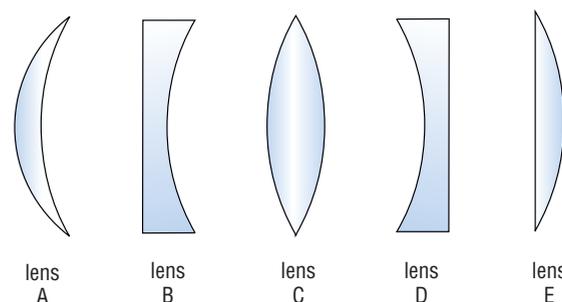


Fig 8.3.13



- 3 Copy and complete the ray-tracing diagrams in Figure 8.3.14 to **demonstrate** the path taken by the light rays.

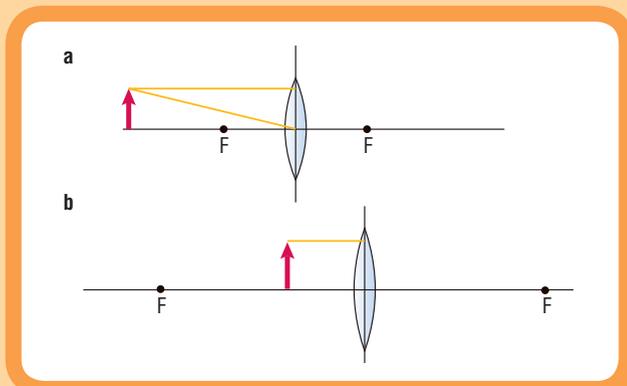


Fig 8.3.14

### Image type and location

- 4 Copy the following and **modify** any incorrect statements so they become true.
- Real images formed by convex lenses are always bigger than the original object.
  - Virtual images formed by convex lenses are always bigger than the original object.
  - Concave lenses can form only virtual images.
  - Images in a concave lens are always the right way up.
  - Real images in a concave lens are always the right way up.

### Optical instruments

- 5 **Identify** two optical instruments that probably contain lenses.
- 6 **Deduce** what problems would occur if binoculars did not contain triangular prisms.

### Curved mirrors

- 7 **Identify** the two main types of curved mirror and sketch each one, indicating the mirrored side in both cases.

- 8 A curved mirror produces a large upright image when held close to an object. **Identify** the type of mirror it is likely to be.

### Think

- 9 Use ray tracing to **explain** how the thickness of a lens affects:
- the focal length of the lens
  - the size of the image
- 10 Use ray tracing to **describe** what happens to the image when a distant object is brought closer to (but not closer than the focal length of):
- a convex lens
  - a concave lens
- 11 A student is using a magnifying glass to set a piece of paper on fire. **Work out** what type of lens is being used and what the 'hot spot' on the paper is an image of.
- 12 **Justify** why a slide must be placed upside down in a slide projector.
- 13 At the movies we see real images, not virtual ones. **Assess** how you can tell.
- 14 **Identify** which type of mirror would be best for use:
- at a dangerous intersection
  - by a dentist

### Analyse

- 15 A convex lens can produce an enlarged image of an insect. **Analyse** why it can't produce an enlarged image of the Moon.
- 16 You have two lenses—one thick and one thin—at your disposal to build a telescope. **Propose** which one you should use for the eyepiece, and which one for the objective lens.
- 17 **Compare** telescopes and binoculars by listing the things that are:
- similar
  - different





**18** To see an object clearly, an image of it must be formed on the retina (the back inside surface of the eye).

**Propose** what sort of lens may be used in spectacles or contact lenses to correct each vision defect shown below. **Illustrate** your answer with a diagram.

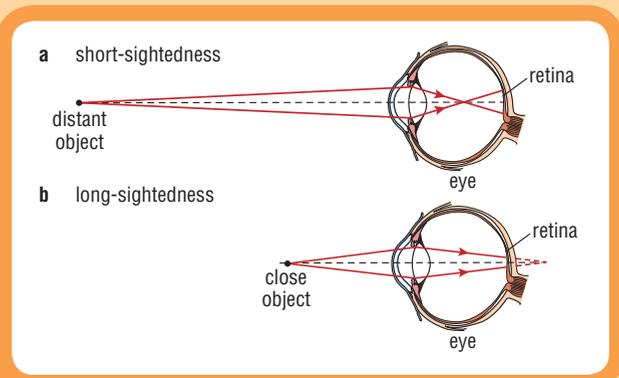


Fig 8.3.15

**19 Describe** how a lens or mirror could be used to start a fire.

**Skills**

**20 Calculate** the magnification in each case for images produced by various lenses:

Object height	Image height
2 cm	6 cm
5 cm	20 cm
25 mm	5 mm
16 mm	4 mm
8 cm	160 mm

[ **Extension** ]

**Investigate**

**1 Investigate** the history of an optical instrument such as the telescope or camera. Include the following information:

- a who invented it and when
- b what improvements have been made over the years and by whom
- c a diagram of the first instrument developed and a diagram of a modern version of this instrument. Include a discussion of some of the differences or improvements between the original and modern versions of the instrument

Present your information in a written report.

**2 Investigate** one type of sight defect such as long-sightedness, short-sightedness, cataracts, night blindness or colour blindness. Find out the following information:

- a what causes the defect
- b the symptoms displayed (include diagrams if applicable)
- c any treatment(s) available to control or cure the defect

Present your information as an information leaflet that may be found in a doctor's surgery.

**Action**

**3 Investigate** the magnification produced by a water drop lens using different-sized drops.

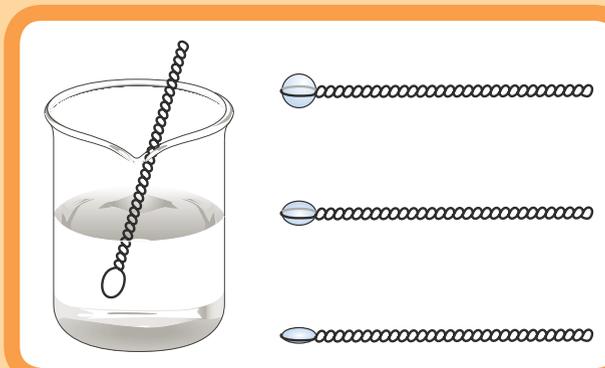


Fig 8.3.16

**4** Does it matter if a lens is hollow on the inside? Will curved surfaces with nothing (but air) in between have the same effect as a solid lens? **Examine** these questions by designing your own experiment.

## introduction

Have you ever wondered why the sky is blue, sunsets are red and rainbows are many colours? Isaac Newton was also puzzled by these questions. In 1665, he conducted an experiment using triangular prisms to split a thin beam of white light into the colours of the rainbow. This experiment established

the basic ideas that we now use to explain the many ideas about light. We can use these ideas to explain the colours we see when looking at objects, the sky, theatre lighting or printed photographs.

yellow, green, blue, indigo and violet. This means that white light is a mixture of many colours of light, which can be separated out by a prism.

## Dispersion

When a thin beam of white light is refracted by a triangular prism, it may be split into the colours of the rainbow. Isaac Newton first described this in 1665 when he was a student at Cambridge University in England.

This effect is known as **dispersion**, and the colours of light produced are called the **visible spectrum**.

The spectrum is made from an infinite number of colours but the seven main colours are: red, orange,



A triangular prism splits white light into the colours of the rainbow.

Fig 8.4.1

## Activity 12

## Dispersion: splitting white light

**Aim** To disperse a beam of white light into the spectrum

**Equipment**

Triangular glass or Perspex prism, light box and power supply, slide with single slit, white paper

**Method**

- 1 Alter the position of the light box and prism to obtain a clear spectrum.
- 2 Mark the ray path and position of each colour within the dispersed beam.
- 3 Use any other light box accessories available to try to recombine the colours into a single white ray.

**Questions**

- 1 **Identify** the colour that refracts:
  - a the most
  - b the least
- 2 **Propose** how it may be possible to recombine colours separated by a prism.

## Blue skies and red sunsets

Blue skies and red sunsets are caused not by refraction of sunlight, but by another phenomenon known as **scattering**, in which molecules of gas and dust particles in the atmosphere alter the direction of light rays. Blue light is scattered more than the other colours



of the spectrum, and the scattered blue rays seen against the dark background of space causes the sky to appear blue. At sunrise and sunset, when sunlight travels further through the atmosphere, almost all of the blue rays are scattered and the light that reaches us is mainly red or orange.

## Rainbows

Small droplets of water behave like tiny prisms in the sky. Sometimes the colours will reach our eyes after refracting and undergoing total internal reflection. As can be seen in Figure 8.4.2, droplets higher in the sky refract red to our eyes, while green and blue go past our eyes over our head. In drops lower in the sky, blue light is refracted and reflected to our eyes, but green and red light bend lower down, missing our eyes.

The overall effect is that we see a **primary rainbow**. This is a band in the sky with red at the top and blue at the bottom.

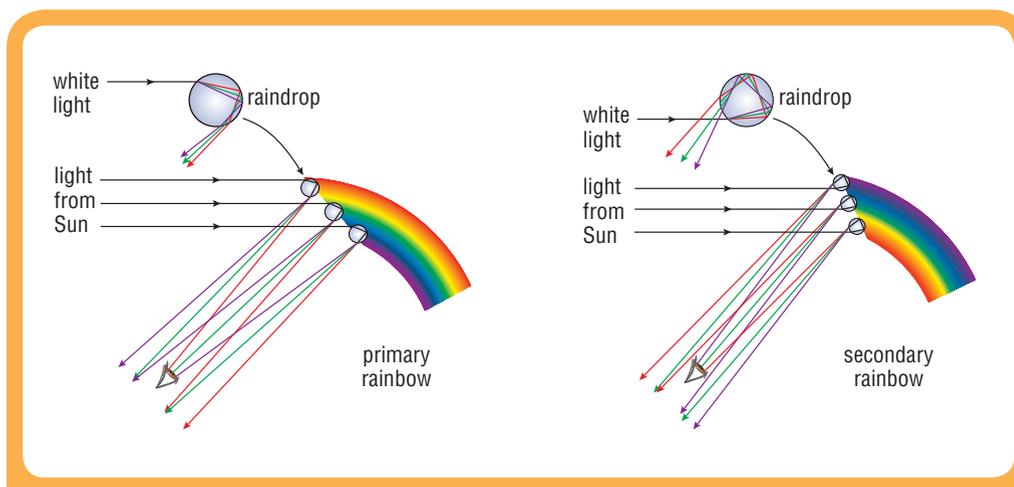


Fig 8.4.2 How primary and secondary rainbows are formed. Note that the colours are reversed in the secondary rainbow.

Sometimes a **secondary rainbow** can be seen above a primary one. Light reaches our eyes from a secondary rainbow after two internal reflections inside each raindrop. This has the effect of reversing the colours so the bottom band is red.

## Colour addition

If you look closely at a television screen, you'll see lots of tiny spots coloured red, blue and green by special chemicals called **phosphors**. These spots are made to glow in various combinations by electron beams inside the television. Our eyes join the glowing

spots and we perceive pictures containing millions of colours. We say red, blue and green are **primary colours**, because they can be combined in various proportions to form all other colours.

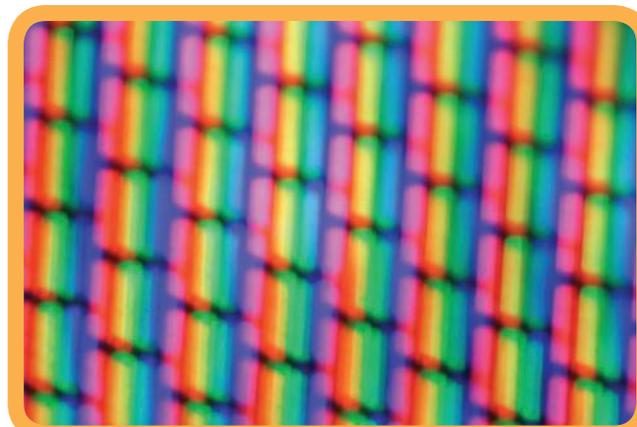


Fig 8.4.3 A magnified view of a television screen reveals lots of tiny coloured spots called phosphors.

Another way of adding colours involves coloured beams of light. Where all three primary colours are combined, white light is produced. This is the opposite to the splitting of light. Where just two primary colours overlap, **secondary colours (cyan, magenta and yellow)** are produced.



Fig 8.4.4 Overlapping light beams demonstrate colour addition.

Two colours of light that mix to make white light are called **complementary colours**. Red and cyan are complementary colours, as are green and magenta. Blue and yellow form another pair.

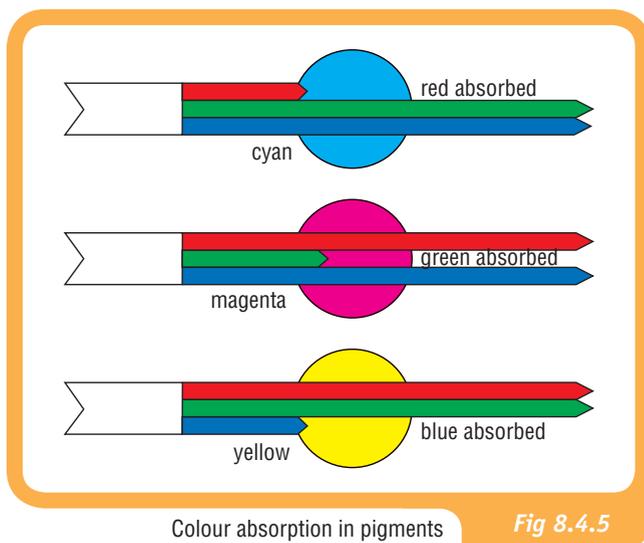
### Mixing pigments

Pigments are finely spread-out solid particles of colour found in substances like paint and ink. These behave quite differently to light. For example, blue and yellow light mix to make white light, but blue and yellow paint mix to make green paint.

We normally view objects in white light that is a mixture of red, orange, blue, green, indigo and violet (ROYGBIV). Paints are not perfect colours and usually reflect and absorb groups of these colours. For example:

- Blue paint absorbs red, orange and yellow light (ROY), but reflects green, blue, indigo and violet (GBIV).
- Yellow paint absorbs blue, indigo and violet (BIV) and reflects red, orange, yellow and green (ROYG).
- A mixture of blue and yellow absorbs all colours that both individual colours do (red, orange, yellow, blue, indigo and violet (ROYBIV)), leaving only green (G) reflected, so the mixture appears green.

Remember in art classes when all the paints you were using eventually got mixed, and you were left with a murky dark colour? This is because most colours were absorbed by the mixture, leaving very little to be reflected.



## 8.4

]

# Questions

UNIT

### Checkpoint

#### Dispersion

- 1 Identify what Isaac Newton used to split light into several colours.
- 2 a List the colours of the visible spectrum.  
b Construct a sentence that helps you remember the colours in order.

#### Blue skies and red sunsets

- 3 a Identify the effect where atoms in the atmosphere spread light.  
b Identify which colour light does this the most.
- 4 Explain why sunrises and sunsets are red or orange in colour.

#### Rainbows

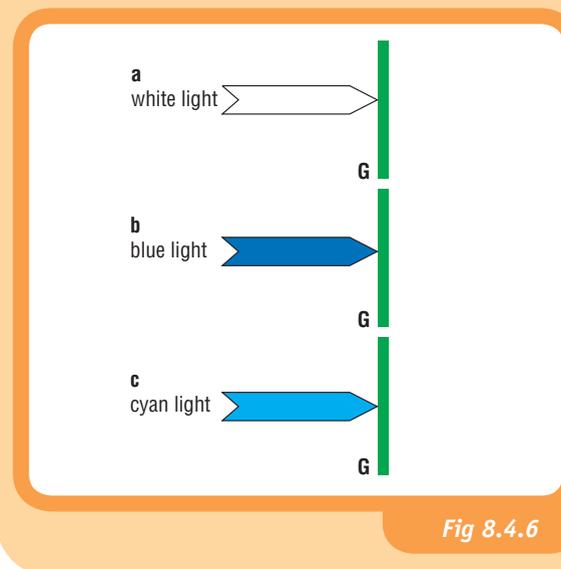
- 5 Describe what happens inside water droplets to cause a rainbow.
- 6 Explain how you can tell whether a rainbow is a primary or secondary one.

#### Colour addition

- 7 Identify the:
  - a primary colours of light
  - b secondary colours of light
- 8 Explain what complementary colours are.
- 9 Identify the complementary colour for:
  - a green light
  - b cyan light

#### Colour subtraction

- 10 Copy and complete the following light filter diagrams in Figure 8.4.6.





- 11 Identify** the colour you would see when paints of the following colours are mixed.
- a cyan and magenta
  - b yellow and cyan
  - c cyan, magenta and yellow

**Printing**

- 12 Identify** the colours important to the printing process.
- 13 Identify** the colour pigments that would be mixed to produce red on a printed page.

**Think**

- 14** Diagram A below shows a ray of red light passing through a glass object.
- Identify** which diagram (A, B, C or D) best shows a ray of blue light passing through the same object.

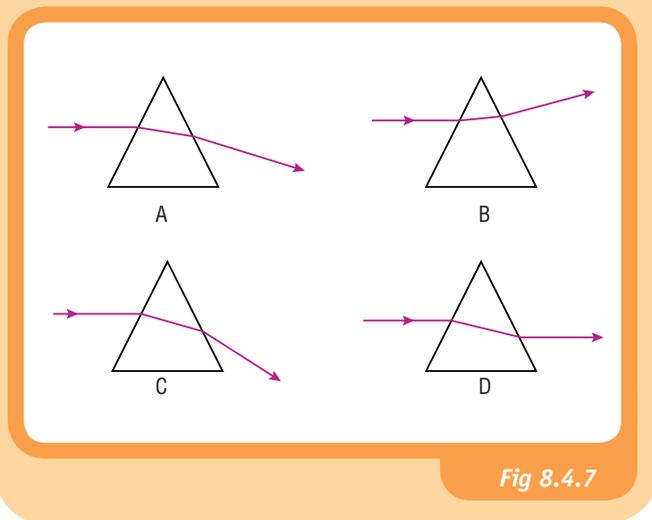


Fig 8.4.7

- 15 Explain** how a television screen produces colour images.
- 16 Propose** what happens to the light energy that is absorbed by a filter.
- 17 Assess** why K, not B, is used for black in the CYMK colour system.
- 18** A stack of coloured blocks appears as shown here in white light.
- Construct** a diagram and label the colour of each block when viewed in:
- a blue light
  - b yellow light

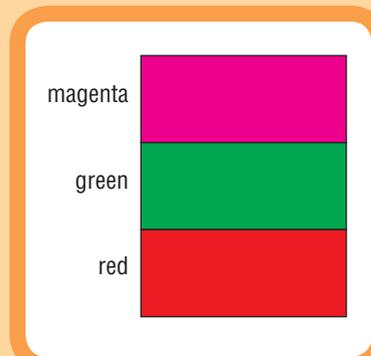


Fig 8.4.8

**[ Extension ]**

**Investigate**

- 1 Investigate** more about how electron beams are controlled to strike just the right spots on a colour television screen.
- 2 Investigate** how colour inkjet or laser printers work. Summarise your findings in a flow chart.
- 3 Research** in detail the process of colour printing or photography from film to print. Present the information in a poster, including diagrams to outline the steps.

**Action**

- 4 Construct** one or more colour wheels and study the effect of 'mixing' various colours in different proportions. Summarise your findings in a table.

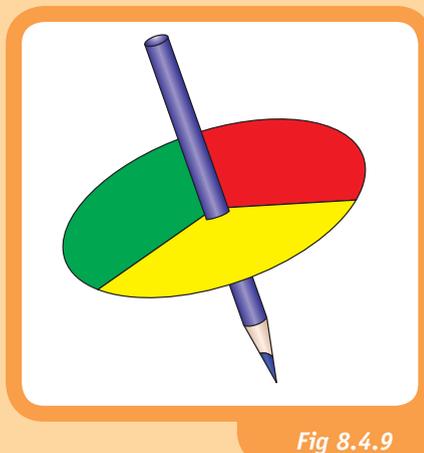


Fig 8.4.9

- 5 Construct** a crossword that provides a summary of the information you have learnt about colour.

## Activity 13

### Mixing colours

**Aim** To investigate the mixing of coloured light using various combinations of coloured filters

**Equipment**

Light box and power supply, a variety of coloured slides, white paper

**Method**

- 1 Place a red and a blue slide in the light box and use a side mirror to combine the coloured beams. Note the resulting colour in a table like the one below, and try various colour combinations.

**Warning:** Do not leave filters in the light box too long or they may be damaged.

Copy the table and record each result.

Slide A	Slide B	Result
Red	Blue	
Red	Green	
Blue	Green	
Red	Cyan	
Green	Magenta	
Blue	Yellow	

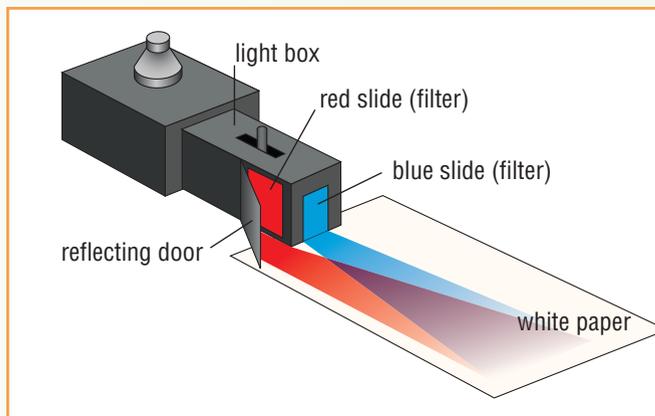


Fig 8.4.10

- 2 Use the light box to combine three colours and record your results.

Slide A	Slide B	Slide C	Result
Red	Blue	Green	
Cyan	Magenta	Yellow	

**Questions**

- 1 Identify the colour that refracts:
  - a the most
  - b the least
- 2 The white produced was probably not quite white but was a little 'off'. **Propose** why some of the results may not have been 'perfect'.



## Activity 14

### Seeing things in a different light

**Aim** To investigate the colour of objects when viewed under different-coloured lights

#### Equipment

Light box and power supply, a variety of coloured slides, a variety of coloured cards

**Note:** The slides and cards should be labelled with their colour.

#### Method

- 1 Check that each slide and card has its colour written on it.
- 2 Use a light box and coloured slides to shine coloured light onto various coloured cards and record the appearance of the card in each case in a table like the one below.

#### Questions

- 1 **Identify** which colour light needs to shine on a red card so that it appears:
  - a red
  - b black or very dark
- 2 **Identify** examples where an object appeared quite different to its actual colour.
- 3 It is important to label each card with its colour. **Explain** why this is the case.
- 4 Theoretically, several combinations should have resulted in cards appearing to be pitch black. **Assess** why you may have seen dark colours instead.

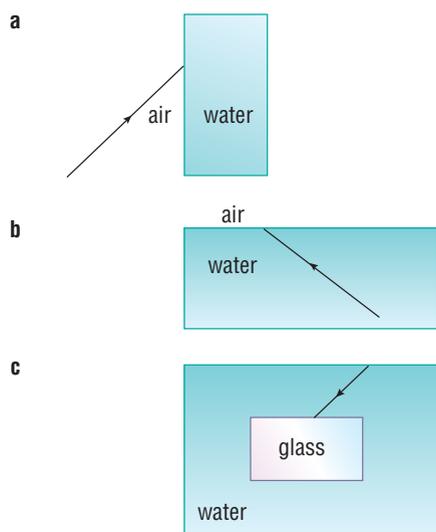
#### Appearance of coloured cards in coloured light

		Card colour					
		Red	Blue	Green	Cyan	Magenta	Yellow
Light colour	Red						
	Blue						
	Green						
	Cyan						
	Magenta						
	Yellow						

# Chapter review

## Summary questions

- Copy and complete:  
When a light ray travelling in air strikes a glass boundary, it bends \_\_\_\_\_ the normal. The speed of the ray in the glass is \_\_\_\_\_ than it is in air.
- True or false?
  - Light always bends when it enters a different substance.
  - Images can be caused by reflection or refraction.
  - Light can bend due to refraction within the one substance.
  - Light passing from water to air will bend towards the normal.
  - The apparent depth of a swimming pool is less than the real depth.
- State two uses of optical fibres.
- Construct ray diagrams by copying and completing the light ray in each diagram below.

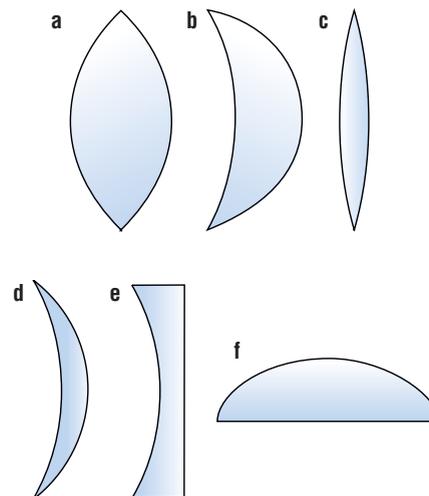


- Copy the following sentence, modifying it to correct any mistakes.  
Light travelling along inside an optical fibre undergoes several total internal refractions.
  - Describe at least two uses for optical fibres.
  - Outline how each use you have described may benefit society.

- Identify the complementary colour to:
  - red
  - magenta
- Identify the type of image produced when an object is close to:
  - a concave mirror
  - a convex mirror
- Describe three situations in which different types of mirrors are used and why.

## Thinking questions

- Identify which of the following lenses are:
  - concave
  - convex



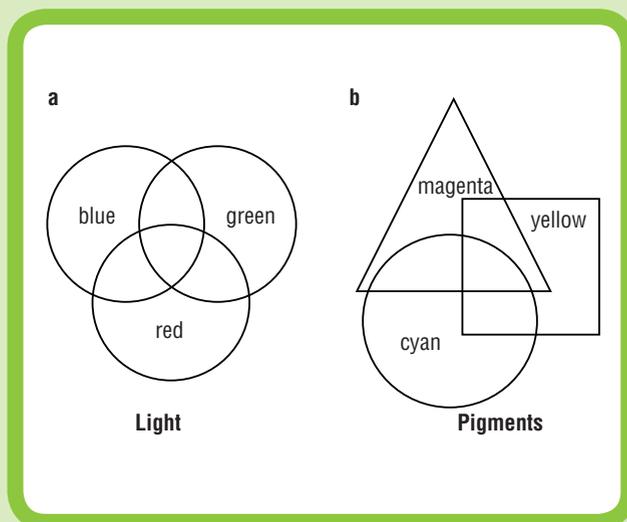
- Construct a diagram to demonstrate how 'ray' tracing can be used to find a real image in:
  - a concave lens
  - a convex lens
- Describe the image type (real or virtual), size (enlarged or diminished) and orientation (inverted or upright) when a candle is placed:
  - 20 cm in front of a convex lens of focal length 10 cm
  - 100 cm in front of a convex lens of focal length 10 cm
  - 5 cm in front of a convex lens of focal length 10 cm
  - 5 cm in front of a concave lens of focal length 10 cm



- 12 Identify** the two lenses in a basic telescope or microscope.
- 13 Describe** how lenses and/or mirrors are used in the following technological developments:
- microscope
  - security mirror in a shop
  - binoculars
  - slide projector

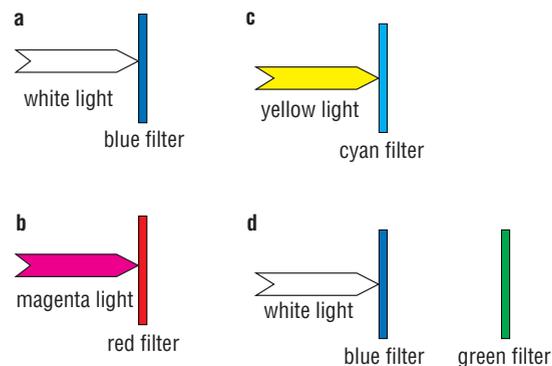
## [ Interpreting questions ]

- 14 Identify** an optical device that produces:
- real images for viewing
  - virtual images for viewing
- 15 Copy and colour** each of the following colour combination diagrams.



- 16 Assess** which colour light in each pair below refracts the most.
- red or orange
  - blue or green
  - yellow or violet

- 17 Identify** how many total internal reflections occur inside a drop of water that helps form:
- a primary rainbow
  - a secondary rainbow
- 18 Analyse** why red sunsets can sometimes be more impressive when there is more dust or pollution in the air than usual.
- 19 Copy and complete** the following diagrams involving filters.



- 20 Describe** the appearance of:
- a green flag viewed in blue light
  - a blue flag viewed in red light
  - a cyan flag viewed in green light
- 21** A printer combines hundreds of tiny cyan dots with a similar number of yellow dots in one region of a page. **Deduce** what colour that part of the page will appear.
- 22** A fruit shop places a red light above a basket of lemons. **Deduce** what colour the lemons will appear to customers.

# Elements, compounds and mixtures

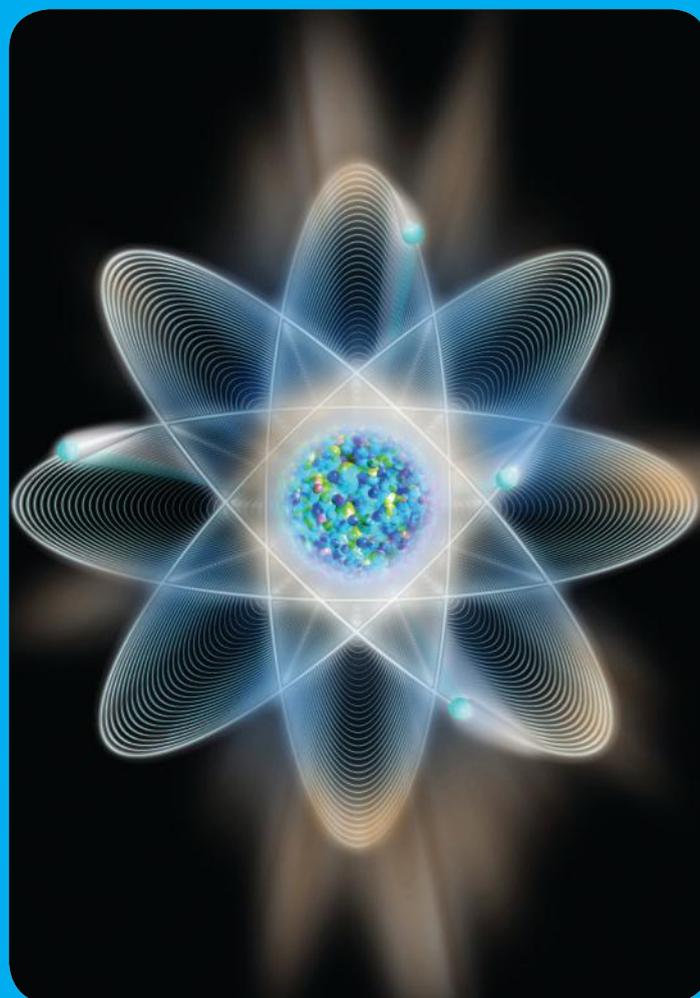
## Specific learning outcomes

7.9.1.1, 7.9.2.1, 7.9.3.1, 7.9.4.1, 7.9.5.1, 7.9.5.1, 7.9.5.1, 7.9.5.2

By the end of this chapter the learner should be able to:

- Give some examples of elements in the environment:
  - i aluminium—aluminium cans, aluminium boats and aluminium foil
  - ii gold—gold earrings, gold wedding rings, gold medals
  - iii silver—silver coins, silver medals
  - iv iron—reinforcing rods, roofing sheet, scrap metal.
- Identify examples of common household compounds: *water, salt, sugar, washing powder, soap, etc.*
- Produce mixtures from common substances: *coffee and sugar, water and sugar, gravel and sand, water and lemon, etc.*
- Separating mixtures using different physical methods: *evaporation (salt and water), filtration (mud and water).*
- Illustrate that it is difficult to separate a compound once it is formed: *flour, sugar, yeast and water from bread.*
- Give examples of metal and non-metal elements:
  - i metals—aluminium, iron, copper
  - ii non-metals—carbon, oxygen, chlorine.
- Identify properties of metals and non-metals:
  - i metals: *conduct electricity, ductile*
  - ii non-metals: *dull appearance.*

- 1 Do you think the symbol Fe stands for ferret, ferocious or iron?
- 2 Which do you think is the symbol for chlorine? C, Ca, Cl or Co?
- 3 Are you making a new substance when you add water to cordial?
- 4 List what is produced when paper is burnt.
- 5 Why are vegetables stored in the refrigerator?
- 6 Which do you think will relieve a headache more quickly: a whole aspirin tablet or the same tablet crushed?
- 7 'You can easily see an atom with an ordinary microscope.' True or false?



## Challenges

# UNIT 9.1

## Elements, compounds and mixtures

### Introduction

In the fourth century BC, Greek philosophers thought that everything was made from four basic ingredients: earth, air, fire and water. We now know that all matter is made from basic ingredients. These are not the ingredients of the ancients, however, but 'elements'—around one hundred of them. These elements make up the planets and the stars and every substance that we see, breathe, drink and use. They even make up our bodies.

### Elements

An **element** is a pure substance. It cannot be broken down into other substances. If you were asked to name some pure substances, you might mention substances such as plastic, paper, air and sugar—however, none of these are elements! The reason—they can all be broken down into simpler substances. There are many possible ways to break down a substance, such as burning or using acids or other chemicals. When plastic, wood or paper are burnt, they break down and the carbon dioxide inside them can be seen. Carbon is an element, because it cannot be broken down any further.

Some other elements are aluminium, copper, oxygen, sodium and chlorine. The periodic table is a complete list of all the known elements.

There are 92 naturally occurring elements. Most of them were discovered in the last 400 years. There are more than 20 artificial elements. These have never been found in nature but were created by scientists in the laboratory. Many of the artificial elements are unstable. They exist for only a few seconds after being created. Some elements are listed in Figure 9.1.2.

### Teacher demonstration

Your teacher may conduct a demonstration in a fume cupboard, showing how sugar may be broken down by concentrated sulfuric acid. The acid breaks the sugar down into water vapour, carbon and other substances. The water vapour bubbles through the carbon to produce a beautiful black cone of charcoal.

**Warning:** This demonstration must be done in a fume cupboard, as the fumes produced may cause respiratory problems. Safety goggles must be worn.

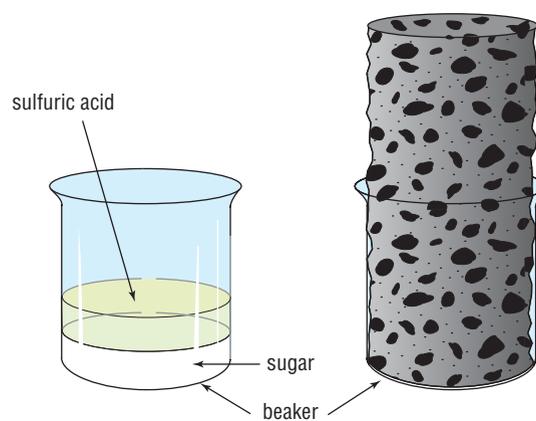


Fig 9.1.1

Concentrated acid may be used to break down sugar into carbon and other substances.

Each element has a unique **symbol** made up of one or two letters. Carbon has the symbol C. Because carbon uses the single letter C, chlorine is given a different symbol, Cl. Cobalt has the symbol Co.

Element	Symbol	Element	Symbol
Aluminium	Al	Lead	Pb
Americium	Am	Magnesium	Mg
Barium	Ba	Mercury	Hg
Boron	B	Neon	Ne
Calcium	Ca	Nickel	Ni
Carbon	C	Oxygen	O
Chlorine	Cl	Platinum	Pt
Chromium	Cr	Plutonium	Pu
Copper	Cu	Potassium	K
Einsteinium	Es	Radium	Ra
Europium	Eu	Sodium	Na
Fluorine	F	Silver	Ag
Gold	Au	Sulfur	S
Helium	He	Tin	Sn
Hydrogen	H	Titanium	Ti
Iodine	I	Tungsten	W
Iron	Fe	Uranium	U
Krypton	Kr	Zinc	Zn

Fig 9.1.2 Some elements and their symbols

The first letter of a symbol is always a capital. The second is always in lower case. But what about copper? C and Co have been used already! Many elements get their symbols from Latin or Greek words. Copper’s symbol, Cu, is taken from the Latin word for copper—*cuprium*. The names of some elements are not at all easy to work out—sodium has the symbol Na, from the Latin word *natrium*. Potassium’s symbol, K, comes from the Latin word *kalium*, while gold’s symbol, Au, comes from the Latin word for the metal, *aurum*.

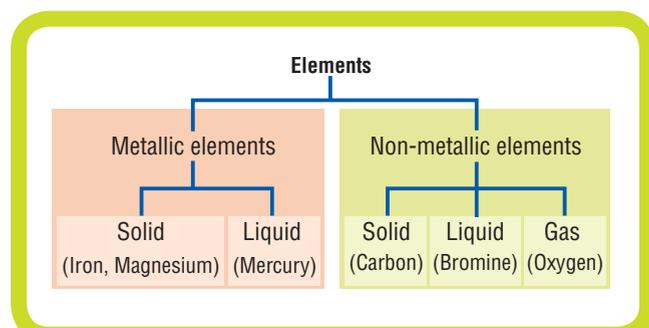
### Metal and non-metal elements

Of the 106 known elements, 84 are metals and 22 are non-metals.

All metallic elements are solids at room temperature except for mercury, which is a liquid. The properties of metallic elements make them very useful to humans. For example, aluminium is

used to form cooking utensils, copper for electrical wires and plumbing pipes, while mercury is used in thermometers.

Non-metallic elements can exist as solids, liquids or gases. They are also very useful to humans.



Metals and non-metals are classified according to their properties.

Fig 9.1.3

Nitrogen gas is used for making fertilisers, carbon (diamond) for jewellery and cutting tools, and carbon (graphite) for bicycle frames and as a lubricant. Sulfur shows all the properties of a non-metal. It is used for making sulfuric acid and fertilisers. It has antibacterial and antifungal properties and its compounds are used to preserve food.



Fig 9.1.4 Many useful products are made of metals.



Fig 9.1.5 The sulfur shown is a typical example of a non-metal.

### The different properties of metals and non-metals

Metals	Properties	Non-metals
solid (except mercury)	<b>physical state</b>	solid liquid or gas
shiny	<b>appearance</b>	dull
high	<b>melting point</b>	low
high	<b>density</b>	low
malleable	<b>malleability (ability to be shaped)</b>	brittle (easily broken)
ductile	<b>ductility (ability to be stretched into wires)</b>	no
good	<b>conductivity</b>	poor

## Activity 1

### Flame tests

**Aim** To identify various elements using the flame test

#### Equipment

Paperclips, tongs, Bunsen burner, heat-proof mat, beaker of water, various chloride salts (e.g. strontium chloride, sodium chloride, copper chloride, potassium chloride), watch-glass

#### Method

- 1 Obtain a tiny sample (enough to cover a match head) of one of the chemicals on a watch-glass.
- 2 Fill a clean beaker with water.
- 3 Dip one end of a paperclip into the water, then into the chemical so some of the chemical sticks to the paperclip.
- 4 Set the Bunsen burner to a blue flame.
- 5 Using tongs, place the end of the paperclip containing the chemical into the flame and observe the colour produced. (See Figure 9.1.6.)
- 6 Rinse the beaker and fill it with clean water. Obtain a new paperclip.
- 7 Repeat steps 1 to 6 for the other chemicals.

#### Extension

Your teacher will supply some unknown samples for you to test. Use your results to identify the elements in the unlabelled samples.

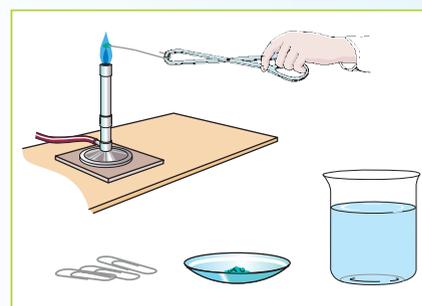
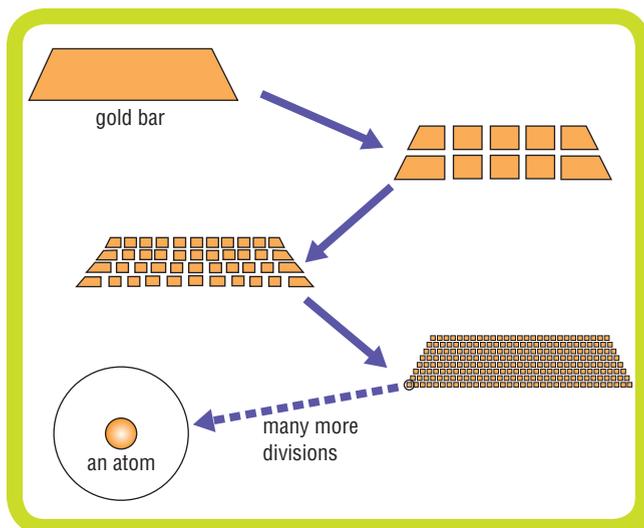


Fig 9.1.6

#### Questions

- 1 **Record** your results in a table. Include the scientific names of each chemical.
- 2 For each chemical **identify** which elements give rise to colour.
- 3 **Describe** how flame tests can be used to identify elements in a compound.
- 4 New water and a new paperclip were used for each chemical you tested. **Explain** why this is important.
- 5 **Propose** a use for this technique, drawing on the experience gained in this experiment.



The smallest piece of gold possible is an atom of gold.

Fig 9.1.7

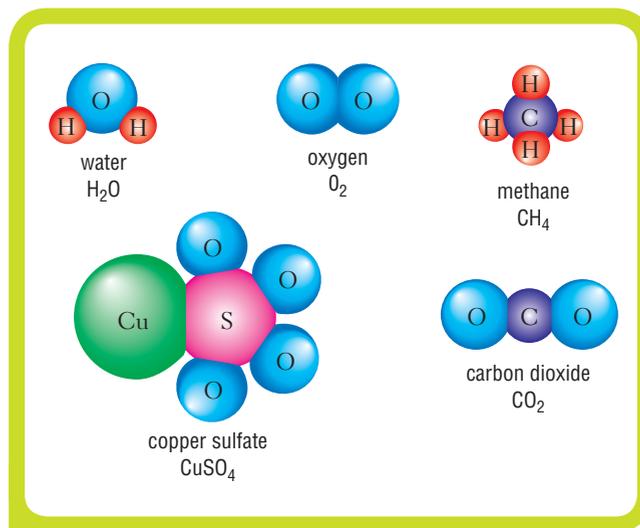


Fig 9.1.9

Common molecules

## Atoms

Imagine you wish to share a thin sheet of gold equally among your class. You begin to divide it by cutting it up with a very fine, sharp knife.

Of course, the small pieces you cut off from the original sheet are still gold. Now imagine these smaller pieces are divided into tiny pieces to be shared among everyone in Year 7. If the slicing continues, how far could you go before the pieces of gold could not be divided any further? At the end you must get to the smallest piece possible. This 'smallest piece' is called an atom, in this case an atom of gold. The word 'atom' comes from the Greek word *atomos*, meaning 'that which cannot be divided'. In other words, an **atom** is the smallest piece of a substance that is still that substance. The element gold (symbol Au) is simply lots and lots of individual atoms of gold.

We represent atoms in a picture as spheres. Only recently has the powerful electron microscope made it possible for scientists to observe atoms.

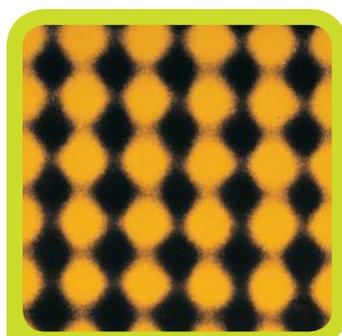


Fig 9.1.8

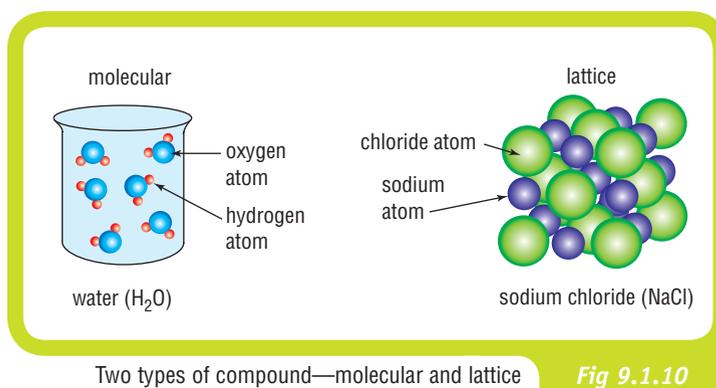
Gold atoms are easily recognised in this electron microscope photograph.

## Compounds

Everything is made of atoms. But since there are only about 100 different atoms, how are there millions of different substances in the world?

The answer lies in the fact that atoms usually link to form small groups called **molecules**, or larger structures called **lattices**. Special forces called atomic bonds hold the atoms together. Water is perhaps the most famous molecule. Each water molecule is made up of two hydrogen atoms and one oxygen atom. This gives us H<sub>2</sub>O, the familiar chemical symbol for water.

A **compound** consists of a number of identical molecules or a lattice containing different atoms joined or 'bonded' together. Water is a compound. A glass of the compound water contains billions of water molecules. The compound sodium chloride (table salt) consists of grains made up of a lattice of sodium and chlorine atoms held together by atomic bonds.



Two types of compound—molecular and lattice

Fig 9.1.10



Baking soda



Sugar



Medicines



Rubber gloves



Fig 9.1.11 Some compounds

Millions of compounds are possible since there are so many ways the 100 or so different types of atoms can be combined.

Compounds have different properties (e.g. colour, texture, smell, density) than the elements whose atoms they contain. For example, the compound water is a liquid at room temperature. Water ( $\text{H}_2\text{O}$ ) contains atoms of the elements hydrogen and oxygen. Hydrogen and oxygen exist in air as colourless gases, very different from water! Sodium is an explosive metal. Chlorine is a poisonous gas. But they combine or join to form sodium chloride ( $\text{NaCl}$ ). Sodium chloride is the table salt that we safely sprinkle on food when we have our meals.

Our bodies contain hundreds of different compounds. Trees, the Earth's crust and the many human-made or synthetic materials, such as medicines and plastics, also contain many hundreds of different compounds.

## Activity 2

### Mathomat molecules

**Aim** To construct diagrams of molecules

**Equipment**

A Mathomat or similar template

**Method**

- 1 Construct diagrams of as many atom combinations as possible using Mathomat circles (let each different circle represent a different atom). You may not use more than four identical circles in each combination.
- 2 Colour each different size circle a particular colour. A few possibilities are shown below.

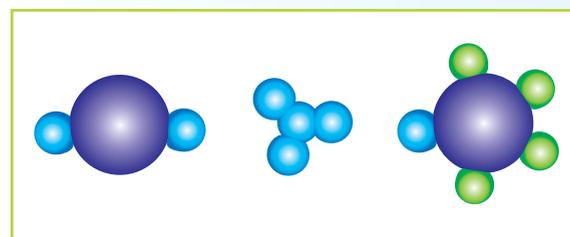


Fig 9.1.12

**Questions**

- 1 **State** the number of molecular combinations made.
- 2 **Compare** the number of 'atoms' with the number of 'molecules'.

### Compound formulas

Scientists use a shorthand way of describing which atoms are bonded in a molecule or lattice. They write chemical **formulas** using element symbols, with subscripts (small numbers after the symbol of the element) to show how many of each atom there are in the compound. Water has two atoms of the element hydrogen and one atom of the element oxygen, so its formula could logically be written as  $\text{H}_2\text{O}_1$ . Scientists never include the subscript 1 and so the formula for water becomes  $\text{H}_2\text{O}$ . The following table on page 182 gives the formulas for some compounds.

Compound (common name)	Scientific name	Formula	Structure	Number of atoms of each type per group
Water	Dihydrogen oxide	H <sub>2</sub> O	Molecule	2 hydrogen 1 oxygen
Oxygen	Oxygen	O <sub>2</sub>	Molecule	2 oxygen
Ozone	Ozone	O <sub>3</sub>	Molecule	3 oxygen
Table salt	Sodium chloride	NaCl	Lattice	1 sodium 1 chlorine
Natural gas	Methane	CH <sub>4</sub>	Molecule	1 carbon 4 hydrogen
Hydrochloric acid	Hydrogen chloride	HCl	Molecule	1 hydrogen 1 chlorine
Quartz	Silicon dioxide	SiO <sub>2</sub>	Lattice	1 silicon 2 oxygen
Sugar	Sucrose	C <sub>12</sub> H <sub>22</sub> O <sub>11</sub>	Molecule	12 carbon 22 hydrogen 11 oxygen
Petrol	Octane	C <sub>8</sub> H <sub>18</sub>	Molecule	8 carbon 18 hydrogen
Rust	Iron oxide	Fe <sub>2</sub> O <sub>3</sub>	Lattice	2 iron 3 oxygen

## Mixtures

A **mixture** contains two or more substances (elements or compounds) simply mixed together. These substances are not bonded together and no new substance is formed when they are combined. This also means that a mixture can easily be separated into its ingredients using simple techniques that you have already come across in Chapter 6.

Szeba drink is an example of a mixture. It contains sugar, water, flavouring, colouring and carbon dioxide. A bottle filled with water and sand is another example of a mixture. Water and sand can be easily separated using the filtration method.

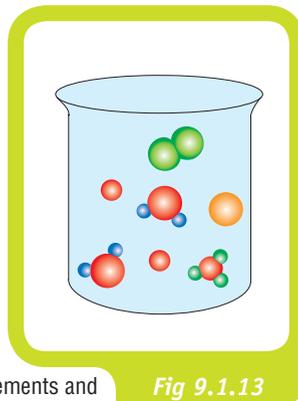


Fig 9.1.13

How many different elements and different compounds are in this mixture?

## Activity 3

### Breaking down substances

**Aim** To identify elements in various substances

#### Equipment

Small samples of various materials (paper, plastic straw, aluminium foil, wood (e.g. toothpick), cloth, green leaf, wool, cotton wool, bread), Bunsen burner, heat-proof mat, metal tongs, safety glasses, squares of contact adhesive to stick samples into workbook

#### Method

- 1 Hold a sample in the metal tongs and place part (but not all) of it in a blue Bunsen burner flame. The sample should be small enough to later stick into your workbook without causing too much of a bulge.
 

**Warning:** Use a fume cupboard if testing plastic or other substances that produce dangerous fumes.
- 2 Allow the sample to burn only partially before removing it from the flame. If it does not burn, withdraw it from the flame after a couple of seconds.
- 3 After withdrawing the sample from the flame, put out any flame on the sample (e.g. by prodding with the tongs, blowing or using water).
- 4 When cool, stick the sample into your workbook.
- 5 Repeat steps 1 to 4 for the other samples.

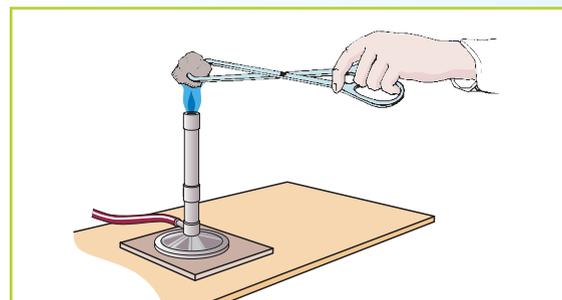


Fig 9.1.14

#### Questions

- 1 **Record** your results in a table, describing observations made for each sample.
- 2 **a List** any observations that were common to each sample tested.
 

**b** Use observations to **identify** an element common to several samples.

## [ Questions ]

**Checkpoint****Elements**

- 1 Clarify** what is meant by the term 'element'.
- 2 Identify** methods that can be used to break down substances into elements.
- 3 State** the number of naturally occurring elements.
- 4 Identify** the two most abundant elements in the Earth's crust.
- 5 Outline** the properties of metals.
- 6 Identify** two metals and **state** their uses.
- Repeat questions 5 and 6 for non-metals.

**Atoms**

- 8 Define** the term 'atom'.
- 9 Describe** the connection between atoms and elements.

**Compounds**

- 10 Define** the term 'compound'.
- Using examples, **identify** the two types of compound structures.

**Mixtures**

- 12 Define** the term 'mixture'.
- 13 Distinguish** between mixtures, elements and compounds.

**Think**

- 14 List** the name and symbol of three elements starting with C.
- 15 List** six elements with single-letter symbols.
- 16 List** the name and symbol for two elements whose names are unlike their symbol.
- 17 Identify** the names of the following elements:  
a Ne      b P      c Li      d Mg.
- 18 Identify** the symbols for the following elements:  
a hydrogen   b helium   c sulfur   d sodium.
- 19** For each of the following examples, **assess** whether a mixture or a compound is formed.  
a Cordial is diluted with water.  
b Toast is burnt.  
c Strawberry topping is added to milk to make a milkshake.
- 20 Identify** two compounds that have a lattice structure.
- 21 State** whether you would use a metal or non-metal for the following items. **Justify** your choice in each case.  
a ship's hull                      c electrical wires  
b fishing rod                      d barbecue hot plate.

**Analyse**

- 22** Use the information in the table on page 182 to **construct** diagrams of four different molecules.

- Using the descriptions given, **classify** each substance as a metal or non-metal, and try to **identify** the element.
  - I am used to make bicycle frames. I am light in weight but very strong. I can be polished to a shiny finish.
  - I have a density so low that I am found in the air. I am used by your body to make energy.
  - I can be stretched into wires used to carry electricity. I am also used to make water pipes and can be easily bent in different directions.
  - I am a liquid that is used in thermometers. Although I look very shiny and pretty I am highly poisonous.

## [ Extension ]

**Investigate**

Use the element gold (Au) and **describe** the following information:

- history of the element's discovery
- uses for the element
- how the element is obtained
- relevant safety issues
- physical properties that make the element useful.

## Chapter review

## [ Summary questions ]

- Write the symbols for these elements:  
a potassium   b sodium   c chlorine   d argon.
- State** two properties of metal and non-metal elements.
- What is the only metal element that is in a liquid form at room temperature?
- What are the two types of compound structures?
- In the water compound, how many atom(s) of hydrogen and oxygen are there?

## [ Thinking questions ]

- 6 Explain** one major difference between a compound and a mixture.
- One of the properties of metals is that they are malleable. What does this mean?
- 8 Explain** how there are millions of different substances in the world while there are only about 100 different existing atoms (elements).

# Living structures and plant reproduction

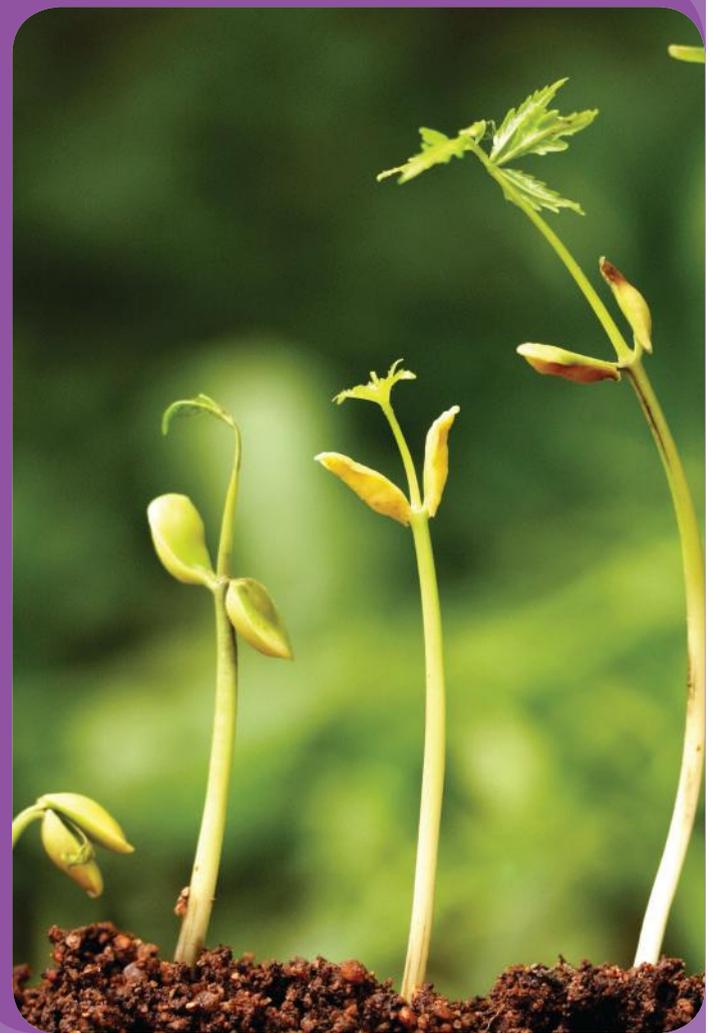
CHAPTER

10

By the end of this chapter learners should be able to:

- Identify some living things that reproduce:
  - i **sexually**—*human, fish, mango*
  - ii **asexually**—*banana, potato, slippery cabbage.*
- Identify living organisms that reproduce asexually by: *budding, splitting, vegetative regeneration, spores.*
- State that in sexual reproduction each parent (male and female) produces special *sex cells* that join together to form a new organism.
- Name some animals that reproduce sexually by:
  - i *externally—fishes, frogs*
  - ii *internally—humans, birds, snakes.*
- Perform dissection of a flower to identify the reproductive parts, e.g. *hibiscus flower.*
- Identify parts of a seed as: *testa, cotyledon, embryo, plumule, radicle.*
- Identify a range of seed dispersal methods: *wind, animal, water, explosion.*
- Carry out the germination process of corn and bean seeds (hypogeal and epigeal).
- Draw the sequence of events in the life cycle of a plant:
  - i *mature plant*                      ii *flowering*
  - iii *pollination and fertilisation*    iv *seeding*
  - v *germination*                      vi *new young plant develops.*

- 1 How many parents are needed for reproduction?
- 2 What is a hermaphrodite?
- 3 Why don't clones all look identical?
- 4 Outline the main stages in the growth of a seed.
- 5 List the various methods of seed dispersal and assess their effectiveness.



# UNIT 10.1

## Types of reproduction

### introduction

The only way a species can survive is if more individuals of the same species are constantly being produced. **Reproduction** is the process of producing one or more new individual. For example, cats have kittens, dogs have puppies, flowers have seeds and humans have babies. Not all living things or **organisms** reproduce in the same way. There are two types of reproduction: **asexual** and **sexual**.

### Asexual reproduction

**Asexual reproduction** is where a new organism is produced by an individual organism without the need for two types of sex cells. Sex cells are special cells for reproduction. Asexual reproduction is happening right now within your own body. It occurs when cells in you are growing or when they are repairing damaged cells. Many plants also reproduce asexually.

In asexual reproduction, there is no need for two types of sex cells. New cells are formed by older ones called **parent cells**. Parent cells split to make two identical copies, called **daughter cells**. Because the new organism is made from cells from only one parent, little variation is passed into the new organism. Organisms produced this way are called **clones**.

Clones may not always look exactly the same—for example, two cloned trees may look different because of the environment they live in.



**Fig 10.1.1** These mushrooms were produced by asexual reproduction, so they look very similar to each other and the parent plant.

Asexual reproduction is useful if:

- the environment is constant and the organism is suited to it (no advantage in changing)
- the species is rare and there is not much chance of meeting an organism of the same type of the opposite sex
- the organism can't move much.

Sometimes changes may happen in daughter cells when they have slightly different genes from the parent cell. This may occur when cell division fails to produce exact copies of the cells and the offspring shows new and unexpected characteristics. This is called a **mutation**.

Types of asexual reproduction include **fission**, budding, spores and fragmentation followed by **regeneration**.

### Fission

**Fission** is a type of cell reproduction where the matured parent cell divides across the middle and splits, producing two new young cells. The two new cells are identical to the parent cell. This is how most bacteria reproduce. Single-celled organisms, including some types of algae and fungi, also reproduce by fission.



**Fig 10.1.2** Bacteria divide by fission—this cell is about to divide.

Reproduction can occur very quickly by fission. Because bacteria can reproduce so quickly by fission, some types can kill a human within hours of infection. In conditions of plenty of food and the right temperature, a single bacteria cell could ‘breed’ more than a million new cells in hours. This is why some foods ‘go bad’ very quickly. The bacteria that cause food poisoning can kill a healthy adult in fewer than 24 hours.

### Budding

**Budding** is a type of uneven fission. A new individual develops from an outgrowth of a parent, splits off and lives independently. When the parent cell divides, one part, the **mother cell**, is much larger than the other, the **bud cell**. The buds later form buds of their own. Organisms that reproduce by budding include yeasts and many cnidarians (coral, jellyfish and sea anemones).



Fig 10.1.3

Scanning electron microscope image of budding yeast cells. Yeast is important in food production, particularly bread and alcoholic beverages.

### Spores

Some organisms have special structures called **spore vessels**. Inside these structures the reproductive cells (or spores) form. Spores are released from time to time. They are spread by air, water or other living things. When the spores reach a suitable environment, they grow and form a new organism. Many fungi, mosses, ferns and algae use spores to reproduce.



Fig 10.1.4

This fern will release millions of spores into the air.

### Imperfect fungi

Although most fungi reproduce asexually, some reproduce sexually. They are known as ‘imperfect fungi’. Ringworm, or the skin disease commonly called *bakua* in Solomon Islands pidgin, is not a worm at all, but an ‘imperfect fungi’.

### Fragmentation and regeneration

**Fragmentation** occurs when pieces break off from an organism. The pieces that break off can then grow or divide to form new organisms. Each piece **regenerates** or grows into a new organism. This occurs in starfish, earthworms, mushrooms and many flowering plants. When plants reproduce by this



Fig 10.1.5

This starfish is lucky—a new arm is regenerating at its centre, to replace one that has been lost. The broken-off arm can also regenerate as a new individual.

method, it is known as **vegetative reproduction** or **vegetative propagation**.

Some common examples of vegetative propagation are given in the table below.

Plant organ	Method of vegetative propagation
Bulb	An underground, reduced stem surrounded by fleshy, close-set leaf base, e.g. onion.
Rhizome	Creeping underground horizontal stem, swollen with stored food. Aerial shoots formed from lateral or terminal buds, e.g. ginger.
Runner	Lateral branches that arise close to the ground grow along the surface, e.g. strawberry, African violet.
Stem tuber	Swollen tip of underground lateral stem, e.g. Irish potato.
Sucker	Shoots that arise from underground part of plants growing upward, e.g. banana.
Root tuber	Swollen fibrous root or tap root capable of forming new plant, e.g. sweet potato.

## Sexual reproduction

**Sexual reproduction** requires two different sex cells. Sex cells are special cells for reproduction. Reproduction that involves sex cells is called sexual reproduction. These cells may come from an individual organism (as in many plants and some animals) or from two parents of different sex. The two sex cells, called **gametes**, fuse together to form a new cell called a **zygote**, which then divides over and over to form a new organism.

A plants or animal that has both male and female reproductive organs and produces both types of sex cells is called a **hermaphrodite**. Hermaphrodites are capable of **self-fertilisation**.



**Fig 10.1.6**

The hibiscus flower has both male and female reproductive organs.



**Fig 10.1.7**

The offspring of sexual reproduction are quite different from each other and their parents.

The offspring of asexual reproduction are very similar to the parent, but the offspring of sexual reproduction are quite different from their parents.

### Gametes

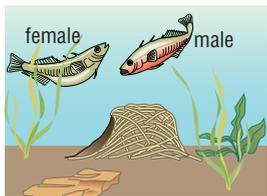
The sex cells or gametes produced by males are called **sperm**, and move about using a tail called a **flagellum** (plural: flagella).

The gametes produced by females are larger and are called **ova** (singular: ovum) or **eggs**. Eggs carry a store of food to nourish them. They do not have flagella and so do not move about of their own accord. The release of an ovum in the female is called **ovulation**.

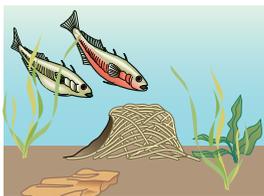
### Fertilisation

When the male and female gametes successfully join together, a zygote is formed. This process is called fertilisation. For the fertilisation process to occur, the gametes must be released at the same time, properly formed and fully developed, and the environment must be just right.

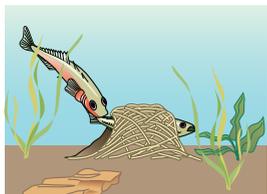
Fertilisation in animals may be **external** (outside the body) or **internal** (inside the body). After internal fertilisation, the zygote may develop inside the female or can be laid as an egg.



A male approaches a female, who is attracted to his red belly.



The male leads the female to the nest.



The female lays her eggs after being tapped on the tail by the male.



The female leaves the nest after being bitten by the male. The male goes in and sheds sperm over the eggs.

Fig 10.1.8

Fish fertilise many eggs at once because only a few will survive to maturity.

## Development of the embryo

Zygotes continue to divide to form a bundle of cells called an **embryo**. If the embryo receives sufficient nourishment and is not harmed by environmental factors (like a hungry predator), it will grow to become a fully developed organism.

Some organisms lay a large number of eggs at one time, but only a few will survive to adulthood. Other organisms have only one offspring at a time. Generally, organisms that do not provide much parental care fertilise many eggs at once. In contrast, organisms that provide a lot of parental care fertilise as little as one egg at a time.



Cow and calf

Fig 10.1.9

## 10.1 [ Questions ]

UNIT

### Checkpoint

#### Asexual reproduction

- a Identify** three types of asexual reproduction.

**b Distinguish** between them.
  - Match the following organisms to the type of asexual reproduction they use:
- |          |                                |
|----------|--------------------------------|
| Bacteria | Fragmentation and regeneration |
| Yeast    | Budding                        |
| Ferns    | Fission                        |
| Starfish | Spores                         |
- Describe** the characteristics of spores that enable them to be spread by air, water and other organisms.
  - Explain** how you think spores might be spread by other organisms.
  - Define** 'vegetative propagation' and give an example of how it might happen.

#### Sexual reproduction

- Sexual reproduction is the better method of reproduction in a varied environment. **Explain** why.

- Define** 'fertilisation'.
- Explain** what a hermaphrodite is.
- State** the two types of gametes and **identify** where each is produced.
- Describe** what things are necessary to bring about successful fertilisation.
- Copy the following, **modifying** any incorrect statements so they are true.
  - The release of an ovum by the female is called pregnancy.
  - All fertilised eggs survive to maturity.
- Explain** why nectar is located deep inside the lower part of the flower and below the anthers.
- Compare** the advantages and disadvantages of internal and external fertilisation.

>>

**Think**

- 14** Copy the following, **modifying** any incorrect statements so they are true.
- a** In asexual reproduction, two parents are needed.
  - b** Fission is a type of sexual reproduction.
  - c** If the daughter cell is identical to the parent cell, a mutation has occurred.
- 15** Do clones always look exactly the same as their parents? **Explain**.
- 16** **Evaluate** the advantage of reproducing by spores, compared with budding.
- 17** If organisms such as earthworms and mushrooms can regenerate lost body parts, **propose** why they eventually die.
- 18** If bacteria reproduce easily in humans, **propose** which temperature suits them best.
- 19** New plants are often made by taking a 'cutting', a small piece of the original, which is then placed in soil until it forms roots.
- a** **Explain** why reproduction does not always need two parents.
  - b** **Explain** what type of asexual reproduction this is an example of.
- 20** Many plants can reproduce both sexually and asexually. **Explain** why this is an advantage.

**Analyse**

- 21** **Describe** an advantage of asexual reproduction over sexual reproduction.
- 22** Cloning human cells can help in making replacement body parts, like skin for burns victims. If cloning is so useful, **propose** reasons why so many people are against it.
- 23** If a bacterial cell divides once every five minutes, **calculate** how many cells will be present at the end of:
- a** 10 minutes
  - b** 30 minutes
  - c** 1 hour
  - d** 1 day
- 24** Fish do not provide much care to their young. **Explain** why it is beneficial that they fertilise many eggs at once.

**[ Extension ]****Create**

- 1** Construct a crossword to **summarise** sexual and asexual reproduction. Include definitions and specific examples of the different types of reproduction.

**Investigate**

- 2 a** **Investigate** how vegetative propagation is used in agriculture.
- b** Choose one example of this and **design** an experiment or demonstration to show how it is done.
- c** **Perform** your experiment or demonstration.

## Activity 1

Asexual reproduction  
in plants

**Aim** To examine asexual reproduction in plants

**Equipment**

An onion and a potato with eyes, knife

**Note:** Many other things could be substituted for the onion and potato, such as strawberry runners, Chinese willow-stem cuttings or orchid bulbs.

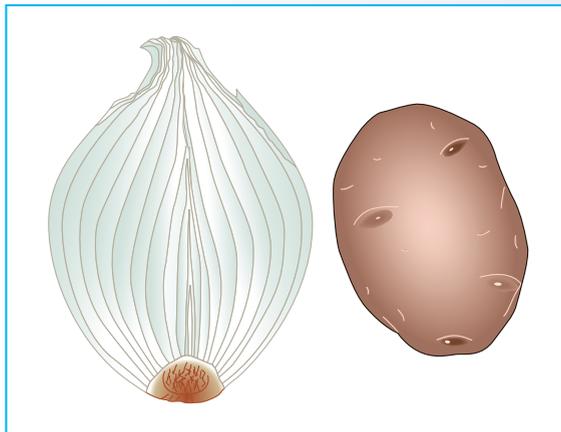


Fig 10.1.10

**Method**

- 1 Cut the onion in half lengthways.
- 2 Draw the onion, labelling the parts shown in the diagram above.
- 3 Draw the potato. Identify the buds.

**Questions**

- 1 The buds of an onion can become new individuals. **Explain** why this is an example of asexual reproduction.
- 2 If the 'eye' of a potato is a bud, **predict** what might happen if you cut out a potato eye and planted it.

## Activity 2

## Examination of spores

**Aim** To examine spores using a stereomicroscope

**Equipment**

Stereomicroscope, fern leaf with visible spores, tweezers, filter paper

**Method**

- 1 Place your leaf under the microscope and examine the spore vessels. Draw a section of the leaf and describe in words what you see.
- 2 Use the tweezers to break open some of the spore vessels onto the piece of filter paper. Examine these under the microscope and describe them.

**Questions**

- 1 **Describe** how easy it was to break open the spore vessels.
- 2 **Predict** how many spores you think were in each spore vessel.
- 3 **Describe** how easily you think the fern spores could be spread.
- 4 **Identify** some ways in which the spores will be spread.

# UNIT 10.2

## Plant reproduction

**introduction** Flowers are the reproductive organs of flowering plants. They come in many different shapes, colours and structures. When studying flowers, remember that there are many types of flowers that will look quite different from each other. However, if you look carefully, you may see the basic structures described. The parts of a flower are shown in Figure 10.2.1.

### Parts of a flower

Although flowers may vary in many ways, most flowers have the following parts that can be easily identified: **anther, filament, stigma, style, ovary, petal** and **sepal**.

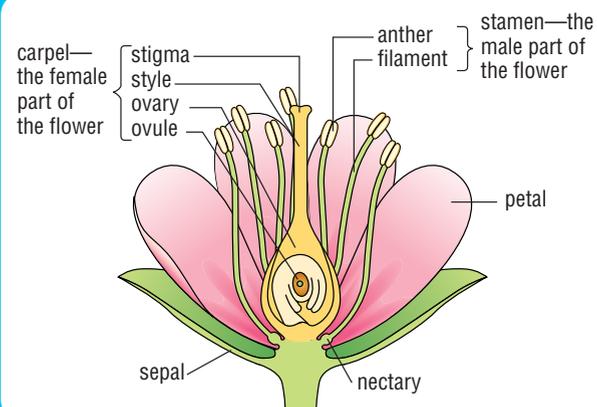
The outside of the flower is surrounded by five green structures called sepals. A sepal is a special kind of leaf that protects the young flower when it is folded up in a bud. Most sepals are green and leaf-like in structure.

The petals are the coloured parts of the flower. They are inside the sepals. They are leaf-like structures. Petals are usually red, pink, yellow, orange or blue.

An important function of both the sepals and petals is to protect the sexual organs of the flower. The colourful petals attract insects to the flower. When insects jump from one flower to another, pollen on their bodies falls on the female part, the stigma. This helps **pollination** to occur. At the base of the petals is the nectary gland. It produces a liquid called nectar. Insects, birds and some mammals hunt for flowers to feed on this sugary liquid.

Inside the ring of the petals is the male part called the **stamen**. The stamen contains small stalks called filaments. On the ends of the filaments are anthers, which produce pollen grains. Inside each pollen grain are the male cells that will fertilise the female cells after pollination is successful.

In the centre of the flower is the female part called the **carpel**. At the top of the carpel is the stigma. The



**Fig 10.2.1** Many flowers are hermaphrodites, meaning they contain both male and female parts.

stigma is sticky and is ready to catch pollen grains. The stigma is connected to the ovary by the style. Inside the ovary are the ovules containing the eggs (ova).

### Activity 3

#### How do flowers vary in their structure?

Collect two flowers from the flowers available for you to study around your school compound. Good varieties to look at include sweet peas, lilies, lemons, orchids, pawpaws, hibiscus and frangipani.

Study and compare two different flowers carefully and answer the following questions.

#### Questions

- 1 Did each of the flowers you looked at have the same number of sepals and petals?
- 2 Were the petals separate or sometimes joined together?
- 3 Did both the flowers you looked at have both a stamen and a carpel? How many of each?
- 4 Slice each flower vertically down the centre and draw what you see. Was the ovary above or below where the petals joined the base of the flower?
- 5 How many ovules can you see in the ovary?

### Sex and plants

Many plants reproduce sexually, using flowers that may contain both female and male parts. The female gametes are produced in the plant's ovaries, inside structures called **ovules**. Each ovule contains one female gamete. Male gametes are produced in the flower's **anthers** and are found inside pollen grains.

Plants cannot deliberately move closer together to cause fertilisation, so they rely on the wind or insects to transfer pollen from the anthers to the stigma. This is called **pollination**.

**Self-pollination** is when pollen from an anther of a flower is transferred to the stigma on the same flower. Cross-pollination is when pollen is transferred from the flower of one plant to another flower on a different plant.

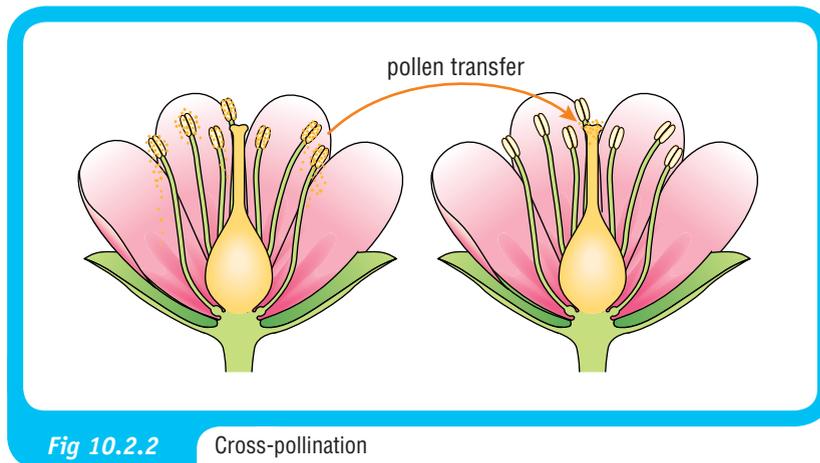


Fig 10.2.2 Cross-pollination

It is easy to determine if a plant relies on insects or wind to transfer pollen. Each plant has flowers with special adaptations to suit their method of pollination (see table below).

Insect-pollinated flower	Wind-pollinated flower
Flowers large and colourful	Flowers small and not colourful
Flowers produce scent and nectar	No scent or nectar produced
Pollen grains are spiked or sticky	Large amount of light pollen produced

Once a pollen grain lands on the stigma, a pollen tube grows out of the pollen grain down into the stigma. The tube grows down until it reaches the ovary. Inside the ovary are ovules. Each ovule contains an egg cell (an ovum, or female gamete). The sperm cell (male gamete) inside the pollen grain then travels down the tube and fertilises the egg cell by joining with it.

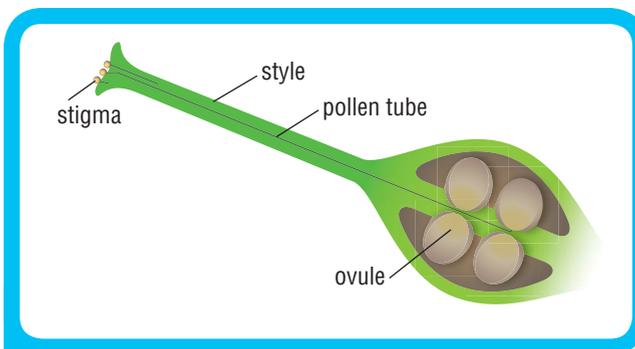


Fig 10.2.3 The growth of the pollen tube enables the sperm to fertilise the ovum.

### Activity 4

#### Flower dissection

**Aim** To examine the reproductive parts of a flower

**Equipment**

Dissecting instruments, large flower, hand lens

**Method**

- 1 Examine your flower. How many petals and anthers does it have?
- 2 Carefully cut the flower so you can see all the parts.
- 3 Draw the flower and label the different parts.
- 4 Use two different-coloured pencils or highlighters to colour the male and female parts of the flower drawing.
- 5 Examine the flower with your hand lens and note any unusual features.

**Questions**

- 1 Predict whether you think your flower would have been capable of self-fertilisation.
- 2 Examine the flower of different plant.
  - a Compare the differences and similarities
  - b State whether these flowers reproduce by sexual or asexual reproduction.



# 10.2 [ Questions ]

## Checkpoint

### Plant reproduction

- 1 Define the term 'flower'.
- 2 Draw a simple flower diagram and label its main parts.
- 3 Match the following parts of the flower to their specific functions.

petals	receives and catches pollen grains
sepals	produce pollen grain
stigma	attract insects to flower for pollination
anthers	contains ovules
ovary	protect the young flower when it is folded up in a bud
- 4 Why do flowers have colourful petals?
- 5 What is the male part of the flower called? What is produced in the anthers?
- 6 What is the female part of the flower called? What is produced in the ovules?

- 7 In flowering plants, the sperm are produced in the male parts of the flower called \_\_\_\_\_. They are carried inside \_\_\_\_\_ grains to the female \_\_\_\_\_, a process called \_\_\_\_\_. After fertilisation, the bottom of the carpel swells to form the \_\_\_\_\_. The ovules form the \_\_\_\_\_.
- 8 What is the difference between petals and sepals? How do stamens and carpels differ?
- 9 Honey bees crawl all over hibiscus flowers searching for nectar. What help could this be to the flowers?

### Reproduction in flowering plants

- 10 What is pollination? Name three different ways flowers are cross-pollinated.
- 11 Why does the base of a flower swell after fertilisation?
- 12 Describe the process of fertilisation in flowers.
- 13 Describe the difference between fertilisation and pollination. Use sketches to help with your explanation.
- 14 Compare and contrast insect-pollinated flowers and wind-pollinated flowers.
- 15 Many insect-pollinated plants are brightly coloured and have flowers that contain a sweet sugary solution called nectar. Explain how features such as this help the reproduction of these flowers.

# UNIT 10.3

## Fruits and seeds

### introduction

After fertilisation, the ovary of the flower begins to enlarge as the petals shrivel. The ovary wall swells to form the fruit. Inside, the ovules also grow, forming the seeds. The fertilised egg inside the ovule grows into the embryo plant found inside the seeds. A seed is the entire reproductive part, containing the embryo and cotyledon.

The embryo inside the seed needs a supply of food to nourish it until it has germinated and the new leaves start making food by photosynthesis.



Fig 10.3.1 Fruits, vegetables and seeds

### Seed structure

The ovule transforms or changes into a seed. The zygote divides and develops into an embryo. This consists of a plumule, a radicle and one or two cotyledons. The outer layers of the ovule form the tough and hard seed coat or testa.

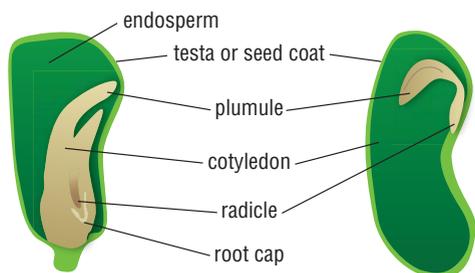


Fig 10.3.2 Seeds consist of stored food (in cotyledons and endosperm) and a tiny embryo plant.

Food, usually in the form of starch, is stored inside the seed. In many seeds the food is stored in the cotyledons (for example, beans); while in others, it is stored in a special tissue called endosperm that surrounds the embryo, for example, maize.

### Seed dispersal

Seeds must be spread away from the adult plant to give the plants that sprout from the seeds a better chance of survival. This is called seed dispersal and is important in a plant's life cycle.

There are four ways that plants spread or disperse their seeds.

- 1 Dispersal by wind:** The seeds fall out of the fruit and are carried away by the wind. Seeds with wing or hair structures catch the wind, e.g. dandelion, thistle, sycamore.
- 2 Dispersal by animals:** The fruit plus seeds are eaten or partly eaten by animals and later pass out in its droppings (e.g. all fleshy fruits, berries). In other cases, the fruit has hooks or barbs that attach to fur of mammals or feathers of birds (e.g. bidibidi, hook grass). These seeds may be carried a long way before they fall off.
- 3 Dispersal by water:** This method is used by plants that grow near water. Many seeds are readily dispersed by water, even when they lack special buoyancy structures, e.g. mangroves, coconuts.
- 4 Dispersal by explosion:** In some plants, the fruit splits open suddenly and violently, throwing out the seeds (e.g. legumes, beans).



Fig 10.3.3 Seed dispersal—the adaptation for dispersal is obvious



### Activity 5

### Seed dispersal activity

- 1 Collect about 10 different types of fruits or seeds.
- 2 Draw up a data table and classify the seeds into one of four groups depending on the way you infer they are dispersed. You may have to use a hand lens to look closely at the seeds.
- 3 Write a description of the way each group of seeds is dispersed.
- 4 Find more fruits or seeds, classify them and add them to your table.

## 10.3 [ Questions ]

### Checkpoint

#### Fruits and seeds

- 1 What use are fruits and nuts to plants? How can they be useful to other living things?
- 2 What is the function of the testa in seeds?
- 3 Explain why the seed requires a food store.
- 4 Complete the following table:
- 5 What takes place during fertilisation?
- 6 Give a brief definition of a seed.
- 7 Place the following in correct order: flowering, germination, pollination, fruiting.

Seed parts	What happens to this part of the seed?
testa	
cotyledon	
plumule	
radicle	

- 2 The spreading of seeds is called \_\_\_\_\_. When they reach favourable conditions, the seeds \_\_\_\_\_ to produce new plants.
- 3 Sketch and name one seed for each dispersal mechanism:

Dispersed by	Name of seed	Sketch

#### Seed dispersal

- 1 Look at the photos and describe how each seed would most likely be dispersed.



Fig 10.3.4

# UNIT 10.4

## Germination

### introduction

The re-starting of growth by the embryo inside a seed is called **germination**. When the young plant has germinated, its roots and shoots grow. The direction of their growth depends on moisture, gravity and light.

The food that is supplied to the dividing cells is broken down by the process of respiration to release energy needs for growth. This is why germinating seeds need oxygen.

The temperature needed for germination varies. Seeds that germinate in the tropics obviously require much warmer conditions than seeds from cooler regions.

Most seeds will grow just as well in the dark as in the light; but some seeds will only germinate in the dark, while others need light. Plant hormones play a vital role in germination and also in breaking seed dormancy.

When seeds are dispersed, many land in good conditions for growth while others do not. We can easily study the conditions needed for proper germination using experiments in the laboratory.

### Conditions for germination

To germinate, seeds need moisture, oxygen and a suitable temperature. The seed absorbs water and swells up; this causes the testa to split, enabling the radicle (young root) and the plumule (young shoot) to grow out of the seed. The radicle grows down into the soil to anchor the plant and the plumule opens up and starts to absorb sunlight and make its own food by photosynthesis.

### Activity 6

#### What changes take place when a seed germinates?

- 1 Set up five test tubes (marked A to E) as shown in Figure 10.4.1.
- 2 In three test tubes (A, B and C), place some bean seeds on moist cotton wool. Place test tube A in a dark cupboard, test tube B in a refrigerator, and test C in bright, but not direct, sunlight.

- 3 In test tube D, place some bean seeds on dry cotton wool. In the last test tube (E), place some bean seeds on cotton wool and cover with water. Place test tubes D and E in normal sunlight (as for C).
- 4 Observe the test tubes for five days and record your results.

#### Questions

- 1 How do you know a seed has germinated?
- 2 Which seeds germinated first?
- 3 Which grew tallest?
- 4 How did the plants in test tubes A and C compare?
- 5 What conditions are needed for germination?

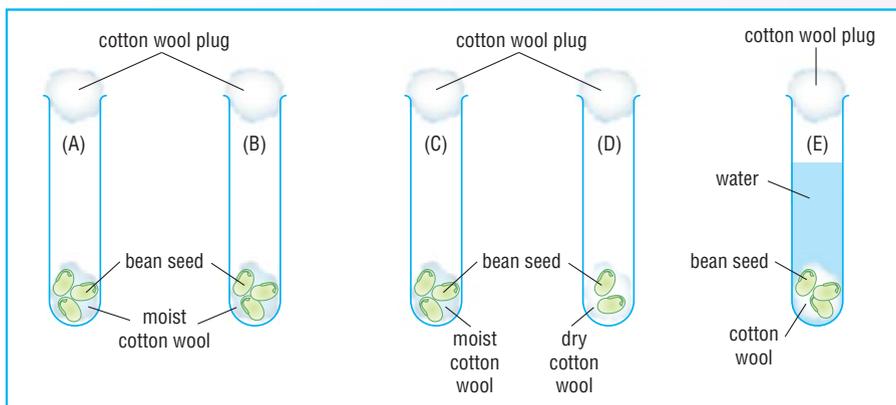


Fig 10.4.1

## Types of germination

If you observe seeds from different plants during their germination you will notice that: their rates of growth vary; their water, oxygen and temperature requirements differ; the parts do not always appear in the same sequence.

Epigeal germination occurs in dicotyledon seeds such as beans, peanuts and sunflowers. The cotyledons emerge from the seed coat, rise above the ground, develop chlorophyll and begin to perform the function of green leaves.

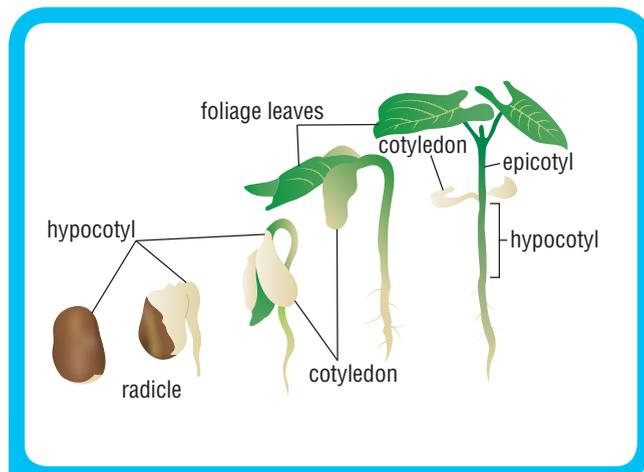
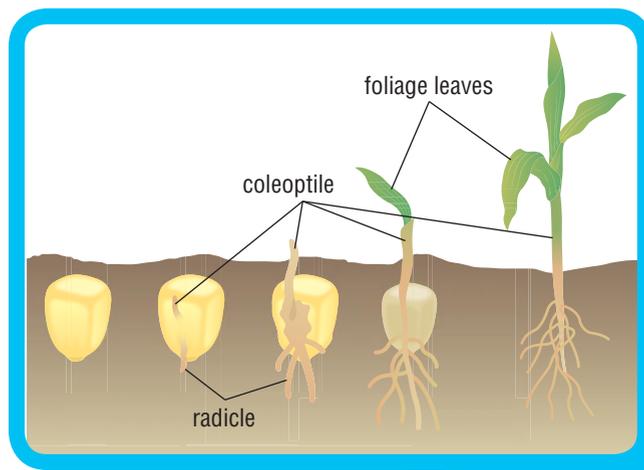


Fig 10.4.2

Stages in the germination of a bean seed (epigeal germination)

Hypogeal germination occurs in seeds such as maize (corn). The cotyledons remain below ground, while the stem above the cotyledon pushes through the soil surface, pulling the plumule out of the cotyledon as it does so. Above the ground, the stem straightens and the leaves unfold to trap sunlight.

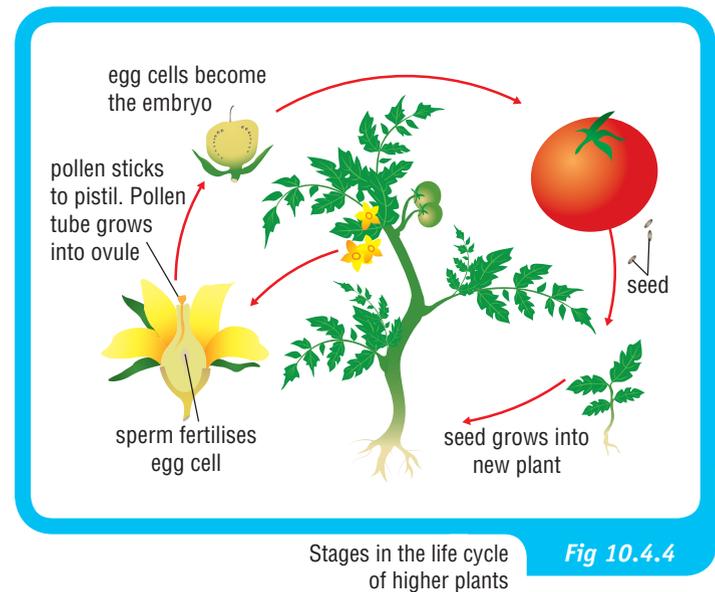


Stages in the germination of a maize seed (hypogeal germination)

Fig 10.4.3

## Growth in plants

One of the characteristics of living organisms is that they grow. During growth the organism takes in materials from the environment and changes them into its own living substances (protoplasm). It produces new cells, which later become specialised for certain purposes, by mitosis.



Stages in the life cycle of higher plants

Fig 10.4.4

Growth may not be continuous. It may be confined to a set period in the life cycle, or to specific parts of the organism. Eventually all growth ceases and death occurs. Before it dies, the organism usually reproduces during one of the active growth periods, either asexually or sexually. This sequence of events is known as the life cycle of an organism.

For growth to occur, each plant must have adequate water, carbon dioxide and mineral salt to make food, and enough oxygen for its respiratory needs. The right conditions, such as good soil, optimum temperature and adequate sunlight, are also necessary.

# 10.4 [ Questions ]

## Checkpoint

### Germination

- 1 Look at the germination diagrams. List the differences you can see in the way the plants grow after germination.
- 2 What is germination? What conditions are needed for this to occur?
- 3 In a seed, what is the function of:
  - a the radicle?
  - b the plumule?
  - c the cotyledons?
- 4 Rewrite the following in the correct order for germination in a bean seed:
  - a cotyledons exposed to sunlight
  - b radicle grows down into the soil

- c hypocotyl straightens
- d root hairs develop
- e radicle emerges from testa
- f cotyledons pulled out of the soil
- g testa splits

- 5 What factors are necessary for a seed to germinate? Do you think light is needed for germination? How could you test this?
- 6 Where does the food and energy come from for seed growth? How did it get there?

### Growth in plants

- 7 What does the term 'life cycle' mean?
- 8 Draw and label the life cycle of a typical plant.
- 9 Explain briefly the different stages in the life cycle of a plant, starting from seed.
- 10 List the conditions necessary for growth in plants. Explain why each condition is important.

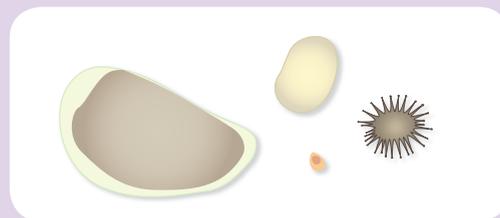
## Chapter review

### [ Summary questions ]

- 1 Arrange these processes in order: germination, fertilisation, seed dispersal, fruit formation, pollination, petal attraction.
- 2 Match each of the words on the right with one of the words on the left.
 

male	carpel
female	stamen
	ovule
	pollen
	stigma
- 3 Identify where fertilisation takes place in plants.
- 4 Some of the following statements are false. Choose the false ones and rewrite them to make them correct.
  - a Pollen contains the male sex cell and is produced in the ovary.
  - b Pollination occurs when pollen from an anther travels and lands on the stigma.
  - c Seeds develop after the pollen fertilises the ovary.
  - d Sepals are leaf-like structures at the base of the flower.
  - e The salty substance on the stigma makes the pollen tubes grow down the stigma.
- 5 List examples of organisms with different types of asexual reproduction.
- 6 Define vegetative reproduction.

- 7 As any gardener knows, you can use cuttings or bulbs to grow many flowering plants. Explain how you can help tubers to reproduce a new plant.
- 8 The seeds below are drawn to actual size.
  - a Which one(s) do you think would be found inside fleshy, edible fruit? Give a reason for your answer.
  - b Which one(s) might be caught on the fur of animals? Give a reason for your answer.



- 9 List three methods of vegetative reproduction and explain each one.
- 10 Explain the difference between asexual and sexual reproduction.
- 11 List the four ways seeds can be dispersed.
- 12 Explain the difference between self-pollination and cross-pollination.
- 13 Explain the process of germination of seeds.
- 14 Describe epigeal germination.
- 15 Explain the differences between epigeal and hypogeal germination.

# CHAPTER 11

# Earth and the solar system

## Specific learning outcomes

7.11.1.1, 7.11.1.2, 7.11.1.3, 7.11.2.1, 7.11.3.1, 7.11.4.1, 7.11.4.2, 7.11.5.1, 7.11.6.1, 7.11.7.1, 7.11.7.2, 7.11.8.1, 7.11.8.2, 7.11.9.1, 7.11.9.2, 7.11.9.3, 7.11.10

By the end of this chapter learners should be able to:

- Describe the theory of the solar system.
- List the planets in order of their distance from the Sun.
- Describe characteristics of the nine planets.
- State different facts about the different planets including: *mass, diameter, surface, atmosphere, gravity, surface temperature, period of rotation, tilt axis, distance from the Sun, time to orbit the Sun and their moon.*
- Describe the movement of the planets around the Sun.
- Identify planets that have moons.
- State the properties of the Sun: *mass, diameter, gravity, surface temperature, period of rotation, tilt of axis.*
- List the importance of the Sun to life on Earth.
- Describe the different solar eclipses: total solar eclipse, partial solar eclipse, annual solar eclipse.
- Model how the Earth spins on its axis.
- State that it takes 24 hours for the Earth to make one complete spin on its axis.
- Demonstrate day and night, using a globe of the Earth.
- State that our Moon takes 28 days to orbit the Earth.
- State the properties of the Moon: *mass, diameter, gravity, surface temperature, period of rotation, tilt of axis.*
- Draw the different phases of the Moon.
- Record the phases of the Moon at this time of the year at their school.
- Explain how the phases of the Moon affect low tide and high tide on planet Earth.
- Describe and draw the phase of lunar eclipses.

- Which planet has a day that is longer than its year?
- Name the planets that humans have visited either in person or with probes.
- Why do we experience longer days in summer than in winter?
- How hot is it on the Sun?
- The Moon has seas that are not really seas. What are they?
- Name a famous astronomer.



## Challenges

# UNIT 11.1

## The solar system

### introduction

For thousands of years astronomers saw lights that appeared to move among the stars. They called these 'planets'. This means 'wanderers'. They named them after the Roman gods. If you look up at a clear night sky, you too will see many of the planets that the astronomers saw. You might also see space material and

satellites that also move in the night sky. Today we use telescopes to look closer at the planets. This gives us a good understanding of Earth and the eight other planets of the solar system which we live in.

### Theories of the solar system

**Pythagoras** was a Greek scientist and mathematician. In the sixth century BC, he proposed a theory that the Earth was the centre of the universe. Aristotle (384–322 BC), Hipparchus (died after 127 BC) and Ptolemy (127–145 AD) proposed more detailed models in which Earth was placed at the centre of the solar system. This model is known as the **geocentric model** (*geo* = Earth).

Another ancient Greek, **Aristarchus** (310–230 BC), questioned the geocentric model and proposed another model in which the Earth and other planets

move around the Sun. This is known as a **heliocentric model** (*helio* = Sun). Aristarchus also thought that the Moon went around the Earth.

In the fifteenth century, religious authorities thought that humankind and Earth had to be the centre of everything.

In the 1530s, Polish astronomer **Nicolas Copernicus** (1473–1543) agreed with Aristarchus and suggested that the Earth and other planets orbited the Sun. There was a lot of opposition to his ideas.

**Galileo** (1564–1642) supported Copernicus's ideas. In 1609, he used a telescope for the first time to make detailed observations of the Moon and planets. His observations exposed mistakes in the geocentric model. The Danish astronomer **Tycho Brahe** (1546–1601) did not support Copernicus's heliocentric

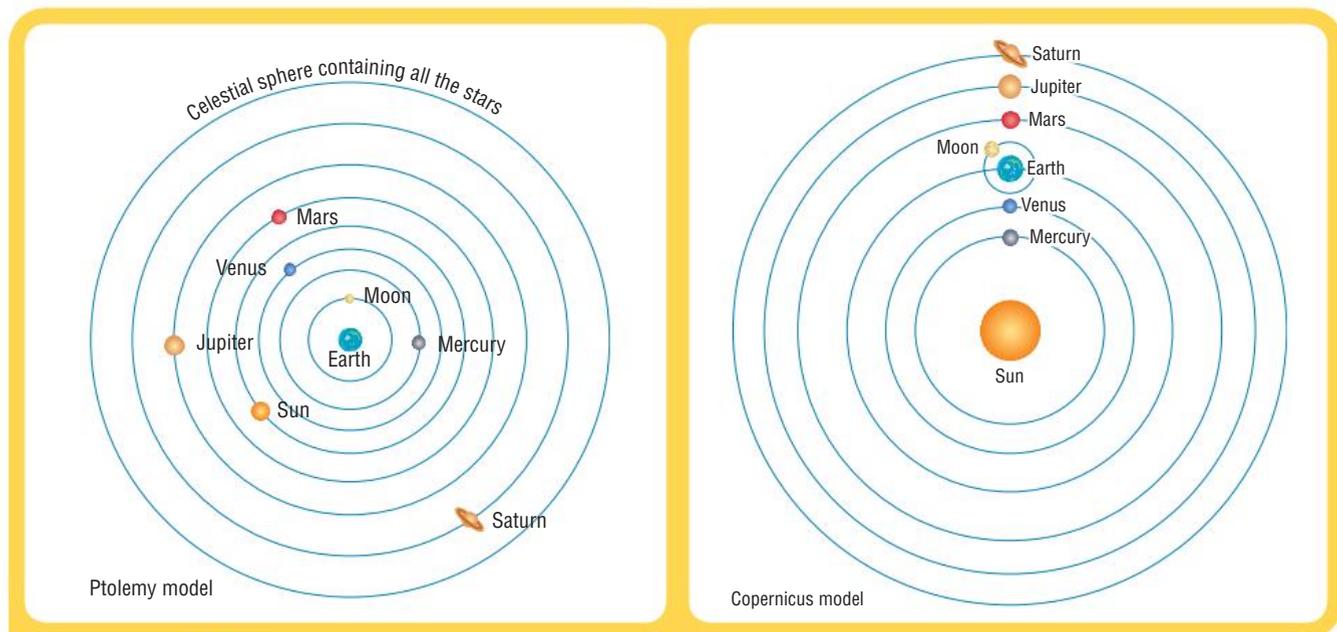


Fig 11.1.1 The geocentric model by Ptolemy (left) and the heliocentric model of Copernicus (right)



model. He took many detailed measurements of the positions of stars and planets to improve the geocentric model. The German astronomer **Johannes Kepler** (1571–1630) finally showed that Copernicus’s idea of a heliocentric model was correct. He used Tycho Brahe’s information to solve the confusion.

## The solar system

The term ‘solar system’ takes its name from the Sun. The nine planets of the solar system starting from closest to the Sun, are: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune and Pluto. One way of remembering this list is to use a ‘mnemonic’:

**My Very Early Morning Jog Starts Up Near Phillip’s.**

Each planet orbits the Sun. They rotate on their axes as they do so. The time taken for a planet to spin once on its axis is called its **day**. The time taken to orbit the Sun once is called its **year**. All the planets have days and years of different lengths.

The four innermost planets are called **terrestrial**. This means ‘Earth-like’. They orbit the Sun in almost circular orbits. The outer planets move in oval orbits. All planets move in the same plane except for Pluto. Its orbit is tilted about 17° compared to the other planets’ orbits. For this reason, some astronomers think that Pluto should not be classified as a planet.

The larger outer planets are Jupiter, Saturn, Uranus and Neptune. They are known as the **gas giants**. Their outer layers are made of hydrogen and helium gases.

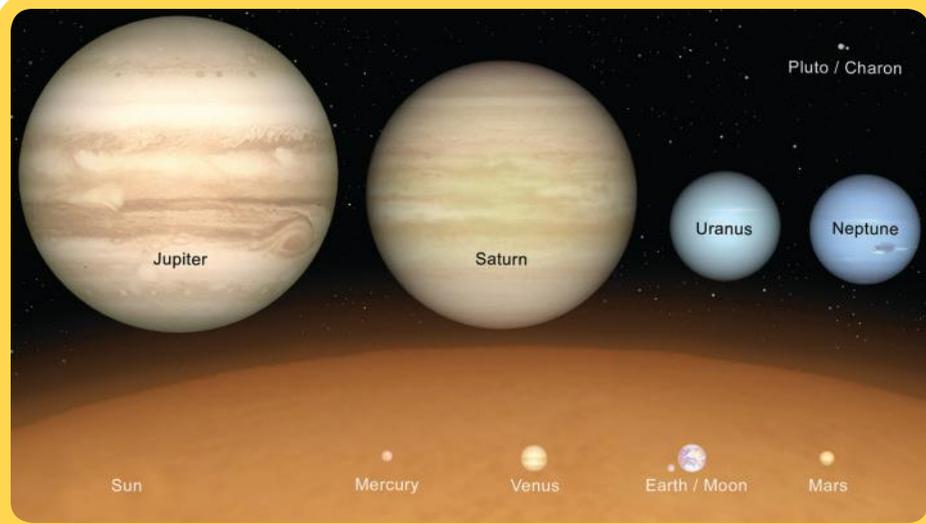


Fig 11.1.2

The planets to scale. The rings of the gas giants are not shown.

## Activity 1

### A model solar system

**Aim** To represent the relative sizes and distances of the planets

#### Equipment

Modelling clay, ‘fact file’ information from Unit 11.1, a basketball to represent the Sun, photocopy of street map of the local school area, trundle wheel

#### Method

- 1 Split into small groups of students.
- 2 Copy the ‘scale model’ information from the ‘fact file’ for each planet into one table.
- 3 Using clay or play dough, make a model of each planet according to the size in the scale model.
- 4 Obtain a street map of the local school area. Decide where the Sun will be located and use the scale of the map to find the position of the outer five planets.
- 5 Go outside and place the Sun in position.
- 6 The inner planets should be placed in position from the Sun within the school grounds. Measure the distance for each planet using a trundle wheel.
- 7 Ask your teacher whether your group may place the outer planet models in position outside the school grounds. Measure the distance for each planet using a trundle wheel and check your street map to see if this is correct. Otherwise, mark on the street map where the other planets should be located.

#### Questions

- 1 For the outer planets, did the distance measured by the trundle wheel agree with the position marked on your street map?
- 2 **Compare** the spacing of the inner planets to that of the outer planets.

## The ancient planets

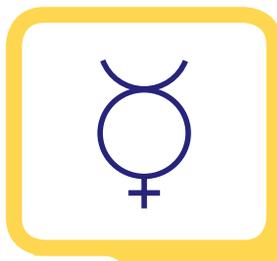
The following planets are called the **ancient planets** because people have known about them since ancient times: Mercury, Venus, Earth, Mars, Jupiter and Saturn.

The diameter is measured at the equator for each planet. To compare, the diameter of the Sun is 1 392 000 km. The symbols used for each planet are still used by astrologers. They were invented by the Greeks. They imagined each planet to be a god.

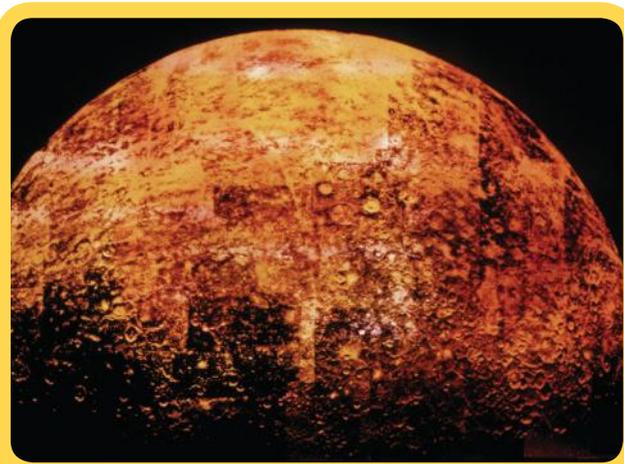
### Mercury

Mercury moves very quickly across the sky. It was named after the Roman god, Mercury. He was the swift messenger of the gods.

Mercury is the second-smallest planet in the solar system. It is the closest planet to the Sun. However, it is not the hottest. Because it is so close to the Sun, it is hard to observe. It appears as a morning or evening star. Mercury is very similar to Earth's Moon. Its surface contains craters and plains and it has no atmosphere of its own. The *Mariner 10* space probe flew past Mercury three times in 1974 and 1975, photographing more than half the planet's surface. The *Messenger* space probe was launched in 2004 and is the first spacecraft to have orbited the planet. *Messenger* will investigate Mercury's geology, atmosphere and magnetic field.



Symbol for Mercury **Fig 11.1.3**



**Fig 11.1.4** Mercury showing its heavily cratered surface

### Mercury

#### Fact file

Mythology	God of travel, commerce and thieves
Mass	0.056 times that of Earth
Moons	None
Diameter	4878 km (= 0.38 × Earth's diameter)
Surface	Similar to Earth's moon, with craters, lava-flooded plains and smooth mountains
Atmosphere	Mainly helium, which blows past Mercury from the Sun
Gravity	0.38 times that on Earth
Surface temperature	-170°C to 430°C
Period of rotation (day)	59 Earth days
Tilt of axis	0°
Distance from Sun	0.39 AU (58 million kilometres)
Time to orbit Sun (year)	88 Earth days

#### Scale model (Sun = 300 mm)

Diameter	1 millimetre
Distance from Sun	12.5 metres

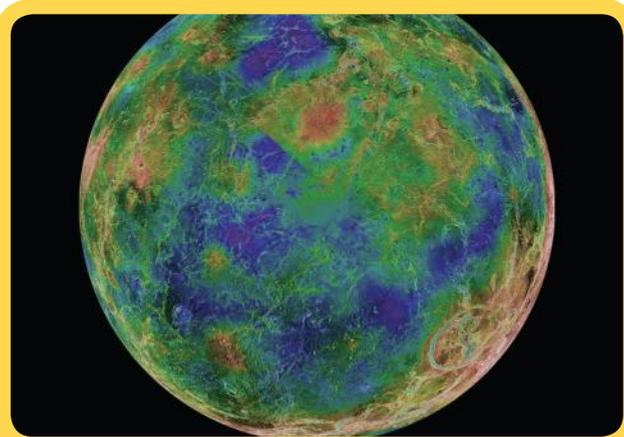
### Venus

Venus was recorded by the Babylonians in 3000 BC.

Venus is the hottest planet. Its size is similar to the Earth. Humans cannot survive there because of its acidic and crushing atmosphere. Venus is the brightest object in the sky. It is known as the morning and evening star. Venus is unusual for several reasons. It spins in the opposite



Symbol for Venus **Fig 11.1.5**



**Fig 11.1.6** Venus radar image from the 1990–94 *Magellan* mission

## Venus

### Fact file

Mythology	Goddess of love and beauty
Mass	0.815 times that of Earth
Moons	None
Diameter	12 103 km ( = 0.95 × Earth's diameter)
Surface	Extensive cratering, volcanic activity. Mountain ranges, a 1500 km trench.
Atmosphere	80 km thick layer of carbon dioxide with some water vapour. Clouds contain concentrated sulfuric acid droplets.
Atmospheric pressure	90 times that on Earth (enough to crush early space probes)
Gravity	0.9 times that on Earth
Surface temperature	460°C
Period of rotation (day)	243 Earth days
Tilt of axis	30°
Distance from Sun	0.72 AU (108 million kilometres)
Time to orbit Sun (year)	225 Earth days

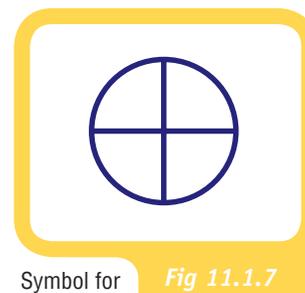
### Scale model (Sun = 300 mm)

Diameter	2.6 millimetres
Distance from Sun	23.3 metres

direction to the Earth and other planets, from east to west. A Venus day is longer than its year. It has a thick cloud layer.

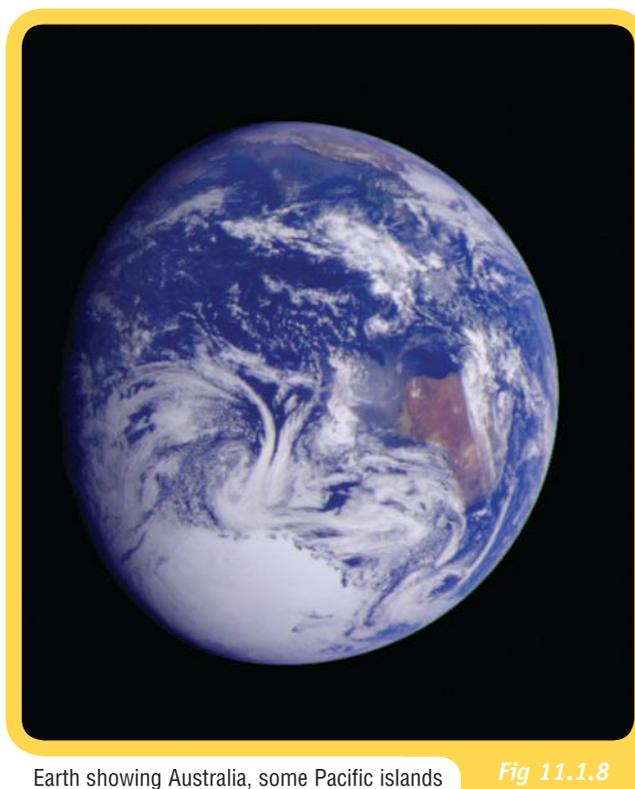
## Earth

The third planet from the Sun is Earth. It is known as the blue or water planet. It is the only planet currently known to support life. The Earth has a molten core covered by floating plates that make up its surface. Seventy per cent of the Earth's surface is under water. The Earth is orbited by the Moon and many communication satellites.



Symbol for Earth

**Fig 11.1.7**



Earth showing Australia, some Pacific islands and Antarctica

**Fig 11.1.8**



## Earth

### Fact file

Mythology	Gaia—mother Earth
Mass	1.0 times that of Earth (5 980 000 000 000 000 000 000 kg)
Moons	One ('the Moon')
Diameter	12 756 km
Surface	Two-thirds water, one-third land
Atmosphere	78% nitrogen, 21% oxygen, 1% carbon dioxide, argon and water vapour and other gases
Gravity	1.0 times that on Earth
Surface temperature	Average 22°C
Period of rotation (day)	1 day
Tilt of axis	23.5°
Distance from Sun	1 AU (150 million kilometres)
Time to orbit Sun (year)	365.25 days

### Scale model (Sun = 300 mm)

Diameter	2.7 millimetres
Distance from Sun	32.2 metres

twice as long. The movement of Mars across the sky is sometimes direct and sometimes backwards. This is called retrograde motion.

The *Viking 1* and *Viking 2* space probes landed on Mars in 1976 after orbiting the planet. They looked for signs of microscopic life. The results are still being debated. In July 1997, the *Pathfinder* mission landed

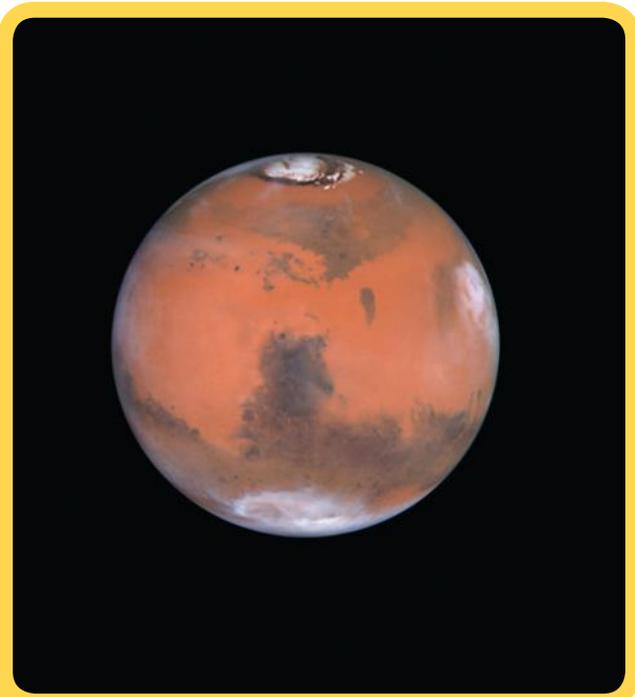


Fig 11.1.10 Mars showing red earth and polar caps

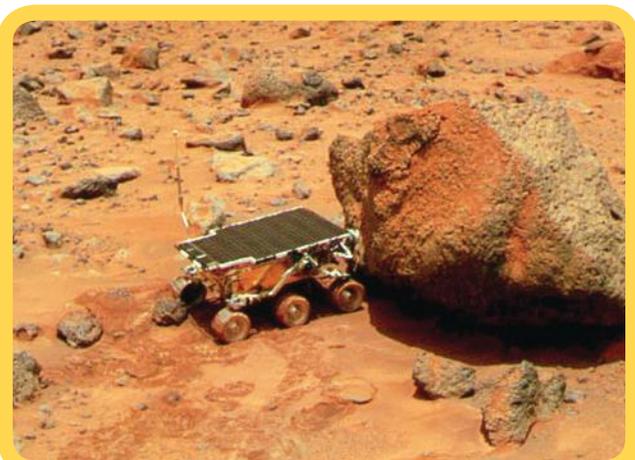
## Mars

Mars is called the 'red planet'. This is because it appears red. The red appearance is due to the presence of rust—iron oxide in its soil and on its surfaces. The Earth and Mars are similar in some ways. A Martian day is only 30 minutes longer than an Earth day. Its 25° tilt causes seasons similar to Earth's, but they are



Symbol for Mars

Fig 11.1.9



The Sojourner rover sampling the large rock known as 'Yogi' on Mars in July 1997

Fig 11.1.11

on Mars to collect information about the rocks and weather. In September 1999, the *Mars Climate Orbiter* ‘disappeared’ while orbiting Mars. In 2003, two rovers, *Spirit* and *Opportunity*, were launched to search for evidence of liquid water on Mars. More Mars trips are planned in the future.

### Mars

#### Fact file

Mythology	God of war
Mass	0.107 times that of Earth
Moons	2 (Phobos—diameter 23 km, Deimos—diameter 10 km)
Diameter	6794 km ( = 0.53 × Earth’s diameter)
Surface	Soft red soil containing iron oxide (rust), giving the planet its red appearance. Cratered regions, large volcanoes, a large canyon and possible dried-up water channels. Polar caps of frozen carbon dioxide and water.
Atmosphere	Very thin, mainly carbon dioxide
Gravity	0.376 times that on Earth
Surface temperature	−120°C to 25°C
Period of rotation (day)	1.03 Earth days
Tilt of axis	25.2°
Distance from Sun	1.52 AU (228 million kilometres)
Time to orbit Sun (year)	687 Earth days

#### Scale model (Sun = 300 mm)

Diameter	1.4 millimetres
Distance from Sun	49.1 metres

### The asteroid belt

Orbiting the Sun between Mars and Jupiter is an asteroid belt. It is composed of small rocks and dust. The largest asteroid in the asteroid belt is Ceres. It has a diameter of about 1000 kilometres. Another asteroid is called Vesta. We can see it from Earth with the naked eye.

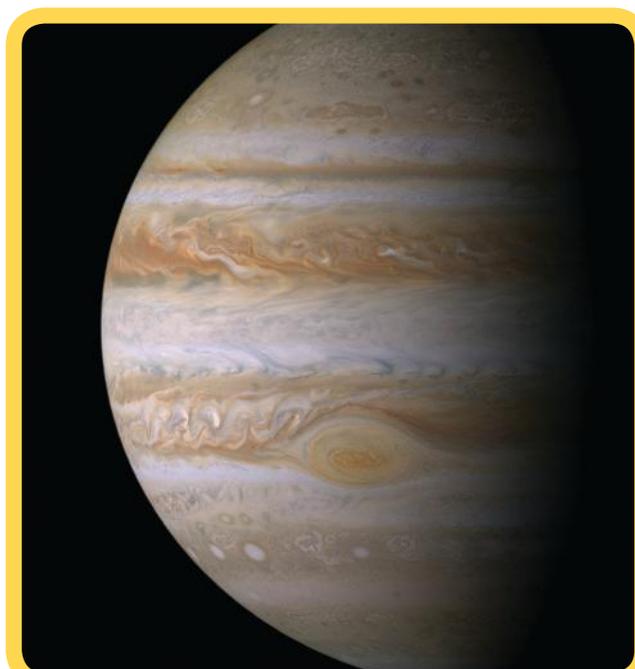
### Jupiter

The largest of the planets is Jupiter. It has a diameter 11 times that of the Earth. It got its name from the ruler of the gods in the Roman state. It is famous for its Great Red Spot. It is really a giant hurricane about three times the size of the Earth.

In 1977, two space probes, *Voyager 1* and *Voyager 2*, were launched. In March 1979, *Voyager 1* flew by Jupiter and detected many ring-like structures around the planet. They were about 29 km thick and 6400 km wide. The first active non-Earth volcano was also detected—on Io, one of Jupiter’s moons. In July 1994, a telescope photographed the comet Shoemaker-Levy 9 hitting Jupiter.

2

Symbol for Jupiter  
Fig 11.1.12



Jupiter showing alternating east and west wind belts. The Great Red Spot is the large oval shape.  
Fig 11.1.13



## Jupiter

### Fact file

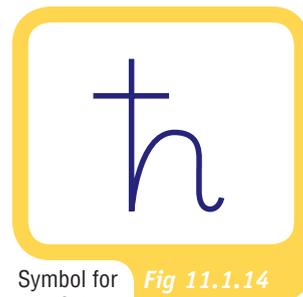
Mythology	Ruler of the Gods
Mass	318 times that of Earth
Moons	At least 28 moons and four rings, including the four largest moons: Io, Ganymede, Europa and Callisto. These are known as the 'Galilean' moons.
Diameter	142 984 km (= 11.21 × Earth's diameter)
Surface	Liquid hydrogen
Atmosphere	Hydrogen (84%) and helium (15%). Upper layer contains white clouds, probably composed of solid ammonia.
Gravity	2.525 times that on Earth
Surface temperature	Cloud top -150°C
Period of rotation (day)	9 hours 55 minutes
Tilt of axis	3.1°
Distance from Sun	5.2 AU (778 million kilometres)
Time to orbit Sun (year)	11.8 Earth years

### Scale model (Sun = 300 mm)

Diameter	30 millimetres
Distance from Sun	168 metres

## Saturn

Saturn is the second-largest planet in the solar system. It has rings around it. The ring system was discovered by Galileo in 1610. The rings are only tens of metres thick. They have a diameter of 270 000 kilometres. The rings are composed of particles of ice and ice-covered rocks. Like Jupiter, Saturn is surrounded with gas. Saturn is so light that it would even float on water. The space probe *Voyager 2* detected over 100 000 rings when it flew by Saturn in 1981.



Symbol for Saturn **Fig 11.1.14**

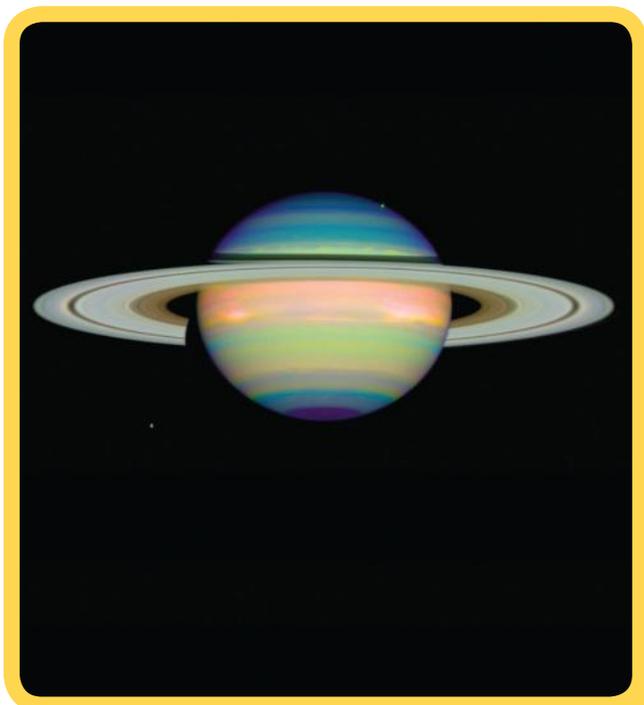
## Saturn

### Fact file

Mythology	God of agriculture
Mass	95.184 times that of Earth
Moons	At least 30 moons and rings in seven bands
Diameter	120 536 km (= 9.45 × Earth's diameter)
Surface	Liquid hydrogen. Winds up to 1800 km/h
Atmosphere	Very thick layer of hydrogen and helium
Gravity	1.064 times that on Earth
Surface temperature	-180°C
Period of rotation (day)	10 hours 39 minutes
Tilt of axis	26.7°
Distance from Sun	9.6 AU (1400 million kilometres)
Time to orbit Sun (year)	29.5 Earth years

### Scale model (Sun = 300 mm)

Diameter	25 millimetres
Distance from Sun	307 metres



Saturn showing the cloudy atmosphere and the separation between the two bright rings (the Cassini Division) **Fig 11.1.15**

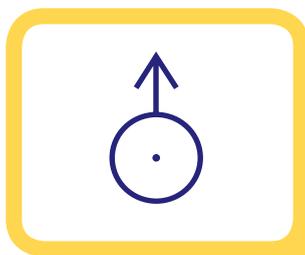
## The modern planets

The following planets were recently discovered: Uranus, Neptune and Pluto. They are called the **modern planets**. In fact, their names do not appear in any textbooks printed before Captain Cook landed at Botany Bay in 1770. These books only show six planets—the ancient planets.

### Uranus

The English astronomer **William Herschel** discovered Uranus in 1781. Its axis is tilted at an angle of 98°. So it virtually lies on its side as it orbits the Sun.

This tilt gives Uranus different seasons compared to the other planets. Each season lasts 21 years. Uranus has a large number of moons, and a ring system like Saturn's. *Voyager 2* discovered additional moons and rings when it flew by in 1986.



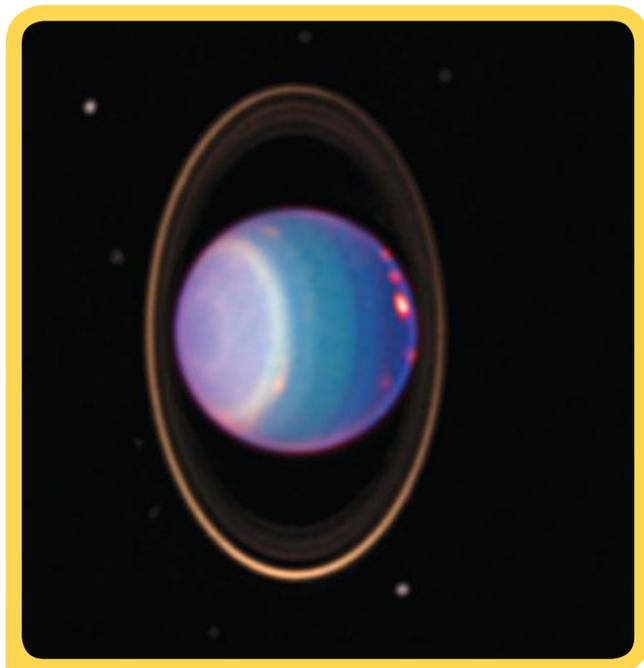
Symbol for Uranus **Fig 11.1.16**

### Uranus

Fact file	
Mythology	Father of Saturn
Mass	14.54 times that of Earth
Moons	At least 21 moons and 11 rings
Diameter	51 200 km (= 4.01 × Earth's diameter)
Surface	Likely to be frozen hydrogen and helium
Atmosphere	Hydrogen, helium and very turbulent, with winds over 600 km/h
Gravity	0.903 times that on Earth
Surface temp.	-220°C
Period of rotation (day)	17 hours 14 minutes
Tilt of axis	98°
Distance from Sun	19.2 AU (2875 million kilometres)
Time to orbit Sun (year)	84 Earth years

Scale model (Sun = 300 mm)	
Diameter	10.1 millimetres
Distance from Sun	618 metres



**Fig 11.1.17** Uranus showing the vertical rings and moons (white) orbiting the planet

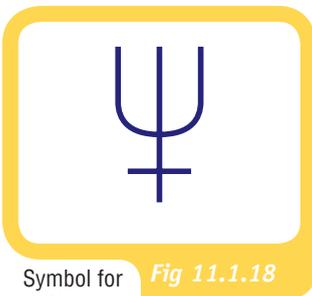


## Neptune

Neptune is sometimes referred to as the twin of Uranus. Neptune was identified by German astronomer **Johann Galle**. On 23 September 1846, Johann Galle saw that Uranus had moved off its orbit. The cause was the gravitational attraction of ‘nearby’ Neptune.

The Great Dark Spot, which can be seen in Figure 11.1.19, is a huge cyclonic storm. It has winds up to 2400 km/h.

*Voyager 2* also flew past Neptune in 1989. It saw the recently discovered ring systems. Today, nobody knows for certain what these rings are.



Symbol for Neptune *Fig 11.1.18*



Neptune showing its blue-green atmosphere. The Great Dark Spot seen at the centre is about 13 000 km by 6600 km in size. *Fig 11.1.19*

## Neptune

### Fact file

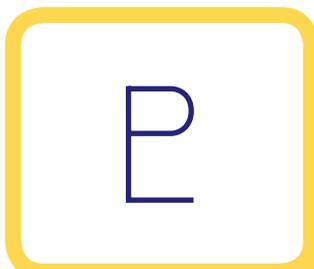
Mythology	God of the sea
Mass	17.15 times that of Earth
Moons	8 moons and 5 rings
Diameter	49 528 km ( = 3.88 × Earth’s diameter)
Surface	Frozen hydrogen and helium
Atmosphere	Mainly hydrogen, helium. Very high winds over 600 km/h
Gravity	1.135 times that on Earth
Surface temperature	−220°C
Period of rotation (day)	16 hours 7 minutes
Tilt of axis	29.3°
Distance from Sun	30.1 AU (4500 million kilometres)
Time to orbit Sun (year)	165 Earth years

### Scale model (Sun = 300 mm)

Diameter	9.7 millimetres
Distance from Sun	968 metres

## Pluto

Pluto is the furthest planet from the Earth. American scientist **Clyde Tombaugh** found it on 18 February 1930. It appeared as a dim ‘star’. It has a 248-year orbit around the Sun. Since it was sighted, it has completed about a third of its orbit of the Sun. Pluto has an unusual orbit that comes inside Neptune’s orbit for 10 per cent of the time. Pluto is the smallest of all the planets. There were plans for a probe to be launched in 2006 to arrive at Pluto in 2015. Today, scientists still do not know whether Pluto is a planet or a comet trapped by the Sun’s gravitational field.



Symbol for Pluto **Fig 11.1.20**



**Fig 11.1.21** Pluto is called a double planet because Charon (Pluto’s moon) is about half the diameter of Pluto.

### Pluto

#### Fact file

Mythology	God of the underworld
Mass	0.002 times that of Earth
Moons	1 (Charon)
Diameter	2300 km ( = 0.18 × Earth’s diameter)
Surface	Icy crust of methane
Atmosphere	Very thin, if any
Gravity	0.061 times that on Earth
Surface temperature	−223°C
Period of rotation (day)	6 Earth days
Tilt of axis	122°
Distance from Sun	39.6 AU (5914 million kilometres)
Time to orbit Sun (year)	249 Earth years

#### Scale model (Sun = 300 mm)

Diameter	0.4 millimetre
Distance from Sun	1275 metres

## Activity 2

### Classification of the planets

**Aim** To classify the planets using different criteria

#### Method

- The classification used in Unit 11.1 is according to history—ancient and modern planets.
- Reclassify the planets according to the following rules.
  - Size*—small planets have diameters less than 13 000 km, and large planets greater than 13 000 km.
  - Composition*—rocky or terrestrial planets, and gas planets.
  - Distance from the Sun*—the inner planets and the outer planets. The asteroid belt is the separating boundary.

- Write a key for identifying the planets from their descriptions.
- Use someone else’s key to identify the planets and **evaluate** whether their key is effective.

#### Question

**Describe** any problems that you had when classifying Pluto.

## 11.1

## [ Questions ]

**Checkpoint***Theories of the solar system*

- 1 Identify** three astronomers who proposed that the Earth and other planets moved around the Sun.
- 2 Explain** what you think the underlined part of the following words means.
  - geocentric
  - helicentric
- 3 Describe** the difference between a geocentric and a heliocentric model of the solar system using a diagram.
- Many scientists believed for a long time that the planets moved around the Sun, but they did not speak up. **Explain** why you think this was.

*The solar system*

- 5 Identify** the gas giants.
- Unscramble these planet names.
 

a PETENUN	f ITUPREJ
b SUNEV	g SUNRAU
c TOLUP	h TEHAR
d ARMS	i RECYRUM
e RATUNS	
- 7 List** the planets in order from:
  - largest to smallest
  - closest to furthest from the Sun

*The ancient planets*

- 8 Clarify** what is meant by a terrestrial planet.
- 9 Explain** why the terrestrial planets are also classified as the 'ancient' planets.

*The modern planets*

- This group of planets is not new. **Explain** why they are classified as the 'modern' planets.
- Name two 'modern planets' and **describe** the main features that could be used to identify them.

**Think**

- 12 Identify** three space probes, and at least one planet visited by each.
- 13 Identify** the space probes that disappeared in 1999.
- There is less information available about the outer planets than the inner ones. **Explain** why.
- 15 Propose** a reason why it is unlikely that life exists or has existed on planets other than Earth.
- 16** Estimate the diameter of Pluto's moon, Charon, and its distance from the planet using Figure 11.1.21. (Hint: the diameter of Pluto is 2300 km.)

**Skills**

- 17 Construct** a table to **summarise** the main astronomers in this unit. Include three columns for their name, date and a description of their ideas and discoveries.
- 18 Identify** which planet:
  - is the hottest
  - is the coldest
  - has a giant hurricane raging that is larger than the Earth
  - doesn't have its own atmosphere
  - spins the opposite way to all the others
  - has a similar day length to the Earth's
  - spins on its side as it orbits the Sun
  - has a crushing atmosphere
  - has a rusty surface
  - is covered by a thick gas layer composed mainly of carbon dioxide
  - is two-thirds under water
  - has the biggest ring system
  - was discovered because it was noticed that a neighbouring planet moved from its orbit
  - has a day that is longer than its year
  - has the strongest gravity
  - is known as the morning and evening star
- 19 Identify** which planets have:
  - moons
  - ring systems
  - methane in their atmosphere

## [ Extension ]

**Investigate**

- 1 a** Calculate planet sizes or distances from the Sun for a scale diagram of the solar system that will fit on poster paper.
  - Construct** your scale model on paper. (Hint: you may need to change one of the scales to make it fit.)
  - Explain** why it is not convenient to have both size and distance to scale.
- Investigate what or who each planet was named after.

**Action**

- 'Money spent on space exploration would be better spent on things like medical research and aid programs.' **Research** what this statement means and have a class debate on this issue.

# UNIT 11.2

## The Sun

### introduction

Historically, many cultures have recognised the Sun as a god, demon or spirit.

Whatever role the Sun takes, most cultures see it as the controller of all life on Earth. It is true that we depend on the Sun to supply the energy that has allowed life on Earth.

### The importance of the Sun

The Sun is also known in astronomy as Sol. It is our nearest star. It is currently in 'middle age'. It is about 4.5 billion years old, with another 4.5 billion years of 'life' left. Astronomers believe that the Sun is a second-generation star. It was formed after a previous star collapsed. Its remains combined with interstellar gas to form the Sun.

The Sun is our source of heat and light energy. It is important to the continuation of life on Earth. Plants use energy from the Sun. It helps them make the food they need for growth, and in the process make oxygen. Animals that feed on plants, and the animals that feed on those animals, also depend on the Sun.

Remains of dead plants and animals in the Earth's crust have been converted over millions of years into oil, coal and gas. They are further examples of energy sources related to the Sun. Solar cells can now convert the Sun's energy into other forms of energy.

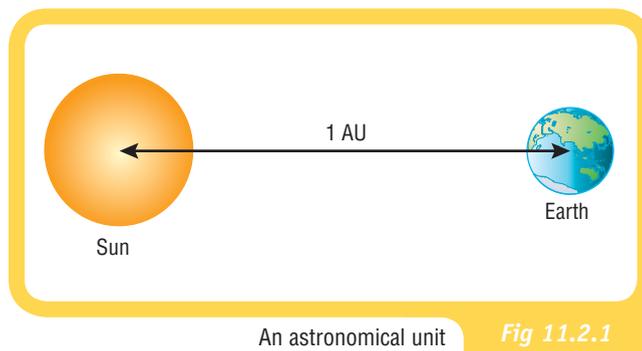


Fig 11.2.1



Fig 11.2.2 The Sun showing a spectacular solar flare about 588 000 km across the solar surface

They are being used more and more widely as technology improves their efficiency.

As well as heat and light, other types of radiation such as ultraviolet (or UV) radiation reach us from the Sun. The Earth's atmosphere screens out much of this harmful radiation. It provides an insulating layer to trap heat.

Different parts of the Earth heat up by different amounts. This creates pressure differences in the atmosphere, which in turn create winds that increase evaporation, leading to rainfall.

The Sun also provides the large gravitational force necessary to keep the Earth and other planets in orbit around it.

### Energy production in the Sun

Like all stars, the Sun produces energy in reactions in its core. The temperature and pressure at the core cause hydrogen particles to join together and form helium. This reaction releases a large amount of energy and is called **nuclear fusion**.

The term 'nuclear' is used because each particle referred to above is the centre, or nucleus, of a hydrogen atom. You will study more about atoms later in Science.

## Solar statistics

The term **solar** is used to describe things related with the Sun. The Sun is a star. It is much closer to us than other stars, so it appears much larger and brighter.

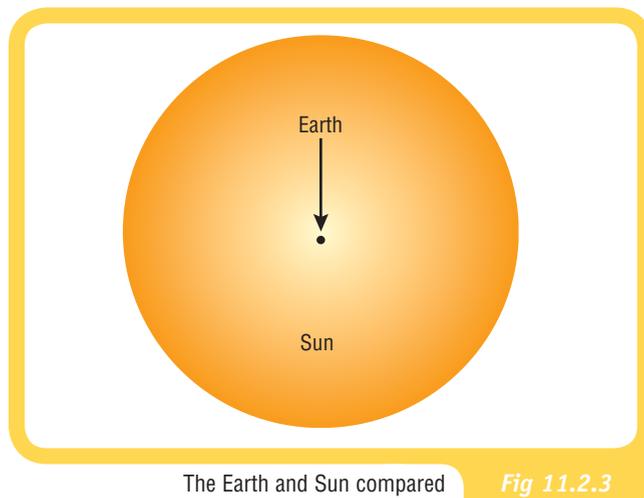
**Sun**

**Fact file**

Mythology	The Sun God. Greeks called it Helios
Mass	333 400 times the mass of the Earth
Diameter	1 392 000 km ( = 109 × Earth's diameter)
Gravity	28 times that on Earth
Surface temperature	6000°C (average). From 4500 to 2 000 000°C up to 15 000 000°C in the core.
Period of rotation (day)	Equator 26 days, poles 37 days
Tilt of axis	122°

**Scale model**

Diameter	300 millimetres
----------	-----------------



The Earth and Sun compared Fig 11.2.3

## Features of the Sun

Some features of the Sun can be observed from the Earth using special solar telescopes.

**CAUTION: Although we can see these features from Earth, you should never look at the Sun if you are not using special protective apparatus. You can permanently damage your eyes.**

In 1611, Galileo observed for the first time sunspots and solar flares on the Sun's surface. **Sunspots** are lower spots on the Sun's surface. They appear darker because they are thousand degrees cooler than the surrounding gas. The number of observable sunspots follows an 11-year cycle. It varies from zero to about 200 in a year.

### Activity 3

#### The sunspot cycle

##### Equipment

Graph paper

##### Method

- 1 The approximate numbers of sunspots recorded over a 14-year period are given below. Use these data to construct a sunspot line graph. Place the years on the horizontal axis.
- 2 If the graph follows a similar cycle for the next 11 years, plot the next year that would have the smallest number of sunspots.

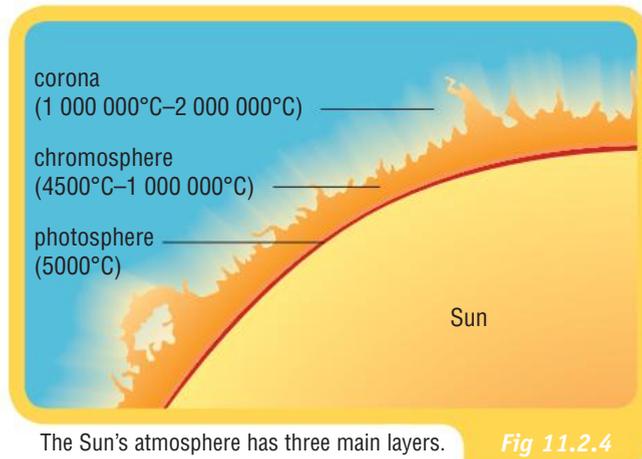
Year	Sunspots
1989	157
1990	142
1991	146
1992	94
1993	54
1994	30
1995	18
1996	9
1997	22
1998	64
1999	93
2000	120
2001	111
2002	104

**Solar flares** come from sunspots. They can reach a height of hundreds of thousands of kilometres above the Sun's surface. They can interfere with radios and television on Earth.

Prominences are a larger type of solar eruption and consist of a streamer of glowing gas. They can be observed from Earth during a total solar eclipse.

The Sun's atmosphere consists of three main layers as shown in Figure 11.2.4. The layers are: the visible surface of the Sun or **photosphere**; a thin ring around the edge of the Sun, called the **chromosphere**; and a faint halo extending out a great distance, known as the **corona**. The corona includes clouds of gas called **prominences**.

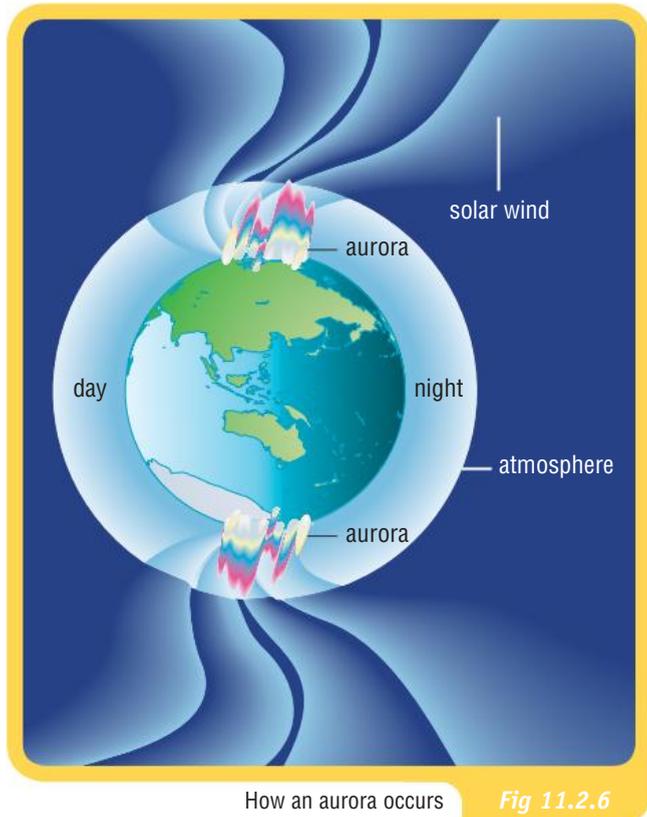
The Sun gives out a stream of particles into space at speeds of about 500 kilometres per second. These **solar winds** send particles towards the Earth's north and south polar regions. They interact with gas particles in the atmosphere to cause beautiful light displays called **aurorae**. One such display occurs in Antarctica. It is called the Southern Lights or Aurora Australis.



The Sun's atmosphere has three main layers. **Fig 11.2.4**



**Fig 11.2.5** Aurora Australis—the Southern Lights



How an aurora occurs **Fig 11.2.6**

## Solar eclipses

'Eclipse' is a Greek word for 'abandonment'—the eclipse was seen as the Sun abandoning the Earth. There are three types of solar eclipses.

- A **total solar eclipse** is when the Sun is covered by the Moon.
- A **partial solar eclipse** is when the Moon covers only part of the Sun.
- An **annular solar eclipse** occurs when the Moon is furthest from the Earth.

All solar eclipses occur when the Moon comes between the Earth and the Sun, and the Moon's shadow falls on the Earth, as shown in Figure 11.2.7.

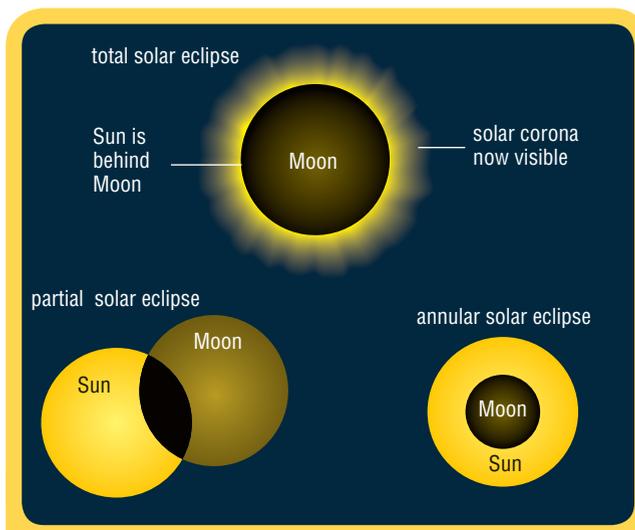


Fig 11.2.7

There are three types of solar eclipse. Solar eclipses can occur up to twice a year but do not all happen in the same place.

## 11.2 [ Questions ]

### Checkpoint

#### The importance of the Sun

- 1 Identify** two types of energy provided by the Sun.
- Plants and animals both depend on the Sun for food. **Explain** how.
- If there had been no Sun, **explain** why there would also be no oil deposits inside the Earth.
- Name a harmful type of radiation from the Sun.

#### Energy production in the Sun.

- 5 Explain** what each word means in the term 'nuclear fusion'.
- 6 State** whether nuclear fusion is a chemical reaction or a nuclear reaction.

#### Features of the Sun

- 7 Identify** three features of the Sun.
- 8 Describe** each feature you have listed above.

#### Solar eclipses

- 9 Draw** a diagram to **demonstrate** the view from Earth during:
  - a partial solar eclipse
  - an annular solar eclipse

### Think

- 10 Explain** how the Sun affects:
  - rainfall
  - wind
- 11 Identify** the name of our nearest star and its distance from Earth.

- 12** If the Earth is drawn as a circle of diameter 1 mm, **identify** how large the Sun would be on the same diagram if the diagram is to be drawn to scale.
- 13** The Sun is less dense than the Earth. **Explain** how this can be when the Sun is much bigger and has a much larger mass.
- 14 List** the following in order from closest to most distant from the centre of the Sun: chromosphere, photosphere, corona.
- 15 a Identify** the region of the Sun's outer atmosphere that is the hottest.  
**b State** the maximum temperature that may be reached there.

## [ Extension ]

### Investigate

**Investigate** where an aurora other than Aurora Australis occurs, and what it is called.

# UNIT 11.3

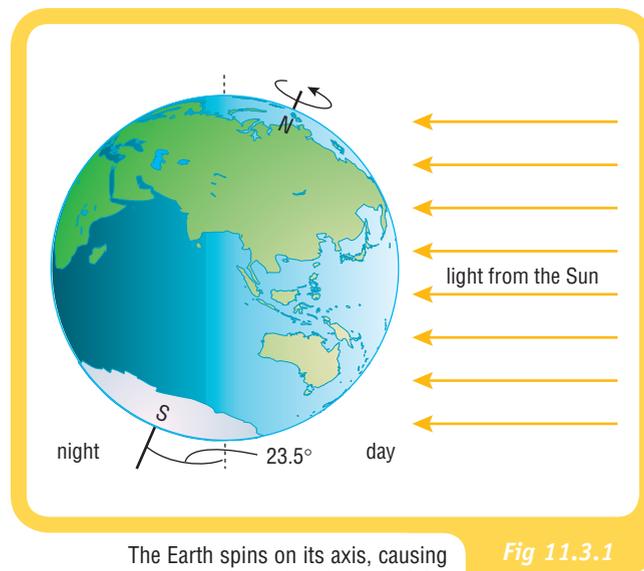
# Earth's movement in space

## introduction

The ancient civilisations defined the days, seasons, months and years by following the movements of the Sun and Moon. Babylonians, Mayans, indigenous Australians, Solomon Islanders and many other cultures all developed complex ways to predict seasonal changes. This enabled people to plan when to plant crops or move to a new location in search of seasonal foods. Survival depended on this ancient scientific knowledge of the Earth's movement in space.

## Day and night

The Earth spins on its axis (an imaginary line joining the north and south poles) once every 24 hours. We experience day and night because the Earth spins.



## Activity 4

### A model Earth

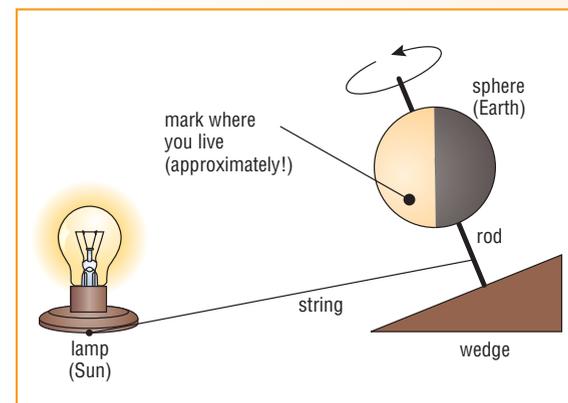
**Aim** To model night, day and the seasons

#### Equipment

A sphere (e.g. a ping-pong ball or foam ball), a skewer or fine rod, a wedge, a lamp, a piece of string (60 cm)

#### Method

- 1 Assemble the apparatus as shown in Figure 11.3.2, and place a mark on the Earth model to represent where you live.



*Fig 11.3.2*

- 2 Rotate the Earth model on its axis to simulate day and night.
- 3 Keeping the axis at the same angle, move the model around the lamp (the Sun) while a partner keeps it spinning on its axis to simulate day and night.
- 4 Repeat step 3 as required in order to complete the questions.

#### Questions

- 1 **Explain** the purpose of the piece of string.
- 2 **Describe** what you notice about the length of day and night as you move around the 'Sun'.
- 3 Draw and clearly label a diagram to **demonstrate** your model in four positions representing each season.



The part of the Earth receiving light directly from the Sun is experiencing **day**, while the other side, not receiving direct sunlight, experiences **night**. The direction of this spin is from west to east. This is why people in the eastern Solomons start each day before those in the western Solomons.

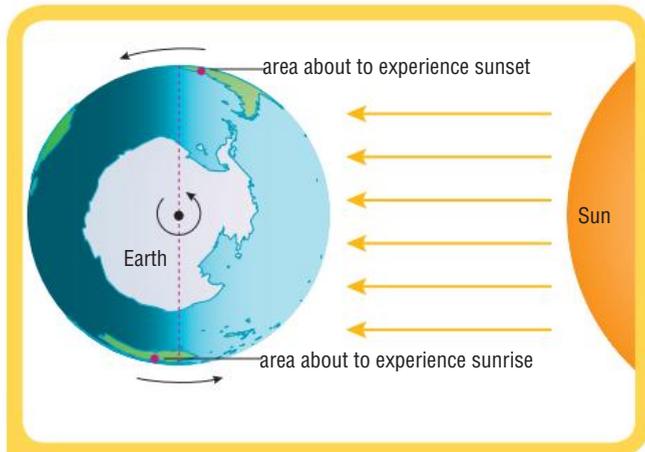
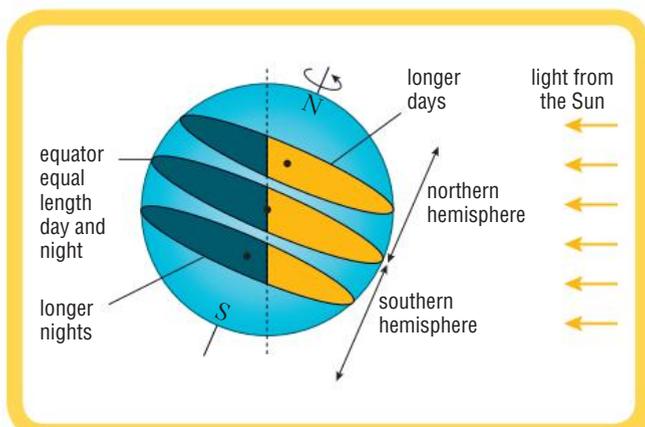


Fig 11.3.3

Point A is about to experience 'sunrise', while on the other side of the Earth point B is about to experience 'sunset'.

Day and night are not usually of equal length, except at the equator. This is caused by the tilt of the Earth's axis. The diagram below shows the Earth in a position where the southern hemisphere experiences longer nights than days.

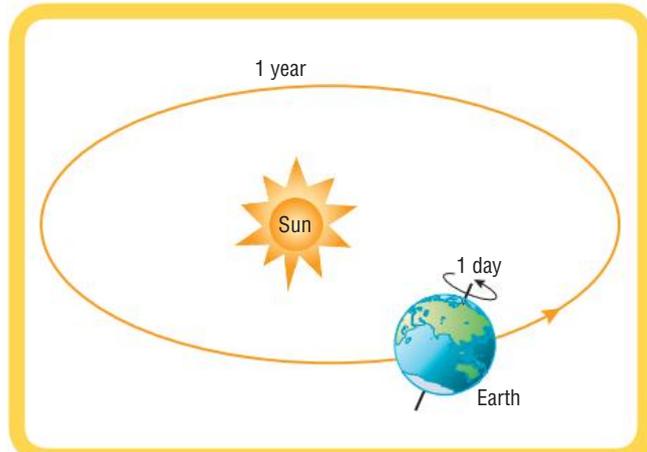


When Earth is in the position shown, days are shorter in the southern hemisphere and longer in the northern hemisphere.

Fig 11.3.4

## The year

The time taken by a planet to **orbit** (travel around) the Sun is called a **year**. Earth spins on its axis while it orbits the Sun, just as a spinning top may move in a circular path while it spins.



The Earth spins once on its axis in a day, and takes a year to orbit the Sun.

Fig 11.3.5

An Earth year is not quite  $365\frac{1}{4}$  days. So that our calendar has an exact number of days, it is based on 365 days, with an extra day added in February each **leap year**. A leap year occurs every four years and is divisible by 4. Years ending in 00 (1900, 2100, 2200, etc.) are not leap years unless they are divisible by 400.

It is the Earth's orbiting of the Sun that causes stars to appear in different positions throughout a year. It also causes the length of day and night to change through the year.

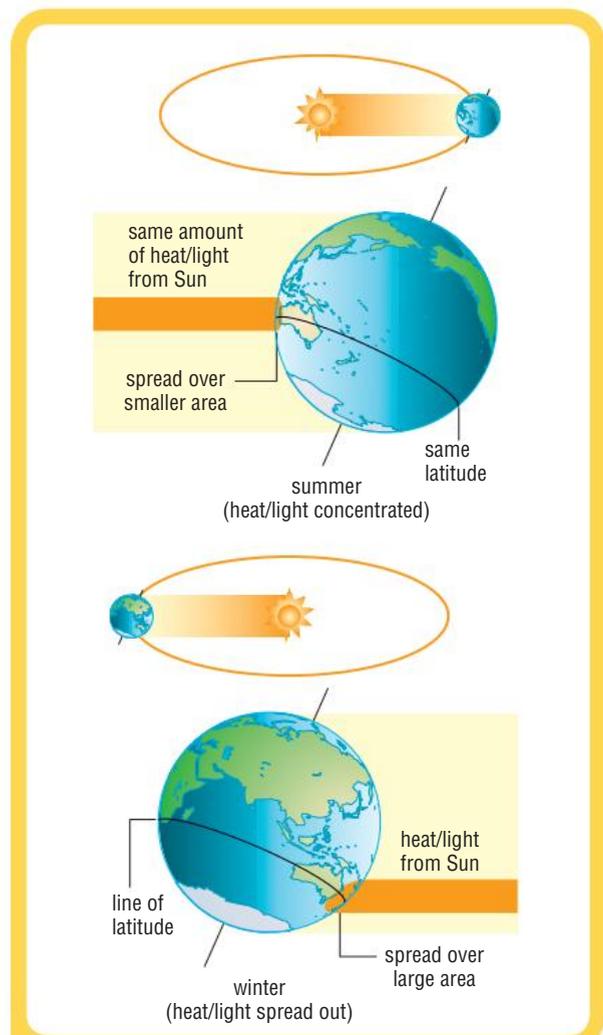
## Seasons

As the Earth orbits the Sun, the tilt causes different parts of the Earth to experience different heating effects—different **seasons**.

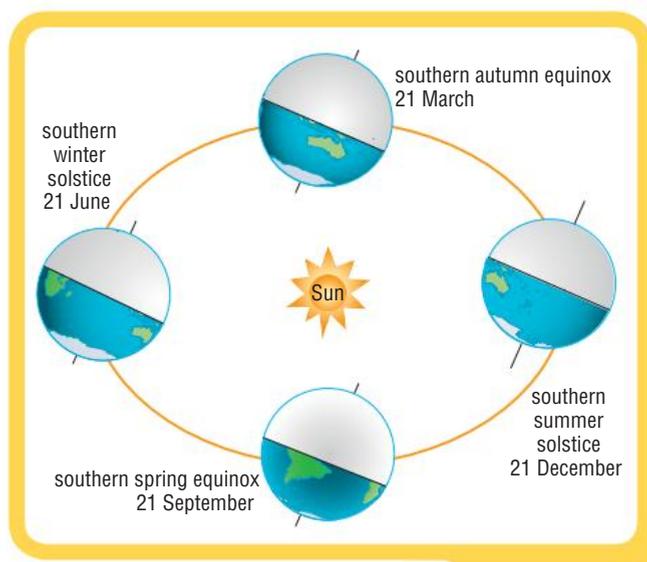
In summer, the Sun's energy is concentrated over a smaller area, and therefore produces a greater heating effect and higher temperatures. In winter, the same amount of energy is spread over a larger area and that area does not heat up as much.

The Earth may be thought of in terms of two **hemispheres**, or half spheres. When it is summer in the southern hemisphere (which contains Australia and the Pacific islands), it is winter in the northern hemisphere.

At the summer **solstice**, days are longest. At the winter solstice, days are shortest. Between these two times, at the two **equinoxes**, day and night are of equal length.



**Fig 11.3.6** Different concentrations of light and heat from the Sun produce the seasons.



Seasons in the southern hemisphere **Fig 11.3.7**

## 11.3 [ Questions ]

### Checkpoint

#### Day and night

- 1 **Clarify** what is meant by the 'Earth's axis'.
- 2 **State** how long it takes the Earth to rotate once on its axis.

#### The year

- 3 **State** how long it takes the Earth to travel once around the Sun.
- 4 True or false:
  - a A leap year is one that 4 divides into without any remainder.
  - b The year 2000 was a leap year.
  - c The year 2100 will be a leap year.

#### Seasons

- 5 **Describe** the feature of the Earth that is responsible for the seasons.
- 6 **State** the angle of the Earth's tilt.
- 7 **Clarify** the following terms:
  - a hemisphere
  - b line of latitude
  - c solstice
  - d equinox
- 8 Draw a diagram to **demonstrate** your understanding of how a season occurs.



## Think

- 9 **Identify** the location on Earth where day and night are always the same length.
- 10 **a Identify** the location on Earth where it could be dark for more than 24 hours at a time.  
**b Explain** why this is possible.
- 11 If the Earth's axis was not tilted, **explain** whether there would be:
  - a seasons
  - b day and night
- 12 If the Earth tilted even more, **explain** how the seasons would be affected.
- 13 **Describe** the difference between an equinox and a solstice.
- 14 It is hot at the equator all year. **Explain** why.

## Analyse

- 15 **Identify** which is longer, day or night, for the area marked A on Earth in Figure 11.3.8.

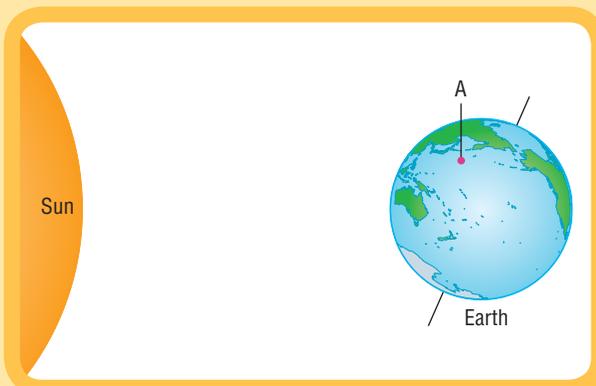


Fig 11.3.8

- 16 **Identify** which direction the stars appear to move: west to east, or east to west.  
Hint: Think about the direction of the Earth's rotation.
- 17 **Use** Figure 11.3.7 to determine when the particular seasons occur in the northern hemisphere compared to the southern hemisphere.

## [ Extension ]

### Investigate

- 1 Use newspapers or other sources to record sunrise and sunset times for two weeks. **Describe** any changes in the length of day and night.
- 2 **Research** what the five climatic zones on Earth are and **produce** a poster to display your information, with examples of what these zones commonly are like.
- 3 **Investigate** at what speed the Earth:
  - a spins on its axis
  - b moves around the Sun

### Create

- 4 **a Construct** a model to demonstrate either the seasons, day and night, or the year.  
**b Present** your model to the class to teach them about your chosen concept.

## Creative writing

### Not in a spin!

Scientists have just announced that the Earth is about to stop spinning on its axis!

What may be the consequences? How will the weather and climate be affected? Will plants grow? Is this the end, or will life be possible in some areas? Write an account of how you prepare, and events afterwards.



# UNIT 11.4

## The Moon

### introduction

The Moon has more stories, myths, prayers and rituals about it than anything else in history. Look at a full moon and you will see why different cultures see a man, a rabbit or a woman weaving. The name of the goddess Luna was given to the belief that a full moon makes people mad—*lunatics*.

Easter is also associated with the Moon. It falls on the first Sunday after the first full moon after 21 March. Maybe the Easter bunny is related to the image some cultures see in the Moon.

The Moon is the only celestial body on which humans have landed. In 1969, Neil Armstrong uttered those now famous words: ‘One small step for man, one giant leap for mankind’.

Astronauts must wear space suits with breathing apparatus on the Moon. The Moon has no atmosphere and therefore no air to provide oxygen to breathe. Astronauts have the same mass on the Moon as they do on Earth. However, their weight (the force of gravity on them) is about one-sixth on the Moon because the Moon is much smaller than the Earth. So lunar astronauts were able to take huge steps and jump further than on Earth before falling to the surface once more.

### Introducing the Moon

The Moon shines brightly in the sky at night-time. We see it shine because it reflects light from the Sun. The Moon is smaller than the Earth.



Buzz Aldrin near *Apollo 11* and the US flag. Buzz was the second man on the Moon.

Fig 11.4.1

### The Moon

#### Fact file

Mythology	God of the night
Mass	0.012 times that of Earth
Diameter	3476 km ( = 0.27 × Earth’s diameter)
Gravity	0.16 times that on Earth
Surface temperature	−230°C to 123°C
Period of rotation (day)	27.3 days
Time to orbit Earth	29.5 days
Tilt of axis	5°

Notice that the time for the Moon to orbit the Earth is nearly the same as the time it takes to spin once on its axis—this results in us only ever seeing the one side of the Moon from Earth. The other side is often called ‘the dark side of the Moon’ since it had never been seen until the Apollo missions.

## The lunar landscape

In 1609, Galileo first used a telescope to view details of the Moon's surface. Many had previously thought that the Moon's surface was smooth. The two main types of lunar landscape he observed were plains (called **maria**) and **highlands** (which includes craters).

An Italian astronomer, Giovanni Riccioli, in 1651, thought the dark areas on the Moon were seas. This method of naming continues today, even though the Moon has no surface water, with names such as 'Sea of Tranquility' and 'Sea of Serenity'.

Though only one face of the Moon is visible from Earth, space probes have photographed the other side ('the dark side') to reveal very few maria there.



A full moon showing dark areas of lava-filled impact basins **Fig 11.4.2**

Scientists believe that about 4 billion years ago the Moon was a hot, fluid mass that eventually cooled enough to form a crust. This crust was hit by meteorites to create the highland regions. Some of the low regions caused by meteorite impacts were filled with lava from lunar volcanoes. The lava solidified to form large, smooth areas or maria.

In 1971 and 1972, *Apollo* missions discovered that the interior of the Moon is still hot. In 1998, the Lunar Prospector found evidence of water in the form of ice mixed with lunar dirt at the Moon's poles.

## Activity 5

### Crater formation

**Aim** To investigate how craters get their shape

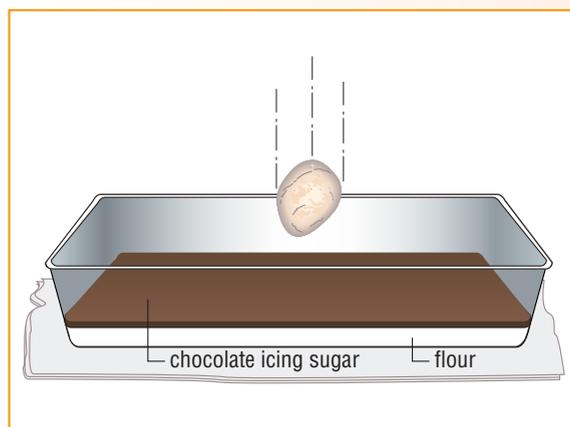
#### Equipment

Flour, chocolate icing sugar (or Milo or coffee powder), shallow tray (e.g. foil tray), three rocks about 1 cm to 7 cm, newspaper, metre rule

#### Method

- 1 Spread newspaper under the shallow tray.
- 2 Place a fairly thick layer of flour in the tray, and smooth it into the tray.
- 3 Cover this with a thin layer of chocolate icing sugar to represent an outer layer of rock.
- 4 Drop the rocks onto the flour from a height of 1 metre. Remove them after each drop.
- 5 Increase the height to two metres and repeat.
- 6 Record the diameter of each crater and its shape for the three rocks.

**CAUTION:** Do not dispose of the flour down the sink (your teacher will advise you of the correct method of disposal).



**Fig 11.4.3**

#### Questions

- 1 Make a **list** of the factors that affected the type of crater formed.
- 2 Did the same rock make the same size crater every time? **Explain.**
- 3 The experiment assumes that all objects hit planets or moons vertically. **Design** an experiment to see the effect of an impact at an angle.



## Phases of the Moon

The Moon takes about a month to orbit the Earth. It spins at a similar rate, and therefore we always see the same face of the Moon. How much of the Moon's face we see depends on where it is in its orbit around the Earth. We call these different views **phases**. There are eight main phases of the Moon.

To understand Figure 11.4.4, imagine yourself on the Earth, under point A looking towards Moon A. Because the Sun is directly behind the Moon, you see nothing of the Moon (we call this a new moon). Now imagine yourself on Earth under point C, looking directly towards Moon C. From here you would see only half the Moon.

Now try the other positions (D to H) and check out how each phase occurs. A summary of the phases is shown in Figure 11.4.5.

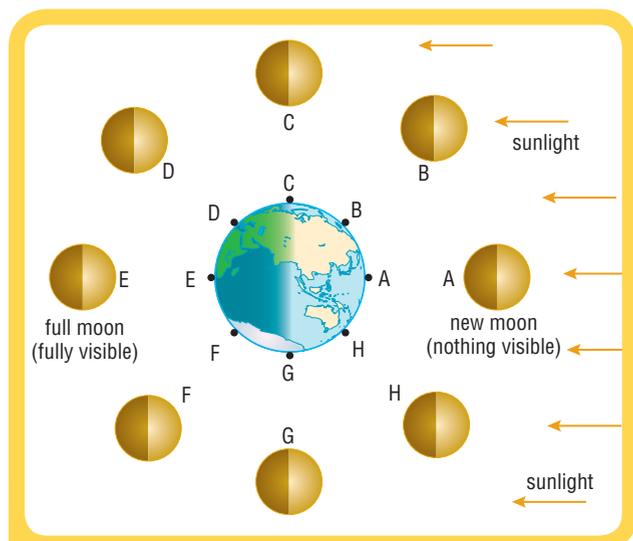


Fig 11.4.4

Look from a letter on Earth to the same letter near the Moon and try to imagine the view from Earth in each case.

## Activity 6

### Phases of the Moon

**Aim** To construct a flip book to show the main phases of the Moon

**Method**

- 1 Record the phases of the Moon every third night for one month, using multiple copies of a record box like the one in Figure 11.4.6.

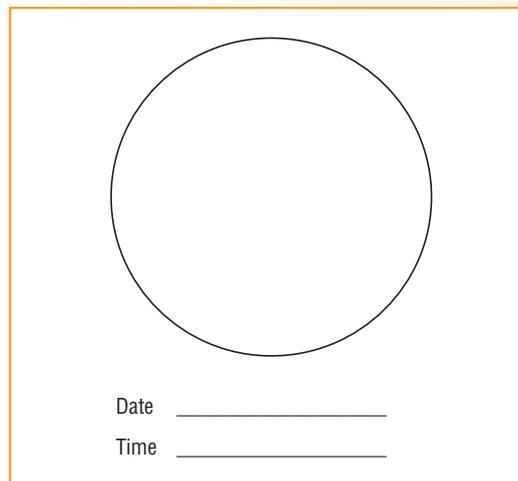


Fig 11.4.6 Moon view record box

- 2 If the sky is cloudy, guess what the Moon may look like.
- 3 Paste the diagrams onto stiff cardboard.
- 4 Place them in order from a new moon and secure to make a small booklet.
- 5 Flip the pages with your thumb to see the Moon's phases.

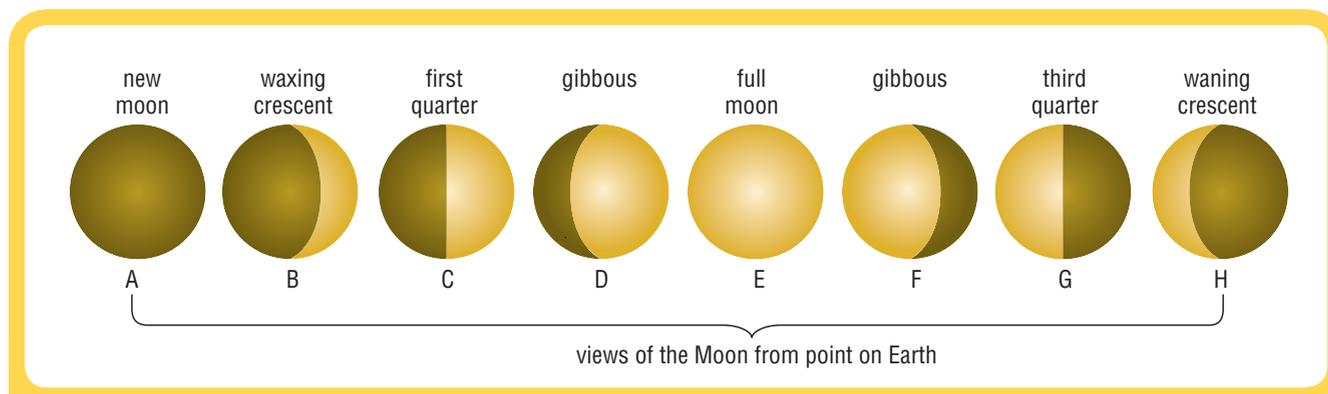


Fig 11.4.5

The eight phases of the Moon

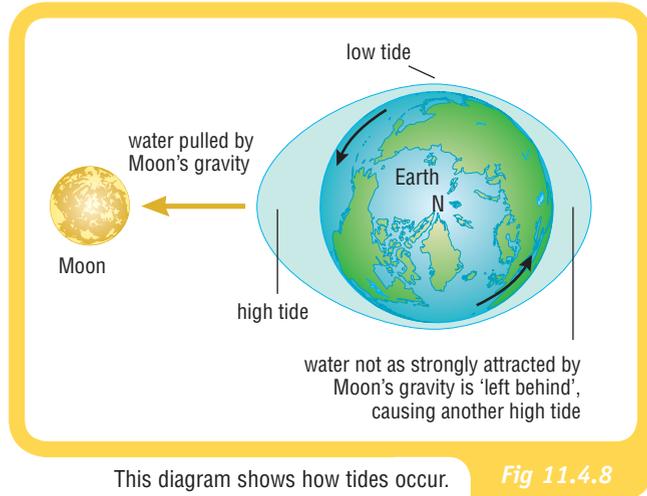


A composite image of the phases of the Moon **Fig 11.4.7**

## Tides

In the second century BC, the Chinese had recognised a connection between tides and the Moon's cycle. About twice a day the sea level rises to a high tide and falls to a low tide—the average time between two high tides is 12 hours 25 minutes.

In the 1600s, Newton proposed the theory of gravity: that tides were caused by the Moon's gravitational pull on the Earth.



This diagram shows how tides occur. **Fig 11.4.8**

The gravitational force between two objects is only noticeable when one or both objects are very large, as is the case with the Moon and the Earth. The Moon attracts the oceans towards it, causing a bulge in the oceans facing the Moon. If this were the only effect, there would only be one high tide and one low tide a day, not two. The Earth's rotation, however, causes a similar bulge on the other side of the Earth.

## Lunar eclipse

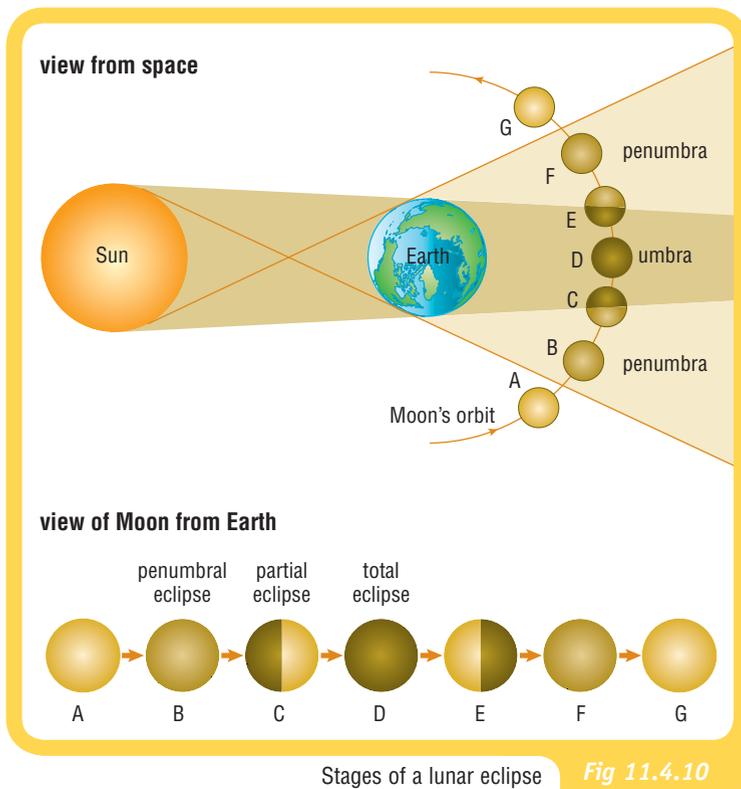
A **lunar eclipse** occurs when the Moon passes into the shadow of the Earth, as shown in Figure 11.4.9.

Lunar eclipses occur in stages as shown in Figure 11.4.10.

Lunar eclipses can occur up to three times a year.



A lunar eclipse **Fig 11.4.9**



### Phases of the Moon

- 8 State** how long it takes for the Moon to orbit the Earth.
- 9 Explain** why we always see the same side of the Moon.
- 10 Explain** what a 'phase' of the Moon means.
- 11 Draw** each of the following:
  - a** a gibbous moon
  - b** a crescent moon

### Tides

- 12 Identify** what causes the tides on Earth.
- 13 State** the number of tides that occur per day.
- 14 Draw** a diagram to **demonstrate** how the tides are created.

### Lunar eclipse

- 15 Describe** how a lunar eclipse occurs.

### Think

- 16** More meteorites reach the surface of the Moon than the surface of the Earth. **Propose** a reason why.
- 17 Identify** the number of Moons (approximately) it would take to equal the mass of the Earth.
  - a** 10
  - b** 100
  - c** 1000
  - d** 10 000
  - e** 1 000 000
- 18 Explain** the difference between a *waxing* crescent and a *waning* crescent.
- 19 Predict** how the tides would be affected if the Moon was:
  - a** larger
  - b** further from the Earth
- 20 Explain** what happens during:
  - a** a penumbral lunar eclipse
  - b** a partial lunar eclipse
- 21 Describe** what is meant by 'the dark side of the Moon'.
- 22** There are more extreme temperatures on the Moon than on the Earth. **Propose** a reason why.

## [ Questions ]

### Checkpoint

#### Introducing the Moon

- 1 State** the year when the first person walked on the Moon, and identify who it was.
- 2 Identify** who the second person was to walk on the Moon.
- 3 State** whether the Moon has:
  - a** atmosphere
  - b** gravity
- 4 Identify** who used a telescope to view the Moon in 1609.

#### The lunar landscape

- 5 Identify** the two main types of lunar landscape, and briefly **describe** them.
- 6 Identify** where water may exist on the Moon.
- 7 Describe** what the Apollo missions discovered about the core of the Moon.





**23 Describe** how the duration of a lunar eclipse would be different if the Earth was smaller.

**Hint: Look at Figure 11.4.10.**

**Analyse**

**24 Copy** Figure 11.4.11, and show where the Earth would be placed if a 'quarter Moon' is to be seen.

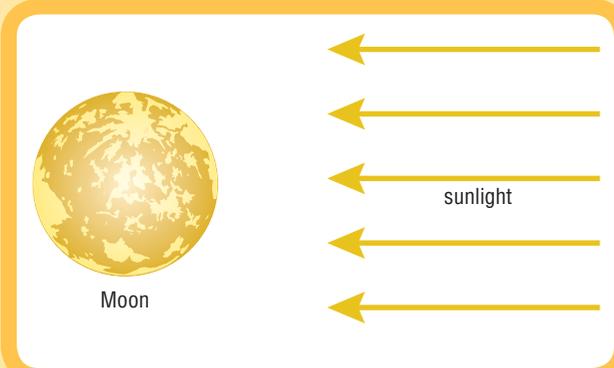


Fig 11.4.11

**25 The tidal bulges** are missing from Figure 11.4.12. Copy the diagram and include them.

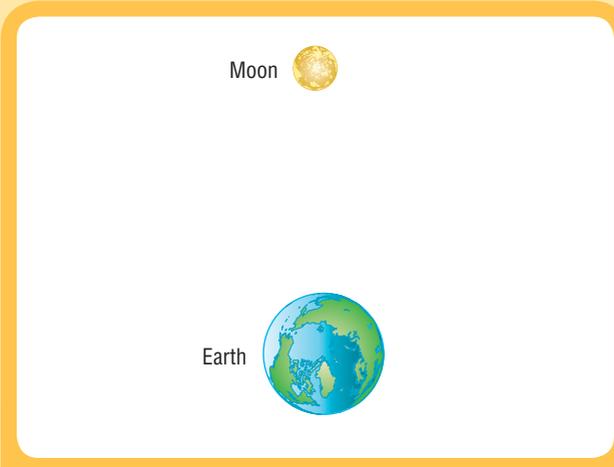


Fig 11.4.12

[ **Extension** ]

**Investigate**

- 1 Produce** a poster of the Moon, showing the names of some major features.
- 2 Obtain** a tides chart and **produce** a key to explain its use.

**Creative writing**

Due to overpopulation on Earth, a settlement is to be established on the Moon. You are a consulting scientist involved in planning and establishing the colony. What requirements will people have on the Moon? Anticipate some of the difficulties of life on the Moon. Consider factors such as food, temperature, oxygen, etc. and the possibility of meteorite strikes. Include a diagram of planned lunar constructions.



## Chapter review

### [ Summary questions ]

- 1 Give scientific definitions of the terms 'day' and 'year'.
- 2 **Identify** the term used when day and night are of equal length.
- 3 **Identify** the word starting with L that is used to describe aspects of the Moon.
- 4 **State** how long it takes the Moon to orbit the Earth.
- 5 **Describe** gravity on the Moon.
- 6 Draw the eight main phases of the Moon.
- 7 **Explain** three examples of our dependence on the Sun.
- 8 Copy and complete: Nuclear \_\_\_\_\_ reactions occur in the core of the Sun.
- 9 Why do sunspots appear dark when they are very hot? **Explain**.
- 10 **List** the planets in order, starting with the one closest to the Sun.
- 11 **Describe** one aspect or fact about each planet.
- 12 **Identify** two space probes and **state** which planet(s) they explored.
- 13 **Identify** the planet that has an orbit which overlaps that of another.
- 22 **Explain** the following phenomena. Include a description of what each phenomenon is and what its cause and effect are. Give examples where appropriate.
  - a tides
  - b seasons
  - c day/night
  - d year
  - e lunar eclipse
  - f solar wind
- 23 **Describe** how many cultures depend on the Sun and Moon for survival.

### [ Interpreting questions ]

### [ Thinking questions ]

- 14 **Explain** the differences between a prominence and a solar flare.
- 15 Use a diagram to **describe** what causes an aurora.
- 16 Draw a diagram to **demonstrate** an annular eclipse.
- 17 **State** whether the year 2500 is a leap year.
- 18 The geocentric model was accepted before the heliocentric model. **Compare** these two models of the solar system.
- 19 **Classify** the following as supporters or opponents of the heliocentric solar system model:  
Aristotle, Copernicus, Ptolemy, Brahe, Kepler.
- 20 **Explain** why scientists did not speak up in favour of the heliocentric model for a long time when they knew it to be a better model than the geocentric model.
- 21 **Identify** the astronomer who first used a telescope to find errors in the geocentric model.
- 24 Use the 'fact files' in this chapter to answer the following questions.
  - a **Identify** the planets with more than 15 moons.
  - b **List** the terrestrial planets.
  - c **Identify** the planets that have methane in their atmosphere.
  - d **Identify** the planet that is most similar to Earth and **explain** your reasons for choosing this planet.
  - e **State** how long a day and a year are on Pluto.
  - f **Identify** the planet that looks red and **explain** why this is the case.
- 25 Construct a table that shows the distance from the Sun, the day length and the year length for each planet.
- 26
  - a **List** the things that make it possible for us to survive on Earth.
  - b Could any other planets in the solar system support life? **Explain** why.
  - c Which planet would be easiest to move to if we had to leave the Earth? **Explain** why.
  - d Of the nine planets and the Sun, **evaluate** which is the most important body in the solar system. Give reasons for your decision.

# Ecology

By the end of this chapter learners should be able to:

- Identify examples of local ecosystems in their community, e.g. *mangrove, forest, river, coral reef*.
- Identify examples of other ecosystems, e.g. *desert, grassland*.
- Give an example of an organism interacting with:
  - i living things, e.g. *a cow feeding on a grass, a bird nesting in branches of mangrove trees*
  - ii non-living things, e.g. *a fish breathing air in water, a chicken drinking water*.
- Identify levels of the biosphere and the biomes.
- Give common examples of organisms and identify abiotic factors that influence their survival:
  - i *mangrove tree—salinity, nutrients*
  - ii *bonito—sea current, temperature*
  - iii *hard coral—sunlight, waves*
  - iv *mosquito—water, air, heat*.
- Draw and describe food chains and food webs in the following ecosystems: *mangrove, coral reef, deep-sea, rainforest*.
- Identify the origin of the energy in the food chain or food web and describe the energy flow.
- Identify and explain different types of interactions between living organisms.
- Conduct a survey and map the distribution of plants and animals in one of their local ecosystems.

- 1 Why don't plants grow on the deep ocean floor?
- 2 What tree has its roots above the ground?
- 3 How do sharks clean their teeth?
- 4 What is living around you right now, what once lived and what is not living and never was?
- 5 The Australian desert is so dry and inhospitable that no plants or animals are able to live there. True or false?
- 6 How can bushfires sometimes be a good thing for an ecosystem?



# UNIT 12.1

## Ecosystems

### introduction

Humans are animals that live in the environment. Like all other organisms, we take from the environment what we need to survive: food and water, shelter and a breeding mate. It is important to understand the way we live and how we fit into the

environment. It is also important for us to understand how other organisms fit in and how we influence their health and survival.

study of an ecosystem, the interactions and organisms within it, and the interactions of organisms with the non-living environment.

The term **living (biotic) things or organisms** includes all of the plants and animals that live in or visit the region. Together, plants and animals make up the **community** of the ecosystem. Each organism is also present in certain numbers. In other words there is a **population** of organisms. Scientists study these populations to see what factors cause the population to increase or decrease.

### Activity 1

#### Organisms in an ecosystem

**Aim** To discover different organisms in one ecosystem

#### Equipment

Hand lenses (magnifying lenses), forceps, tray

#### Method

- 1 Divide the class into groups of four.
- 2 Provide each group with equipment.
- 3 Identify a number of ecosystems around and near your school.
- 4 From the different ecosystems identified, each group is to choose one ecosystem and do the following:
  - a Name the ecosystem.
  - b Identify and list different organisms.
  - c Make a table of the organisms your group found.
  - d Compare your findings to other groups' findings.

#### Questions

- 1 How many organisms are present in the ecosystem?
- 2 What organism(s) is(are) present in the highest number?
- 3 What organism(s) is(are) present in the least number?
- 4 What conclusion can you make about the ecosystem you studied? Is it rich or poor and disturbed?

### Ecosystems

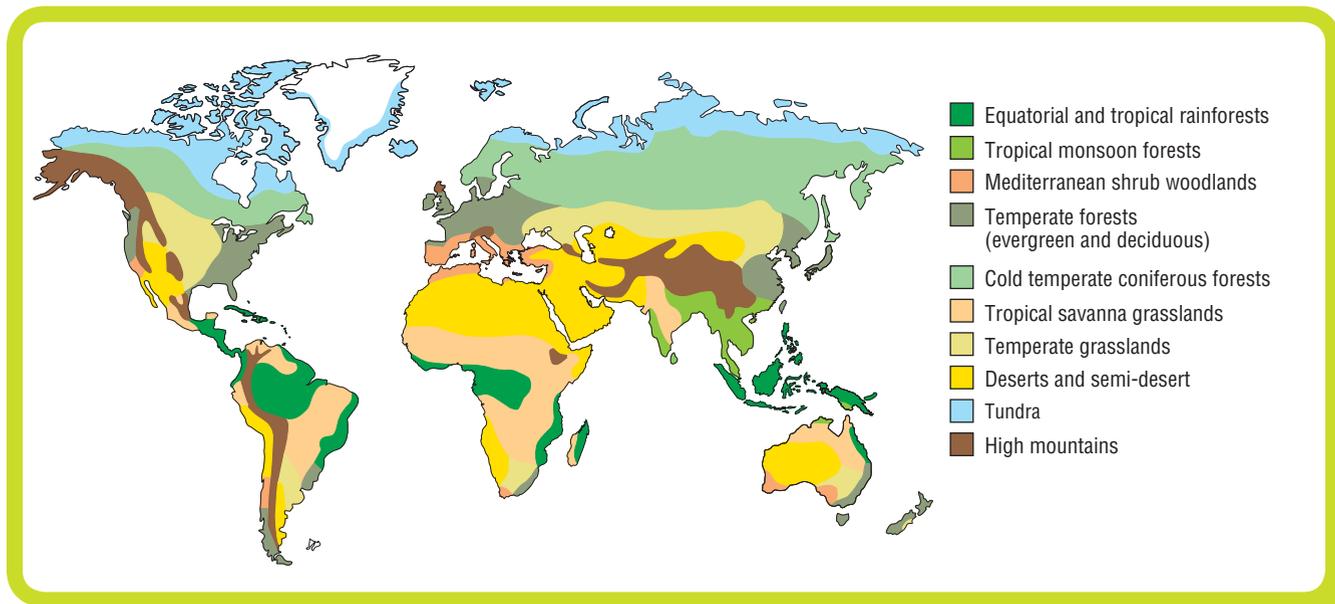
When we talk about an **ecosystem**, we mean the living things or organisms that live in a specific region, how they interact with each other and how the non-living environment around them affects them. **Ecology** is the



**Fig 12.1.1** A white cockatoo is an example of an organism.

The **non-living (abiotic) environment** includes physical factors such as rainfall, temperature, wind, sunlight, rocks, soil and water.

As you can see, an ecosystem, can be quite a complicated thing!



World distribution map of the locations of different biomes

Fig 12.1.2

## Biospheres

Just as you have an address, so too can we give an address to the organisms that live in a specific area.

The **biosphere** is the broadest category in the address. It refers to that part of the Earth (including its atmosphere) in which living organisms can be found. The Earth biosphere is then divided into a second level of **biogeographical** regions. For example, Australia and North America are biogeographical regions. Each region has its own plant and animal life. These interact with each other. They depend on the physical conditions that are present there.

## Biomes

The **biome** is the third level of an organism's address. It refers to areas that have similar conditions. These include similar soil types, rainfall, temperature and so on. Grasslands, deserts, the tropics, subtropics and the Arctic are examples of different biomes. Scientists have observed that organisms living in the same type of biome have similar features, regardless of whether they are in the same biogeographical region. The Simpson Desert, for example, is a desert biome in the Australian biogeographical region. The plants and animals found there show many characteristics similar to those found in other desert biomes around the world.



Fig 12.1.3

Camels were introduced to Australia. The Australian desert biome has a similar climate to the desert biome of their home countries in the Middle East.

## Habitats

Within each biome are different **habitats**. This is the fourth level of an organism's address. This term defines an even more specific area. In a desert biome, the habitats could be the individual sand dunes, the clay particles between them, or a tussock of grass or small tree growing on them. A tropical biome will have many different habitats from a desert biome. For example, as the moist, protected areas at ground level, the very top of the leaf canopy—and everything in between!



## Activity 2

### Cut and paste

**Aim** To compare the different levels of an ecosystem

### Method

Place the diagrams in order from biosphere to niche. You may choose to photocopy the diagrams to cut and paste, or simply redraw the diagrams in the correct order.

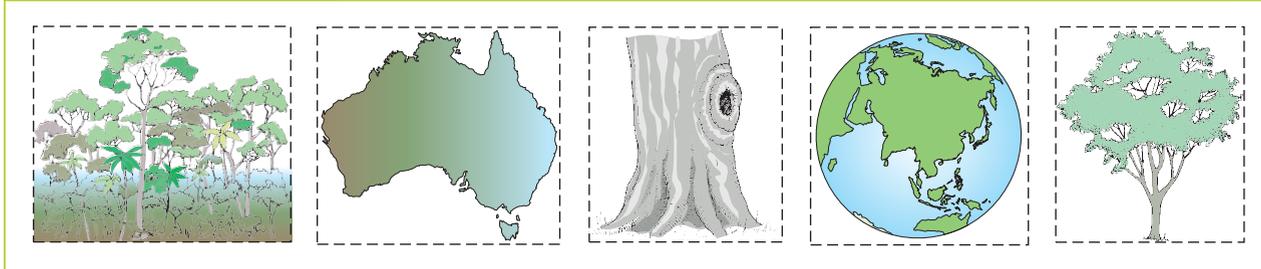


Fig 12.1.4

## Activity 3

### Identification of different habitats within an ecosystem

**Aim** To identify and describe different habitats in an ecosystem

### Method

- 1 Divide students into groups of four.
- 2 Each group is to be assigned to different habitats within an ecosystem and do the following:
  - a Describe the ecosystem.
  - b Identify different habitats found within the ecosystem.
  - c List the habitats you identified and the organisms that can be found in the habitats.
  - d Compare your findings to other groups' findings.

### Questions

- 1 What is the common habitat found by the whole class?
- 2 Consider the state of the habitats. Are they still intact or disturbed?

## Microhabitats

You may think that we can't get any more specific than saying an organism lives on the ground in a tropical rainforest or on a sandy dune in the desert. Think again! In every habitat there are areas where conditions are different from the rest of the habitat.

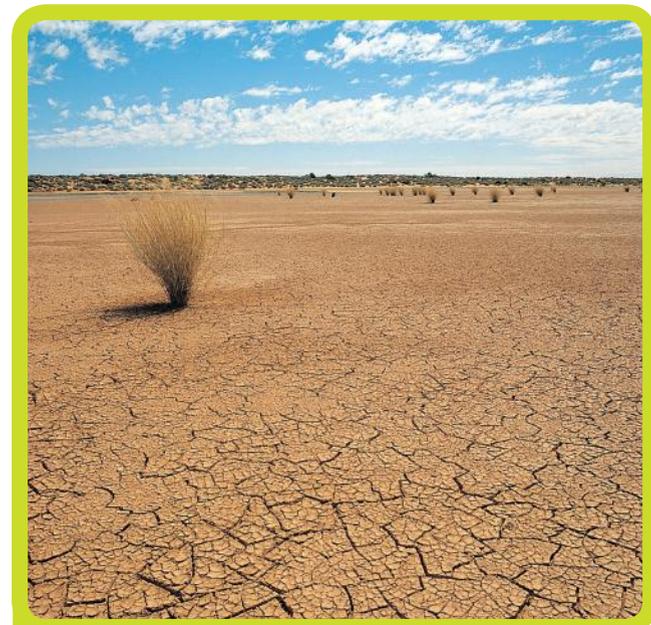


Fig 12.1.5

A clay-pan habitat in the Simpson Desert. Although it looks dry and lifeless, it is the habitat for a number of living things.

In a tropical rainforest, like the ones we have in our islands, some organisms may live between the roots of the trees. Others live under the bark and in the dirt itself. In holes on branches of tall trees in the deep forests of Solomon Islands, you may find a tiny marsupial called an opossum sleeping quite happily in its own **microhabitat**! The microhabitat is the last and most specific part of an organism's 'address'. The microhabitat may also be known as the **niche**.



Fig 12.1.6 The niche of an opossum

The 'address' of the opossum in Figure 12.1.6 could be written as:

- Solomon Islands in the South Pacific (its biosphere)
- Guadalcanal Island (its biogeographical region)
- Holes on branches of tall trees (its biome).

At night, the opossum hunts in the branches of trees and feeds on leaves at the top of trees. These areas are its habitat. During the extreme heat of the day, the opossum returns to its hole on a branch of a tree to sleep. This is its microhabitat.

The opossum's community includes:

- the plants that the opossum uses for shelter or food
- the plants that provide shelter to other animals
- the animals that live in the same tree as the opossum
- the other opossums in the area.

The non-living environment includes the type of trees and vegetation and the temperature up in the trees. Everything in the ecosystem is connected in some way.

## Examples of other ecosystems

Australia is the most arid inhabited continent on Earth. It has unique ecosystems with unique communities living in them. Part of this uniqueness comes from these ecosystems being exposed to various human-made and natural events. The three main events affecting Australia's ecosystems are:

- flood
- bushfire
- drought.

Although these events can devastate much of an ecosystem, they can also have some positive outcomes. Floods can deposit fertile new soil for plants to grow in and fire can trigger the germination of new plants. The effects of these events may be felt for many years, resulting in changes within the ecosystem.

### Flood

**Flooding** can cover extremely large areas of Australia, affecting many varied ecosystems. The flooding of Lake Eyre in 1973–74 covered an area of more than 390 000 square kilometres (this is equivalent to about half the area of New South Wales!), filling the normally dry lake bed to a depth of 10 metres. After the initial quick devastation, floods can have positive ecological effects, such as:

- replenishment of ground and soil water
- increased breeding of water-dependent species such as fish and pelicans, and therefore an increase in numbers
- regeneration of long-living and slow-reproducing trees in arid biomes.



The effect of flooding on an ecosystem

Fig 12.1.7



## Bushfire

For millions of years, lightning strikes have sparked bushfires in Australia and other parts of the world. Many native plants and animals have developed specialised ways to survive fire and respond quickly to its impact, such as the following.

- Some native plant species need fire to release the seeds they need to regenerate. Others will die and never regenerate. The type of bush that regenerates after fire will depend on what plant species were there before and how hot the fire was.
- Highly mobile animals may be able to move out of the way of an approaching fire to safer areas. Slower animals may survive the fire by sheltering in holes or logs while fire passes overhead. Reptiles and amphibians also hide underground. Despite this, many animals die and populations drop.
- Bushfire releases nutrients into the soil. These allow plants to recover and seeds to grow quickly.
- Fire removes vegetation and exposes the soil to wind and water. This encourages soil erosion to occur.



Fig 12.1.8

Fire has both negative and positive effects on the environment.

## Drought

Floods and bushfire bring quick changes to ecosystems. **Drought** occurs over a number of years when rainfall is less than normal. The effects can be devastating to humans and their farms. Droughts can affect huge areas of land, affecting many more ecosystems than fire or flood. The ecosystems easily affected by drought often have a low capacity to respond. Death and hunger is the result for the organisms in the ecosystem. Drought can also destroy the land and affect the way land is used in the future.

‘Drought’ has many meanings. In the United Kingdom, 14 days without rain is considered a drought! In Australia and other parts of the world, a drought is ‘official’ when rainfall over a year is in the lowest 10 per cent ever recorded.

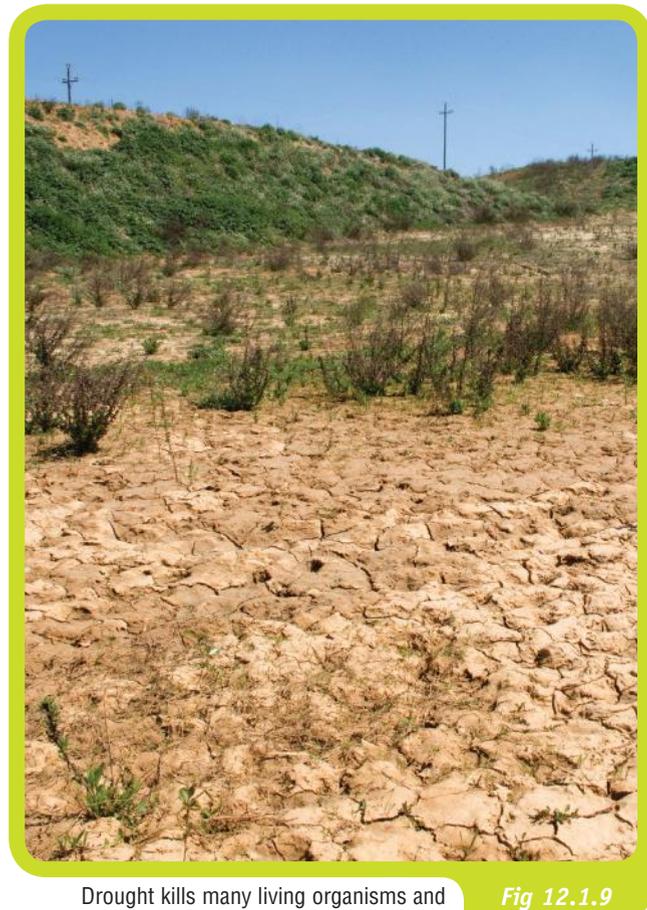


Fig 12.1.9

Drought kills many living organisms and degrades vast areas of land.

# 12.1 [ Questions ]

12.1

## Checkpoint

### Ecosystems

- 1 Identify** terms for each of the following:
- all of the plants and animals in a region
  - physical factors such as rainfall, light etc.
  - many organisms living together.

### Biospheres

- 2 State** an example of a biographical region in Solomon Islands.

### Biomes

- 3 List** four different types of biomes.

### Habitat

- 4** Use an example to **demonstrate** what is meant by a 'habitat'.
- 5 List** two features of the habitat of a tropical biome.

## Think

- 6 Classify** the following as living (L) or non-living (NL) components of the environment:
- |                        |                                   |
|------------------------|-----------------------------------|
| <b>a</b> a seed        | <b>c</b> the bark on a tree       |
| <b>b</b> dried flowers | <b>d</b> the hair in a hairbrush. |
- 7 Modify** the words in *italics* to make the following statements correct.
- The term 'biosphere' refers to that part of the earth (*except* its atmosphere) in which living organisms can be found.
  - The term 'biome' refers to areas that have *different* climatic conditions.
  - The term 'habitat' is used to describe a *less* specific area than the term 'biome'.
  - An example of a desert microhabitat would be the *Simpson Desert*.

- 8** Use the following list as a guide to **identify** where you live (your address). The first level is done for you.

Biosphere	Planet Earth
Biogeographical region	(your country)
Biome	(your city)
Habitat	(your street)
Microhabitat	(your house or apartment number)

- 9** Copy each of the following statements and **modify** any that are incorrect.
- 'Ecosystem' refers to the plants that live in a specific area.
  - The plants and animals in each biogeographical region are unique.
  - Animals that live in a grassland biome in different biogeographical regions are unlikely to show any similarities.
  - The island of Guadalcanal is considered a microhabitat.
- 10** Use an example to **list** the following in order from smallest (most specific) to largest (least specific): microhabitat, biome, biosphere, habitat, biogeographical region.
- 11 Propose** a reason for organisms living in the same type of biome having similar characteristics.

## [ Extension ]

### Investigate

**Examine** your own backyard or school ground to **identify**:

- what plants and animals live there
- what types of soil they live in.
- how the plants there interact with each other.

# UNIT 12.2

## Physical attributes of an ecosystem

### Introduction

Organisms are affected by their environment in many ways. Predators might eat them and their young. Non-living factors such as very high daytime temperatures might mean that they can only be active at night. How are you affected by the living and non-living things in your environment? How do you survive with all these pressures? You adapt or adjust!

### Adaptations

#### Activity 4

### Features of organisms that support survival against predators

**Aim** To determine general features of several organisms that may support their survival against predators

#### Method

- 1 Select five organisms in an ecosystem and observe their adaptive features for survival.
- 2 Determine the habitat of each organism.
- 3 Describe the features of each organism.
- 4 Compare the general features of the habitat to the general body features of each organism.
- 5 Decide what features the organisms use for protection.

#### Questions

- 1 What feature of each organism is used for protection?
- 2 What environmental problems can affect the protective features of these organisms?



**Fig 12.2.1** The colour of this octopus is similar to its surroundings.

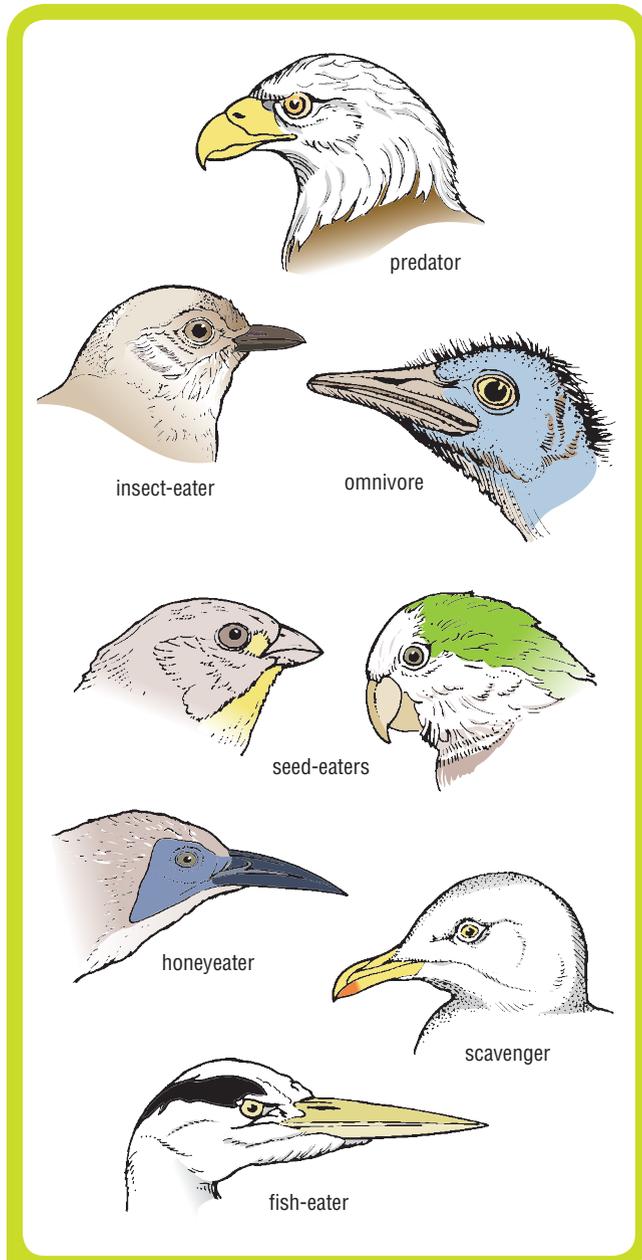
An organism can live only in an environment that it is suited or fit for: it must have behavioural and physical characteristics that will allow it to survive. These characteristics are called **adaptations**.

Consider the common octopus (*Octopus vulgaris*). This mollusc may grow from 30–91 cm in length. Like other octopus species, the soft-bodied common octopus has eight arms. Its arms have many suckers. There are no internal shells. It is found worldwide in tropical and temperate waters. The colour of its body and arms varies: they may be spotted or streaked. The body colouring is an example of **physical adaptations**—the octopus was born with these adaptations and has no control over them.

When an octopus is being attacked by a predator, it will squirt or spray ink to blindside the predator. It can camouflage or change its body colours to look the same as the surrounding environment. This makes it very difficult for predators to identify it. The octopus is an invertebrate, so it can squeeze through very small holes in the rocks. This is an example of a **behavioural adaptation**.

Behavioural adaptations can be **instinctive** or **learnt**. For example, on hot days people and animals like to seek shade because it cools them down—in

cooler weather they cuddle up. This is instinctive behaviour—something we do automatically. When a chick follows and watches its mother chase grasshoppers and dig the soil for worms, it learns how to hunt for food. The chick then practises until it is able to feed itself. This is an example of a learnt behaviour. Likewise, a pet dog will learn the noises associated with its feeding time and will respond accordingly.

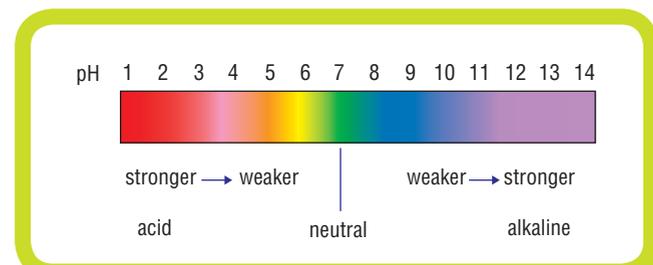


**Fig 12.2.2** These bird beaks show the physical adaptations of various bird species to the different types of food they eat.

## Effects of the non-living environment

Non-living or **abiotic** factors influence where an organism can live. They include:

- **temperature**  
Biological processes such as digestion, respiration, excretion and reproduction take place at an optimum temperature range. When living things get too hot or too cold, they do not function properly.
- **humidity** of the air  
This is the amount of water vapour in the air. The amount of water lost from an organism into the air depends on the humidity of the air. If the air is very humid (as in tropical biomes), plants and animals will lose very little water. In contrast, desert biomes have very little humidity. Plants and animals that live in these areas have special features to help them retain as much water as possible.
- amount of **light** energy available  
Light provides green plants with the energy they need to carry out photosynthesis. Light is readily available on land. In a water environment, however, most of the light is reflected at the surface. Only a small percentage (the green and blue colours of the spectrum) go through the water to any depth. This is called the **photic** zone. It is where green plants such as seaweeds and kelp will grow. Plants are not found on the deep, dark ocean floor.
- **acidity** of the soil and water  
Plants have a preferred soil acidity in which they like to live, as do organisms that live in water. We measure the acidity using the **pH** scale.



The pH scale: 7 is neutral, below 7 is acidic, above 7 is alkaline (basic).

**Fig 12.2.3**

## Activity 5

## The effect of an abiotic factor on plant growth

**Aim** To determine the effect of the amount of light on plant growth

**Equipment**

6 individually potted seedlings (these must be of the same species, at the same stage of development), 2 covers—one should be **translucent** (allowing a small percentage of light through), the other should be completely **opaque** (allowing no light through)

**Method**

- 1 Set aside two of the seedlings as control plants. Place these in a sunlit position.
- 2 Place two of the other seedlings under the translucent cover. Place the last two seedlings under the opaque cover.
- 3 Monitor the plants for at least one week. During this time, each seedling should be watered at the same time with a specific amount of water. (Be careful not to overwater the plants.)
- 4 Record your findings at the end of the specified time period.

**Questions**

- 1 **Justify** the use of more seedlings than required.
- 2 **Justify** why it is important that the seedlings should be of the same species and at the same stage of development.
- 3 **Explain** why the two seedlings that were set aside and given sunlight were needed.
- 4 Design an experiment to **investigate** other abiotic factors such as the soil type, humidity, water availability and temperature.

## Activity 6

## Testing for soil acidity around the schoolyard

**Aim** To test the acidity of the soil at various locations around the schoolyard

**Equipment**

3 or 4 test tubes, distilled water, 3 or 4 beakers, glass stirring rod, litmus paper, filter paper (e.g. coffee filter paper)

**Method**

- 1 Collect samples of soil (each enough to fill a large test tube) from three or four different areas around the schoolyard. Label your test tubes as sample 1, sample 2 and so on. You could collect your samples from:
  - a under a pine or eucalypt tree
  - b from the middle of the playing field
  - c near a rubbish bin
  - d by the bicycle racks.
- 2 Place each sample into a beaker (label your beakers sample 1, sample 2 and so on), and add approximately 100 mL of distilled water.
- 3 Stir the sample for some time, until everything is well mixed. Allow the sample to settle.
- 4 Separate the water from the soil using a filter paper.
- 5 Test the acidity of the water using both red and blue litmus paper.

Note: Red litmus paper turns blue in the presence of basic substances.

- 6 Record the results you obtained in a table. For example:

Sample number	pH value
Sample 1	6

**Questions**

- 1 **Identify** a suitable control for this experiment.
- 2 **Explain** why distilled water was used rather than tap water.
- 3 Use the scale in Figure 12.2.3 to **identify** the pH of each sample and **explain** whether it is acidic or basic.
- 4 **Account** for the results you obtained from your samples.



**Fig 12.2.4** The heron lives close to the sea. Birds that live in this type of environment have special salt glands on their heads. The glands are connected to the nostrils and remove any excess salt they consume.

- **salinity** of the water surrounding, or available to, the organism  
Salinity is a measure of the ‘saltiness’ of water. Freshwater and marine organisms experience very different salinity. They show marked differences in the way their bodies function.
- **mineral salts** and trace elements available  
A plant lives where plant nutrients are available in the soil.
- **wave and water currents**  
The intertidal area is that area that lies between high and low tides. At low tide, the intertidal area is exposed to the air. At high tide, the intertidal area is completely under water. Those organisms that live in this area must be able to live in both conditions. They may also need to be strong to stop being washed away. Organisms that live in fast-flowing streams require great strength to battle against the force of the water.
- **shelter**  
Shelter gives protection for organisms from predators and the weather. Some examples of shelters are: under rocks, bark or leaf litter; inside

hollow trees or hollow logs on the ground; and even underground. Different animals and plants require different types of shelter to survive.

- **wind and air currents**  
Areas that have strong winds can be inhabited only by plants that have strong root systems.



The effect of the wind on this pine tree can be clearly seen. **Fig 12.2.5**

## Effects of the living environment

The living or **biotic** factors that influence where an organism can live include all of the other plants and animals that it comes into contact with directly or indirectly. Sometimes the relationship is beneficial; at other times it isn't.

Biotic factors include:

- **competition**  
Animals living in the same area may have the same food or nesting needs. This means that the amount of available food or nesting materials are shared. Plants compete with each other for nutrients in the soil and for the light that is available.
- **dispersal**  
This refers to how organisms spread throughout an ecosystem. Animals can move freely by themselves. Plants rely on the wind, insects or animals to distribute them. Their seeds are shaped to help them in this process.



Fig 12.2.6

A bee collects pollen and transfers it from one plant to another. It assists the plant in its reproduction.

- **predation**

The term 'predation' refers to the act of one animal catching and eating another. Every organism in the ecosystem needs nutrients. Many will get them by feeding on other organisms living in the area. Of course they might be eaten too!



Fig 12.2.7

The common predatory saltwater crocodile can grow to lengths of up to six metres.

- **human intervention**

Human beings are the most powerful and influential biotic factors on the ecosystem. The effects of humans will be investigated in detail in Year 9.

## 12.2

UNIT

## [ Questions ]

**Checkpoint****Adaptations**

- 1 Use examples to **differentiate** a behavioural adaptation from a physical adaptation.
- 2 Use an example to **differentiate** an instinctive from a learnt adaptation.

**Effects of the non-living environment**

- 3 **Define** the term 'abiotic'.
- 4 **List** three abiotic features of the environment of a coconut tree.

**Effects of the living environment**

- 5 **Define** the term 'biotic'.
- 6 Copy each of the following statements and **change** any that are incorrect.
  - a The non-living factors that influence where an organism can live are called biotic factors.
  - b The more saturated with water the air is, the less humid it is.
  - c On land, the percentage of oxygen in the air increases with altitude.
  - d Water that flows quickly has less oxygen than water that is still.

**Think**

- 7 Animals tend to coil up their bodies when they are cold. They spread out their bodies when they are hot. **Justify** whether this is a behavioural or a physical adaptation.
- 8 Camels have nostrils that can be closed. This is an adaptation to the sandy, wind-blown areas that they live in. **Justify** whether this is a behavioural or a physical adaptation.
- 9 The little penguin (sometimes called the fairy penguin) is a fish-eating bird. Draw the type of beak you would expect it to have and **explain** whether this is a physical or a behavioural adaptation.
- 10 **Identify** whether the following statements are true or false.
  - a The colour of the background on which an organism lives (e.g. a rock face) is an example of an abiotic factor.
  - b The amount of nutrient in the soil is an abiotic factor.
  - c The parasitic nematode is responsible for a condition known as elephantiasis in humans. We can say that the human being is a part of the nematode's biotic environment.
  - d Honey bees and rhinoceros beetles living in the same coconut tree are competitors.

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- 11 Predict** some of the abiotic factors that would influence the following organisms:
  - a** a killer whale
  - b** a cockroach
  - c** a mushroom on a forest floor
  - d** your family pet.
- 12** Elephants are physically adapted to their environment by having very large, thin ears. **Propose** which abiotic factor caused this adaptation.
- 13** Mangroves grow in intertidal areas. **Predict** some abiotic factors that they might have to cope with during the day.
- 14** Marine mammals and marine fish have many similar characteristics. **Identify** some of the abiotic factors that affect both of them.
- 15 List** three abiotic factors that affect you.
- 16 List** three biotic factors that affect you.
- 17** Rivers drain into the sea. **Explain** why fish living in the sea cannot be found in the rivers.
- 18** Why do farmers grow legume crops, such as peas or clover, with other crops? **Justify** your answer.

## [ Extension ]

### Investigate

- 1 Research** the life cycle of a frog and **present** your information as a poster aimed at people visiting a National Park who want to learn more about the wildlife there. On your poster:
  - a describe** the biotic and abiotic factors that influence the water phase of the life cycle
  - b describe** how these factors change when the frog moves onto a land environment
  - c outline** the characteristics that adult frogs display that enable them to move from water to land
  - d explain** whether the adult frog is able to leave its watery environment completely.

### Action

- 2 a Record** ten habits of a family pet for one week.
  - b Explain** whether these habits are instinctive or learnt.
- 3** Bushwalkers think that keeping the environment free from human interference is essential. Land developers say that it is important to utilise the land we have to provide homes and recreational facilities for people to enjoy. Those in the mining and timber industries insist that the land should be used to provide the raw materials to meet the needs of technological progress. **Assess** the validity of each claim by conducting a class debate.

### Creative writing

#### National parks

Comment on the statement 'Solomon Islands should have more national parks'. State whether you agree with this statement, or whether you think we have enough national parks. Explain the role that parks play in the conservation of the ecosystems in Solomon Islands.

# UNIT 12.3

## Food chains and food webs

### introduction

Whatever we eat consists of animal or plant parts. The food we consume contains the energy and nutrients that we require for living. All living things require energy. This energy is used by the organism for growth, repair and reproduction. This allows the organism to do the things necessary for

survival. Considering all the living things on Earth, that is an enormous amount of energy. So where does all this energy come from, and where does it go?

### Energy for life

Some 150 000 000 kilometres from Earth is the Sun—the source of all energy on Earth. Plants, green algae and a number of microorganisms are able to use light from the Sun to provide the energy they need for life. They do this by converting carbon dioxide and water into food (a simple sugar called **glucose**) and oxygen. This process is called **photosynthesis**. It can be written as a simple chemical equation:

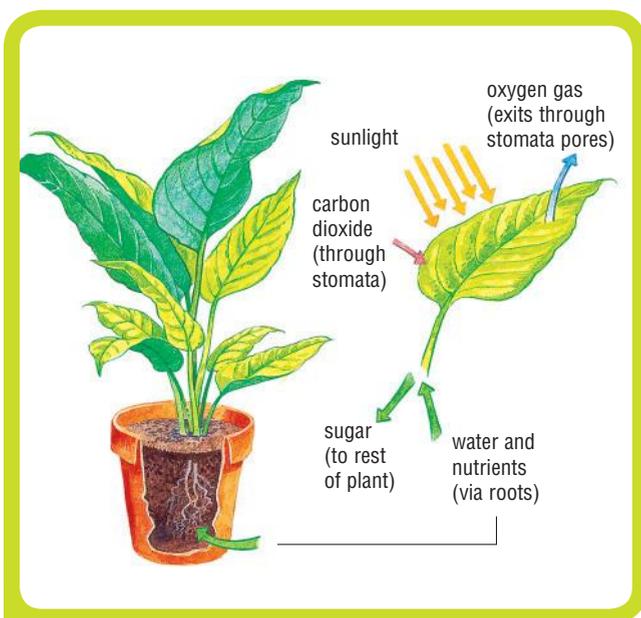
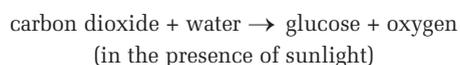


Fig 12.3.1 The process of photosynthesis

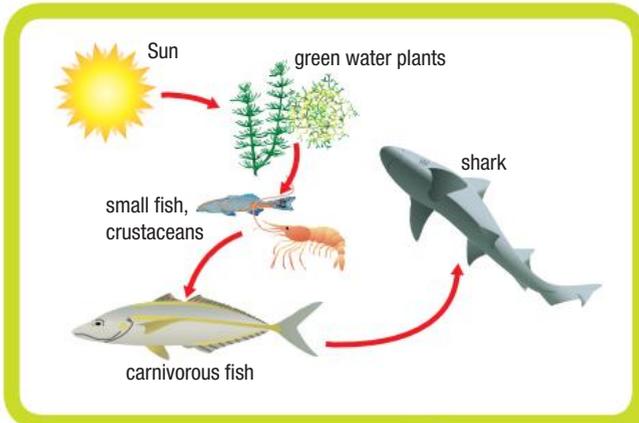
Those organisms that produce their own food are called **producers** or **autotrophs**. They are important because they provide oxygen and food for all the other organisms in the ecosystem.

### The flow of nutrients through an ecosystem

Not all organisms produce their own food. Those that do not are called **consumers** or **heterotrophs**. Animals that eat plants are referred to as **primary consumers** or **herbivores**. These animals provide food for other animals. The animals that eat the herbivores are called **secondary consumers** or **carnivores**. Those consumers that are able to eat both plants and animals are called **omnivores**.

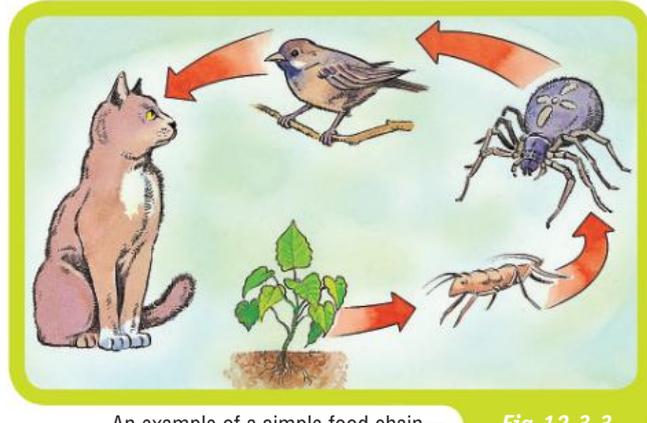
The interaction between producers, primary consumers and secondary consumers (and sometimes tertiary consumers) is illustrated in Figure 12.3.2.

This nutritional relationship is called a **food chain**. It is called a 'chain' because each living organism in the chain is like a 'link'. Each one depends on the organism that comes before it. In general, food chains rarely have more than six links (called **trophic levels**). In every ecological community, several food chains are interrelated because the organisms that make up those food chains have various food sources. This interaction of food chains is known as a **food web**.



The interaction between producers, primary consumers, secondary consumers and tertiary consumers

Fig 12.3.2



An example of a simple food chain—the arrow is drawn so that it points in the direction in which the food is going. The arrow really means 'is eaten by'.

Fig 12.3.3



Fig 12.3.4

An example of a food web. Animals are able to survive unfavourable conditions if they have more than one source of food.



**Fig 12.3.5** A primary consumer—an insect—is eaten by a secondary consumer—a spider.

**Biodiversity** refers to the number of different species present in a community. Communities with high biodiversity are those that have many different species of plants and animals. Plants and animals live together. They survive the changes in the environment. High biodiversity communities are better than low biodiversity communities where there are few plants and animals. There are many different sources of food in a community of high biodiversity: there are many food sources if one food source is destroyed. The community is more stable and is able to survive changes in the environment more easily.

If the herbivores in a community rely on one particular plant species for all of their food needs, then their survival depends on the survival of that plant. If the plant were to be wiped out by disease then the herbivores would be wiped out too. In turn, the carnivores that eat herbivores would be wiped out. However, if the herbivores have a variety of plants to choose from, they can still survive the loss of one particular plant species. Humans have reduced the biodiversity of many ecosystems. They have removed the natural vegetation and replaced it with one specific type of plant, for example oil palm and coconut. As a result, many species are now extinct.

## Biodiversity

### Activity 7

#### Richness of an ecosystem

**Aim** To determine whether an ecosystem is rich in organisms

#### Equipment

Trays, gloves, hand lenses, a metre ruler

#### Method

- 1 Divide the class into groups of four.
- 2 Assign each group one ecosystem close to your school and do the following:
  - a Mark out an area of 1 m x 1 m.
  - b Identify (but do not pick up) different species present in the marked area.
  - c Count the number of different species present.
  - d Present your results to the class.
  - e Compare your results to the other groups' results.
  - f Make a bar graph of your result.

#### Questions

- 1 Is the ecosystem you studied diverse or poor?
- 2 What species is most abundant?
- 3 Explain the difference between **abundance** and **diversity**.
- 4 What factors affect the diversity of any ecosystem?



**Fig 12.3.6** Fields of oil palm and coconut trees. The biodiversity of an ecosystem is reduced when many species of plants are replaced by a single species, causing the ecosystem to be less stable.

## The flow of energy through an ecosystem

Energy in an ecosystem moves in one direction only. During photosynthesis, glucose is produced inside the leaves of plants from carbon dioxide and water. The energy for this reaction is provided by the Sun's light. We can say that light energy from the Sun has been converted into chemical energy inside the plant. Plants use only a small amount of the Sun's energy available to them. At each level of the food chain only about 5–20 per cent of the energy available is transferred to the next level. For this reason, the number of plants in any ecosystem is greater than the number of herbivores and carnivores that eat them.

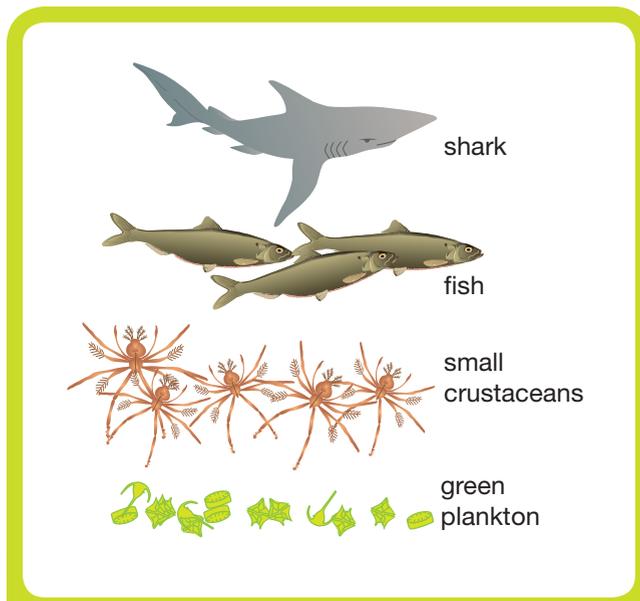


Fig 12.3.7

At each level of the food chain, energy is lost. The 'food pyramid' shows the decrease in numbers from the first level of producers (plankton) to the final level of consumers (sharks).

## Decomposers: the last link in the food chain

The term **organic matter** refers to all matter or everything that comes from living organisms. All of this matter contains the element carbon. Organic matter is recycled within the ecosystem due to the activity of **decomposers**. This group of organisms breaks down the organic matter in dead bodies of

plants and animals. Nutrients contained in the organic matter are released. Plants use these nutrients for their growth. Decomposers include bacteria and fungi. In effect, they are nature's recyclers.



Fig 12.3.8

A decomposing apple. Food turns mouldy when attacked by a fungus.



Fig 12.3.9

Dung beetles have recently been introduced into public parks by many urban councils in an effort to reduce the amount of dog faeces.

## Relationships between organisms

No plant or animal living in a community lives by itself. This interaction may be by direct contact, especially when predators eat other animals! It can also be indirect as in the case of competition for food.

The different types of interaction include:

- **mutualism** (symbiosis)  
Both organisms benefit by their relationship with each other. An example of mutualism is the relationship between the clown fish and the sea anemone. The sea anemone provides shelter for the clown fish. The slime of the clown fish's body prevents it being stung by the sea anemone. It lives

and feeds under the protection of its host (the sea anemone). In return, the sea anemone receives scraps of food from the fish. The fish also cleans the sea anemone of parasites.



**Fig 12.3.10** A mutual relationship—both organisms gain from the relationship.

- **commensalism**  
One species benefits from the interaction. The other species is unaffected. Tropical fish called remora attach themselves to faster fish such as sharks. They do this with a sucker-like pad on the top of their heads. The sharks don't benefit from the remora's presence, but they are not harmed.
- **amensalism**  
One species is harmed by the interaction while the other species is unaffected. Cows and sheep form trails or walkways as they walk to and from feeding areas. They are unaffected by the trail, but the plants they step on are destroyed.
- **competition**  
Different animals or plants may use the same food resource, water or nesting material. Competition happens when there is a shortage of these important resources.
- **exploitation**  
One species benefits from the interaction. The other is harmed. This type of interaction includes:
  - a **predation**  
One species kills the other for food, such as a cat hunting a lizard.
  - b **herbivory**  
Although herbivores eat plants they do not eat the whole plant. This usually does not kill the plant. The size of the plant suffers, of course. Cattle feeding on para-grass keep it short.
  - c **parasitism**  
A **parasite** is an organism that lives in or on another organism, called the **host**. In most cases, the parasitic organism does not kill its host. However, it can cause severe problems. Tapeworms are parasites that live in the digestive system of animals. If not treated, dogs and cats often have tapeworms. Humans can have parasites too. Head lice are parasites.

## 12.3 [ Questions ]

### Checkpoint

#### Energy for life

- 1 **Recall** the name of the process represented by the following equation:  
carbon dioxide + water → glucose + oxygen
- 2 Use an example to **outline** the role of producers in a food chain.

#### The flow of nutrients through an ecosystem

- 3 **State** whether the following statements are true or false.
  - a All organisms can produce their own food.
  - b Heterotrophs can produce their own food.
  - c Animals that eat plants are primary producers.
  - d Carnivores eat herbivores.
- 4 **Define** what is meant by a 'food web'.

#### Biodiversity

- 5 Use an example to **explain** how biodiversity can help a community to survive.

#### The flow of energy through an ecosystem

- 6 **State** the name of the simple sugar that acts as food and stores the energy from the Sun in plants.
- 7 **Account** for the fact that the number of plants in an ecosystem is greater than the number of herbivores and carnivores.

#### Decomposers: the last link in the food chain

- 8 **List** two features of organic matter.
- 9 **Explain** how organic matter is recycled by decomposers.

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## Relationships between organisms

- 10** Use an example to **explain** the meaning of the following terms:
- a mutualism
  - b commensalism
  - c amensalism
  - d competition
  - e exploitation.
- 11** **Compare** predation, herbivory and parasitism.

### Think

- 12** Do you think the Sun really is the source of all life on Earth? **Justify** your answer.
- 13** Copy the text below into your workbook and draw a line to **identify** the words in the first column that match the names of the organisms in the second column:

autotroph  
heterotroph  
omnivore

human being  
banana plant  
pig

- 14** Is the term 'producer' an accurate description of a green plant? **Justify** your answer.
- 15** **Identify** the correct term (parasitism, mutualism or commensalism) for the following relationships:
- a the tapeworm and its dog host
  - b the fungus that causes tinea (a fungus infection) on a human foot
  - c honey bees feed on the pollen of a number of hibiscus plants, dispersing the pollen as they move from tree to tree.
- 16** **Classify** the relationship between a dog and its fleas.
- 17** Cooperative hunting could benefit a carnivore species. **Justify** this statement.
- 18** **Propose** a reason for the fact that two organisms of the same species might require different quantities of food.

## Skills

- 19** **Construct** a simple food chain in your workbook, using the animals listed and including arrows to indicate which organism is eaten by the other: mouse, owl, snake, grass.
- 20** **Identify** the producer and the primary, secondary and tertiary consumers in the food chain in the previous question.
- 21** **Construct** a simple food chain for a set of organisms that you might find in your own backyard.
- 22** A scientist was determining the number of food chains present in several different areas. In area A, he found 10 different food chains. In area B, he found 50 different food chains. In which area would you expect to find the greatest biodiversity? **Explain** your reasoning.

## [ Extension ]

### Investigate

Many carnivorous animals use unique strategies to catch their prey. An angler fish uses a 'lure' to attract its prey to come closer, so it can kill it. Other organisms, such as the praying mantis, are the same green colour as the plants around them (they are camouflaged). Some, such as the killer whale, work in a cooperative group.

**Research** one particular organism that uses a unique strategy to catch prey.



Fig 12.3.11