



Solomon Islands Science

Year **8**

Learner's Book



Solomon Islands
Science
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Learner's Book

Solomon Islands Curriculum Development Division

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Contents

Introduction	iv		
1		Simple machine structure and stability	1
UNIT			
1.1	2	The ramp	
1.2	6	Levers	
1.3	13	Going for a spin: wheels, axles and gears	
1.4	19	Pulleys	
1.5	24	Structure and stability	
	26	Chapter review	
2	28	Body systems	
UNIT			
2.1	29	Food	
2.2	37	Digestion	
2.3	43	Blood and circulation	
2.4	50	Excretion: getting rid of waste	
2.5	53	Respiratory systems	
	57	Chapter review	
3	61	Chemical reactions and everyday uses	
UNIT			
3.1	62	What are chemical reactions?	
3.2	67	Reaction types	
3.3	72	The rate of chemical reactions and their importance in our daily lives	
	76	Chapter review	
4	77	Atmosphere, climate and weather	
UNIT			
4.1	78	The atmosphere	
4.2	81	Weather	
	86	Chapter review	
5	87	Plant processes and marine systems	
UNIT			
5.1	88	Plant transport systems	
5.2	92	Photosynthesis and respiration	
5.3	100	Marine systems	
	109	Chapter review	
6	111	Heat and sound	
UNIT			
6.1	112	Heat	
6.2	121	Expansion of solids, liquids and gases	
6.3	128	Sound	
6.4	135	Hearing	
	138	Chapter review	
7	140	The fragile crust	
UNIT			
7.1	141	Plate tectonics	
7.2	147	At the edges	
7.3	153	Earthquakes	
7.4	159	Volcanoes	
7.5	163	Faults and folds	
7.6	167	Geological time	
	172	Chapter review	
8	174	Small particles of matter	
UNIT			
8.1	175	Elements	
8.2	177	Inside atoms	
	180	Chapter review	
9	181	Microbes	
UNIT			
9.1	182	What is a microbe?	
9.2	189	Reproduction in microbes	
9.3	195	Friend or foe?	
	200	Chapter review	
10	201	The periodic table	
UNIT			
10.1	202	Atoms and the elements	
10.2	207	Arranging the elements	
10.3	211	Discovery of the elements	
10.4	214	The role of electrons	
	218	Chapter review	
11	220	Electricity	
UNIT			
11.1	221	Static electricity	
11.2	228	Moving electricity	
11.3	236	Using electricity	
11.4	242	Electrical energy calculations	
	244	Chapter review	

Introduction

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

- is relevant to 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 8 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

Simple machine structure and stability

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

- identify examples of simple machines in your community: levers, pulleys, wheels and axles, inclined planes, gears
- explain that the transfer of energy does the work in simple machines
- list three classes of lever systems and identify the effort, load and pivot positions in each system
- demonstrate that the turning forces in a lever are the forces applied times the distance from the pivot
- use a seesaw arrangement to demonstrate the turning force effects in levers
- calculate mechanical advantage
- calculate the velocity of a pulley system
- perform tasks to demonstrate the use of a simple machine
- identify simple machines that:
 - i multiply (increase) force (eg tap knob, door knob)
 - ii multiply (increase) speed (eg bicycle gears, fan belt in vehicle)
- locate the centre of gravity of a hanging object
- demonstrate that changing the centre of gravity of an object affects its stability
- identify examples of building structures or large objects that are stable or unstable in the local community or school.

- 1 Make a list of machines around your house that make jobs easier for you.
- 2 What can humans physically do now that could not be done 100 years ago?
- 3 What do you think is the most important invention in human history? Give reasons for your choice.
- 4 Name an indigenous machine and describe what it is used for.

8.1.1.1, 8.1.2.1, 8.1.2.2, 8.1.3.1, 8.1.3.2, 8.1.4.1, 8.1.4.2,
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Specific learning outcomes

Challenges



UNIT 1.1

The ramp

Introduction

Even before written records began, humans were using simple machines to help them hunt for food, build shelters and make life easier. Simple machines such as the ramp, wedge, screw, lever, wheel and pulley were some of the first and most useful devices ever invented. These simple machines are useful enough to be used on their own. Complex machines are formed when simple machines are combined.

Activity 1

Ramps for disabled people

Ramps for disabled people must be constructed with a slope of no more than 1:14 for ramps more than 1250 mm long and 1:8 for ramps less than 1250 mm long.

Aim

To test commonly used ramps to determine whether they comply with the requirements of the disabled

Method

- 1 Find ramps around the school, at the shops or at home and take appropriate measurements to find their slope.
- 2 Carry out appropriate calculations and compare their slopes with those listed above.

Questions

- 1 Suggest why shorter ramps are allowed to be steeper than longer ramps for the disabled.
- 2 Did the ramps you checked comply with the regulations?

Work in science

Simple machines are all about force. They generally reduce the amount of effort required, making a job much easier. Sometimes they allow us to move bigger objects that we would not normally be able to move. Effort is the force we need to apply to move an object. The object and its weight are called the load.

The word 'work' is used in many ways. 'Hard work', 'a lot of work' and 'homework' are expressions we hear every day. Scientists mean something very different by the word 'work', however. To understand how simple machines make a job easier we need to understand the scientific meaning of work.

Scientifically, work is the energy needed to move something over a certain distance. Like all energy, work is measured in joules (J).

$$\text{work} = \text{effort force} \times \text{distance}$$

↑
moved in doing the job

↓
needed to get the job done

Some simple mathematics will help us to understand what is happening here.

Let us say that a certain job takes 12 joules to do. We could do the job in a number of ways:

Energy needed to do the job (joules)	Effort force needed to do the job (newton)	Distance we need to move to do the job (metres)	Proof that this will do the job
12	12	1	$12 \times 1 = 12$
12	6	2	$6 \times 2 = 12$
12	4	3	$4 \times 3 = 12$
12	3	4	$3 \times 4 = 12$
12	2	6	$2 \times 6 = 12$
12	1	12	$1 \times 12 = 12$

What this means is that if the distance we move is greater, the effort we need to put in is less. All simple machines use this principle.

The inclined plane

A ramp (sometimes called an inclined plane) is one of the oldest and simplest machines. It is used when we need to get a heavy object up to a higher level.

If you want to lift a load, you need to do a certain amount of work regardless of how you go about it. The work will depend on the weight of the object and the height you lift it, not on how you do it.

Imagine you are helping your family to move house and need to load the refrigerator onto a truck.

The shortest path onto the truck is straight up, vertically. This is going to be very difficult (perhaps impossible), since it requires you to put in an effort force at least equal to the weight of the fridge.

Yet if you pull or push the refrigerator up a ramp, you will find the job easier. Although the work is the same, less effort is required because you are moving the fridge a greater distance.

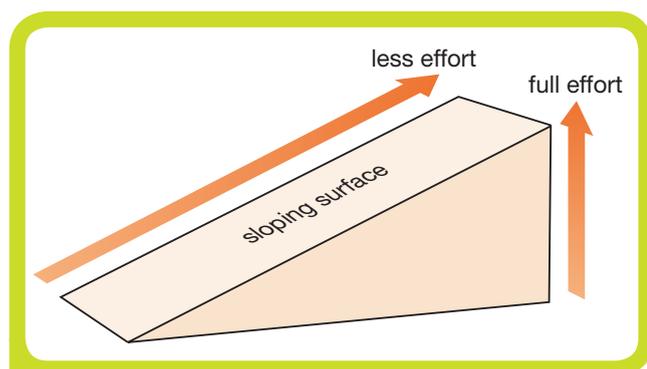


Fig 1.1.1 Effort is less when distance is greater.

Mechanical advantage

Mechanical advantage is a measure of how effective the machine is. This can be calculated by dividing the load you want to move by the effort you need to put in.

$$\text{mechanical advantage} = \frac{\text{load}}{\text{effort}}$$

For example, if a simple machine lifted a 60 newton (N) weight (this is about 6 kg) but an effort of only 20 N was required, the mechanical advantage would be:

$$\text{mechanical advantage} = \frac{\text{load}}{\text{effort}} = \frac{60}{20} = 3$$

Better machines have larger mechanical advantages, so better machines than this one would be able to *either*:

- lift a bigger load (say, 600 N) with the same effort (20 N). This would give a larger mechanical advantage:

$$\text{load/effort} = \frac{600}{20} = 30$$

or

- lift the same load as before (60 N) but with a lot less effort than before (say, 2 N):

$$\text{mechanical advantage} = \frac{60}{2} = 30$$

The better the machine, the larger the mechanical advantage.

Wedges

A wedge is simply an inclined plane that moves through another object, forcing apart or splitting the object as it does so.

An axe or wood splitter is an obvious wedge. It reduces the effort needed to split a log by forcing the wood to travel up the long edge of the blade. The sharper the blade, the longer the edge and the less effort required to split the timber.

Knives and our front teeth (the incisors) also act in this way, making it easier to cut and slice through food.

The zip fastener is an example of a twentieth-century technology that uses three wedges. The slide of the zipper contains wedges that turn a little effort into a strong force that opens and closes the fastener. Without this assistance, the teeth of the zip are nearly impossible to join or part.

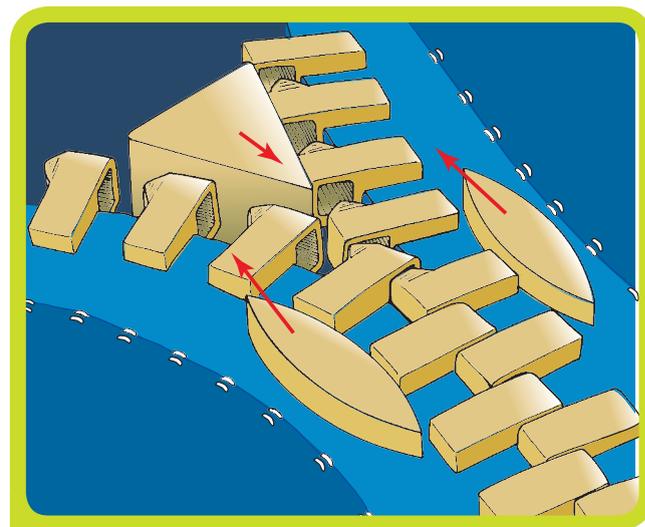


Fig 1.1.2 A zipper uses three wedges.

Screws, nuts and bolts

A screw is like a wedge in that it is also a ramp, spiralling around a metal cylinder. Screws also penetrate materials such as:

- solids—woodscrews are screwed into timber
- liquids such as water—a propeller on a boat is a screw
- gases such as air—propellers on an aircraft, or an electric fan.

If you try to hammer a woodscrew into a piece of timber you will not get very far. It would need an extremely large force to do so. Yet if the screw is turned, the timber is moved along the spiral ramp.



Because of the greater distance covered, a much smaller force is required, although a lot of turning has to be done. Once again, distance is increased, so the effort is less. A bolt and its nut work the same way, although in this case the nut is wound down the screw of the bolt.

1.1 [Questions]

UNIT

Checkpoint

Work in science

- 1 Define the term 'work' when used in the scientific sense.
- 2 Clarify whether work is energy or a force.
- 3 Identify the unit normally used for work.

The inclined plane

- 4 Copy and complete the following sentence: A ramp reduces effort by increasing _____.
- 5 List five examples of ramps being used to make a job easier.
- 6 Construct a rule about how ramps make the job of lifting a load easier.

Mechanical advantage

- 7 Define 'mechanical advantage'.
- 8 Assess whether a machine with a high or low mechanical advantage is better.

Wedges

- 9 List five examples of where wedges are used to more easily separate or split objects.

Screws, nuts and bolts

- 10 Describe how a screw is really just a ramp.
- 11 Outline three uses of screws.

Think

- 12 Explain why a path zigzagging up a mountain is easier to walk than a track straight up to the top.
- 13 Calculate the mechanical advantage.
 - a load = 12 N, effort = 6 N
 - b load = 18 N, effort = 6 N
 - c effort = 3 N, load = 18 N
 - d load = 5 kg (about 50 N weight force), effort = 10 N
- 14 Determine which of a, b, c or d in Question 13 is the best machine.

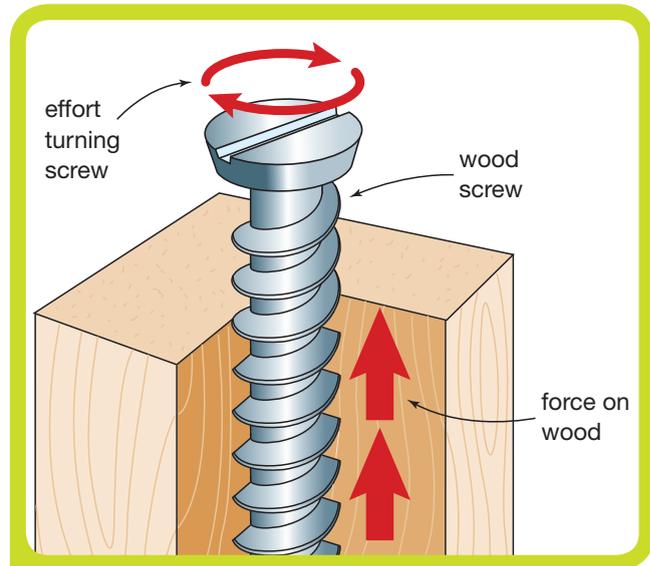


Fig 1.1.3 A screw is just a curved ramp.

- 15 Construct a table to summarise simple machines that use ramps, such as the screw or wedge. For each machine outline briefly how it makes doing a job easier.

Analyse

- 16 Twenty-four joules of work was needed to lift an object up to a certain height. Sarah measured the object's weight with a spring balance and found it to be 24 N. Calculate the load force that Sarah was trying to lift.
- 17 Sarah then thought about the ramp that would do the job most easily and constructed the following table to help her. Copy and complete her table.

Work (J)	Ramp length (m)	Effort needed (N)	Proof that this will do the job	Mechanical advantage
24	1	24	$1 \times 24 = 24$	$24/24 = 1$
24	2		$2 \times 12 = 24$	
24		8		$24/8 = 3$
24	4			
24			$6 \times 4 = 24$	$24/4 = 6$
24	8			
24				
24				

- 18 Which of the ramps listed in the table above would make the job easiest for Sarah? Explain.

[Extension]

Investigate

- 1 Design a ramp that would have made something you did during the day easier. Try to design something unusual, not just replacing stairs with a ramp, for example.
- 2 Investigate the design of the Archimedes water screw and draw a diagram to show how it works.

Activity 2

Ramps

Aim

To investigate the relationship between the slope of a ramp and effort

Equipment

Spring balance, ramp, dynamics cart and wooden block, small masses, sticky tape, books, protractor

Method

- 1 Make a pile of textbooks on your desk about 10 cm high.
- 2 Construct a table or spreadsheet as shown below.
- 3 Weigh the dynamics cart and the block of wood with a spring balance. Tape masses on them until both are about the same weight. Record their new weights.
- 4 Slowly lift the cart vertically up until it reaches the top of the stack. Record the effort required from the spring balance.
- 5 Repeat with the block.
- 6 Now place the ramp on the books so that its angle with the desk is very small.

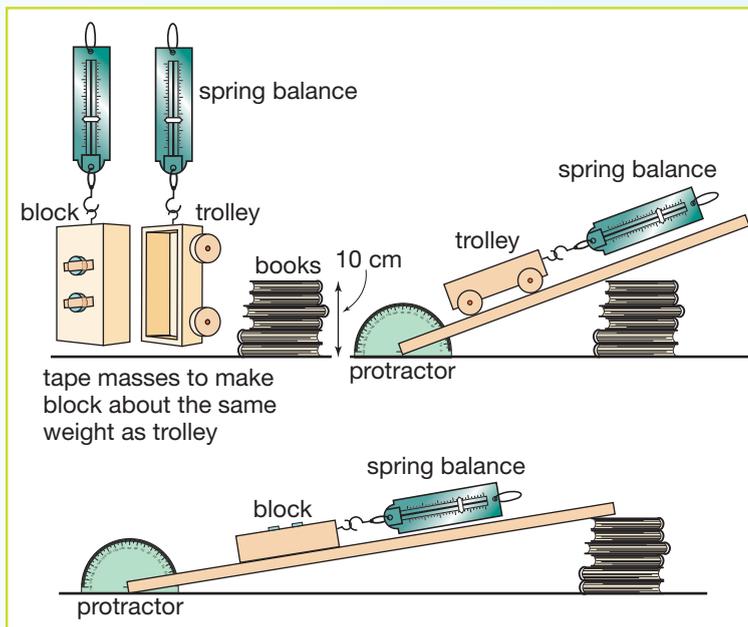


Fig 1.1.4 Testing a ramp

- 7 Measure the angle with a protractor and measure the distance along the ramp from the bottom to the top of the books. Record it.
- 8 Drag the cart up the slope with the spring balance until it reaches the top of the books once more. Record the effort needed, then repeat with the block.
- 9 Try three different angles. You might need to overhang the books to do so. Take angle and effort measurements each time for both the cart and the block.

Questions

- 1 The work required to drag the cart and block up was the same in each case. Explain why.
- 2 Describe what happened to the effort force needed as the ramp got longer.
- 3 Which was the better ramp? Explain.
- 4 Which was easier to get up the slope—the block or the cart? Propose reasons for your answer.

Angle (°)	Distance along ramp (cm)	Effort to move cart (N)	Mechanical advantage	Effort to move block (N)	Mechanical advantage

UNIT 1.2

Levers

Introduction

The lever is a simple machine that dates back about 5000 years. You use many different forms of levers every day, such as a shovel, a spoon or a fishing rod. A lever can be any solid object that is made to turn round a pivot or fulcrum. A load is placed somewhere along the lever and an effort force causes the turning.

Generally, levers are force multipliers: we put in a small effort and the lever system multiplies our effort so that we can lift much heavier loads. Levers reduce the effort needed to lift a load, just like ramps. Once again the disadvantage is distance: the more we wish to reduce effort, the further we need to move the lever.

Activity 3

The seesaw

Aim

To investigate the seesaw as a lever

Equipment

7 small masses (such as 5-cent coins), ruler, a fulcrum or pivot (a pencil is ideal), an elastic band

Method

- 1 Set up a seesaw as shown in Figure 1.2.1.

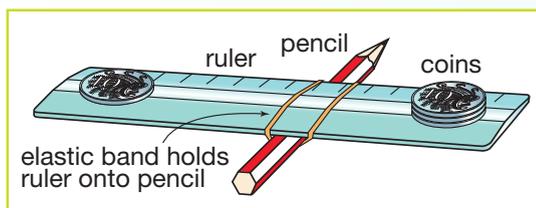


Fig 1.2.1 A seesaw is a class 1 lever.

- 2 Use the elastic band to hold the ruler in place on the pencil.
- 3 Copy the results table below into your workbook.

- 4 Place four of the small masses on the left side of the ruler and another four on the right and arrange them until the seesaw is balanced.
- 5 In the table, record the distance of each pile of masses from the pencil fulcrum. Repeat with two masses on the left and three on the right.
- 6 Repeat for all the other masses shown.

Questions

- 1 What do you notice about your answers in columns 3 and 6? Interpret what you notice.
- 2 You have just discovered the principle of levers. Use it to predict where you would place a 2 g mass to balance:
 - a another 2 g mass placed 4 cm from the pivot
 - b a 10 g mass, 2 cm from the pivot
 - c a 6 g mass, 6 cm from the pivot
 - d a 1 g mass, 2 cm from the pivot

Left-hand side			Right-hand side		
Number of masses	Distance from pivot	Number of masses × distance from pivot	Number of masses	Distance from pivot	Number of masses × distance from pivot
4			4		
3			2		
4			3		
5			2		
6			1		

Force multipliers: class 1 and class 2 levers

Class 1 levers (or first order levers) have the load at one end, the effort force at the other and the fulcrum somewhere in between (Figures 1.2.2 and 1.2.3).

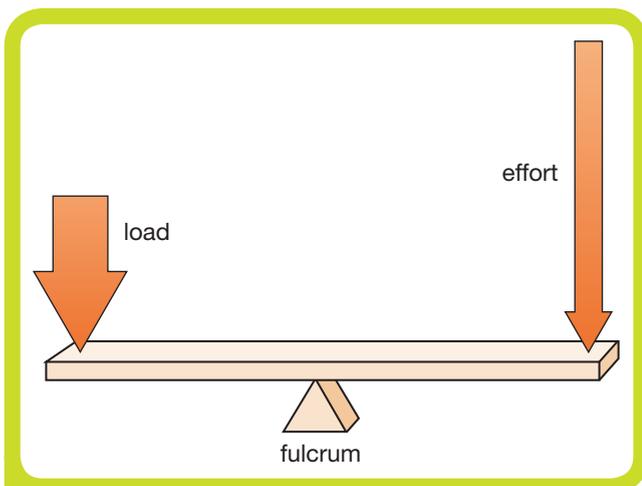


Fig 1.2.2 A class 1 lever

Class 2 levers (or second order levers) are also force multipliers and have the fulcrum at one end, the effort at the other and the load somewhere in between. They can move heavy loads by putting in a little effort a long way from the pivot (Figures 1.2.4 and 1.2.5).

Where you apply the effort in these levers is just as important as the effort itself. The effort required depends on the distance of the load from the fulcrum and where on the lever we put our effort.

As with the ramp, these levers reduce the effort by increasing the distance the load must be moved.

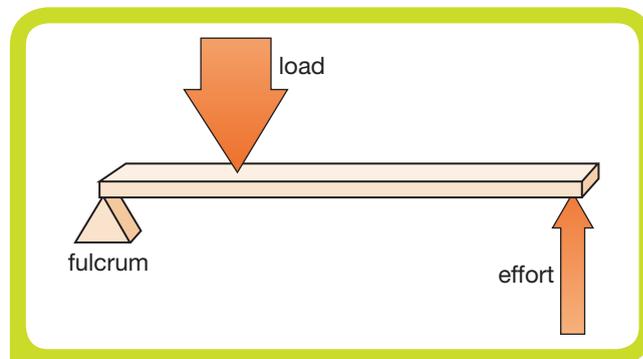


Fig 1.2.4 A class 2 lever

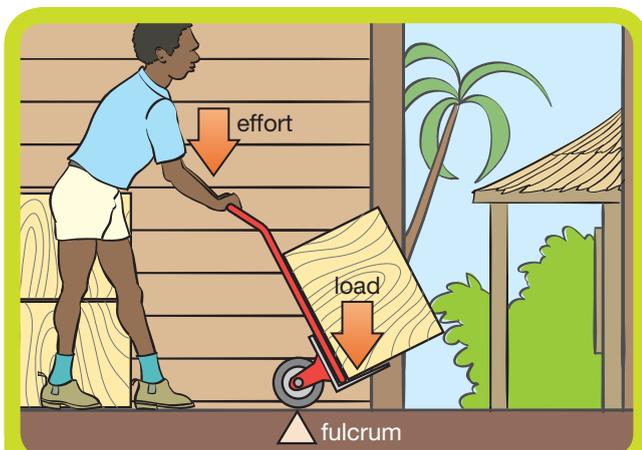


Fig 1.2.3 Some class 1 levers

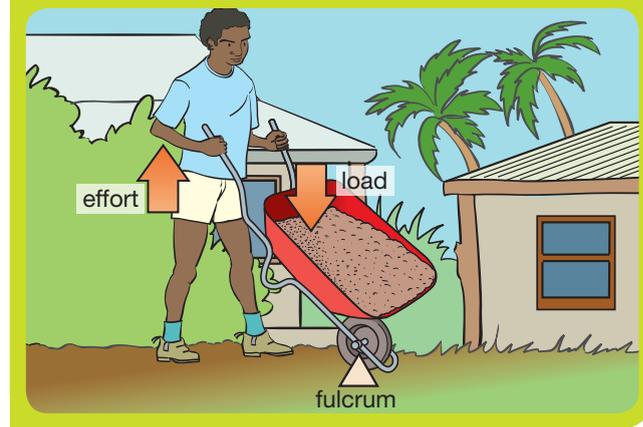
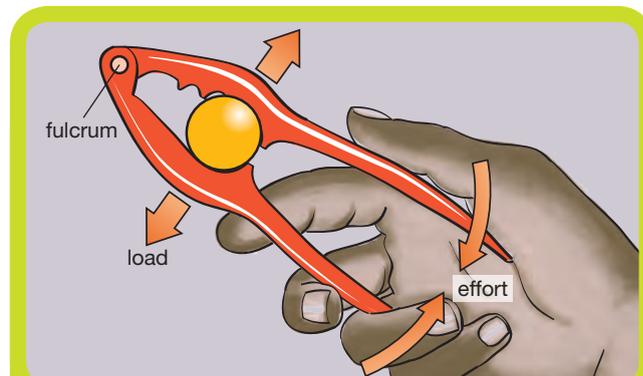


Fig 1.2.5 Some class 2 levers

Class 1 and 2 levers obey a rule called the principle of levers:

$$\text{effort} \times \text{distance} = \text{load} \times \text{distance}$$

↓
↑

of effort from fulcrum
of load from fulcrum

This means that a 60 kg student would need to sit 2 m from the pivot of a seesaw to balance their 40 kg younger sister who is sitting at the very end, 3 m from the pivot. Proof: $60 \times 2 = 40 \times 3$.

Activity 4

Lifting books

Aim

To investigate the relationship between fulcrum position and effort on a class 1 lever

Equipment

Metre ruler, rubber stopper, textbook

Method

- 1 Set up the lever shown in Figure 1.2.6.

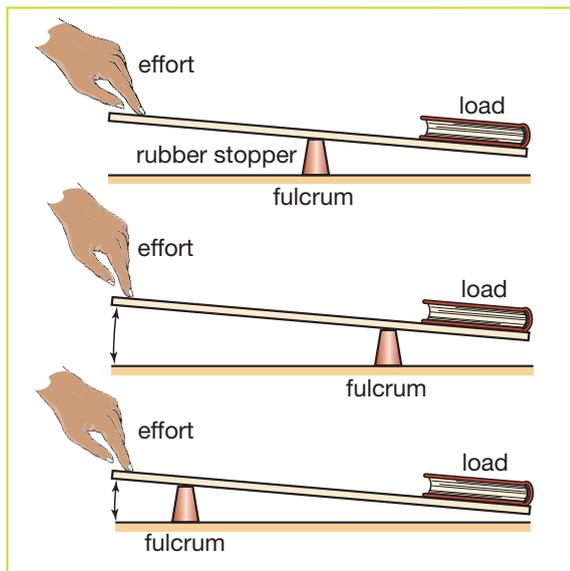


Fig 1.2.6 Lifting a book using a class 1 lever

- 2 Lift the book by pushing down on the ruler with your finger.
- 3 Place the stopper close to the book and repeat the experiment.

- 4 Repeat once more but with the stopper placed at the far end away from the book.
- 5 Copy the table below. Complete it using the words 'high', 'medium' or 'low'.

Position of stopper	Effort required to lift the book
Far away from book	
Midway	
Close to book	

- 6 Now try lifting the book using the class 2 and class 3 levers shown in Figure 1.2.7. (Class 3 levers are explained on page 9.)

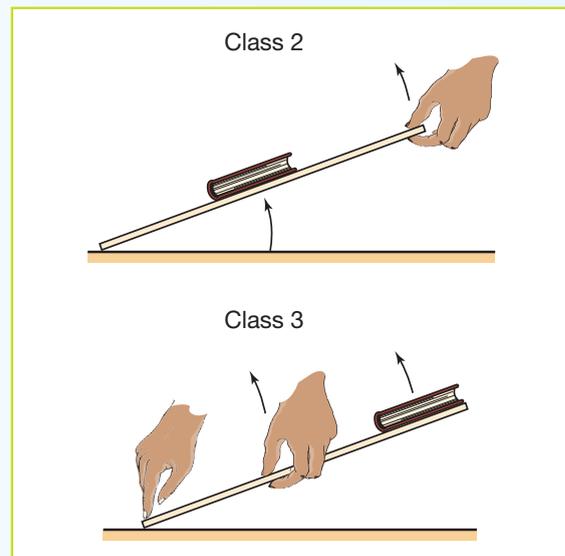


Fig 1.2.7 Lifting using class 2 and class 3 levers

Questions

You might need to read ahead to find the information to answer some of these questions.

- 1 Copy the three diagrams (class 1, 2 and 3) into your workbook. Add arrows to show the effort and load forces. Label the fulcrum.
- 2 The force needed to lift the book using the class 1 lever changed as the stopper moved away from the book and towards your finger. Analyse what happened.
- 3 Use the principle of levers to explain why, with a class 1 lever, it is easier to lift the book if the fulcrum is close to it and far away from your finger.
- 4 Assess which class of lever made it most difficult to lift the book.

Mechanical advantage in levers

You will remember that mechanical advantage gives us an idea about how effective a simple machine is. For levers, mechanical advantage can be calculated in two ways:

$$\begin{aligned} \text{mechanical advantage} &= \frac{\text{load}}{\text{effort}} \\ &= \frac{\text{distance of effort from fulcrum}}{\text{distance of load from fulcrum}} \end{aligned}$$

For levers, the best mechanical advantage is achieved when the effort is far from the fulcrum and the load is close to it (Figures 1.2.8 and 1.2.9).

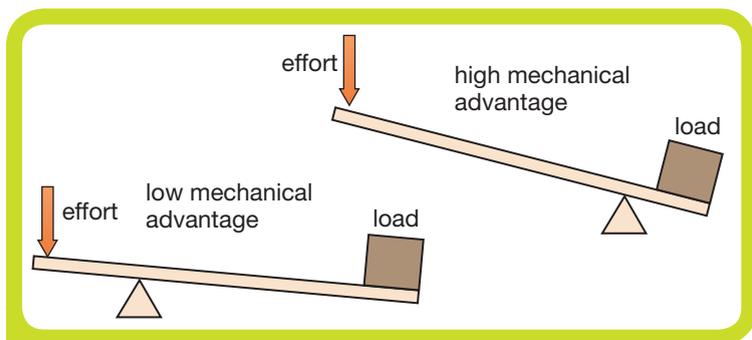


Fig 1.2.8 The higher the mechanical advantage, the better the machine.

Speed multipliers: class 3 levers

Class 3 levers (or third order levers) are not used to decrease the required effort. Instead they get the load (often a small one) moving at a greater speed. These levers have the fulcrum at one end, the load at the other end and the effort (usually from our hands) somewhere in between.

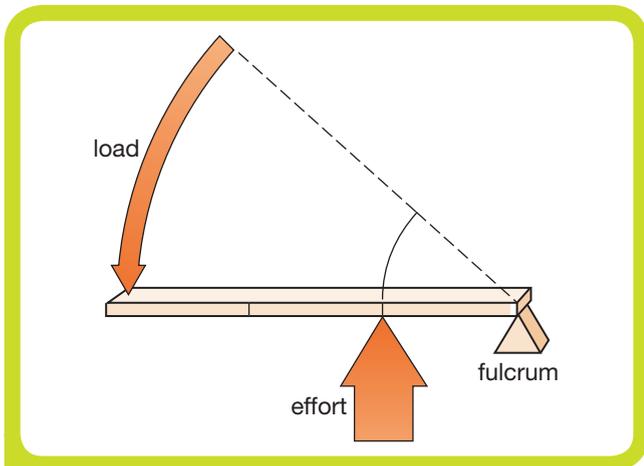


Fig 1.2.9 A class 3 lever

A bat is a class 3 lever. We move our hands a short distance at high speed so the ball travels from the bat at an even higher speed: class 3 levers are speed multipliers. Because the distance the ball moves is large, the force on it is small. This requires your hand to move a small distance but with a large effort. A fishing rod is another example of a class 3 lever.

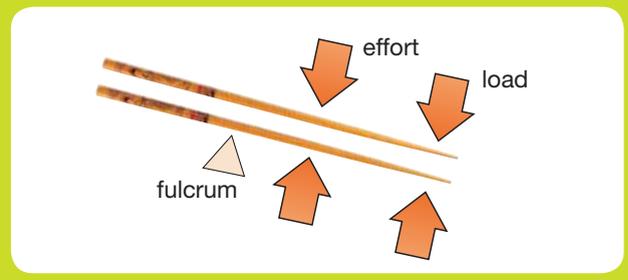
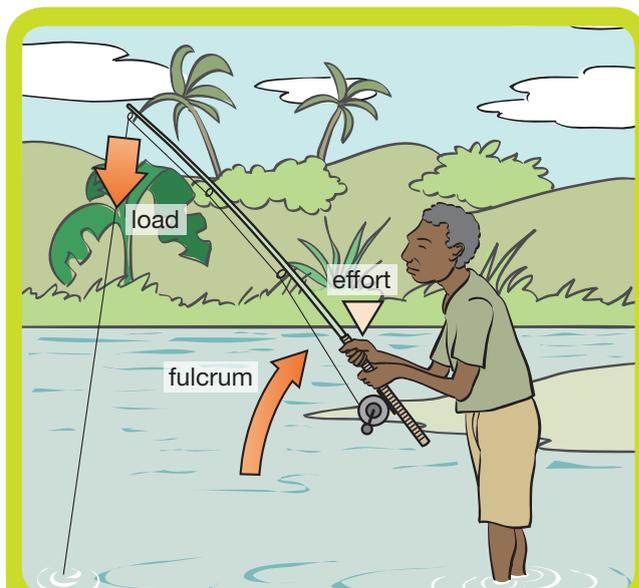


Fig 1.2.10 Some class 3 levers—a fishing rod and a pair of chopsticks

Activity 5

Class 3 levers

Aim

To investigate a class 3 lever

Equipment

Metre ruler, 1 kg mass, spring balance, brick or block to act as the fulcrum





Method

- 1 Copy the following table into your workbook and then set up a class 3 lever as shown in Figure 1.2.11.

Load (kg)	Distance of load from fulcrum (cm)	Spring balance reading (N)	Spring balance reading (kg)	Distance of spring balance from fulcrum (cm)	Mechanical advantage
1	100			30	
1	100			40	
1	100			50	
1	100			60	
1	100			70	

- 2 Use the spring balance to measure the effort force needed to raise the load slowly.
- 3 Record your measurements in the table. You might need to convert the newton readings of your spring balance into kilograms by dividing your measurements by 10.
- 4 Calculate the mechanical advantage for each measurement.

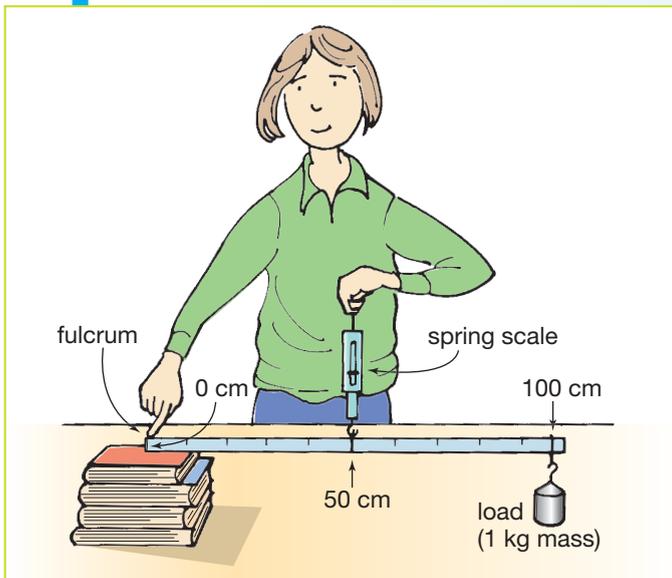


Fig 1.2.11 A class 3 lever at work

Questions

- 1 Identify which was bigger—the load or the effort required to lift it.
- 2 Identify which was the most effective lever. Justify your answer.

Activity 6

Class 3 levers at work

Aim

To examine various common implements to determine which class of lever is being used

Equipment

Stapler, nail clippers, scissors, pruning shears, nutcracker or bulldog clip

Method

- 1 Accurately draw each machine.
- 2 Label the fulcrum, load and where the effort needs to be applied.
- 3 Identify the purpose of other parts of each machine.

Questions

- 1 Classify each lever as class 1, 2 or 3.
- 2 State whether each lever is a force or speed multiplier.

Activity 7

Making body parts

- 1 Make a larger version of the 'skull' shown in Figure 1.2.12 out of cardboard. Use a paperclip to hinge the jaw to the skull and a deflated balloon for the muscle that controls it. Explain what happens to the 'muscle' as the jaw opens and closes.

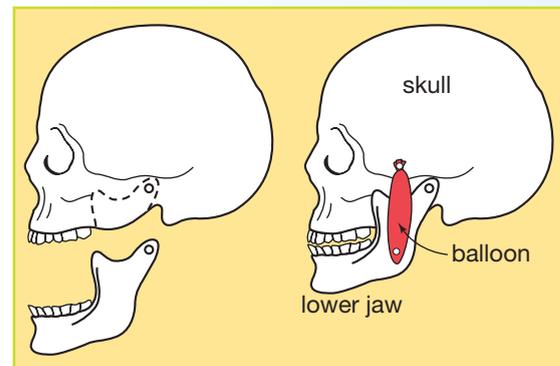


Fig 1.2.12 Constructing a jaw lever

- 2 Use the diagram in Figure 1.2.13 to construct a model of the human arm, its bones and muscles. Describe what happens to your 'balloon muscles' as you straighten and flex your model arm. How does this compare with your real arm muscles?



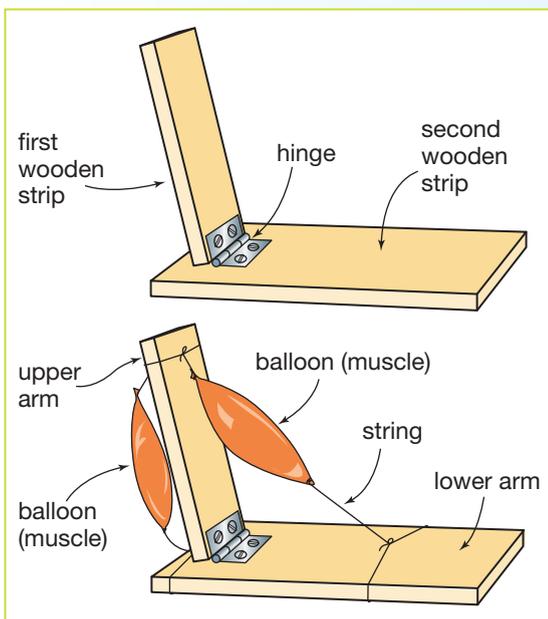


Fig 1.2.13 An arm lever

Think

- 9 Describe three examples of a lever in action.
- 10 Copy the following into your workbook, changing any incorrect statements so they are true.
 - a All levers are force multipliers.
 - b The fulcrum of a lever is always somewhere in the middle.
 - c A bat is an example of a force multiplier.
 - d A pivot is the same as a fulcrum.
 - e A speed multiplier is needed in most ball sports.
- 11 Define the principle of levers.
- 12 A heavy rock is to be shifted, and all you have is a long metal bar and another smaller rock. Illustrate how you would shift the rock. Label the load, fulcrum and effort.
- 13 Which class of lever is the most effective in lifting a load? Justify your answer.

Analyse

- 14 Classify the objects in Figure 1.2.14 as class 1, 2 or 3 levers.

Questions

Checkpoint

Force multipliers: class 1 and class 2 levers

- 1 What is a force multiplier? Explain using an example.
- 2 Define the term 'fulcrum'.
- 3 Construct a sketch of a playground seesaw. Draw where you would place a heavy person to balance a light person sitting on the very end of one side. On your diagram, mark the fulcrum, effort and load.

Mechanical advantage in levers

- 4 Explain how mechanical advantage is calculated for levers.
- 5 Describe how a greater mechanical advantage may be obtained when using a lever.

Speed multipliers: class 3 levers

- 6 Explain how a class 3 lever acts as a 'speed multiplier'.
- 7 State the advantage of using a class 3 lever in most ball sports.
- 8 A brush knife is an example of a class 3 lever. Explain why.

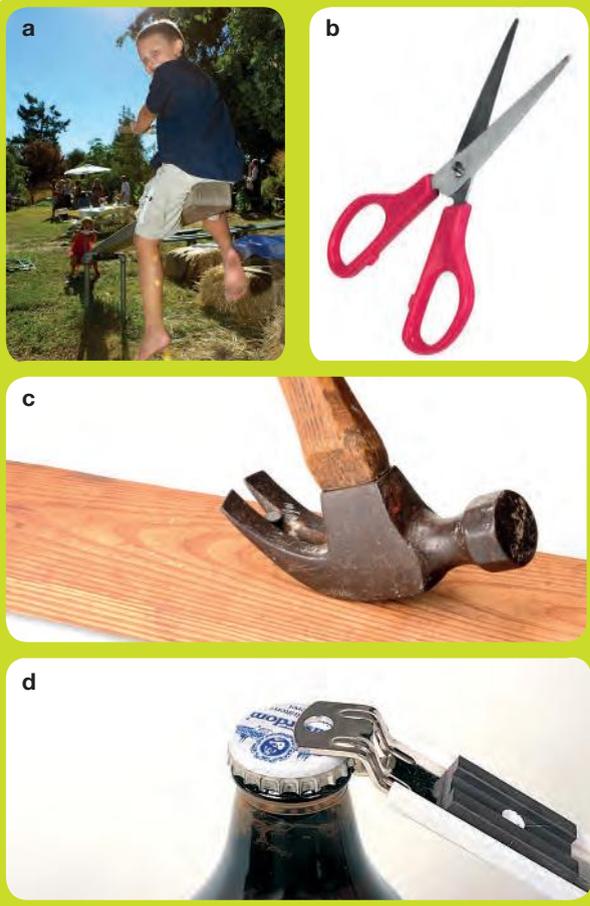


Fig 1.2.14





15 Calculate the mechanical advantage of the levers shown in Figure 1.2.15.

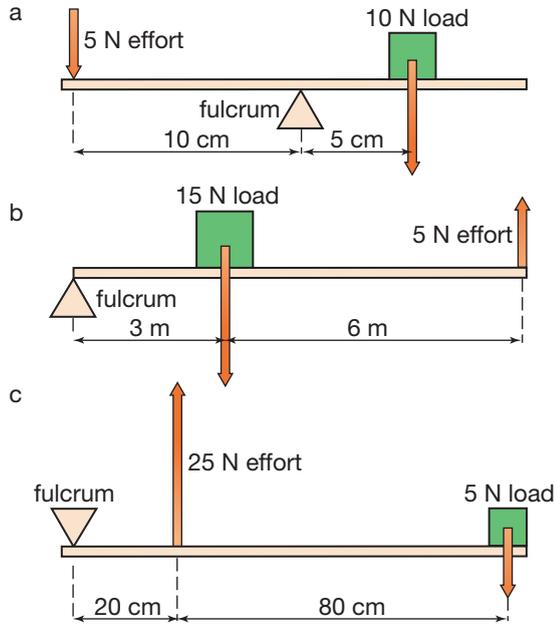


Fig 1.2.15

16 A seesaw ruler was set up as shown in Figure 1.2.16. Different masses were added to each side so that the seesaw was just balanced. Copy and complete the results table.

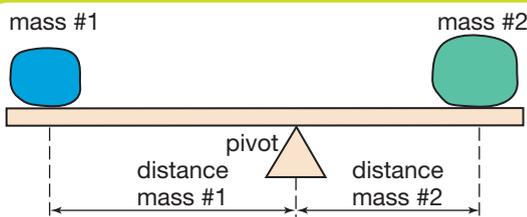


Fig 1.2.16

Mass #1 (g)	Distance of mass #1 from pivot (cm)	Mass #2 (g)	Distance of mass #2 from pivot (cm)
6	4	8	
6	4		12
1		12	2
10	1	5	
3	6		9
8			16

[Extension]

Investigate

- 1 Collect photos or pictures of levers from magazines, advertising brochures and newspapers.
 - a Classify each lever as class 1, 2 or 3.
 - b Identify and label the effort, fulcrum and load on each lever.
- 2 Construct a poster to demonstrate how different levers are used in sport.
- 3 Muscles can only contract (get shorter and thicker) or relax (get longer and thinner), pulling the bone up or letting it down. Muscles provide the effort force that controls bone levers. Use a diagram of the muscles of the body to identify the names of the muscles used to flex your arm and to straighten it.

UNIT 1.3

Going for a spin: wheels, axles and gears

Introduction

Most machines do not use the simple up-and-down movement that ramps and levers produce. They use a spinning or rotary motion instead. Wheels, axles and gears apply the principle of levers to our everyday lives. Although they might

not look like it, a tap and a doorknob are really wheels. Gears are used in many applications from bicycles to corkscrews. Can you imagine life without the wheel?

Activity 8

A simple wheel and axle

Aim

To construct a simple wheel and axle

Equipment

250 mL beaker or can, 100 g mass, 2 paperclips, flexible drinking straw or satay stick, cotton thread, sticky tape

Method

- 1 Set up the apparatus as shown in Figure 1.3.1.
- 2 Try to lift the 100 g mass by turning the straw or satay stick.
- 3 Bend the straw or satay stick without breaking it, and try again.

Questions

- 1 State whether you were able to lift the 100 g mass without bending the straw or stick.
- 2 Propose a way of making the job even easier.

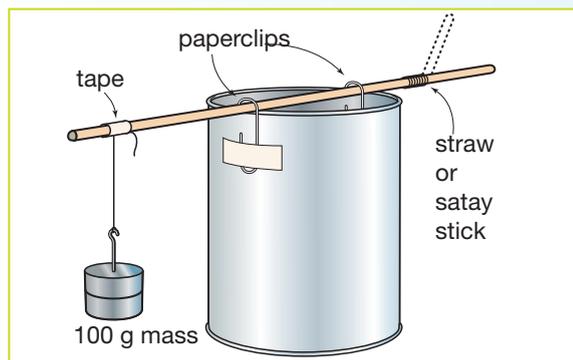


Fig 1.3.1 A simple wheel

The wheel

A wheel has a fulcrum at the centre, called the axle. The rim, the outside of the wheel, is the other end of the lever.

The rim of a rotating wheel moves a larger distance and at a higher speed than the axle, which simply turns on the spot.

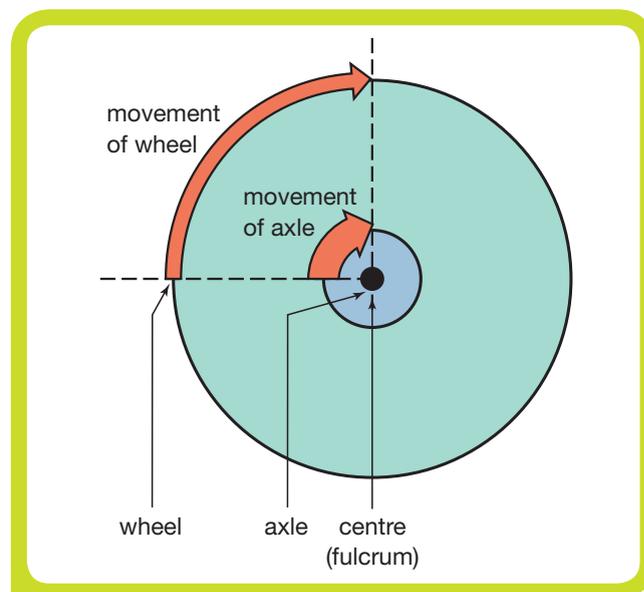


Fig 1.3.2

As with an inclined plane and levers, you gain in force what you lose in distance moved.



Fig 1.3.3 A steering wheel, a screwdriver and the key on a can are all examples of wheels and axles.

The wheel as a force multiplier

As with a lever, a wheel can be used to reduce the force needed to carry out a task. The spindle (axle) of a doorknob or tap is nearly impossible to turn with bare fingers. A doorknob or a tap can be either a simple lever or a 'wheel'. A small force moving the end of the handle or the edge of the knob or tap will turn the spindle easily enough to open the door or turn on the tap. A small effort applied to the rim produces a large turning force at its axle: the force has been multiplied.



Fig 1.3.4 A tap may use a lever or a wheel.



Fig 1.3.5 A doorknob may use a lever or a wheel.

The wheel as a speed multiplier

Wheels can also be used as speed multipliers. A slowly spinning axle turns the rim at a higher speed.

The blades of a fan must spin very fast to move the quantities of air needed for cooling. The motor turns the axle relatively slowly. The bigger the propeller, the faster the blade tips will go and the more air is moved.



Fig 1.3.6 A ceiling fan is an example of a speed multiplier.

Changing the motion

Once a spinning motion has started, its direction, speed or location often needs to be changed.

The simplest way to do this is to connect wheels of different diameters together with belts. A smaller-diameter wheel will spin faster and with greater force if it is connected by a belt to a larger wheel.

Activity 9

Roping them together

Aim

To investigate speed changes by connecting different-sized wheels

Equipment

A variety of circular lids of different sizes from jam jars etc (serrated edges are ideal), elastic bands, a piece of wood, a small sheet of thin cardboard, pins, small nails or tacks (they must have a circular cross-section), marking pen, hammer

Method

- 1 Put small holes in the exact centre of two lids.
- 2 Attach the two lids to a piece of wood, using two small nails or tacks.
- 3 Cut several elastic bands and tie them together so that they go right around two lids.
- 4 Cut out small circular 'washers' from the thin cardboard.
- 5 Assemble your wheels as shown in Figure 1.3.7. The elastic band should be stretched just a little.

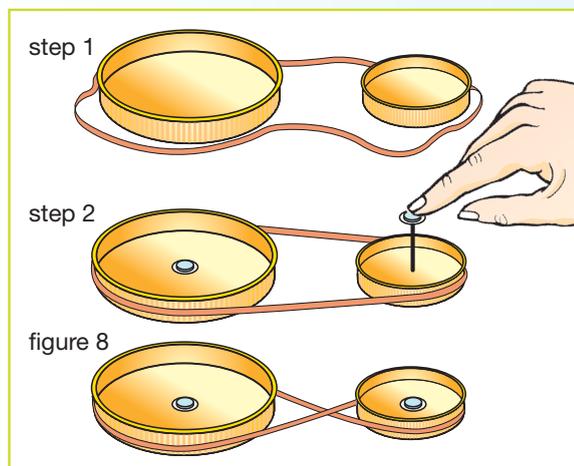


Fig 1.3.7 Roping wheels together

- 6 Draw an obvious line on each of the lids with the marker.

- 7 Measure the diameter of each lid.
- 8 Start one wheel spinning. Note which direction the wheels turn and use the line you have drawn to count how many times each lid turns in one minute. You have just measured the rpm (revolutions per minute) of each wheel.
- 9 Record your results in a table like this:

Diameter wheel #1	Clockwise/anticlockwise?	Rpm wheel #1	Diameter wheel #2	Clockwise/anticlockwise?	Rpm wheel #2

- 10 How does the size of the wheel affect the force needed to do a job?
- 11 Try different combinations of lids.
- 12 Change the elastic band to look like a figure 8, and repeat the experiment.

Questions

- 1 How did the rpm of a small wheel compare with the rpm of the larger wheel it was connected to?
- 2 Analyse whether there is a link between wheel diameter and rpm.
- 3 State whether the wheels spun in the same or different directions.
- 4 Recount what happened when the elastic band was changed to a figure 8.



Fig 1.3.8 A fan belt connects wheels of different sizes.

Gears

Gears can also be used to change speed, effort (force) or the direction of rotation.

A gear is a wheel with identical teeth around its edge. A gear that is part of the axle that turns is called the driving gear. Another gear that is connected to the driving gear is called the driven gear.

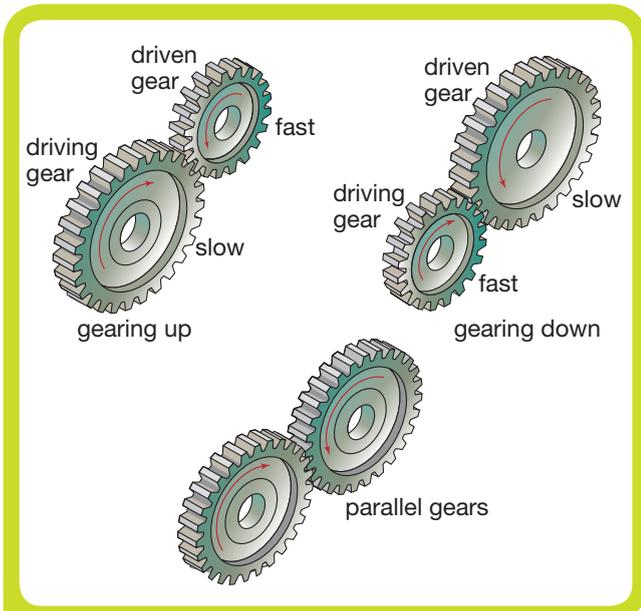


Fig 1.3.9 Gearing up, gearing down and parallel gearing

A gear train is a series of two or more connected gears. If the gears are identical, they both turn at the same speed but in different directions. These are called parallel gears.

If the driven gear is smaller than the driving gear, it will rotate faster: the gear train acts as a speed multiplier. This is called gearing up. This is useful when high-speed rotation is needed, for example in a power drill or hand drill.

Gearing down is when a small driving gear rotates a larger gear, which turns at a slower speed. This gear train acts as a force multiplier. This is useful when a strong turning force is required. For example, gears on bicycles make riding up hills easier. These relationships are shown in Figure 1.3.9.

Types of gears you will commonly find are rack and pinion, spur, worm and bevel gears. These are shown in Figure 1.3.11.



Fig 1.3.10 An eggbeater and a bicycle both use gears to change the speed and direction of rotation.

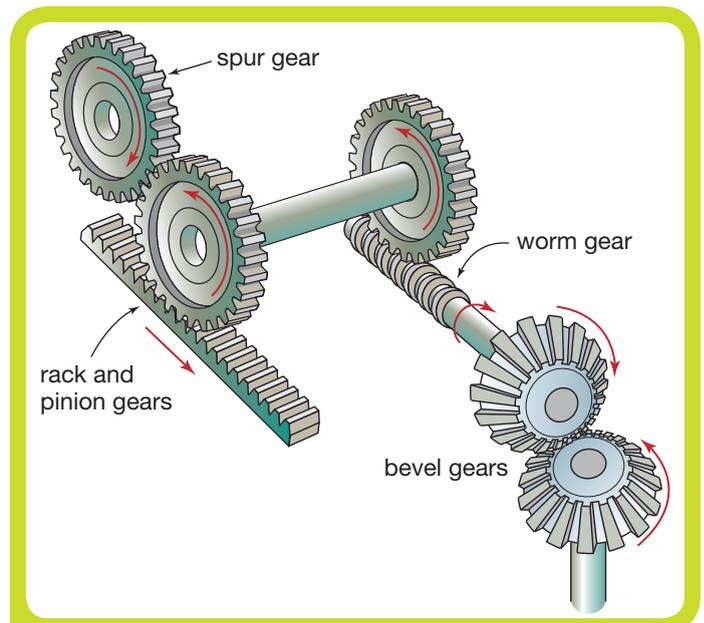


Fig 1.3.11 Spur, rack and pinion, worm and bevel gears

Activity 10

Geared machines

Aim

To investigate common implements that use gears

Equipment

Eggbeater, hand drill, corkscrew, adjustable spanner

Method

- Carefully draw the gear arrangements in the machine you have been given, labelling each type of gear (rack and pinion, worm, etc.).
- Label which gear is driving and which is driven, and the direction each gear moves in.
- Label any levers or wedges that might also be there.
- Count how many teeth are on each gear. Put these numbers on your diagram.
- Make a small mark on the side of the driving gear and another on the driven gear.

- Turn the driving gear slowly and count the number of times each gear turns. Stop when one of the gears has turned ten times. Write the number of turns on the gears on your diagram.

Questions

- Identify which gear was the larger—the driving or the driven gear?
- Explain what the job of your machine is.
- Does your machine need to be a force multiplier or a speed multiplier? Justify your answer.
- Calculate the gear ratio by dividing the number of teeth of the bigger gear by the number of teeth of the smaller.
- Calculate the turning ratio by dividing the bigger number of turns (you chose ten) by the smaller number of turns.
- What do you notice about the two ratios?

[Questions]

Checkpoint

The wheel

- Describe how a wheel is like a lever.
- What is another name for the fulcrum of a wheel?
- What is another name for the axle of a doorknob or tap?
- Draw a labelled diagram to demonstrate how a wheel can act as a speed multiplier.
- List examples of wheels being used as speed multipliers.
- Explain how the direction of a spinning wheel can be changed.

Gears

- Copy and complete the following sentence: Gears can be used to change _____, _____ (force) or the direction of _____.
- Distinguish between a driving gear and a driven gear.
- Explain when gearing up and gearing down are used.
- Define a 'gear train'.
- Draw or trace diagrams of rack and pinion, worm and bevel gears.

Think

- Copy the following sentences into your workbook, changing any incorrect statements so they are true.
 - Rotary motion is up–down motion.
 - The axle and the rim of a wheel are the same thing.
 - The driving wheel of a bicycle is an example of a speed multiplier.
 - Parallel gears turn in the same direction.
 - The steering wheel of a car is an example of a speed multiplier.
 - Gearing up is used when high-speed rotation is needed.
 - Gearing down is used in drills and kitchen blenders.
- Construct a diagram of a bicycle wheel. Label its axle and rim. Show where the wheel would move the fastest and slowest.
- Draw two gears that would act as a speed multiplier and another two that would act as a force multiplier.
 - Identify and label the driving and driven gears in your diagram.

>>

Analyse

15 Predict the direction of rotation and the speed of the gears in Figure 1.3.12.

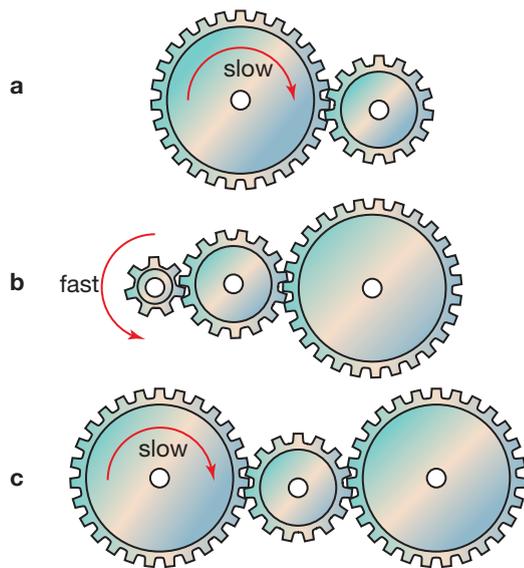


Fig 1.3.12

[Extension]

Investigate

- 1 Examine a bicycle closely.
 - a What are the gears in a bicycle called?
 - b Draw a diagram to illustrate your answers to the following questions.
 - i How many gears are there front and back in a ten-speed bicycle?
 - ii How many teeth does each gear have on it?
 - iii Do they mesh together? How are they connected?
 - c Construct diagrams to show the arrangements of front and rear gears that a cyclist would use to:
 - i travel at high speed
 - ii climb a steep hill
 - iii ride downhill.
 - d Gear ratio is the number of teeth on the front gear divided by the number of teeth on the back gear.
 - i Count the number of teeth on each gear used in part c above and calculate the gear ratio for each situation.
 - ii Describe what sort of gear ratios are needed for each situation.

Create

- 2 Use the diagram in Figure 1.3.13 to construct a mouse-trap racer.

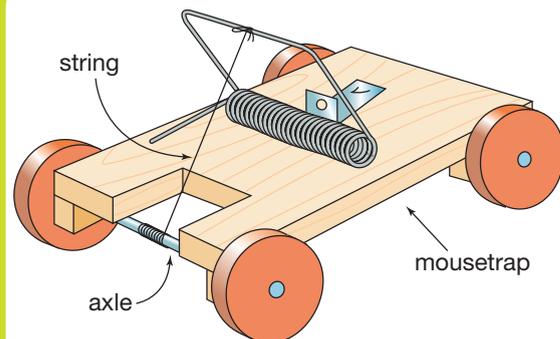


Fig 1.3.13

UNIT 1.4

Pulleys

Introduction

Humans usually find pulling an object down a lot easier than lifting it up. Our weight already acts downwards and so we can use it to help us pull down. A pulley can be used to convert a pulling-down force into a lifting force.

A pulley is simply a wheel with a grooved edge in which a string, rope or chain can run.

Activity 11

Fixed and moveable pulleys

Aim

To investigate the mechanical advantage of various pulley configurations

Equipment

100 g mass, spring balance, retort stand, strong cotton thread

Method

- 1 Use a spring balance to measure the effort force needed to hold a 100 g mass in each of the situations shown in Figure 1.4.1.
- 2 Record your readings in a table similar to the one shown here.

'Pulley'	Effort needed to hold the mass (N)	Effort needed to lift the mass (N)	Mechanical advantage
a No pulley			
b Fixed pulley			
c Moveable pulley			

- 3 Now use the fixed pulley (b) and moveable pulley (c) in Figure 1.4.1 to gently lift the 100 g mass. What are the spring balance readings now?

Question

You might need to read ahead to find the information to answer this question.

Did the fixed or moveable pulley require less effort to hold and lift a mass? Propose a reason why.

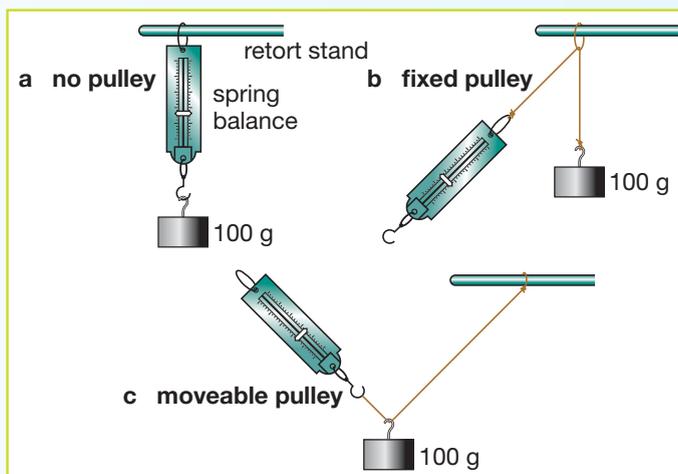


Fig 1.4.1 Pulley arrangements to try

Introducing pulleys

A single pulley makes the job of lifting an object easier. It is easier only because simple pulleys change the direction of the effort force. We still need to put in the same effort to lift the object. That means that the mechanical advantage of a single pulley should be equal to one. In fact, we probably need to put in more effort, since we need to overcome the load *and* some friction in the pulley.

Friction always makes us work harder, by reducing the effectiveness or efficiency of machines.

Bigger loads can be lifted with less effort if a system of two or more pulleys is strung together. The pulleys now become a force multiplier: we put in an effort and the pulley multiplies it, so we can lift heavier loads.

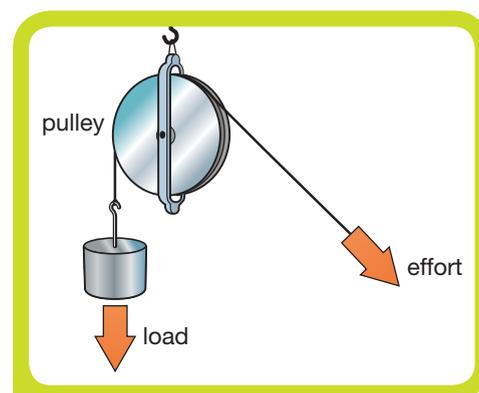


Fig 1.4.2

A single pulley makes the job easier by changing the direction of the effort.

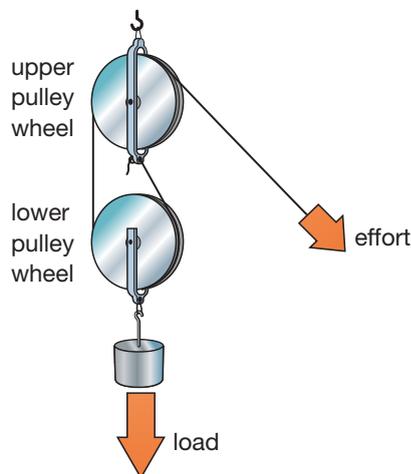


Fig 1.4.3

A double pulley system halves the effort required. Double the load can be lifted, but the distance we need to pull the rope is also doubled.

A multiple pulley system, such as that shown in Figure 1.4.3, is often called a block and tackle or sometimes a chain hoist.

Paperclip pulleys

Aim

To compare single and double pulleys made from paperclips

Equipment

100 g mass, spring balance, retort stand, strong cotton thread, paperclips

Method

- 1 Use a spring balance to measure the effort needed to hold a 100 g mass as shown in Figure 1.4.1 part a. Record its reading.
- 2 Twist the two paperclips apart as shown in Figure 1.4.4 and construct the double-paperclip pulley as shown.
- 3 Now use the paperclip pulley to gently lift the 100 g mass. Record the new spring balance reading.
- 4 Measure the effort required to hold the 100 g and then the effort required to gently lift it.

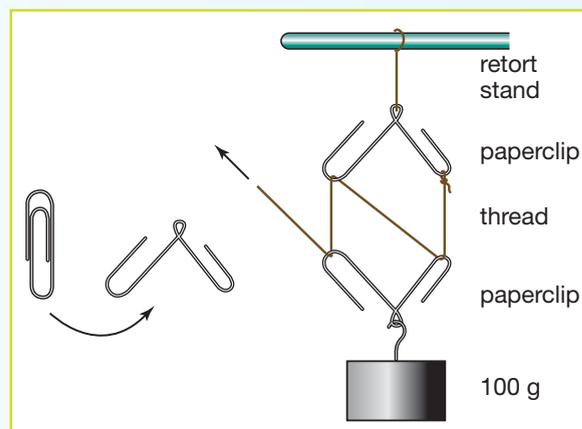


Fig 1.4.4 A double pulley system

Questions

- 1 Did the double pulley make the jobs of holding and lifting easier or harder?
- 2 These paperclip pulleys are not as good as pulleys with moving wheels. Assess why.
- 3 Calculate the mechanical advantage of the single and double paperclip pulleys.

How do pulleys reduce effort?

Imagine we need to lift a bag of copra onto a truck that is 2 m high. With a single pulley we need to pull the rope down the same distance, 2 m. If we use a double pulley, the length of the rope used needs to be doubled. That means that the rope needs to be 4 m long. The advantage is that we need to use only half the effort.

You will remember from the section on ramps that work is the energy needed to move something:

$$\text{work} = \text{effort force} \times \text{distance moved}$$

If the distance we move the load is greater, the effort we need to put in is less. This is how multiple pulleys work: we need to pull further but we put in less effort.

The effort needed gets less if more pulleys are added to the system: the mechanical advantage equals the number of pulleys used.

Unfortunately, friction once again makes us work harder, by reducing the efficiency of a pulley system.

Activity 13

Using pulleys

Aim

To construct pulley systems to lift various masses

Equipment

2 single pulleys, 2 double pulleys, 1 m string, a set of 50 g masses, spring balance, ruler

Method

- Construct a table or spreadsheet as shown below.
- Use the spring balance to measure the effort needed to hold a 500 g mass. This is its weight force.
- Pile some textbooks on your desk to about 5 cm to 10 cm high, then measure the exact height.
- Place the 500 g mass (the load) on the desk next to the books and lift it slowly to the top with the spring balance.
- Read the effort force required and record it in your table.
- Measure the distance your hand had to move to lift the load to the top of the books.
- Repeat, but with the spring balance upside down.
- Pass a string over a single pulley and use it to lift the 500 g mass to the top of the books. Once again, measure the effort required and the distance your hand had to move.
- Repeat with the other combinations shown in Figure 1.4.5 or some of your own designs.
- Calculate the mechanical advantage for each arrangement.

Questions

- Was there any difference in the reading of the spring balance when it was upside down? If so, propose reasons for this.
- Identify any advantage in using a single pulley.
- Describe what happened to the effort force as more pulleys were added.
- Describe what happened to the distance your hand moved when lifting the mass.
- Write a conclusion for your findings.

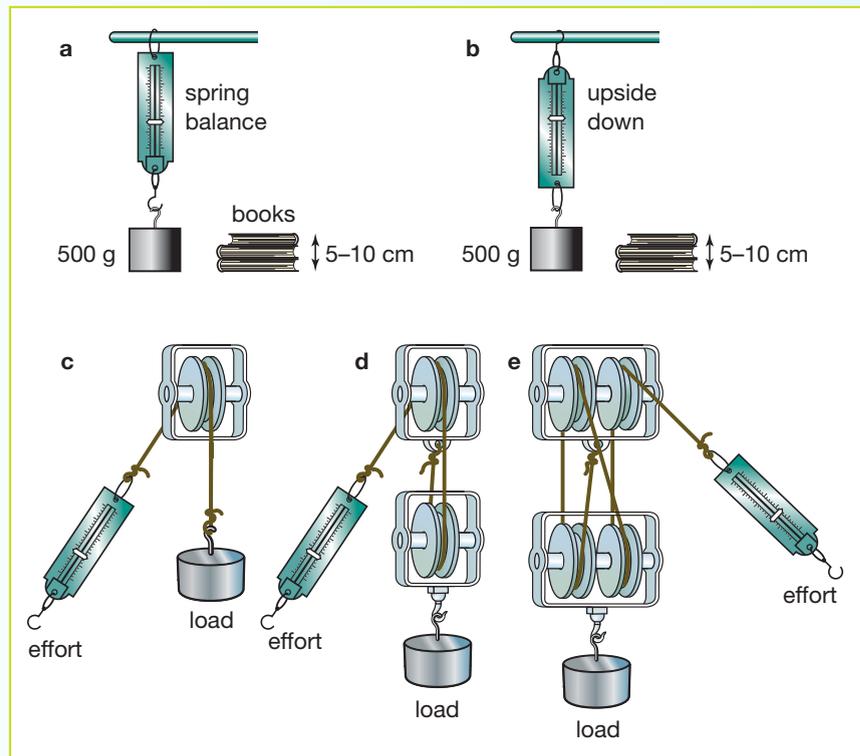


Fig 1.4.5 Test these pulley systems.

Arrangement	Mass used (g)	Weight force (N)	Effort force required (N)	Distance mass lifted (cm)	Distance hand moved (cm)	Mechanical advantage
a No pulley	500					
b Spring balance upside down	500					
c One pulley	500					
d Two single pulleys	500					
e Two double pulleys	500					

Activity 14

Rope sections

Aim

To construct a pulley system using common materials

Equipment

Strong wire that can be bent (coat hangers are ideal), retort stand and clamp with ring, strong cotton thread or string, 100 g mass

Method

- 1 Construct a table like the one shown here.

Number of sections of thread	Distance mass moved (cm)	How far hand moved (cm)
2	5	
4	5	
6	5	
8	5	

- 2 Build the 'pulley' arrangement as shown in Figure 1.4.6.
- 3 Pass the cotton thread or string over the 'pulley' so that there are two sections of string (a 'section' consists of one 'up' and one 'down' bit of thread or string) supporting the mass.

- 4 Use the 'pulley' to lift the 100 g mass a height of 5 cm. Measure how far you needed to move your hand to do so.
- 5 Repeat, but with four, then six, then eight sections of thread.

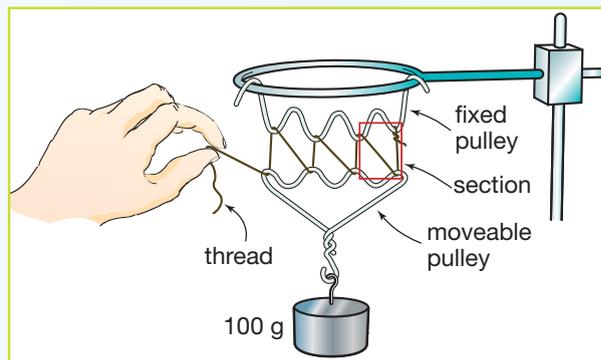


Fig 1.4.6 Making a multiple pulley

Questions

- 1 Describe what happened to the distance your hand moved to lift the mass when the number of sections of thread increased.
- 2 Evaluate what this suggests about the effort required.
- 3 Explain your answer using your knowledge of the formula $\text{work} = \text{effort} \times \text{distance}$

1.4 [Questions]

Checkpoint

Introducing pulleys

- 1 Explain why humans naturally find pulling an object down easier than lifting it up.
- 2 State the main advantage of using a single pulley to lift a load.
- 3 Describe the mechanical advantage of a single pulley.
- 4 Define a 'block and tackle'.

How do pulleys reduce effort?

- 5 Using the work formula, describe how a pulley reduces effort.
- 6 If we use two pulleys instead of one, describe what happens to the effort and distance we must pull.

Think

- 7 Distinguish between a pulley and a gear.
- 8 Friction is a nuisance in a pulley. Explain.
- 9 Identify the advantage of using a clamp together with a pulley.
- 10 A hoist does not use rope over a pulley. Identify what it does use.
- 11 Are pulleys force or speed multipliers? Explain.

Analyse

- 12 Outline the advantages and disadvantages of using multiple pulleys.

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- 13 Identify how many pulleys are in each arrangement in Figure 1.4.7.
- 14 Determine what force multiplication each pulley arrangement in Figure 1.4.7 would give.

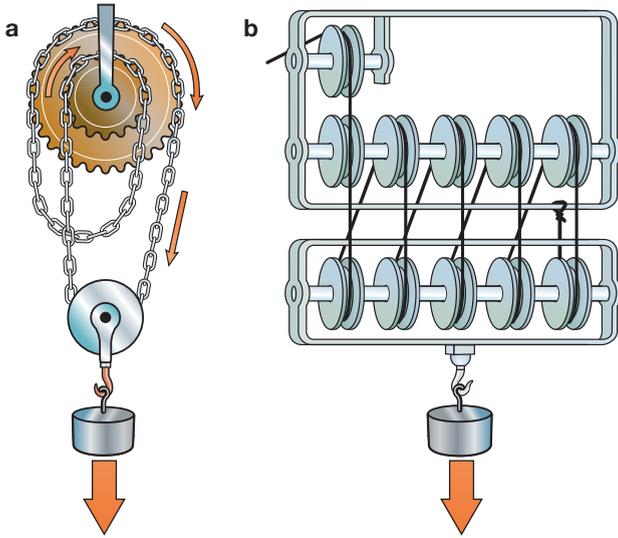


Fig 1.4.7

[Extension]

Create

- 1 Construct models of pulley arrangements, using weights to mimic the real thing.
- 2 Construct a model to demonstrate how ramps, wedges, wheels, pulleys (and any other machines) were used in construction of buildings.

Action

- 3 Use Figure 1.4.8 to design a tug-of-war competition that you cannot lose. Add more opponents until you find the maximum number of people you can defeat.

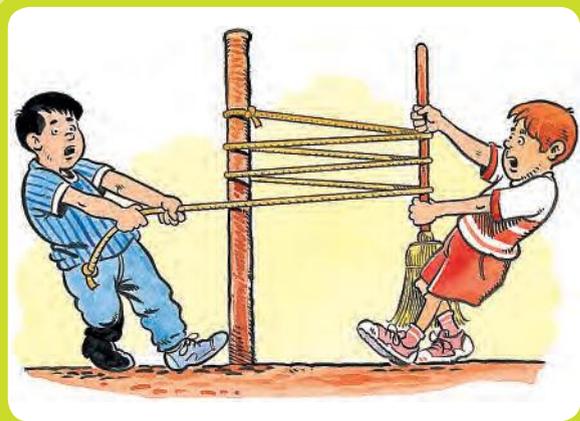


Fig 1.4.8

UNIT 1.5

Structure and Stability

Activity 15

Introduction

On Earth, forces are needed to move objects. Even if an object is not moving, there are still forces acting on it. One of them is the downwards force of gravity. The other is the upwards push of the surface. We say an object is in a stable condition once the forces acting on it are balanced. The stability of an object very much depends on its centre of gravity and structure.

The centre of gravity

Aim

To find the centre of gravity of a hanging object using a plumb-line

Equipment

Cardboard, cotton thread, 2-inch nail, one small stone or weight

Method

- 1 Cut the cardboard into the shape of a bean seed.
- 2 Make three holes in different spots around the bean-shaped cardboard.
- 3 Hammer the nail into a wall or post and suspend the cardboard on it through one of the holes.
- 4 Tie the small stone on one end of the cotton thread (plumb-line) and tie the other end to the nail. Allow the cotton thread to hang freely in front of the hanging cardboard.

- 5 Draw a line on the cardboard in line with the cotton thread.
- 6 Repeat the steps above with the other two holes.
- 7 After you successfully draw the three lines on the cardboard, identify where the three lines intersect.

Questions

You might need to read ahead to find the information to answer these questions.

- 1 What do we call the point where all the lines intersect?
- 2 State a conclusion about the stability of the cardboard at the point of intersection.

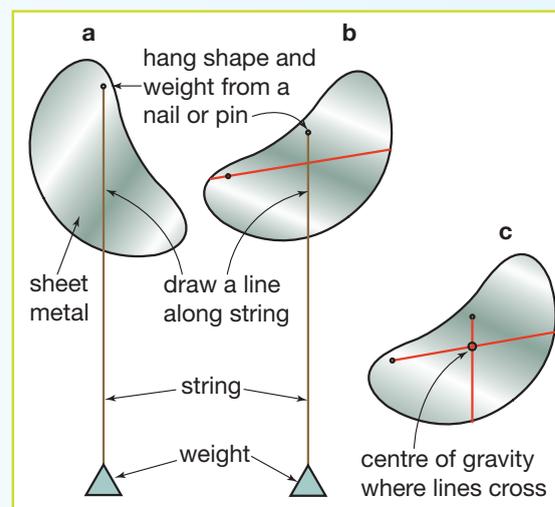


Fig 1.5.1 The hanging object

The centre of gravity

All objects on Earth have mass and weight. The weight force appears to act through a point in every object. This point is called its centre of gravity. The location of the centre of gravity depends on the shape and the mass of the object. The centre of gravity is the balance point of the object. An object is more stable if its centre of gravity is located close to its base, where mass is concentrated. This is the same as the centre of mass.

The position of the centre of gravity can affect the stability of objects. Objects with a low centre of

gravity are more stable than objects with a higher centre of gravity. For example, a ship's centre of gravity is close to the base. This makes the ship more stable on the sea. Trucks also have a low centre of gravity.

A heavy load added to the back of a truck can raise its centre of gravity. This makes the loaded truck less stable. This is same for a canoe. Heavy and higher cargo loaded onto a canoe can cause it to overturn because its centre of gravity is raised higher from its base.

Activity 16

Stability and structure

Aim

To construct a stable structure from a deck of cards

Equipment

Deck of playing cards

Method

- Using the playing cards, build a structure. Place some cards vertically then place some other cards horizontally on top of the vertical ones. Make sure the vertical ones do not fall. Repeat with more layers until the structure collapses.
- Design your own structure and construct it. Try to build a structure that goes higher before it collapses.

Question

Give some reasons why the structure you build can go higher before it collapses.

Structures and stability

Most structures, such as buildings, boats and trucks, are designed and built so that they are stable. This is to make sure that these structures do not easily fall over, overturn or collapse when they are used. Designers and engineers need to consider the centre of gravity and centre of mass in order to construct a stable structure. For example, for a house to be stable, most of the heavy structures are placed near the base or the floor, not on the top or the roof. Most tall buildings also have broad bases and narrow tops.

Heavy weights of metal or sand bags are placed at the base of most ships in order to increase their stability on the sea. The heavy weights at the bottom lower the centre of gravity of the boats. This makes them more stable.

Aircraft must be stable. When loading an aircraft, great care must be taken not to cause its centre of gravity to move. If the centre of gravity moves due to unbalanced loading of cargo, the aircraft will not be stable in the air. This can be dangerous and the aircraft might crash.

[Questions]

Checkpoint**Centre of gravity**

- Explain the term 'centre of gravity'.
- The location of the centre of gravity of any object depends two things. What are they?
- When we load heavy and higher loads in a canoe, it becomes unstable. Explain why this happens.

Structure and stability

- How does the stability of an object relate to the location of its centre of gravity?
- Explain why most tall buildings have broad bases and narrow tops.
- Describe one way you can lower the centre of gravity of a ship.

Think

- How would you load a truck or a canoe with heavy cargo and still make sure that it is stable?

[Extension]

Investigate

Identify and describe some examples of structures or objects in your community or school that are designed to be stable.

Chapter review

Summary questions

- True or false?
 - Machines make less work.
 - Machines reduce the effort required to do a job.
 - A ramp is the same as an inclined plane.
 - Ramps reduce effort because the distance travelled is less.
 - A screw is an example of a ramp.
 - A machine that gives a high mechanical advantage is a good one.
 - A pivot and a fulcrum are different things.
 - Ramps and levers use rotary motion.
 - Wheels can never act as speed multipliers.
 - Two connected gears always turn in opposite directions.
 - Gearing up is when the driven gear turns faster than the driving gear.
 - Single pulleys reduce the effort needed to lift something.
- Explain what a simple machine does.
- List six simple machines.
- Copy and complete the following equation:
work = effort force \times _____
- Distinguish between the effort and the load on a machine.
- Construct a diagram of an aircraft, showing all important forces that act on it.
- Define mechanical advantage.
 - State whether mechanical advantage should be high or low in a machine.

Thinking questions

- Explain how ramps reduce effort.
- Construct diagrams of class 1, 2 and 3 levers and give three examples of each.
- Identify what spur, worm and bevel are examples of.
- Identify what parallel gears are.
- Discuss the advantages and disadvantages of a single pulley.
- A double pulley can lift twice the load of a single pulley. Determine what distance the rope must be pulled in order to do so.
- Copy and complete the following sentence: The more pulleys in a system, _____.

Interpreting questions

- Use the principle of levers to predict where a 20 g mass should be located to exactly balance each of the seesaws in Figure 1.6.1.

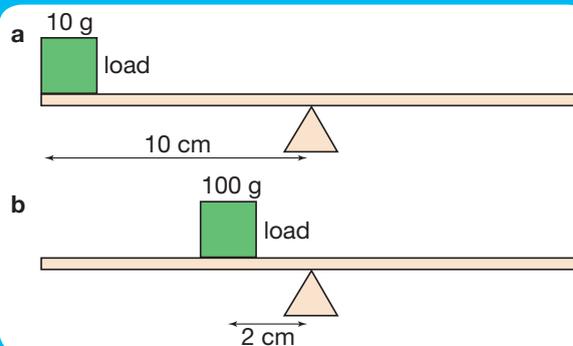


Fig 1.6.1

- Describe how mechanical advantage is calculated for levers.
- Calculate the mechanical advantage for the levers in Question 17.
- Predict the direction and speed of the wheels and gears shown in Figure 1.6.2.

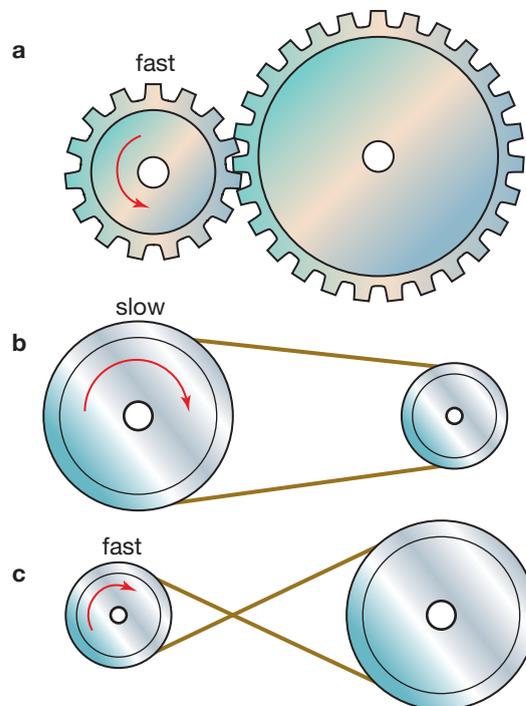


Fig 1.6.2

- 19 Use examples to demonstrate a wheel acting as:
- a a force multiplier
 - b a speed multiplier.
- 20 Construct diagrams to show how gears could be connected to:
- a gear down
 - b gear up
 - c rotate in the same direction
 - d increase the speed of rotation
 - e decrease the speed of rotation
 - f change the direction of rotation by 90°.
- 21 Examine the pictures of common kitchen appliances shown in Figure 1.6.3.
- a Identify the simple machines that are used in each appliance.
 - b Describe how each appliance uses simple technologies to make life easier.



Fig 1.6.3

Body systems

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

- identify common local foods that provide the following nutrients: carbohydrates, protein, fats and oils, vitamins and minerals
- describe the functions of these nutrients
- draw and identify the parts of the human digestive system
- describe the main processes in the digestive system
- identify from a diagram the heart and blood vessels (arteries, veins and capillaries)
- describe the two main functions of the heart
- name the four components of blood
- describe the main functions of the components of blood
- identify from a diagram the main parts of the excretory system
- state that urea is the main waste product of the body
- explain how the respiratory system takes in oxygen gas from the air through your nose and mouth and removes carbon dioxide gas from your body, also through your nose and mouth
- identify from a diagram the main parts of the respiratory system
- explain the process of breathing
- list the common health problem associated with the digestive, circulatory, excretory and respiratory systems.

- 1 Why is food a little like petrol?
- 2 Your stomach has a very dangerous acid in it. Why isn't this a problem?
- 3 What tube runs the length of your body with openings at both ends?
- 4 Blood is red, so why do your veins look blue?
- 5 What is your resting pulse rate?
- 6 How much urine can your bladder hold?



UNIT 2.1

Food

Introduction

We need fuel to be able to do all the things we want to do. For us, the fuel is food. It provides energy for movement and the production of heat, just as petrol provides energy for a car to run. A car needs more than just fuel, however. It also requires oil, brake fluid, water and air filters. Our bodies also need other substances to maintain health and make new cells to enable growth and repair of body tissue. To maintain healthy bodies we need to include water, fibre and nutrients in our diet.

Water

Water is an important part of body cells and makes up about two-thirds of the body. Water has several important functions in the body. It:

- is a reactant in many of the chemical reactions that take place inside us
- helps to give organisms their shape and structure
- is a means of transporting substances in the body
- stores heat and helps to maintain a steady body temperature.

In fact, blood is almost all water (90 per cent). Lack of water (dehydration) can cause low blood pressure and become life-threatening.

Fibre

Fibre (sometimes called roughage) is found in the cell walls of plants such as cereals, vegetables, fruit, nuts and seeds. Though fibre is not fully broken down during digestion, it assists by providing bulk, which speeds the movement of matter through our intestines. Without fibre, undigested food would spend too much time in the large intestine, and too much water would be removed, resulting in harder, drier faeces and constipation (difficulty passing faeces). Fibre also soaks up some poisonous wastes for removal from our bodies. Research shows that a lack of fibre in the diet increases the risk of diseases such as bowel cancer. Processing of foods often removes fibre, which is found in the bran surrounding grains such as wheat.

Nutrients

There are five main nutrients—carbohydrates, lipids, proteins, vitamins and minerals.

Carbohydrates

Carbohydrates include starches and sugars, and are our main source of energy. Carbohydrates are made from carbon, hydrogen and oxygen. The body converts most carbohydrates into glucose, which is then transported to body cells for use. Excess glucose is converted to body fat and stored.

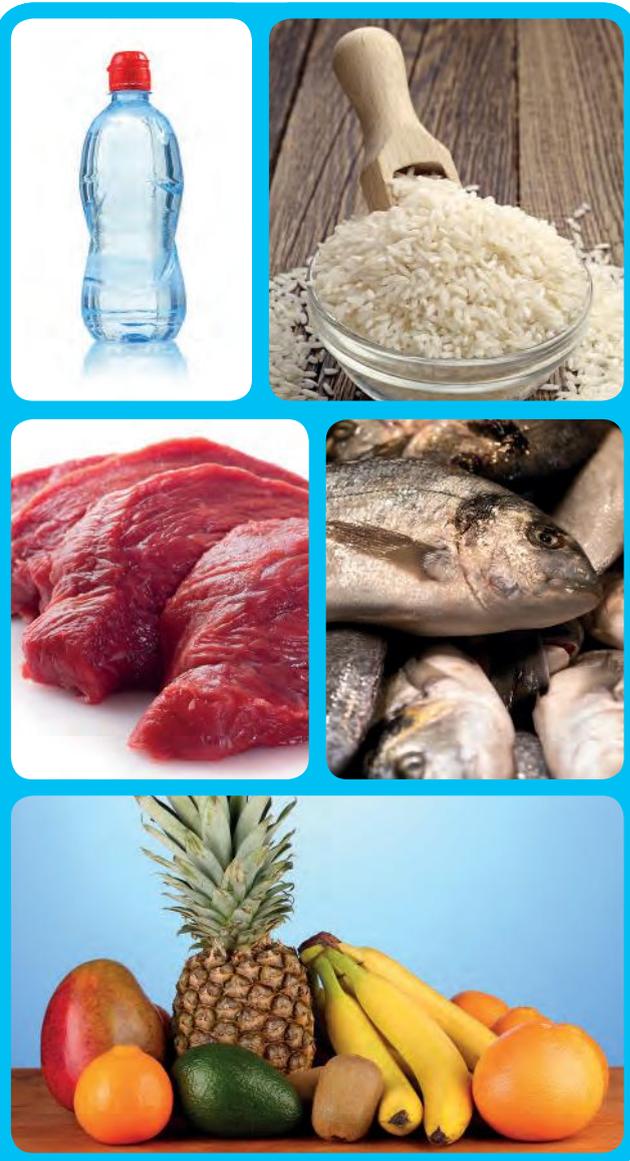


Fig 2.1.1

A balanced diet includes water, fibre and nutrients.

Activity 1

Nutrition

Aim

To investigate nutrients provided by common food types

Equipment

Breakfast or lunch pack, plate, spoon, water bottle

Method

- 1 Wash your hands.
- 2 As a class, take your food to a shady area nearby.
- 3 Sit in a circle and begin to unpack and eat your food.
- 4 Share your food with your friends.
- 5 Drink some water after your meal.

Questions

You might need to read ahead to find the information to answer some of these questions.

- 1 List the different types of food that you ate.
- 2 What do these foods provide your body with?
- 3 What effects do the foods you eat have on your body?
- 4 What types of food did your meal contain?
- 5 What kind of nutrients does your food provide?

Lipids

Lipids are fats and oils. These are a rich source of energy, containing twice as much energy as carbohydrates. Fat is stored under the skin as an energy reserve, and to provide insulation against loss of body heat. Fats contain important vitamins, and are used for making cell membranes and nerve cells.

Proteins

Proteins are body-building compounds—the raw materials required for growth and repair of damaged or worn-out tissues (eg when a wound heals). Proteins provide only 10 per cent of the body's energy.

A lack of protein can lead to a disease called kwashiorkor, which generally affects children between 1 and 3 years old. In severe cases, muscles waste away and body fluids build up under the skin, causing swelling. This is why starving children in poor nations often appear thin, but have swollen stomachs.



Fig 2.1.2 Foods rich in fats



Fig 2.1.3 Foods rich in proteins

Vitamins

Vitamins provide no energy, but are needed in small amounts to speed up various chemical reactions in the body and to maintain good health.

Lack of vitamins or other nutrients can result in what are known as deficiency diseases. Excess vitamin intake can also cause problems.

Vitamin	Some sources	Important for	Deficiency may cause
A	Milk, dairy products, eggs, carrots, oranges, butter, margarine, green vegetables liver, fish liver oil	Healthy skin, eyes, bones and teeth, lining of digestive and respiratory systems, pregnancy and foetal development	Poor vision in dim light, retarded growth, infections
B1 (thiamine)	Milk, meat, liver, kidney, wholegrain breads, wheat germ, bran, brown rice, beans, peas, nuts, pasta, fish	Helps body release energy from food	Fatigue, muscle cramps, nausea, beriberi (symptoms: muscular weakness, paralysis, heart failure), nervous disorders
B2 (riboflavin)	Milk, cheese, eggs, meat, kidney, liver, whole grains and cereals, fish, cheese	Healthy skin, eyes and tissue, helps body obtain energy from food	Greasy and scaly skin, mouth sores, poor growth
B3 (niacin)	Wholegrain breads and cereals, potatoes, eggs, liver, lean meat, poultry, fish, nuts, leafy vegetables	Healthy skin, helps body obtain energy from food	Pellagra (symptoms: skin rashes, diarrhoea, weakness, loss of appetite, mental illness)
B6	Wholegrain breads and cereals, chicken, pork, liver, fish, potatoes, eggs, cabbage, bananas	Healthy teeth and gums, red blood cells and blood vessels, helps digest protein	Weakness, poor appetite, infection, dermatitis, anaemia (lack of oxygen in red blood cells)
B12	Meat, fish, liver, milk, eggs, cheese, green vegetables	Formation of red and white blood cells, healthy nerves, skin, hair	Loss of appetite, headache, nausea, diarrhoea, fatigue, confusion, loss of memory, depression
C	Oranges, lemons, grapefruit, green peppers, blackcurrants, strawberries, tomatoes, potatoes, green vegetables	Healthy bones, teeth and tissues, wound healing	Scurvy (symptoms: bleeding gums and internal organs, easy bruising, depression)
D	Milk, margarine, butter, sardines, salmon, tuna, liver, egg yolk, also made by the body in sunlight	Helps the body use calcium and phosphorus for healthy teeth and bones, healthy nervous and immune systems	Children: rickets (symptoms: bones become soft and bend under the body's weight) Adults: bone pain, muscle weakness, increased risk of osteoporosis, arthritis and cancer
E	Bread, butter, margarine, egg yolk, cereals, nuts, leafy green vegetables	Protects cells against damage by certain chemicals	Deficiency rare, irritability, anaemia, increased risk of heart disease, cancer, premature ageing
K	Cauliflower, cabbage, broccoli, turnip, cereal, eggs, green vegetables, pork, liver, also made by bacteria in the gut	Blood clotting, kidney function	Bleeding, bruising

Activity 2

Basic food tests

Aim

To test for the presence of starch, glucose, lipid and protein in food

Equipment

Starch solution, iodine solution, a white tile, glucose solution, Testape, watch-glass, margarine, vegetable oil, brown paper, protein solution, vitamin C solution, test tube, eye dropper, spatula, Benedict's solution, HCl solution, 1% copper sulfate solution, 5% sodium hydroxide solution, beaker, Bunsen burner or kerosene stove, pestle and mortar

Method

Do the tests shown in Figure 2.1.4 and Figure 2.1.5 and study the reactions (use clean equipment for each one).

1 Test for starch

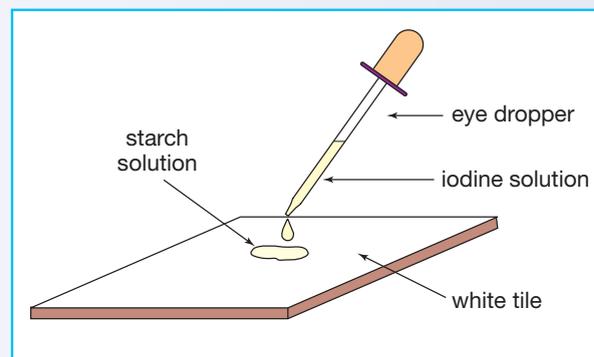


Fig 2.1.4 Test for starch

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2 Test for lipids

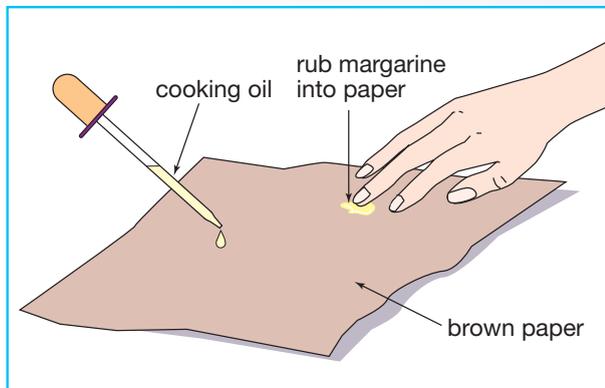


Fig 2.1.5 Test for lipids

3 Test for glucose

If your school has glucose, use it, otherwise prepare a solution of food.

- 1 Cut a ripe fruit into pieces and put it in a mortar. Add 5–10 mL of water and grind the fruit with a pestle. Filter the solution and then transfer the solution into a clean test tube.
- 2 Add 5–10 mL of Benedict's solution to the food solution.

3 Heat the mixture by placing the test tube in a beaker of boiling water.

4 If the food contains glucose, you should observe a yellow-green-red/orange precipitate.

4 Test for protein

If there is no protein solution available, use an egg yolk instead.

- 1 Pour the egg yolk into a test tube to a depth of 1–2 cm.
- 2 Add the same amount (1–2 cm depth) of 5% sodium hydroxide solution.
- 3 Add 5–10 drops of 1% copper sulfate solution. Gently shake the tube to mix the contents after you have added each drop. If the food contains protein, it will turn purple.

Questions

- 1 List the observed results for the following food tests:
 - a starch
 - b lipids (fats and oils)
 - c glucose
 - d protein.
- 2 Why is it necessary to mash the food with water before it is tested?
- 3 What is the difference between fat and oil?

Minerals

Minerals are elements or other chemically simple substances that are also required for healthy growth and to avoid deficiency diseases. Minerals that are needed in larger amounts are called major elements.

Those needed in smaller amounts are called trace elements. As with vitamins, health problems can be caused by too little or too much of some minerals.

Mineral	Some sources	Important for:	Deficiency may cause:
Major elements			
Calcium	Milk, cheese, dairy products, tinned salmon, peanuts, tofu	Healthy bones and teeth, muscle contractions, heart, nervous system, blood clotting	Nerve and bone disorders, osteoporosis, rickets, insomnia
Sodium and chlorine	Table salt (sodium chloride), green vegetables	Water balance in the body, muscle contractions, transmission of nerve impulses, production of stomach acid	Deficiency rare (excess more likely); apathy, loss of appetite, vomiting, muscle cramps
Phosphorus	Milk, cereals, wholegrain breads, vegetables	Healthy bones, energy production	Weakness, loss of appetite, bone pain and joint soreness
Sulfur	Shellfish, beef, eggs, chicken, pork	Formation of keratin, a protein found in hair and nails	Beriberi, but deficiency is unlikely with a normal healthy diet
Potassium	Meat, fruit and vegetables, grilled snapper, raisins, orange juice, peanuts, ham	Water balance in the body, heart, blood vessels	High blood pressure
Magnesium	Cheese, nuts, green vegetables, whole grains	Energy, healthy muscles, bones, heart and blood vessels	Fatigue, mental and heart problems

Mineral	Some sources	Important for:	Deficiency may cause:
Trace elements			
Boron	Avocado, red kidney beans, prunes, chickpeas, raisins, apricots, red grapes	Healthy bones and joints	Osteoporosis, arthritis
Cobalt	Meat, fish, liver, milk, eggs, cheese, green vegetables	Formation of red and white blood cells; healthy nerves, skin, hair	Loss of appetite, headache, nausea, diarrhoea, fatigue, confusion, loss of memory, depression
Copper	Liver, peanuts, walnuts, sesame seeds, sardines	Healthy bones, joints, skin, blood vessels, blood cells	Anaemia, tissue defects, heart disease
Fluorine	Tap water (in some countries), seafood, cereals, fruit	Helps tooth enamel to resist decay	Increased risk of tooth decay
Iodine	Water, fish, iodised table salt	Growth and development	Hyperthyroidism (overactivity of the thyroid gland resulting in cells functioning at an increased rate), goitre
Iron	Red meat, liver, cereals, green vegetables	Energy, oxygen transport in blood and storage in muscles	Fatigue, reduced resistance to infection, anaemia
Zinc	Meat, green vegetables	Energy, detoxification of chemicals such as alcohol, healthy brain, bones, teeth, skin, reproductive and immune systems	Skin problems, reproductive defects, loss of eye function, osteoporosis

A balanced diet

To stay healthy, everyone should have a balanced diet. A balanced diet contains all the food groups in their correct amounts. A balanced diet should provide us with the energy we need to live, as well as the raw materials to grow and replace worn-out cells and to assist in the complex chemical processes in our body. We also need to balance what we eat with what we need. We need to eat the right foods in the correct proportions.

Various dietary guidelines have been produced that recommend how much of different categories of food we should eat. One set of guidelines produced by Australia's national science agency divides foods into the six groups shown in Figure 2.1.6. It is called the 12345+ plan, and the 1, 2, 3 and so on refer to the number of daily servings from each group that are recommended for adults. As teenagers, you have different nutritional requirements from adults. The recommended daily servings for 12- to 15-year-olds are shown in Figure 2.1.6.

Nutrient	Males	Females
Protein	51 grams	50 grams
Vitamin C	30 milligrams	30 milligrams
Calcium	1200 milligrams	1000 milligrams
Iron	12 milligrams	12 milligrams
Sodium	920–2300 milligrams	920–2300 milligrams

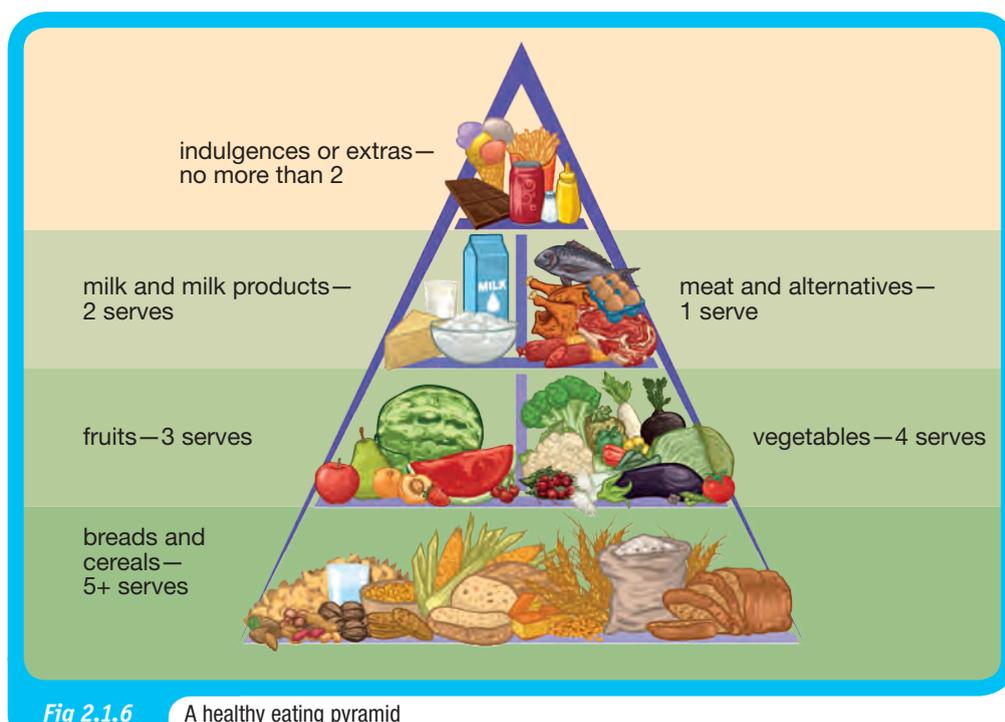


Fig 2.1.6 A healthy eating pyramid

Energy

Energy in food

We need food for energy. Food constantly supplies the energy we need to walk, to cook food, to play soccer or do gardening. The amount of energy we need in a day depends on factors such as how much we are growing, how active we are and how big we are. The more active a person is the greater is their energy requirement. Adults need a much greater amount of energy than children. If you eat food containing a lot more energy than you actually use, your body stores it as additional body fat. The energy in food is measured in units called joules (J). It can also be measured in kilojoules (kJ). A kilojoule is quite a small amount of energy. People require thousands of kilojoules of energy per day. Scientists who specialise in food technology use an instrument called a bomb calorimeter to measure the amount of energy in food. This instrument can measure the energy content of food very accurately.

The table below gives the amount of energy in some common foods used in Solomon Island meals.

The energy value of some common foods

Food—single serving	Amount	Energy in kilojoules (kJ)
Banana	1 medium—125 g	440
Bread (white)	1 slice—23 g	250
Coconut, fresh	1 piece—30 g	340
Egg	1 large—50 g	340
Fish	100 g	800
Ice-cream	100 g	890
Kumara, orange flesh	100 g	280
Kumara, white flesh	100 g	250
Maggi noodles	100 g	1540
Milk	250 g	670
Peanut butter	16 g	380
Peanuts, dry roasted	50 g	1255
Pineapple, fresh	85 g	140
Soft drink	240 g	450
Tuna chunks in oil	100 g	86
Vegetables, green	100 g	100
White rice, cooked	80 g (half cup)	390

Activity 3

Energy input

- 1 During a 'custom feast' a community baked 120 kg of orange kumara in several motus and also cooked ten bags of rice (20 kg) to feed the people. Calculate the energy input of these foods.
- 2 Billy had the following foods for breakfast: four slices of bread, 1 boiled egg and a soft drink (large). Calculate his total energy intake in kilojoules for the breakfast.
- 3 If Billy eats one cup of rice, fish and green vegetables for dinner, what is his total energy intake for this meal?

How much energy do you need?

The amount of energy required by people for the various activities they do daily varies according to their bodies. However, it is estimated that the minimum amount of energy needed to keep a person alive and functioning is about 7000 kJ a day. People who do a lot of manual work, such as farmers, builders and plantation workers, usually require a larger amount of energy than people who work in offices.

Young teenagers required about 9000 to 11 000 kJ per day. It is estimated that half of this energy is used to keep the body's basic systems working. The rest of the energy is used for movement.

Children's and adolescents' daily energy needs

Age group	Age	Average mass (kg)	Energy needs (J per kg)
Infant	0–6 months	6	480
	6–12 months	9	627
Children	1–3 years	13	5 440
	4–6 years	20	7 116
	7–10 years	28	10 046
Boys	11–14 years	45	11 302
	15–18 years	66	11 720
Girls	11–14 years	55	8 790
	15–18 years	55	8 790

Source: Borushek, A (1992). *Pocket Calorie Counter* (19th edn), Perth, Western Australia.

Activity 4

Energy requirements

- Using the information above, calculate the energy requirement for:
 - a 5-month-old infant
 - a 13-year-old boy
 - a 17-year-old girl.
- Give reasons for difference in the energy intake for each age group.
- Suggest reasons why girls between the ages of 15 and 18 years require less energy than boys of the same age group.

Using energy

The following table shows the approximate energy used in one hour by an adult doing various activities.

Activity	Energy used per hour (kJ)
Sleeping	250
Sitting	370
Writing	500
Walking	1000
Cycling (slow)	1000
Cleaning	1000
Jogging	1380
Running fast	1680
Dancing	1720
Heavy manual labour	1890
Climbing stairs	2770

Energy in a peanut

Aim

To determine the chemical potential energy stored in a peanut

Equipment

Peanut, cork, pin, test tube, heat-proof mat, retort stand, bosshead and clamp, thermometer, electronic balance

Method

- Use the electronic balance to measure the mass of a single peanut.
- Assemble the apparatus as shown in Figure 2.1.7.
- Measure the temperature of the water in the test tube.
- Light the peanut and allow it to burn so it can heat the water in the test tube.
- When the peanut is completely burnt, measure the temperature of the water again.

Questions

- Calculate the rise in temperature of the water in the test tube.
- It takes 42 joules of energy to raise the temperature of 10 mL of water by 1°C. Multiply your answer to Question 1 by 42. The answer tells you how many joules of energy were transferred from the peanut to the water.
- 'The peanut actually had more energy than was calculated in Question 2.' Assess whether this statement is accurate.

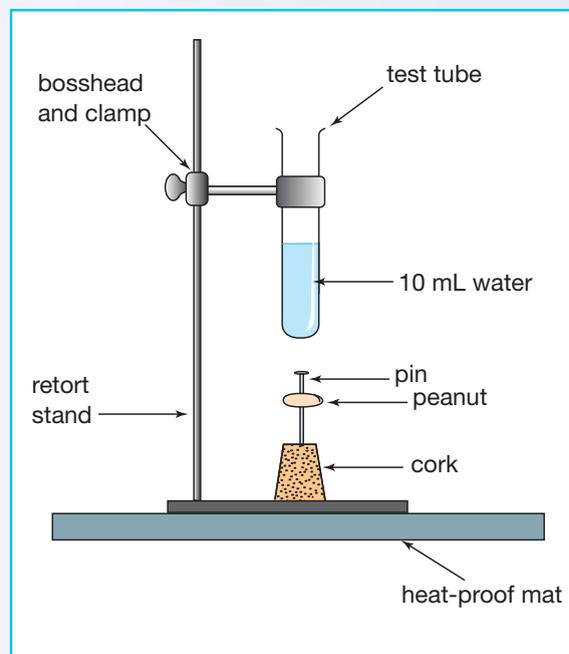


Fig 2.1.7 Apparatus set-up for determining the chemical potential energy in a peanut

- Use your results to calculate how much energy is in a gram of peanuts.
- Specify how this experiment could be made more accurate.

2.1 [Questions]

Checkpoint

Food

- 1 Explain why humans need food.
- 2 State two substances that contain few or no nutrients, yet are essential for good health.

Fibre

- 3 Define the term 'dietary fibre'.
- 4 Identify two foods that are rich in fibre.

Nutrients

- 5 Outline why each of the five types of nutrients is required, giving two examples of foods that contain each nutrient.
- 6 Contrast a trace element with a major element.
- 7 Identify two vitamins and two minerals found in liver.
- 8 List the names of some foods that contain a number of vitamins.
- 9 State the name and symptoms of two diseases that may be caused by a lack of a nutrient.

A balanced diet

- 10 Outline what is meant by a 'balanced diet'.
- 11 State two examples of a 'food serving'.

Energy

- 12 List some factors that might affect the amount of energy your body uses.

Think

- 13 Explain why most teenagers are always hungry and want to eat more often than adults.
- 14 Explain whether dietary requirements are different for females and males.
- 15 List the following in order of energy used, starting with the lowest: cleaning, writing, dancing, sleeping, jogging.
- 16 Calculate how much energy an adult would use:
 - a jogging for 30 minutes
 - b completing a written assignment over 3 hours.
- 17 Explain why the energy requirements listed in the table on page 34 (average daily energy requirements) are only approximate.
- 18 Predict what happens if energy intake is less than the energy used over a period of time.

Analyse

- 19 Construct a simplified sketch of a healthy eating pyramid.
- 20
 - a Construct a day's menu containing mainly healthy foods. Add up the amount of energy in this menu.
 - b Construct a day's menu containing largely junk food. Once again, add up the amount of energy.

Skills

- 21 Construct a pie graph (eg using the percentage pie graph circle on a Mathomat template) showing the composition of the following foods:
 - a meat: 13 per cent fat, 18 per cent protein, 69 per cent water and other substances
 - b potato: 2 per cent protein, 21 per cent carbohydrate, 77 per cent water and other substances
 - c baked beans: 0.5 per cent fat, 5 per cent protein, 7 per cent fibre, 10.5 per cent carbohydrate, 77 per cent water and other substances.

UNIT 2.2

Digestion

Introduction

Digestion begins in the mouth, where we taste all our food as we grind it up until it is ready to swallow. Although the essential process of digestion starts off in an enjoyable way, what happens to the food after swallowing is much less attractive. In this unit we will follow food on a journey through the digestive system.

Introducing digestion

Digestion is the process of breaking down food into smaller substances that can be used by the body. This process happens all along a 6 to 7 m tube called the alimentary canal, digestive tract or gut. Digestion starts when food is placed into the mouth and ends when waste is released from the anus. The process breaks food down into smaller and simpler substances that can pass into the bloodstream. Once absorbed, these substances are carried to the different parts of the body that need energy. There they dissolve in the water within the cells.

There are two main types of digestion:

- mechanical digestion, which occurs in the mouth when food is physically broken down or mashed into smaller pieces
- chemical digestion, which occurs at various stages along the alimentary canal, when special chemicals called enzymes chemically break down food.

Teeth

Adults have thirty-two teeth by the time they are 18 years old, with sixteen teeth in each jaw. These teeth go to work when we eat, cutting and grinding food into smaller pieces. There are several types of teeth and each type is suited to a particular job, as is shown in Figure 2.2.1.

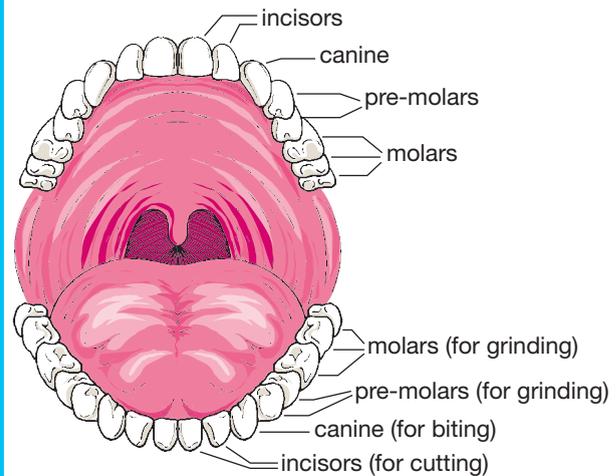


Fig 2.2.1

Different types of teeth help with different tasks.

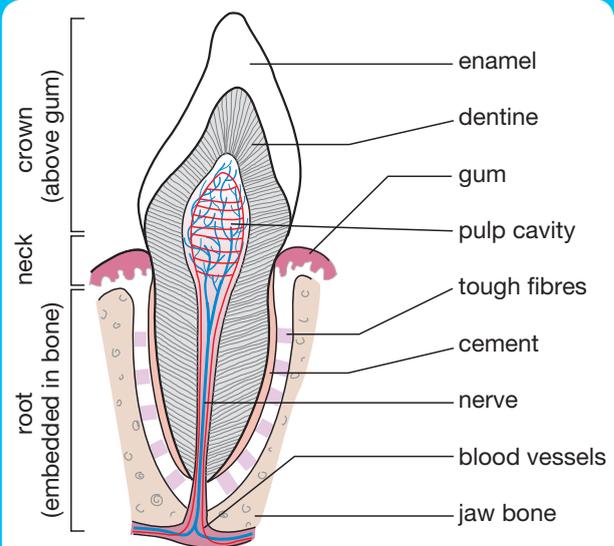


Fig 2.2.2

The structure of a tooth



Tooth decay

Tooth decay is caused by plaque—a thin film of food, saliva and bacteria that builds up on the teeth. The bacteria change sugar into acid that leaks into the enamel and causes weak spots. If untreated, these weak spots may turn into a tooth cavity that requires cleaning and filling. Regular brushing with toothpaste after each meal reduces the chances of tooth decay.

If allowed to spread, decay may enter the pulp where the nerves are. Bacteria from the cavity can cause a painful infection (a toothache), and may require root canal treatment. This involves removing the pulp and disinfecting the pulp chamber, then filling it with a rubber-like material to prevent bacteria from re-entering the tooth.

The digestive system

The digestive system consists of the digestive tract together with several attached enzyme-producing organs. The main functions of each part of the digestive system, together with the time taken for food to pass through each section, are explained on pages 36 and 41. The digestive system produces a remarkable 8 litres of digestive juices per day, as is shown in Figure 2.2.3.

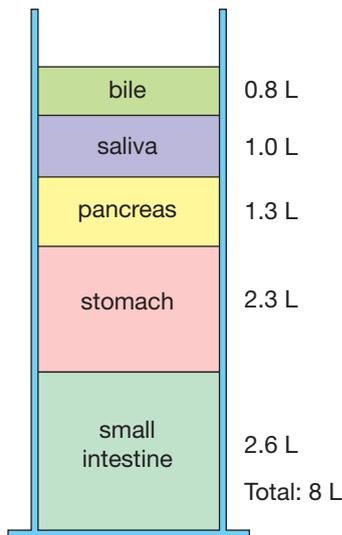


Fig 2.2.3 The digestive juices produced by the body in a day

Mouth (1 minute)

Digestion begins in the mouth. Food is ground into smaller particles by the teeth, mixed with saliva and made into a smooth lump called a bolus. Saliva contains water, mucus and the enzyme amylase, which begins to break down the very large molecules of starch into much smaller glucose molecules.

The water and mucus help make the bolus smooth so that it moves more easily when swallowed.

Oesophagus (3 seconds)

The oesophagus (pronounced O-SOFF-A-GUS), or gullet, is a 25 cm tube that connects the mouth to the stomach. A bolus is moved down the oesophagus by wave-like contractions and expansions of muscles called peristalsis. Peristalsis occurs all along the digestive tract and is the reason why food and drink can be swallowed when lying flat or even upside down. The trachea (or windpipe) branches off the oesophagus and leads to the lungs. When food is swallowed, the top of the windpipe extends slightly, and a flap called the epiglottis folds over to cover its entrance. This stops food from ‘going down the wrong way’.

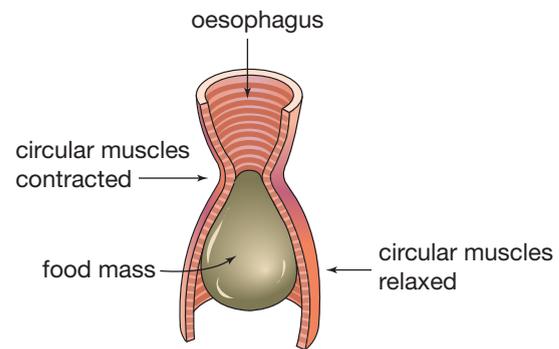


Fig 2.2.4 Food is kept moving through the oesophagus and other parts of the alimentary canal by peristalsis.

Stomach (2 to 4 hours)

The stomach is a J-shaped organ that has a capacity of about 2 litres.

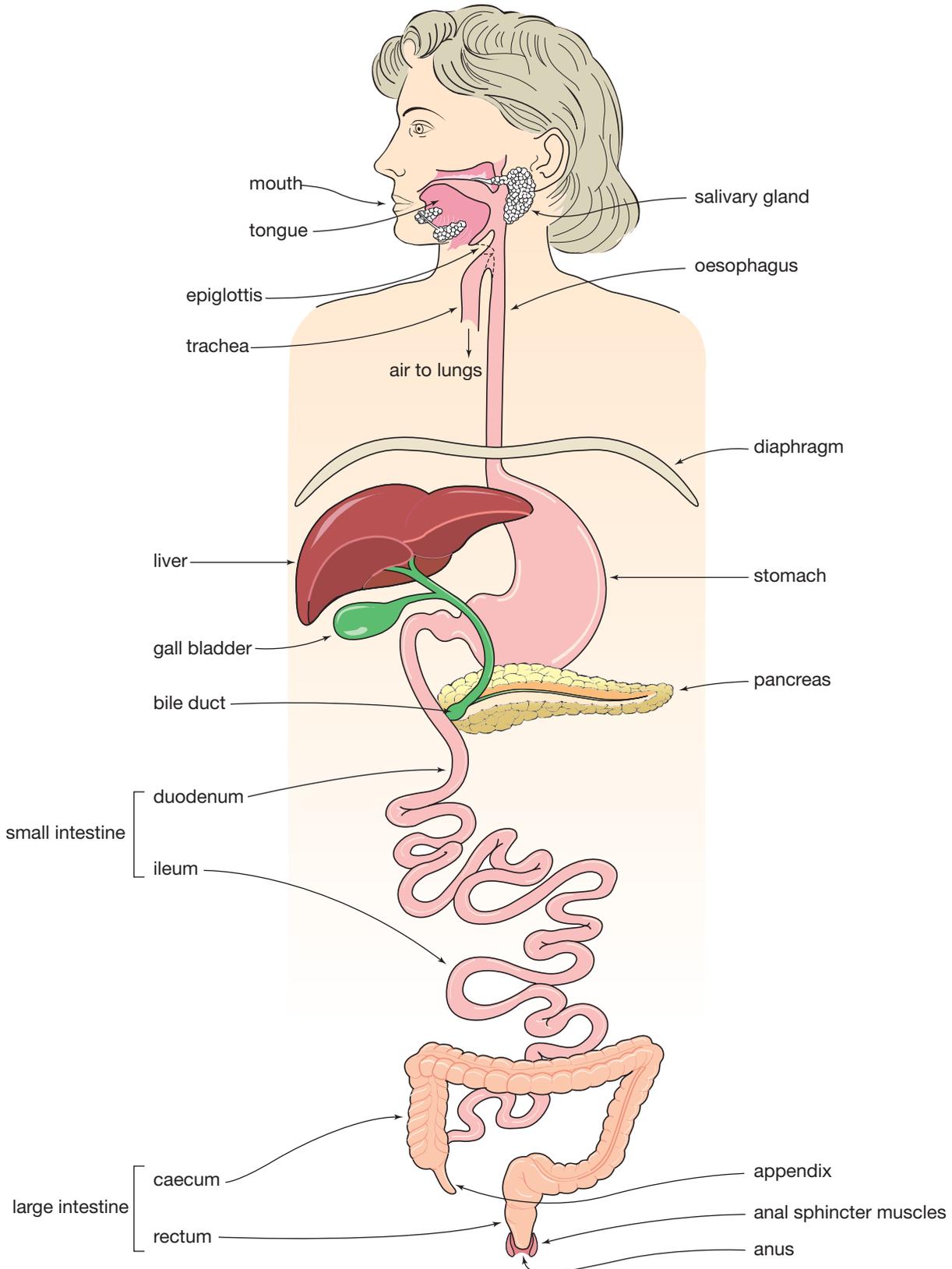


Fig 2.2.5 The human digestive system

Muscles in the stomach stir up the food, helping it to mix with gastric juice. This contains the enzyme pepsin, which helps to break down large protein molecules and fats. Hydrochloric acid in the stomach helps the enzyme and kills harmful bacteria. A mucus lining protects the stomach from the enzymes and acid. (It stops the stomach from digesting itself!)

The entrance and exit of the stomach are controlled by rings of muscles called sphincters. A sphincter at the top of the stomach ensures that acid and other stomach contents do not rise into the oesophagus. The sphincter at the bottom protects the next part of the digestive tract from acid and allows some partly digested, semi-liquid food (called chyme) to pass through every minute or so.

Pancreas

The pancreas is not part of the alimentary canal, but rather a 15 cm multipurpose ‘side attachment’. It produces pancreatic juice that contains:

- more enzymes that help digest carbohydrates, fats and proteins
- an alkali (a liquid that neutralises the acidic stomach chyme).

The pancreas also secretes into the blood a chemical (insulin) that controls the amount of sugar in the bloodstream and how cells use energy. Diabetes is a condition in which the pancreas does not produce enough insulin. People with diabetes must carefully monitor blood sugar levels and the sugar content of the foods they eat.

Gall bladder

The gall bladder, a small muscular sac about 8 cm long, stores bile produced by the liver. It can hold about 50 mL of bile.

Liver

The liver is the largest internal organ. It consists of two parts called lobes and has an extensive blood supply, which gives it a rich red-brown colour. The liver is really a chemical factory, the chemicals it produces being involved in over 500 processes in the body. It:

- converts glucose into glycogen. Digestion produces glucose, which is used by cells all around the body. Glycogen can be stored in the liver and muscles, and converted back into glucose when needed by the body.

- stores vitamins and minerals, including iron
- produces a blood-clotting chemical
- breaks down (detoxification) poisons such as alcohol
- produces about 700–1000 mL per day of bile, a green liquid that helps break down fats into smaller particles
- produces heat—the hundreds of jobs performed by the liver generate heat, which is transferred around the body by the blood.

Duodenum

The duodenum is really the start of the small intestine. About 10 cm along its length, two small tubes come together (one from the pancreas and one from the liver/gall bladder) to allow chemicals, such as bile, and enzymes to enter the small intestine.

Small intestine (1 to 4 hours)

The small intestine is the longest part of the digestive tract (4 to 6 m). It is ‘small’ because it is narrow, only 3 to 4 cm wide. Like the stomach, it contains muscles that mix food, and produces enzymes that help with the digestion of carbohydrates, proteins and lipids.

By the time food gets to the small intestine, it has been broken down enough to pass through the walls of the small intestine and into the bloodstream.

The walls of the small intestine are lined with tiny bumps called villi. Villi increase the surface area of the walls, allowing more nutrients to pass into the bloodstream. Villi contain tiny blood vessels that carry nutrients to the parts of the body that need them. Lymph vessels carry away digested fat.

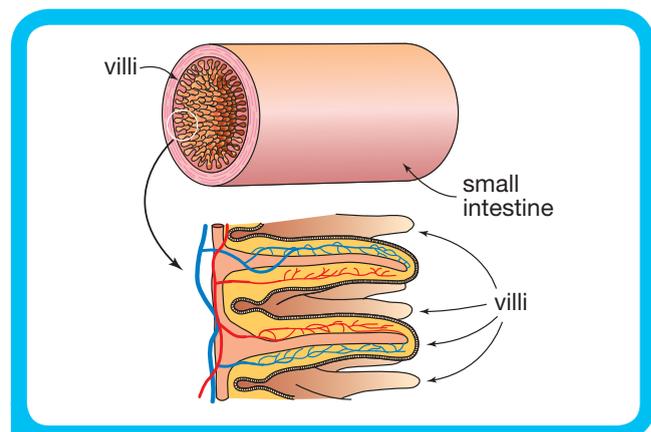


Fig 2.2.6

Villi provide an increased surface area through which digested food can be absorbed into the bloodstream.

Large intestine (10 hours to several days)

The large intestine is about 1.5 m long and 6 to 7 cm wide. It is made up of five parts—the caecum, appendix, colon, rectum and anus. Undigested waste material passes into the large intestine, where water and a few minerals are absorbed. Stools, or lumps of faeces, are removed later from the body via another sphincter muscle, the anus. About one-third of the solid component of faeces is intestinal bacteria. These bacteria have helped to break down fibre and reduce the amount of faeces expelled; they contribute to their smell.

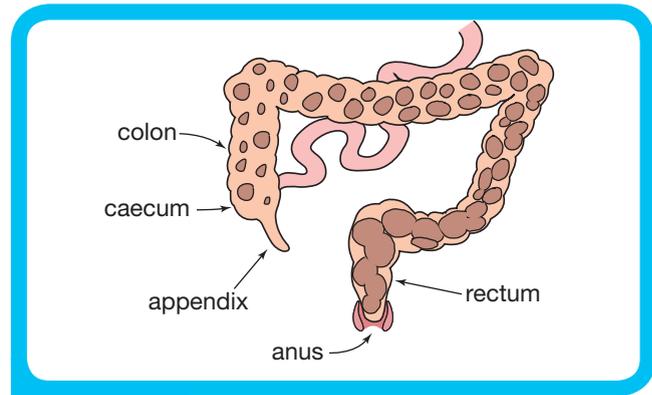


Fig 2.2.7 Faeces formation in the large intestine

Activity 6

A model intestine

Aim

To investigate how the small intestine works

Equipment

Two 500 mL beakers, two 20 cm lengths of dialysis tubing, starch solution, glucose solution, iodine solution, Testape

Method

- 1 Soak both sections of dialysis tubing in a beaker of water for a few minutes.
- 2 Tie a knot in one end of each section and rub the other ends to separate them.
- 3 Fill one tube with starch solution, tie the open end and rinse with water. Place this tube in beaker A, containing water and iodine solution as shown in Figure 2.2.9.
- 4 Fill the other tube with glucose solution, tie the open end and rinse with water. Place this tube in beaker B containing water only. Test the water in beaker B with a piece of Testape.
- 5 After 15 minutes, observe beaker A, and test the water in beaker B with Testape.
- 6 Write down any important observations.

Questions

- 1 Explain how you know when starch or glucose is present in a solution.
- 2 Describe the directions in which starch and glucose molecules were able to move and explain why this was the case.
- 3 Compare dialysis tubing with the small intestine.

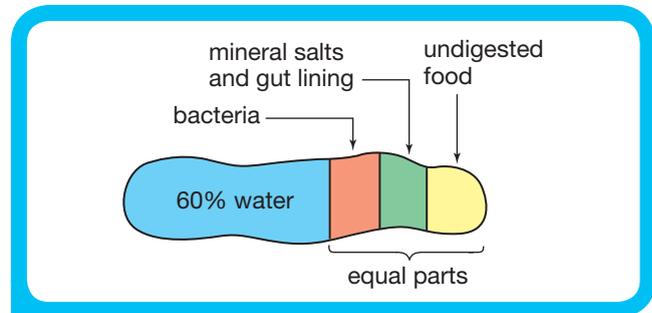


Fig 2.2.8 The composition of faeces

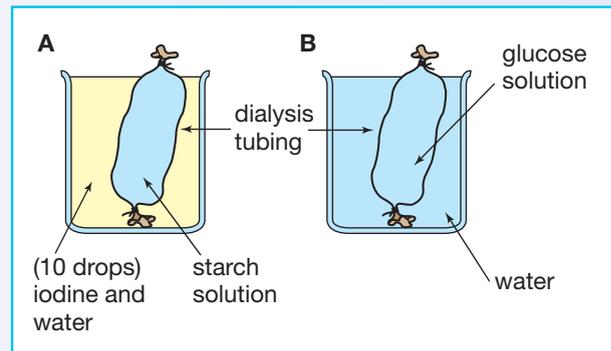


Fig 2.2.9 Apparatus set-up for investigating how the small intestine works



2.2

[Questions]

UNIT

Checkpoint**Teeth**

- 1 List the main types of teeth, and what specialist function each has.
- 2 Explain whether plaque is the same as tooth decay.
- 3 Describe how tooth decay can be prevented.

The digestive system

- 4 List the parts of the digestive system in order from start to finish. Put brackets around those parts that are 'side attachments'.
- 5 Identify the part of the digestive system that:
 - a is the longest
 - b food stays in for the longest period of time
 - c contains the caecum.
- 6 Identify the part of the digestive system in which each of the following occurs.
 - a Poisons are broken down.
 - b Water is absorbed.
 - c Starch starts to be broken down.
 - d Chyme is produced.
 - e Bile is produced.
 - f Peristalsis begins.
 - g Nutrients pass into the bloodstream.
- 7 Outline why the large intestine is shorter than the small intestine.
- 8 Outline why sphincters are necessary.
- 9 Describe the function of enzymes.
- 10 Describe how harmful bacteria are killed in the stomach.
- 11 Define the term 'chyme'.
- 12 Recall three jobs performed by the liver.

Think

- 13 Explain how chewing food for longer saves digestive time in the long run.
- 14 Explain why it is important that food is broken down into such small particles.
- 15 Explain what would happen if the small intestine was smooth, rather than covered with villi.

[Extension]

Investigate

Research the digestive systems of other animals (eg worms, sheep, cows) and compare and contrast them with the digestive system of humans.

UNIT 2.3

Blood and circulation

Introduction

What am I? You have about 5.5 litres of me and you would die without enough of me. I can be red or blue. I fight diseases and keep your toes warm. I deliver food to, and remove waste from cells, anywhere in your body. I do this through a network of highways 150 000 kilometres long. I get pushed around by an amazing pump and I am a chemical cocktail like no other. What am I? I am blood!

What is blood?

Blood carries water, oxygen and the nutrients obtained from digestion to cells around the body. It also removes carbon dioxide and waste material from those cells and maintains our body temperature. The average human body contains about 5.5 litres of blood made up of red and white

blood cells, platelets and plasma.

Red blood cells

Red blood cells are made in bone marrow. They have no nucleus, which allows them to carry more of a substance called haemoglobin.

Haemoglobin attracts and carries oxygen and contains iron, which gives it its red colour. Blood containing oxygen is bright red. Blood without oxygen is a much duller red. Red blood cells last for about 100 days. One drop of blood contains about 5 million red blood cells!

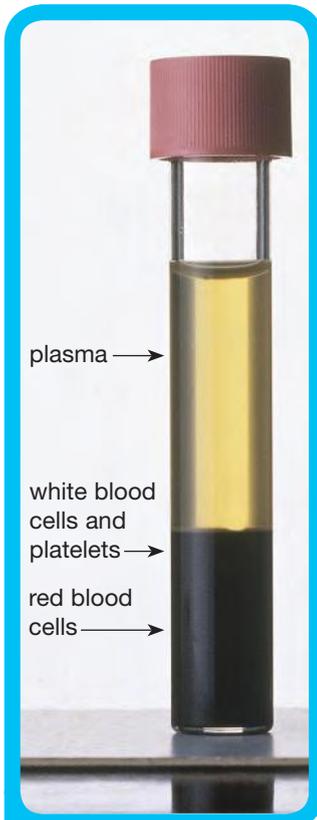


Fig 2.3.1

Blood reveals the proportion of plasma and red cells if left to settle.

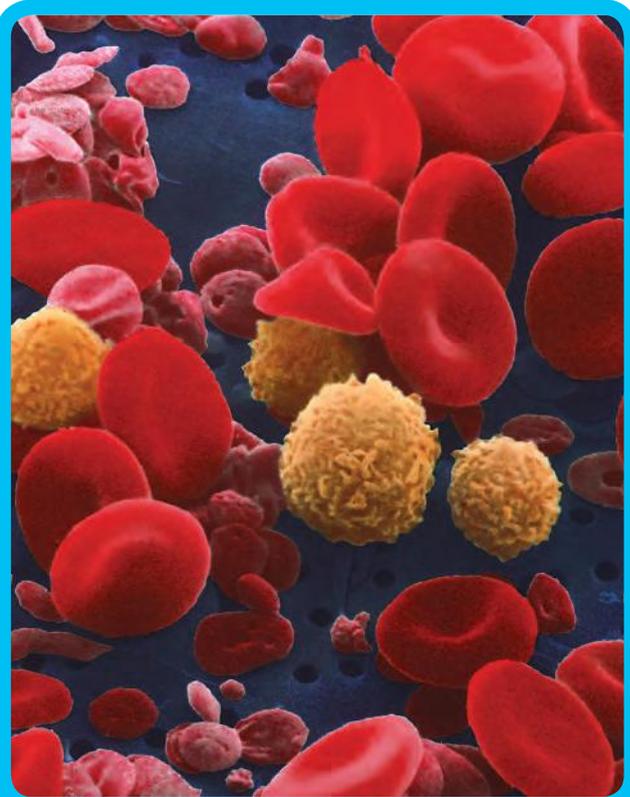


Fig 2.3.2

Blood cells and platelets. Shown are red blood cells (red), white blood cells (yellow) and platelets (pink).

White blood cells

White blood cells are bigger than red blood cells, and have a nucleus.

Our bodies have far fewer white blood cells than red ones. A drop of blood contains 'only' 3000 white cells.

White blood cells help rid the body of harmful bacteria and viruses by surrounding and destroying them, or by producing chemicals to kill them.



Activity 7

Blood cells under a microscope

Aim

To examine a prepared slide of a blood sample

Equipment

A pre-prepared microscope slide containing a blood sample, microscope and lamp

Method

- 1 Place the slide on the microscope stage, and adjust the microscope so it is just above the slide.
- 2 Adjust the microscope mirror and lamp so that the slide is illuminated.
- 3 Adjust the focus while looking through the microscope until a clear image is obtained. Remember: always move the microscope up and away from the slide.
- 4 Sketch the field of view using the lowest magnification. Include the magnification in your sketch.
- 5 Repeat using higher magnifications.

Questions

- 1 Describe in words what you observed.
- 2 Construct diagrams of what you observed.

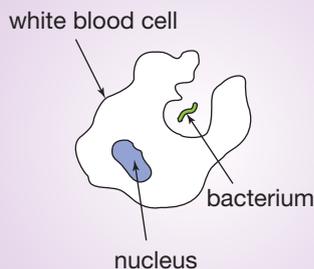


Fig 2.3.3 A white blood cell engulfs a bacterium.

Platelets

Platelets are broken-up blood cells produced in the bone marrow. They have no nucleus, and help trigger formation of fibrin strands, which help blood to clot.

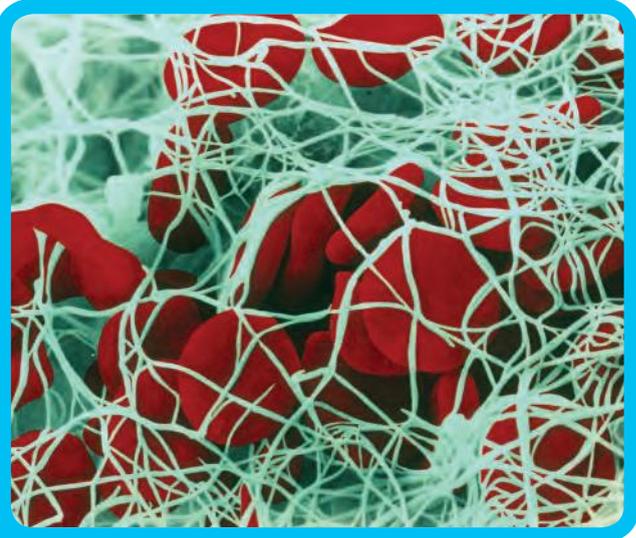


Fig 2.3.4 Clotting blood—red blood cells trapped by tiny threads of fibrin (blue)

Plasma

Plasma is a clear, yellow liquid in which red and white cells and platelets are suspended.

Plasma is 90 per cent water. The rest is dissolved food, waste products and body chemicals called hormones. Plasma helps regulate temperature by transferring heat around the body.

Blood types

There are several ‘varieties’ of human blood. For a blood transfusion to be successful, blood must be matched between the donor and the recipient.

Blood can be classified by both:

- blood type. Blood contains, at most, two types of antigen (antigen A and/or antigen B). Antigens are special chemicals involved in fighting microorganisms in the blood. Type A blood contains antigen A, type B blood contains antigen B, type AB blood contains both, and type O blood contains neither antigen A nor antigen B. The most common type of blood is type O positive
- and
- Rhesus factor. Rhesus is another type of antigen. Blood that contains the Rhesus antigen is classified as Rhesus positive, or Rh positive. Blood without the Rhesus antigen is classified as Rhesus negative.

For a blood transfusion to be safe, the donor blood must not contain any antigens that are not

already in the patient's blood, otherwise blood cells may clump together and form deadly blockages. For example, type A blood may be donated to a patient with type A or type AB blood, but not to a patient with type O blood. The Rhesus factors must also match.

The heart

The heart pumps blood around the body, beating at around 90–120 beats per minute for children and 70 for adults, though super-fit athletes may have heart rates below 30. Nerve impulses generated within the heart trigger each beat. The heart is made of a strong type of muscle called cardiac muscle and, on average, pumps about 4.5 litres of blood every minute in adults, and up to 14 litres when beating more rapidly during exercise or stress.

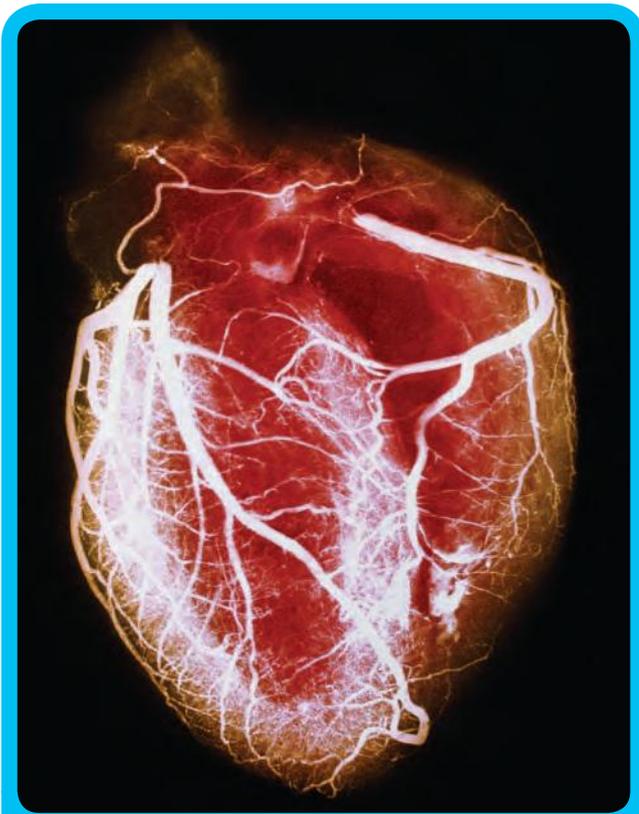


Fig 2.3.5 An X-ray of a healthy human heart showing its shape and the main blood vessels

The human heart is really two pumps joined together that do separate jobs.

One pump sends blood to the lungs to pick up oxygen. The other receives the oxygen-carrying blood and pumps it to the head and around the body.

Blood that is rich in oxygen is said to be oxygenated, while blood that has had most of its oxygen removed is deoxygenated. Both types of blood are red, but oxygenated blood is a brighter red. To show the difference in diagrams, blue is used for deoxygenated blood and red for oxygenated blood.

The main parts of the heart are illustrated in Figure 2.3.6. It may appear that the left and right sides are labelled wrongly, but they are correct—imagine the diagram cut out and pasted onto your chest.

Notice that each half of the heart, or each pump, has two main sections or chambers: the atrium, where blood enters, and the ventricle, where blood is pumped out of the heart. Special valves stop blood flowing or leaking back the wrong way.

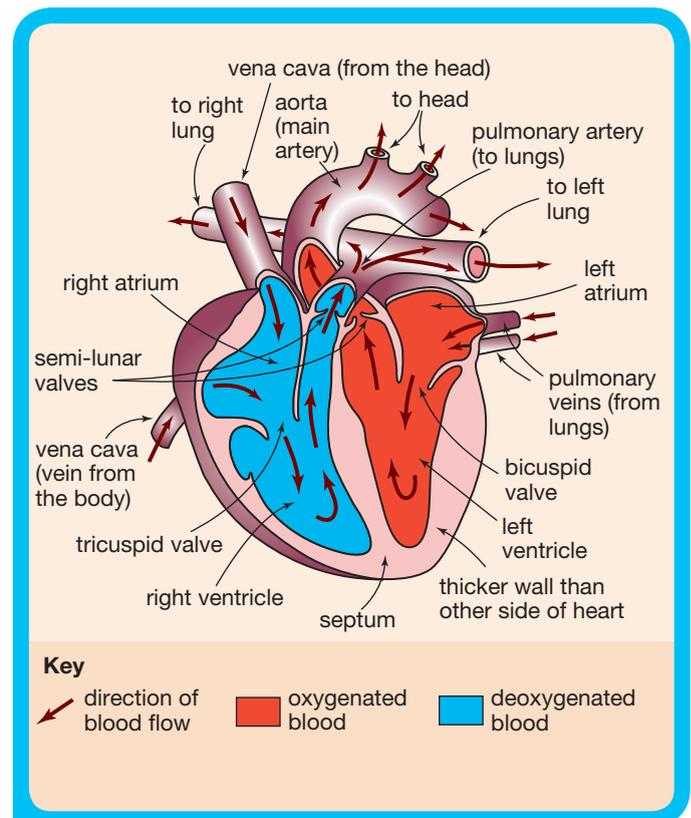


Fig 2.3.6 A cross-section of the human heart

The walls of the ventricle are thicker than those of the atrium, as they must withstand the greater pressure associated with blood being pumped out at high pressure for another circuit around the body.

Blood vessels

The adult body contains over 150 000 km of blood vessels, which are tubes in which blood is carried around the body. There are three types of blood vessels: arteries, capillaries and veins.

Arteries

Arteries carry blood away from the heart to the organs, such as the kidneys and liver, and to tissues, such as the skin and muscles. Arteries have thick elastic walls to withstand the greater pressure this requires.

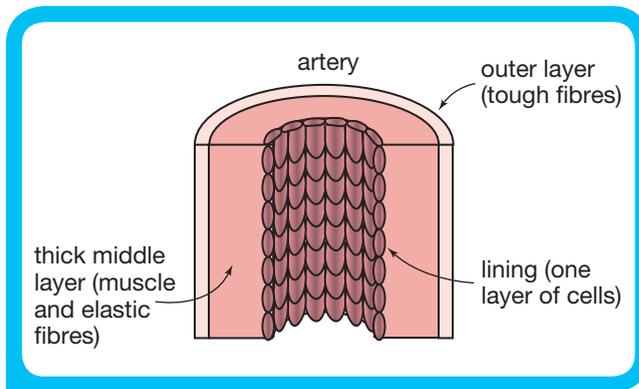


Fig 2.3.7 Cross-section of an artery

If an artery is cut, the high pressure may cause the blood to spurt and blood loss can be very rapid. A regular surge, or 'pulse', can be felt at several pressure points around the body. Here blood passes into arteries close to bones.

Activity 8

Heart rate

Aim

To examine the effect of activity on heart rate

Equipment

A watch or timer, graph paper or graphing software

Method

- 1 Find your resting pulse rate (pulses per minute), while standing, by counting the number of pulses in 15 seconds and multiplying the result by 4. Do this three or more times and average your results. Write down your average resting pulse rate.
- 2 Repeat step 1 while:
 - a lying down
 - b sitting.
- 3 Gently jog or run on the spot for 3 minutes (don't overdo it!). Stop and immediately measure your pulse rate.
- 4 Keep resting and each minute measure your pulse rate until it doesn't get any lower. Record all your results in a table like the one below.

Time after end of jog (minutes)	0	1	2	3	4	5	6	7	8	9
Pulse rate (per minute)										

Questions

- 1 Construct a bar graph of your results for steps 1 and 2 above.
- 2 Construct a line graph for the results in your table for steps 3 and 4.
- 3 State how long your pulse rate took to return to normal.
- 4 Compare your results with those of classmates.
- 5 Account for any differences in results.



Fig 2.3.8 How to measure pulse rate

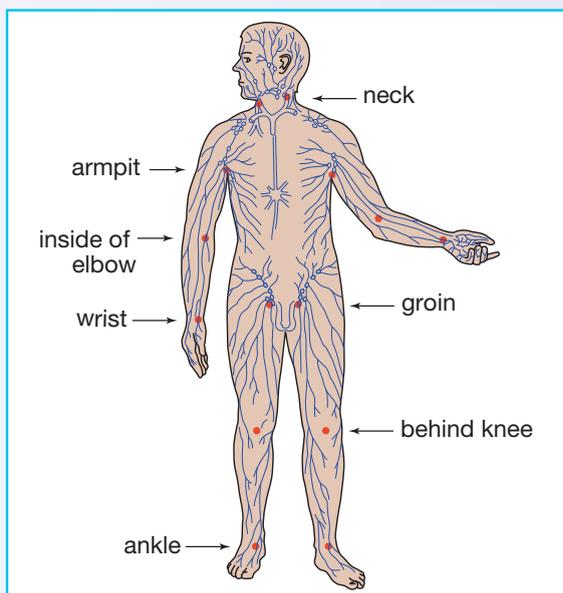


Fig 2.3.9 Pulse pressure points

Capillaries

The arteries divide and connect with smaller tubes which eventually connect with fine tubes called capillaries, which are only one cell thick.

Capillaries lie close to body cells and allow nutrients and oxygen to pass out and then into nearby cells. Waste products from cells pass back into capillaries to be carried away.

Capillaries are the most numerous type of blood vessel and service virtually every tissue.

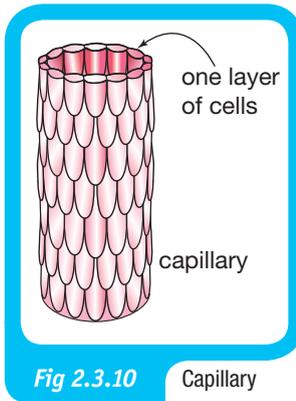


Fig 2.3.10 Capillary

Because it is at the end of a 'circuit', blood in veins is at low pressure. Hence the wall of veins do not need to be as thick as those of arteries. Valves in veins stop blood flowing back the wrong way.

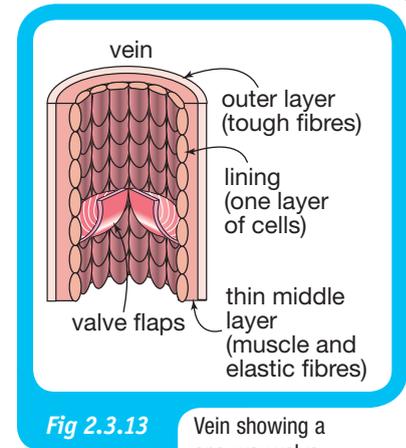


Fig 2.3.13 Vein showing a one-way valve

Blood pressure

You may have heard people discuss their blood pressure. High blood pressure or hypertension may be caused by stress, and increases the risk of heart attack. When blood pressure is measured, two readings are taken. One is taken when the heart contracts (called systolic blood pressure), the other when the heart relaxes (called diastolic blood pressure).

A typical pair of readings for adults is about '120 over 80' (systolic = 120 and diastolic = 80) on the most common scale.

The circulatory system

The heart, arteries, veins and capillaries all combine to form the circulatory system, illustrated in Figure 2.3.14 (on the next page), which transports oxygen, carbon dioxide, digested food, chemicals and heat around the body.

Coronary heart disease and heart attack

Coronary arteries branch off the aorta and supply the heart muscle itself with blood. These can become narrow due to a build-up of fat and a chemical called cholesterol, which is transported in the blood. If the narrowing reduces blood flow enough, it may lead to a condition known as angina (insufficient supply of oxygen and glucose to the heart), the symptoms of which include pressure-like chest pain. Angina may also be triggered by exertion or emotional stress. When a coronary artery becomes blocked, the region of heart muscle it supplies dies—this is called a heart attack. The severity of a heart attack depends on the size of the area affected and the condition of the other arteries.

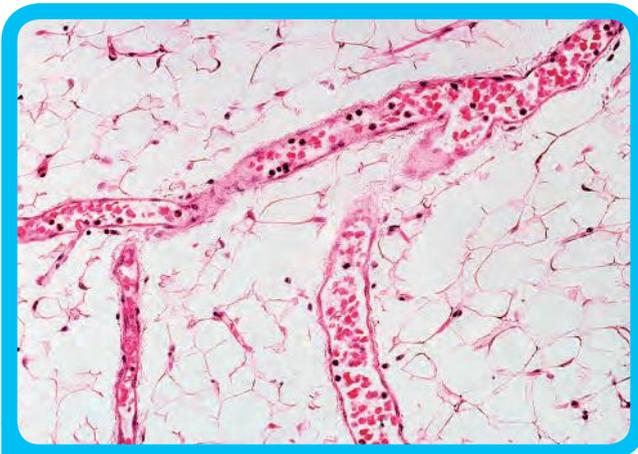


Fig 2.3.11 Blood flow in a capillary

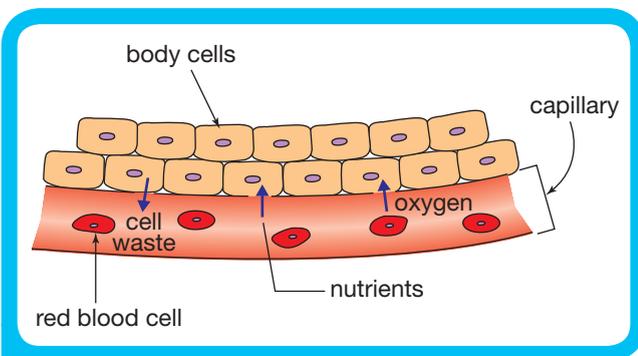


Fig 2.3.12 Flow of materials into and out of a capillary

Veins

Capillaries then join with wider tubes called veins, which allow blood to return to the heart, ready to be pumped to the lungs for another load of oxygen.

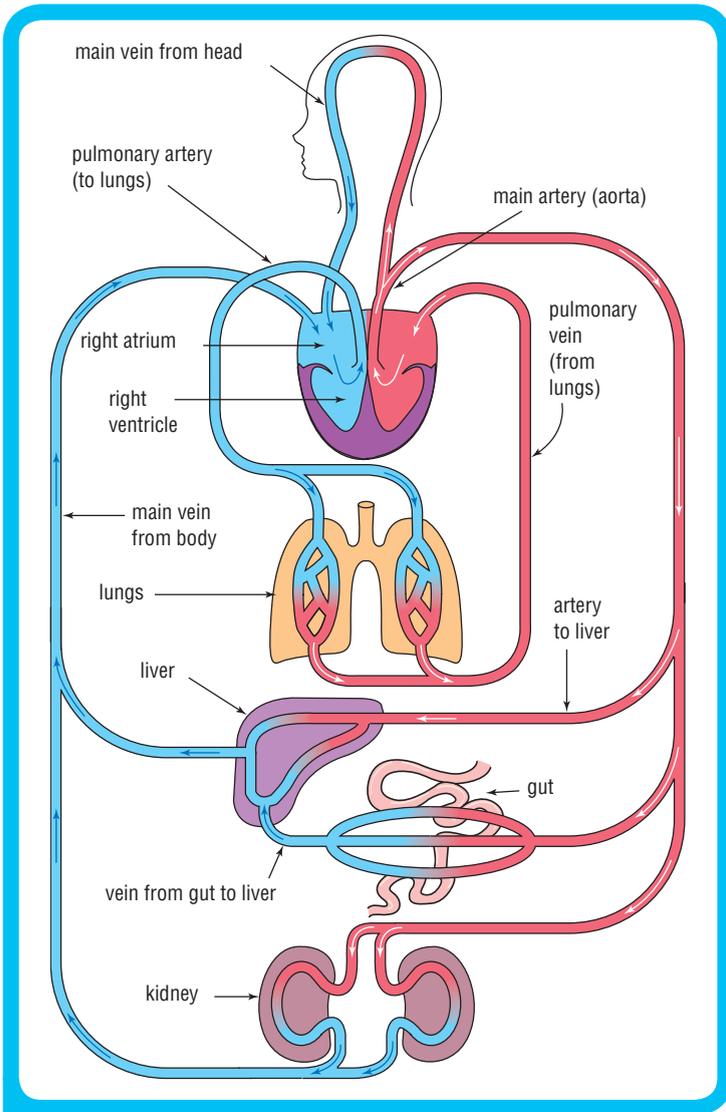


Fig 2.3.14 A schematic diagram of the circulatory system

If it is discovered that a person has a dangerously narrowed artery, the risk of a heart attack may be reduced by various medical procedures.

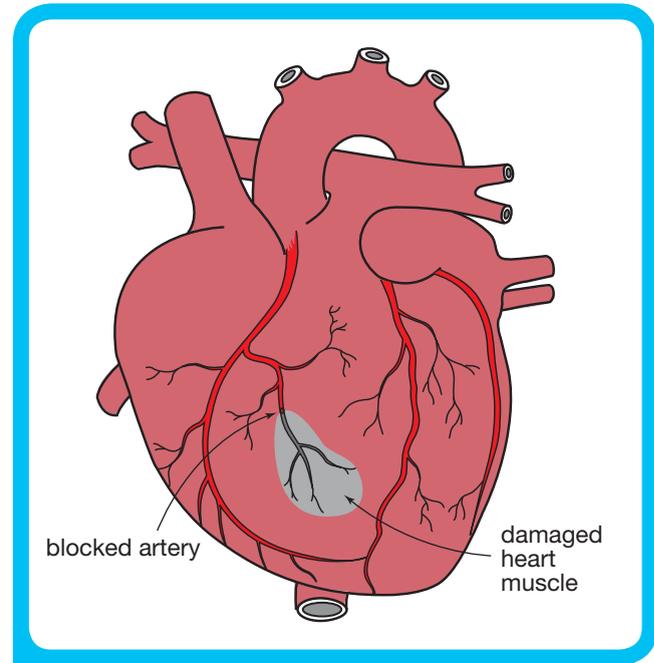


Fig 2.3.16 The shaded region shows the area of the heart damaged due to lack of blood supply.

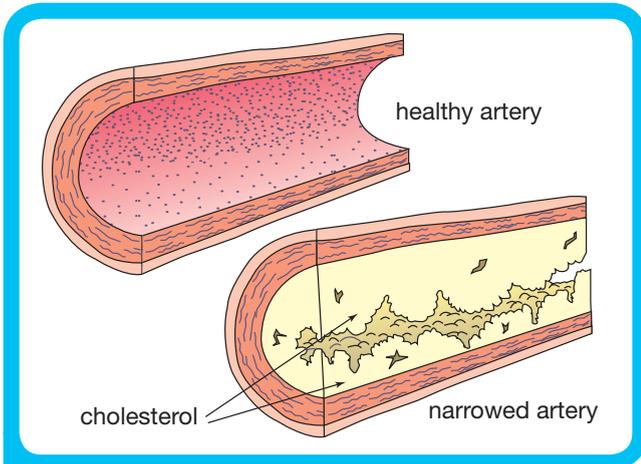


Fig 2.3.15 A healthy artery and a narrowed artery

2.3 [Questions]

UNIT

Checkpoint

What is blood?

- 1 List five things carried by blood.
- 2 Contrast a red blood cell with a white blood cell.
- 3 Outline the function of a white blood cell.
- 4 State the name of the part of blood that helps clotting.
- 5 Define the term 'plasma'.
- 6 Recall the name of a gas that is carried by red blood cells.
- 7 State which type of blood cell has a nucleus.
- 8 State whether the following are true or false.
 - a There are three antigens.
 - b Blood may be Rh positive or Rh negative.
 - c Blood type AB contains both A and B antigens.
 - d Blood having no Rhesus antigen is called Rh negative.
- 9 Propose one advantage of blood being red.

The heart

- 10 Outline what happens in:
 - a the aorta
 - b the pulmonary vein
 - c a ventricle
 - d an atrium.
- 11 State the name of the type of muscle that the heart is made of.

Blood vessels

- 12 Recall the names of the three types of blood vessels.
- 13 Identify the name of the blood vessel that carries blood at the lowest pressure.

Coronary heart disease and heart attack

- 14 Outline what is meant by a heart attack.

Think

- 15 Explain why arteries spurt when cut, but veins don't.
- 16 Identify the parts labelled a to i in Figure 2.3.17.
- 17 Explain why the heart beats faster when you are running.
- 18 Explain how you might minimise the chance of a heart attack.
- 19 Explain why the left ventricle has thicker walls than the right ventricle.

Analyse

- 20 Copy and complete the table below to identify which blood types may be donated to which patients.

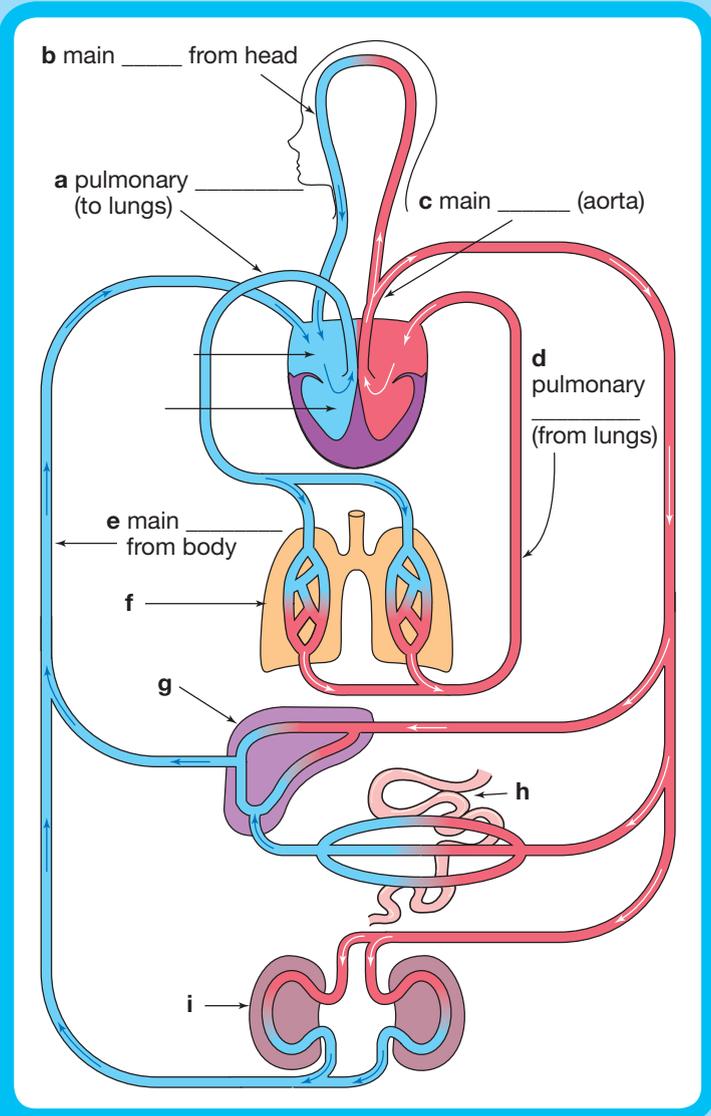


Fig 2.3.17

Patient's blood	Donor's blood			
	A	B	AB	O
A	Yes	No	No	
B				
AB	Yes			
O				

UNIT 2.4

Excretion: getting rid of wastes

Introduction

When you hear the terms 'body waste' and 'excretion', you probably think of the solid waste—faeces, which exit from the anus when we go to the toilet. As well as solid waste, however, we get rid of liquid and gaseous waste, although we get rid of them in different ways.

If your body fails to get rid of these different wastes you will become very ill.

Introducing excretion

A build-up of any waste in the body can be harmful. Excretion is the removal of waste from the body. Even right now, as you read this book, you are excreting waste! You are breathing out, removing the carbon dioxide from your lungs and bloodstream. Along with water, carbon dioxide is a waste product of the respiration happening in your cells.

A waste product that is harmful if allowed to build up is urea, produced by the liver after protein has been digested. Protein is needed for growth and repair, but excess protein is broken down into simpler substances, the main one being urea. Urea passes into the bloodstream, from where it travels to the kidneys to be filtered out with excess water and other waste products in the blood.

Activity 9

Kidney dissection

Aim

To dissect a kidney and observe its structure

Equipment

Newspaper, chicken kidney, dissecting board, scalpel, disposable gloves

Method

- 1 Try to find the ureter in the middle of the kidney, and cut lengthwise as shown in Figure 2.4.1.
- 2 Sketch the inner structure of the kidney.

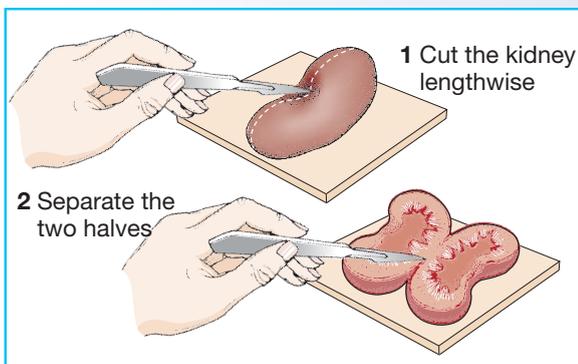


Fig 2.4.1 Dissecting a kidney

Questions

You might need to read ahead to find the information to answer these questions.

- 1 Explain the purpose of fat around the kidney.
- 2 Compare the chicken kidney with a human kidney.

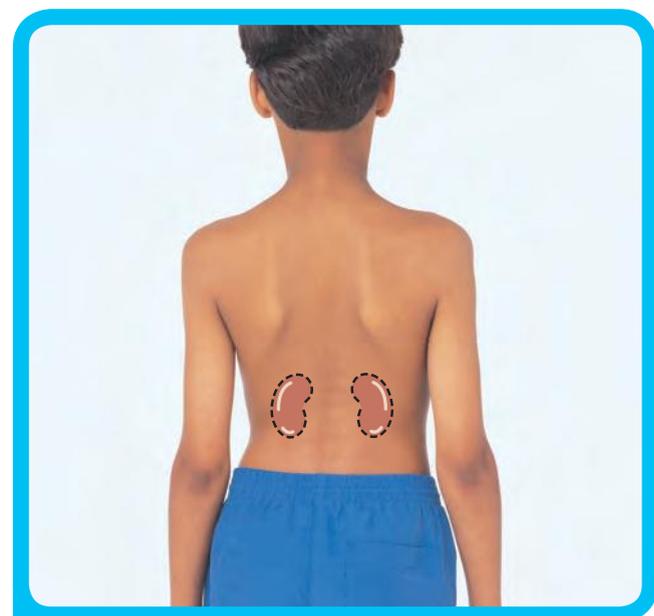


Fig 2.4.2 The location of your kidneys

The kidneys—our filtration plants

Kidneys are red-brown, bean-shaped organs about the size of a fist, which filter an amazing 1.3 litres of blood every minute. This is about a quarter of the blood pumped by your heart! Your kidneys are located at about elbow level, towards the back of your abdomen.

Each kidney contains over a million tiny filtration units called nephrons. About 1 mL of blood per litre is filtered out as waste liquid, or urine. Urine is produced at the rate of a drop per minute, or one to two litres per day. Urine consists of about 95 per cent water and 5 per cent urea, as well as small amounts of salts and other substances such as bile, which gives urine its yellow colour.



Fig 2.4.3 X-ray showing kidneys (purple, top left and right) and two ureters leading down to the bladder (yellow, lower centre)

Urine travels down 20 cm long tubes called ureters to a muscular storage bag—the bladder, which has a maximum capacity of about one litre. However, when the bladder contains about 300 mL of urine, nerve sensors in its walls send messages to the brain that result in the urge to urinate—that is, allow urine to drain from the bladder out of the body through the urethra.

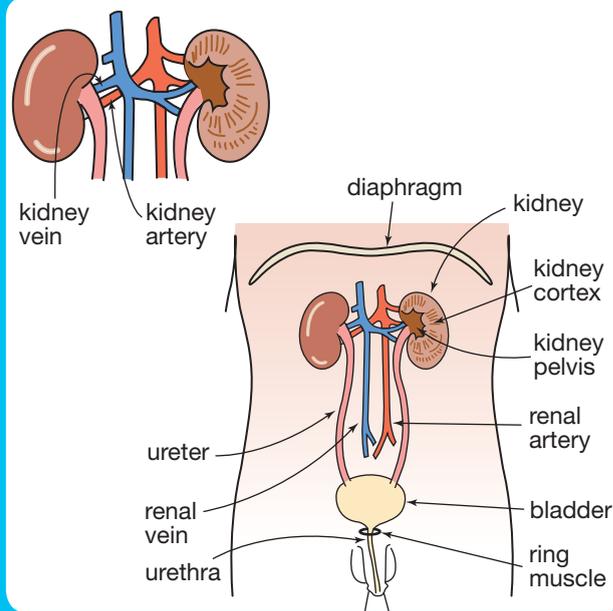


Fig 2.4.4 The urinary system

Kidney stones

Sometimes concentrated substances in urine may crystallise into small, solid particles called kidney stones within the kidneys, ureters or bladder. Kidney stones can cause extreme pain. Often kidney stones will pass out of the body, though in some cases surgical procedures, based on the properties of sound, are used. They are:

- ultrasound—stones are broken up and removed by the direct application of ultrasound waves
- Extracorporeal Shock-Wave Lithotripsy (ESWL)—stones are shattered and are passed out of the body in the urine.

No surgery is required in either method.

One way to reduce the risk of kidney stones is to drink at least a litre of water every day.

Kidney failure

We can lose the function of a single kidney and still continue a normal life with one healthy kidney, but if both kidneys fail, the situation is life-threatening due to the build-up of poisonous wastes in the blood. In this case, options for survival include a kidney transplant or dialysis. A transplant is most likely to be successful if a close relative donates a kidney.

Dialysis is the filtering of blood by a machine, and must be performed regularly (usually three times per week for three to eight hours).



Fig 2.4.5 A dialysis machine removes waste from blood.

2.4 [Questions]

UNIT

Checkpoint

Introducing excretion

- 1 Define the term 'excretion'.

The kidneys—our filtration plants

- 2 Outline how the following wastes are produced:
 - a carbon dioxide
 - b water
 - c urea.
- 3 Explain how waste products get to the lungs and kidneys.
- 4 State how much blood kidneys can filter in an hour.
- 5 Recall how many nephrons are in a kidney.

Think

- 6 Identify the body part that matches each function.

Body part	Function
Circulatory system	Filters blood
Kidney	Allows urine to reach storage area
Ureter	Tube that allows urine to leave the body
Bladder	Urine storage
Urethra	Transports wastes and nutrients

- 7 Explain why people urinate more in cold weather.
- 8 A urine sample can tell a doctor quite detailed information about your health. Explain why.

- 9 Compare the amount of urine that an average-sized bladder can hold with the amount of urine that makes you feel an urge to urinate.
- 10 Explain why the movement of a kidney stone can cause extreme pain.
- 11 Explain why drinking lots of water should reduce the risk of a kidney stone.
- 12 If someone donates a kidney to someone with kidney failure, both are left with one healthy kidney. Explain how both people can live normal lives.

[Extension]

Investigate

- 1 Research in more detail how a kidney works. Include the function of a Bowman's capsule. Create a cartoon strip or series of diagrams to show what happens as blood is filtered by the kidneys.

Action

- 2 Design an experiment to investigate the effects of various foods on urine.

UNIT 2.5

Respiratory systems

Introduction

You can't hold your breath for too long when you dive under water. Your body will tell you that it needs more air in the lungs. The air is needed to supply oxygen that is transported around the body by your circulatory system. The cells in your body need this oxygen for respiration. Respiration produces carbon dioxide. A respiratory system is needed to provide oxygen to, and remove carbon dioxide from, these cells.

The human respiratory system

You have seen in Unit 2.3 that blood in the circulatory system carries nutrients and oxygen to cells, and waste products such as carbon dioxide away from cells.

Where does the blood get the oxygen from, and where does it take the carbon dioxide to? This is the job of the respiratory system, which consists of the lungs and associated structures. You breathe between twelve and twenty-four times per minute, for the most part unconsciously. This rate can vary with age, physical activity and your mood. Each breath exchanges about 500 mL of air. The maximum amount of air you can breathe out (exhale) after taking a deep breath (inhale) is called the vital capacity of your lungs. It is normally around 4500 mL, but may be as high as 6500 mL in a well-trained athlete. The composition of inhaled and exhaled air varies, because gases are exchanged between the lungs and your bloodstream.

Activity 10

Inhaled and exhaled air

Aim

To investigate the gases that are in inhaled and exhaled air

Equipment

Flasks and glassware as shown in Figure 2.5.1, limewater

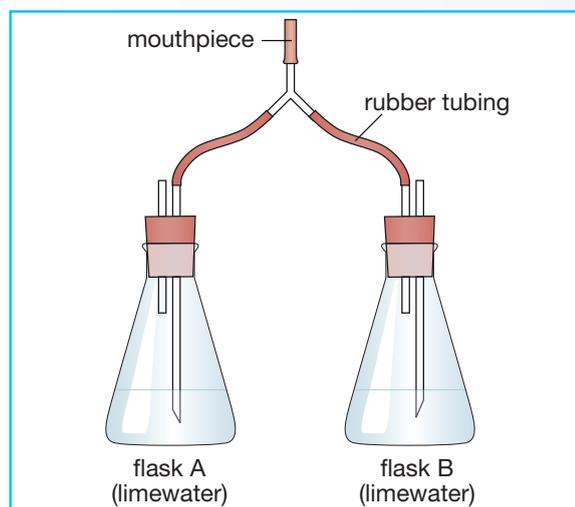


Fig 2.5.1 Apparatus set-up for comparing inhaled and exhaled air

Method

- 1 Set up the apparatus as shown in Figure 2.5.1. Be sure to check that your set-up exactly matches the diagram. Note that only one of the tubes connected to the mouthpiece extends below the level of the limewater.
- 2 Inhale and exhale continuously for several minutes without removing your lips from the mouthpiece.
- 3 Record any changes in the colour of the limewater in flasks A and B.
- 4 Use a disposable straw as the mouthpiece if the equipment is to be used by more than one person.

Questions

- 1 Explain any changes in flask A.
- 2 Explain any changes in flask B.

Percentage composition of inhaled and exhaled air

	Inhaled air	Exhaled air
Nitrogen	79.0	79.5
Oxygen	21.0	14.0
Carbon dioxide	0.04	5.6
Water vapour	Varies with location	Fully saturated

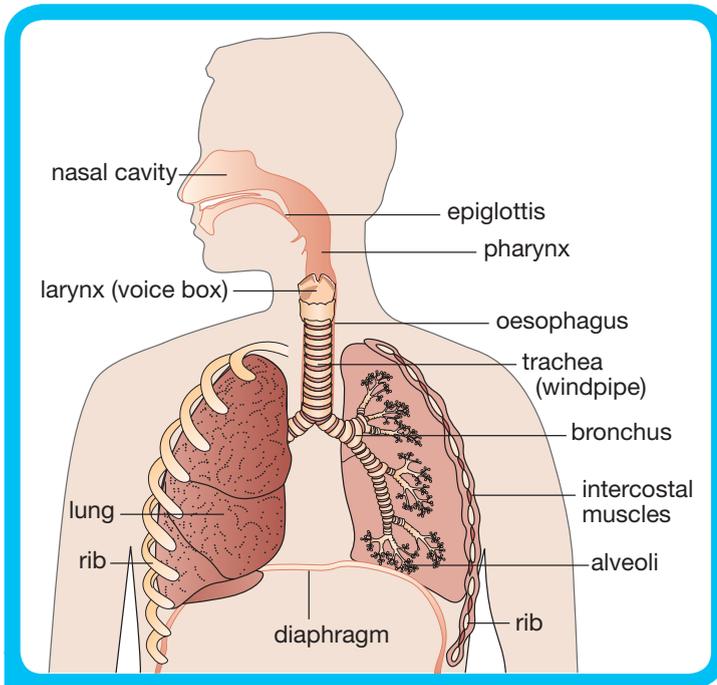


Fig 2.5.2 The human respiratory system

Although air can sometimes enter the respiratory system through the mouth, most inhaled air enters via the nose. Here it is filtered, moistened and warmed. Nostril hairs filter out larger particles, and tiny hair-like cilia on the inside of the nose trap fine particles.

The nose is lined with glands that produce sticky mucus to trap dust particles. The mucus and trapped particles move to the back of your nose and into the pharynx. We swallow around 600 mL of this mucus per day without usually being aware of it.

From the pharynx, air enters the trachea (windpipe), a thin-walled tube with about the same diameter as a garden hose. At the top, the epiglottis, a flap of tissue, stops food entering the trachea. The larynx (voice box) also helps stop food entering. Coughing and sneezing are both reflexes to further protect the trachea.

The trachea branches into two main bronchi, which branch successively into smaller and smaller tubes. At the end of the smallest of these tubes (bronchioles), air enters clusters of sacs, the alveoli. Gas exchange in and out of the blood takes place here. The entire system of tubes is lined with cilia, which beat upwards to send foreign material back to the pharynx to be coughed out or swallowed.

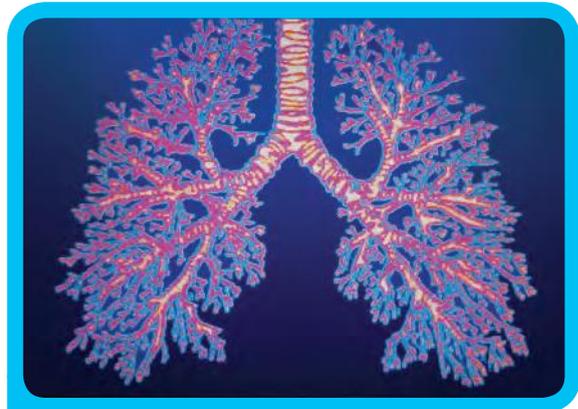


Fig 2.5.3 The respiratory tree—the trunk is the trachea (top, centre) that branches into the bronchi. Smaller branches (bronchioles) end in the alveoli.

Alveoli are sacs with walls only one cell thick. There are around 500 million of these in your lungs, with a total surface of about 80 square metres. Each alveolus lies close to the wall of a capillary. These are also one cell thick, so there is only a short distance for gases to travel between the lungs and the bloodstream. The network of capillaries in the lungs is so large that at any one time, 20 per cent of the total blood volume is in the lungs.

Inside the alveoli, oxygen moves across through the thin walls of the tiny capillaries and into the blood. Once in the blood, oxygen is carried by red blood cells in a special carrier called haemoglobin. Haemoglobin allows much more oxygen to be carried in blood than if it was simply dissolved. At the same time dissolved waste gas—carbon dioxide—comes out of the capillaries back into the alveoli, ready to be breathed out. This gas exchange is shown in Figure 2.5.5.

Replacement of the air is the result of breathing. Breathing is a physical process and is clearly different from respiration, which is a chemical reaction. Normally, you breathe without thinking about it, but you can alter the rate and depth of breathing with conscious effort. Take a deep breath. Notice that your ribs move up and out. This occurs due to the action of muscles in the chest (the intercostals) and the diaphragm. The diaphragm is the sheet of muscular tissue that separates the chest from the abdomen. The larger space in the chest causes a pressure decrease, so air rushes into your lungs. Now breathe out. Air is forced out as the chest returns to its normal size.

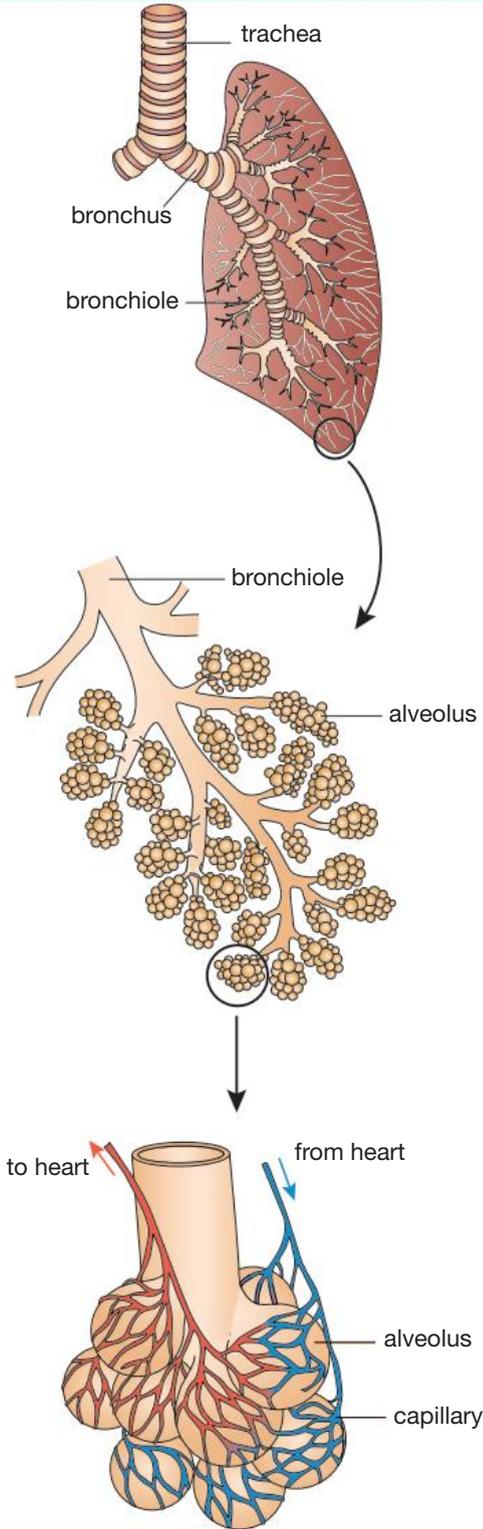


Fig 2.5.4 The respiratory tree, alveoli and blood vessels

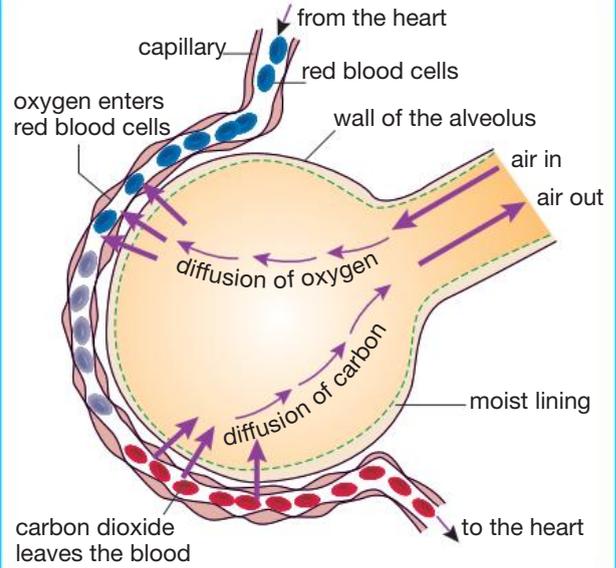


Fig 2.5.5 Gas exchange in the alveolus

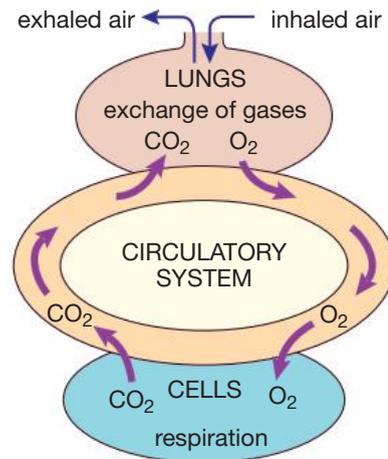


Fig 2.5.6 Movement of respiratory gases

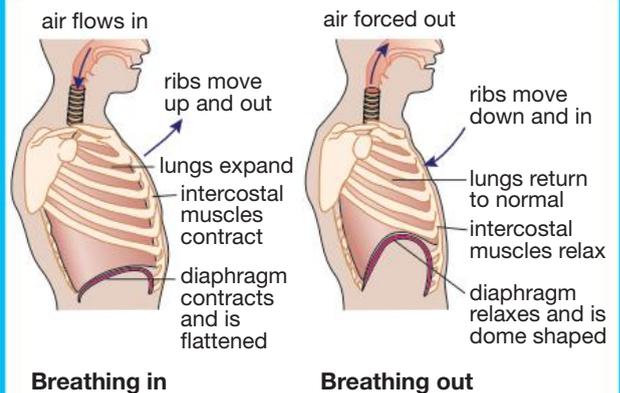


Fig 2.5.7 Breathing movements



2.5

[Questions]

UNIT

Checkpoint

The human respiratory system

1 Identify the structure that relates to each function.

Structures	Functions
Trachea	Filters, warms and humidifies air
Epiglottis	Removes foreign particles from the lungs
Nose	The site of gas exchange
Cilia	Carries air to and from the lungs
Alveolus	Prevents food from entering the trachea

- Recall two structures that prevent food from entering the trachea.
 - Describe what happens if some food finds its way into the trachea.
- Recall the name of the special structures that give the lungs their very large internal surface area.
- Identify the part of the blood that contains haemoglobin.
 - Outline the function of haemoglobin.

Think

- Outline what happens to each of the following when you breathe in:
 - diaphragm (contracts or relaxes?)
 - chest cavity (enlarges or becomes smaller?)
 - ribs (raised or lowered?)
 - intercostal muscles (contract or relax?)
 - pressure in the chest cavity (increases or decreases?).
- Explain why it is important that lungs have a large internal surface area.
- Describe three features needed for effective gas exchange.
- For each of the following gases, assess whether the proportion of the gas in exhaled air is greater than, less than or about the same as the proportion in inhaled air:
 - nitrogen
 - oxygen
 - carbon dioxide
 - water vapour.
- Explain why is it better to breathe through your nose than through your mouth.
- A diagram of the human respiratory system is shown in Figure 2.5.8. Identify each of the structures labelled **a** to **h** on the diagram using the following list of terms: diaphragm, larynx, epiglottis, nasal cavity, trachea, bronchus, intercostals, alveolus.

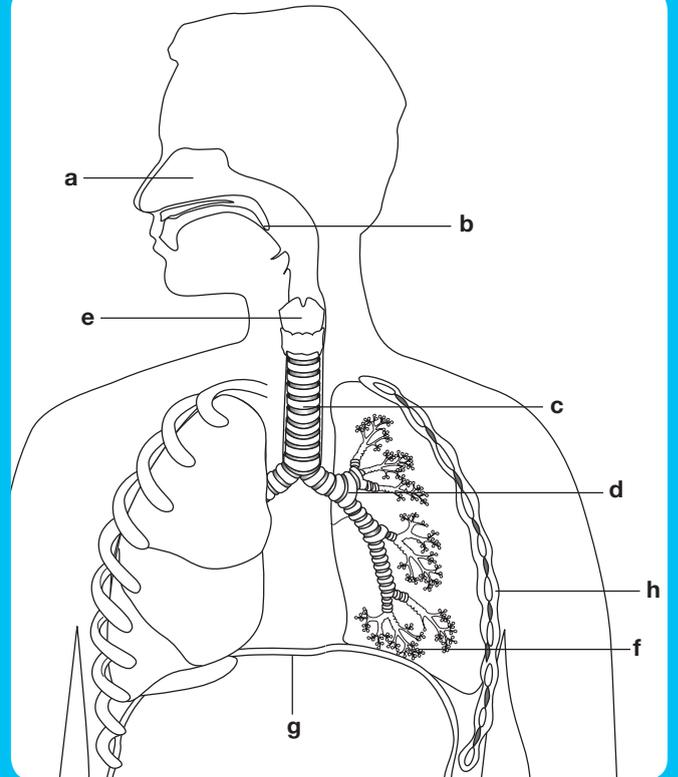


Fig 2.5.8

- A diagram of part of the human respiratory system is shown in Figure 2.5.9.
 - Identify structure X.
 - Outline the function of structure X.
 - Identify structure Y.
 - Outline the function of structure Y.

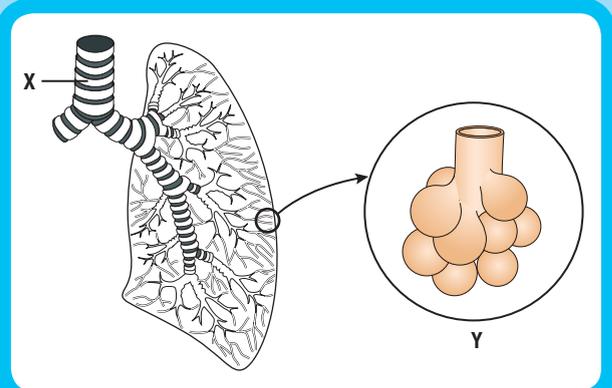


Fig 2.5.9



- 12 The apparatus shown in Figure 2.5.10 is sometimes used as to model what happens when you breathe.
- a Identify the apparatus that best fits with the body part it represents in the following table:

Apparatus	Body parts
Plastic tube	Chest
Balloons	Trachea
Bell jar	Diaphragm
Rubber floor	Lungs

- b Explain why the balloons inflate when the floor is pulled down.
- c Contrast this model with the way you breathe.

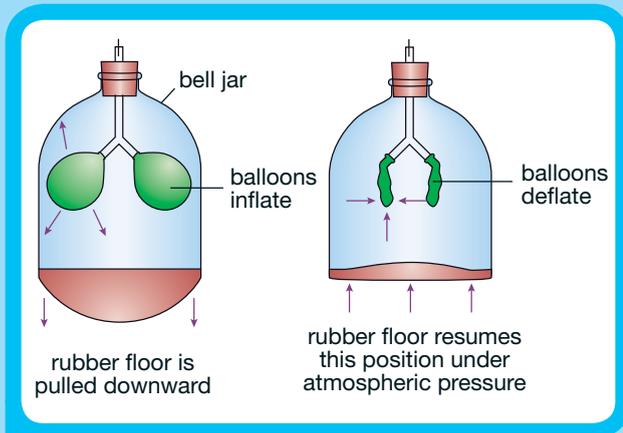


Fig 2.5.10

Analyse

- 13 Figure 2.5.11 shows a diagram of an alveolus and a capillary.
- a Identify which gas diffuses in the direction of A to B.
- b Recall what the gas joins onto when it enters a red blood cell.
- c Discuss whether it is better to have the gas joined to a substance in the blood, or simply dissolved in the blood.

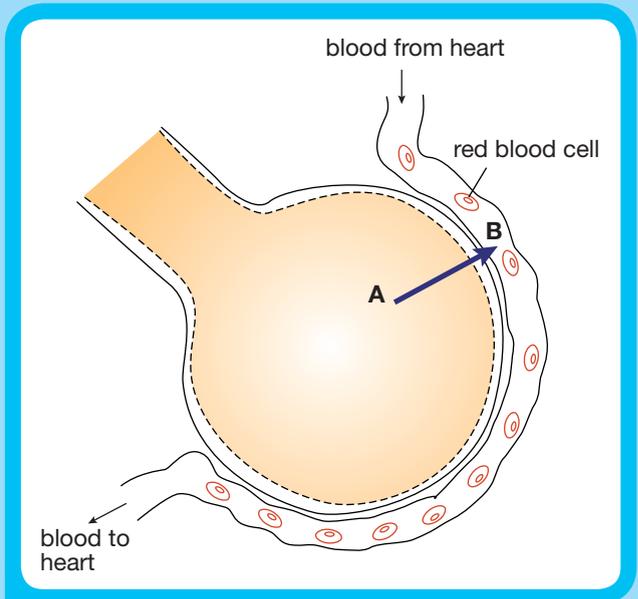


Fig 2.5.11

Chapter review

[Summary questions]

- 1 Identify the nutrient that matches each description.

Descriptions	Nutrients
High in energy.	Carbohydrates
Our main source of energy. Converted to glucose during digestion.	Water
Required in small amounts for good health.	Protein
Provides bulk to move waste through intestines.	Lipids
Required for growth.	Fibre
Not a nutrient, but required for chemical reactions in the body.	Vitamins
Chemically simple, required for good health, provides no energy.	Minerals

- 2 Identify the vitamin deficiency leading to the following diseases:

- a beriberi
b rickets
c scurvy
d pellagra.

- 3 List three:

- a trace elements
b major elements.

- 4 Recall the number of teeth an adult normally has.

- 5 Explain the difference between a normal tooth cavity filling and root canal treatment.

>>

6 Identify each part of the body system shown in Figure 2.6.1.

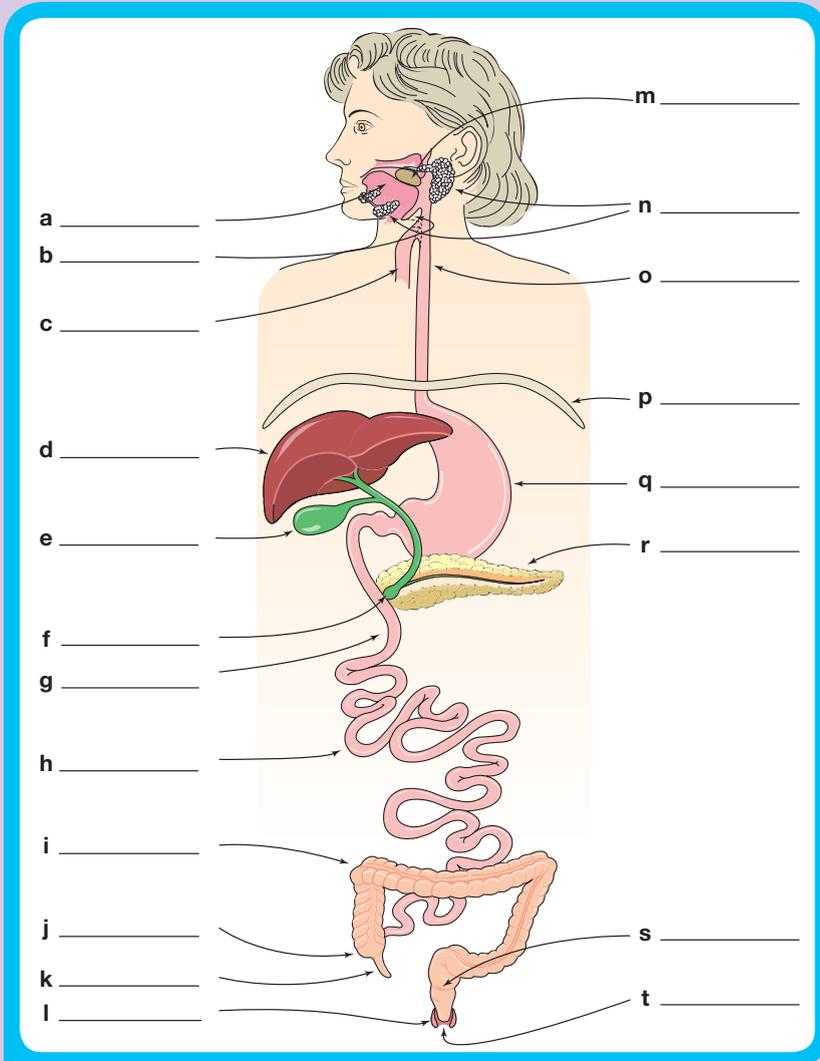


Fig 2.6.1

7 Identify the description that matches each part of the digestive system.

Parts of digestive system	Descriptions
Oesophagus	Connects mouth to stomach.
Gall bladder	Digestion begins here.
Small intestine	Like a cement-mixer for food and gastric juices.
Large intestine	Produces enzymes that help digest carbohydrates, fats and proteins.
Duodenum	The body's chemical factory.
Mouth	Stores bile.
Liver	Start of small intestine.
Stomach	Where most absorption of nutrients occurs.
Pancreas	Where water is absorbed.

8 Label the following diagram.

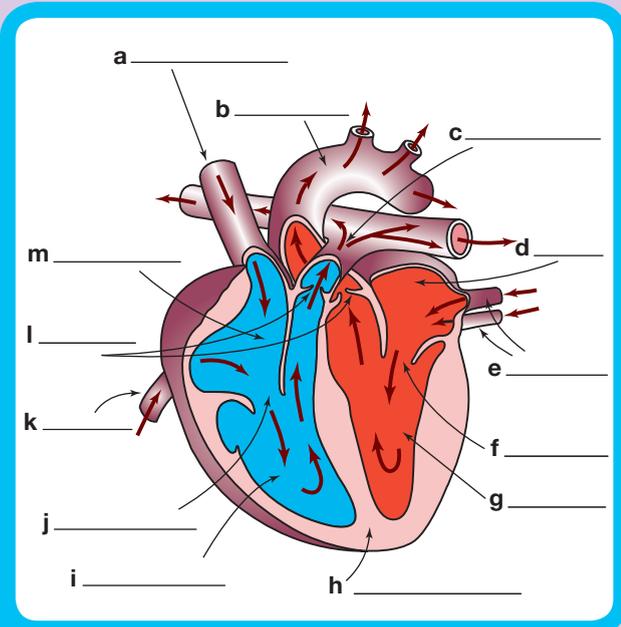


Fig 2.6.2

- 9 Identify two enzymes secreted by the digestive system and state where each may be found.
- 10 Identify the correct percentage of red blood cells normally found in blood:
A less than 5 per cent
B a little under 40 per cent
C a little over 40 per cent
D about 95 per cent.
- 11 Describe the function of platelets.
- 12 Contrast angina with a heart attack.
- 13 Identify the substance that commonly clogs arteries.

Thinking questions

- 14 True or false?
a We excrete when we breathe out.
b Water and carbon dioxide are waste products of cells.
c Your kidneys are about the size of your eyeballs.
d Kidneys filter about half the blood pumped by the heart in the same time.
e Urine travels down tubes called urethras to the bladder, which has a capacity of about 5 litres.
f Drinking at least a litre of water each day increases the risk of kidney stones.
g It is possible to live normally with only one kidney.
- 15 Compare the energy contained in fats with that in carbohydrates.

- 16 Contrast a sphincter with peristalsis.
- 17 Compare and contrast starch with glycogen.
- 18 Identify the description that matches the blood vessel.

Blood vessels	Descriptions
Vein	High pressure
Artery	Fine tubes near cells
Capillary	Return blood to heart

- 19 Identify the functions described in **a** to **f** that match structures **i** to **vi** in Figure 2.6.3:
- a** filters, warms and humidifies air
b contracts and flattens during inspiration
c the site of gas exchange
d carries air to and from the lungs
e prevents food from entering the trachea
f passage of air through this creates sounds.

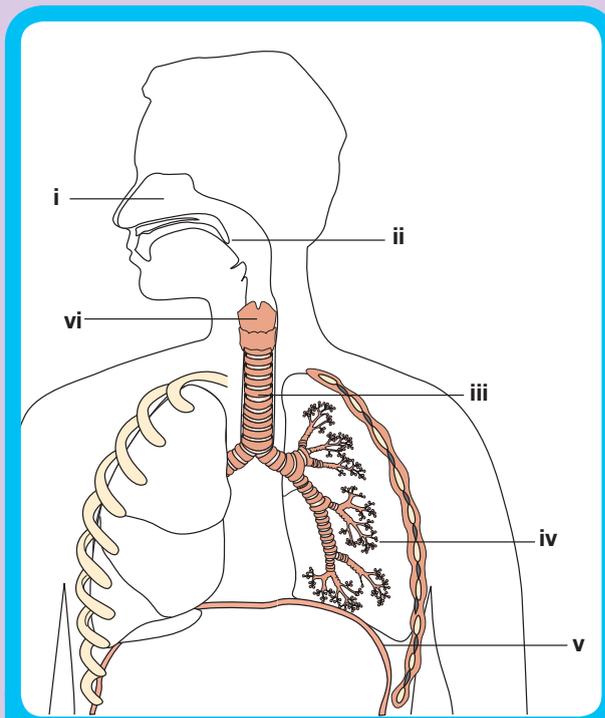


Fig 2.6.3



[Interpreting questions]

20 Modify the following paragraph by rewriting it to include the correct terms:

To breathe in, the diaphragm (contracts/relaxes) and the intercostal muscles (contract/relax). This causes the ribs to move (upwards/downwards) and (outwards/inwards). These movements (increase/decrease) the size of the chest cavity, causing the pressure to (increase/decrease). Air then (flows in/is pushed out).

21 Contrast the energy requirements of adolescent males and females.

22 State whether a person with B positive blood would be allowed to donate blood to a patient with:

- a** A positive blood
- b** AB positive blood
- c** O positive blood
- d** B negative blood.

CHAPTER

3

Chemical reactions and everyday uses

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

- 1 state that in a chemical reaction materials/substances combine (react) to produce new substances called products
- 2 show that in a chemical equation reactants are on the left-hand side and products are on the right-hand side, using word equations only
- 3 identify or perform some basic chemical reactions using everyday substances and identify the reactants and products, such as rusting of iron nails, mixing lemon juice with coral, burning of firewood, ripening of fruits, soap making, boiling of eggs.
- 4 identify and demonstrate factors that influence the rate of chemical reactions: temperature, concentration, catalyst and surface area.
- 5 describe how important chemical reactions are in our daily lives (eg photosynthesis, cell respiration, rusting, boiling food, making bread), using word equations only.

- 1 How can we tell that a chemical reaction has occurred?
- 2 We drink a lot of dihydrogen oxide. What is it really?
- 3 Is water a chemical?



8.3.1.1, 8.3.1.2, 8.3.2.1, 8.3.3.1, 8.3.4.1

Specific learning outcomes

Challenges

UNIT 3.1

What are chemical reactions?

Introduction

Chemical reactions are occurring constantly inside us, around us, in the soil, in sea water, in the air and throughout the universe—absolutely everywhere! Some reactions, like fireworks, are quick and violent. Other reactions, like the reactions that occur in every cell in your body, are slower and more difficult to see. So how do we, as scientists, know whether or not a chemical reaction has taken place?

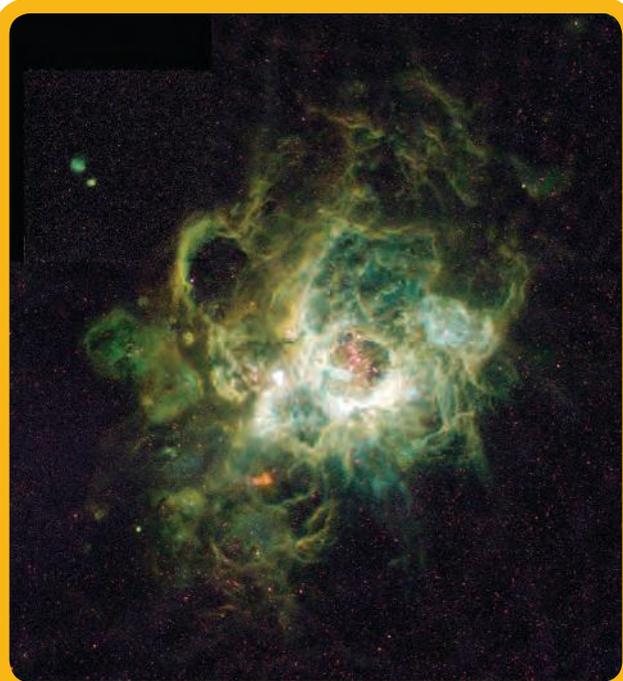


Fig 3.1.1

Chemical reactions occur constantly in this nebula, which is a cloud of gas and dust found in outer space.

Signs of chemical change

We say that a chemical reaction has happened if at least one new substance has been formed. Burning methane gas is an example of chemical change because water and carbon dioxide are formed, and they were not present at the start of the reaction.

Activity 1

Signs of chemical change

Aim

To observe changes during chemical reactions

Equipment

Solid copper carbonate, magnesium, dilute nitric acid, splint, matches, Bunsen burner, test-tube holder, test-tube rack, dilute sodium hydroxide, thermometer, dilute copper sulfate, solid zinc, 4 test tubes (1 with stopper), lab coat, safety glasses

Note: 1.0 M is an appropriate concentration for these solutions, but anything between 1.0 M and 2.0 M would be suitable.

Method

1 Copy the following results table into your book.

Reaction number	Reactant(s)	Observations	Conclusion

- Carefully heat a small amount of copper carbonate in a test tube. Ensure that the test tube is pointed away from people. Stop as soon as you see a colour change. Record your observations.
- Add a small piece of magnesium to 2 cm of nitric acid in a test tube. Stopper the tube to collect some gas. Have your lab partner light a splint and place it near the mouth of the test tube.
- Record the temperature of 2 cm of the nitric acid solution. Add 2 cm of sodium hydroxide solution and record the new temperature.
- Place a small piece of zinc into 2 cm of dilute copper sulfate solution. Record your observations.

Questions

- Identify the gas formed in the reaction in step 3.
- Predict what you think would happen if the zinc in the reaction in step 5 was replaced with silver.

A chemical change differs from a physical change, in which no new substances are created. The melting of ice is an example of a physical change. It is simply a change of state: solid water turns into liquid water.

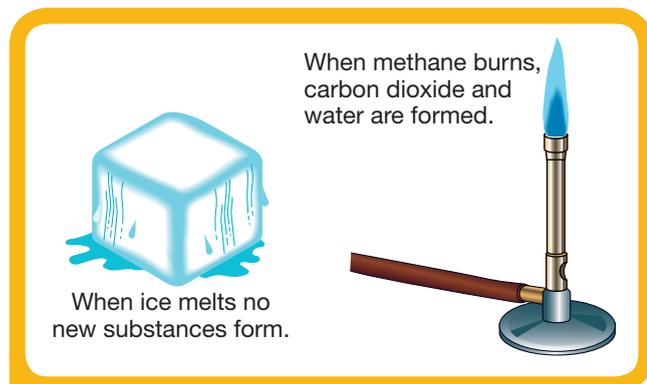


Fig 3.1.2 Melting is a physical change. Burning methane is a chemical change.

The substances present at the start of a reaction are called the reactants, and the new substances formed are called the products. We can write word equations to represent chemical reactions. These are written in the form:



The arrow shows the direction of the reaction and means 'react to form'. Thus the chemical equation above reads 'Substances A and B react to form substances C and D'.

Chemical equations are useful because they provide a quick and easy way to represent complex reactions.

For example, the reaction of magnesium and copper oxide produces copper and magnesium oxide. This can be written as:



Using chemical symbols, this reaction is written:



In this case, the reactants are magnesium (Mg) and copper oxide (CuO). The products are copper (Cu) and magnesium oxide (MgO). Notice that the number of each type of atom is the same on each side of the equation. Atoms are not destroyed or created in chemical reactions. They just get rearranged.



Fig 3.1.3 The reaction of magnesium and copper oxide is spectacular.

There are several signs that a chemical reaction has occurred. A chemical reaction has definitely occurred if one or more of the following is observed.

- There is a permanent colour change.
- A gas is given off.
- Energy is produced or absorbed.
- A precipitate (solid) forms from a solution.
- One metal deposits or forms on another.

Permanent colour change

A permanent change in colour during a reaction is a sign that a chemical reaction has taken place. The corrosion, or rusting, of iron or the burning of a match are examples of colour changes associated with reactions.



Fig 3.1.4 Iron is the main component of steel that makes up cars. Iron can react with oxygen to form iron(III) oxide—rust. The effects of this slow reaction can be very damaging.

A gas is given off

If a reaction is taking place in solution (in a liquid), it is very easy to see a gas being produced because bubbling will be observed. With other reactions it can be more difficult to see the gas because most gases, such as oxygen, hydrogen, nitrogen and carbon dioxide, are colourless and odourless. Figure 3.1.5 shows a reaction between limestone (calcium carbonate) and sulfuric acid that produces carbon dioxide gas.

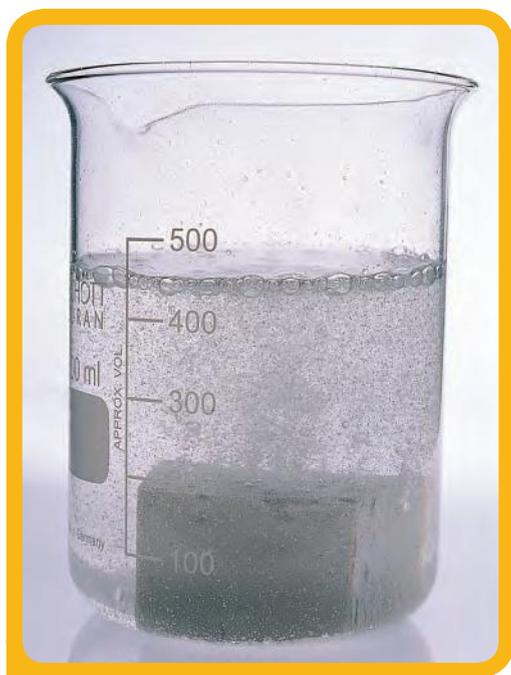


Fig 3.1.5 The formation of a gas is a sign of chemical change.

Energy is produced or absorbed

Many reactions produce or absorb energy, usually in the form of heat. Imagine a reaction taking place in a test tube. If you feel the test tube as the reaction is taking place and it gets colder, then the reaction is absorbing heat energy from the surroundings. Reactions that absorb energy are called endothermic. If you feel the test tube and it gets warmer, the reaction is releasing heat energy to the surroundings. Reactions that produce energy are called exothermic.

Endothermic: energy + reactants \longrightarrow products

Exothermic: reactants \longrightarrow products + energy

Heat is generated when fossil fuels such as petrol, oil and coal are burnt. These are examples of exothermic reactions. The heat produced can be changed into other forms of energy and then used to do things such as making cars move, producing electricity in power stations and lighting up your home. The burning of magnesium ribbon is an exothermic reaction that releases both heat and light energy. The burning of metals such as magnesium produces the amazing effects in fireworks. The equation for this reaction is:

magnesium + oxygen \longrightarrow magnesium oxide + energy



An example of an endothermic reaction is photosynthesis. The chlorophyll in plants absorbs energy from the Sun to make this important reaction occur. The overall chemical equation for this reaction is:

carbon dioxide + water + energy \longrightarrow glucose + oxygen



Fig 3.1.6 Burning magnesium releases both heat and light energy.

A precipitate forms

A solution is made up of a solute (a substance that dissolves) and a solvent (the liquid that the solute dissolves in). For example, a solution of sodium chloride (table salt) is made up of solid sodium chloride dissolved in water. Solutions are clear, and sometimes coloured.

When two solutions are mixed, a precipitate may form. This is an indication that a chemical reaction has occurred. A precipitate is an insoluble substance (a substance that does not dissolve) that forms when two clear solutions are mixed together. The precipitate is observed as cloudiness or solid particles sinking to the bottom of the test tube.



Fig 3.1.7 Lead iodide precipitate is a distinctive yellow colour.

One metal deposits on another

When one metal deposits or settles on top of another metal, the reaction is known as a displacement reaction. Different metals have different degrees of reactivity. A basic rule is that *a more reactive metal will displace a less reactive metal in solution*. If you have a solution of a particular metal salt, and you place a solid piece of a more reactive metal in the solution, a reaction will take place. The electrons from the more reactive metal will be transferred to the ions of the less reactive metal, which will become solid and deposit on the surface of the more reactive metal. Figure 3.1.8 shows what happens when a piece of zinc is placed in a solution of copper sulfate.

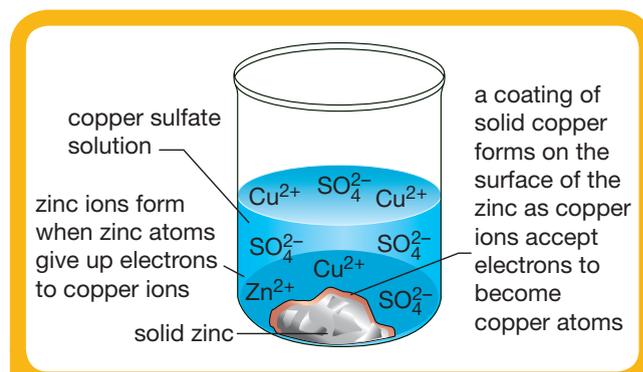


Fig 3.1.8 Less reactive copper is displaced by more reactive zinc.

3.1

[Questions]

Checkpoint

Signs of chemical change

- Identify the five signs of chemical change.
- Define the term 'solution'.
- Explain how a solution may be clear, but not always colourless.
- Describe how a precipitate forms.
- For each of the following reactions:
 - water + energy \longrightarrow hydrogen + oxygen
 - methane + oxygen \longrightarrow carbon dioxide + water + energy
 identify:
 - the reactants
 - the products
 - whether the reaction is exothermic or endothermic.

Think

- Classify the following as examples of chemical change or physical change:
 - cutting up cake
 - burning gas
 - melting an ice-block
 - freezing cordial
 - water evaporating
 - putting a soluble aspirin tablet in water.
- Describe three examples of chemical reactions that occur in your home.
- For each of the following, identify whether a chemical change has occurred or not.
 - A student mixes two unknown solutions together and notices a cloudiness forming.
 - When nitric acid is poured onto limestone, bubbling is seen.

>>



- c Two colourless solutions at room temperature are mixed. After a minute, the temperature of the mixture is 60°C .
- d Ice is taken from the freezer and left on the bench. The temperature rises from 0°C to 20°C and the ice melts.
- e Yellow sulfur powder and iron filings are heated in a crucible. After heating, only a black solid remains.

Analyse

- 9 Chemical equations can be very useful. Explain two reasons why.
- 10 Construct word equations for the following reactions.
 - a When copper is added to nitric acid, copper nitrate, nitrogen monoxide and water are formed.
 - b If sulfuric acid is poured onto solid sodium carbonate, bubbles of carbon dioxide are produced, as well as water and sodium sulfate.
 - c Magnesium burns easily in oxygen, producing magnesium oxide.
 - d During photosynthesis, the Sun's energy, carbon dioxide and water are used by green plants to produce glucose and oxygen.

UNIT 3.2

Reaction types

Introduction

Even though each substance is unique, similar substances behave in a similar way in chemical reactions. This allows scientists to classify reactions into several general categories. In this unit we will investigate some of the main reaction types.

Combination reactions

In combination reactions, two or more substances combine to form one new substance. These reactions have the general equation:



For example, carbon and oxygen can combine to form carbon dioxide:



You can start to write the correct chemical equation as well as the word equation for each reaction. The above reaction can be written as:



O₂ is used instead of O by itself because the oxygen in the air around us exists as diatomic molecules. 'Diatomic' means that two atoms of the same element bond together to form a stable molecule.

Activity 2

Electroplating

Aim

To investigate the displacement reaction associated with electroplating

Equipment

6 V DC power source, 250 mL beaker, 2 insulated wires with crocodile clips on one end, 1 very thin 7 × 4 cm strip of copper metal (coiled copper wire may also be used), 1 strip of stainless steel, sandpaper, tongs, wash bottle of distilled water, 1 M zinc sulfate solution, 2 M nitric acid, lab coat, safety glasses, gloves

Method

- 1 Clean the copper strip with the sandpaper.
- 2 Dip the copper in the acid and then rinse with distilled water. Don't touch the part that will go in the solution.
- 3 Attach the copper to the negative terminal of the power source. Rest it in the beaker.
- 4 Put 150 mL of 1 M zinc sulfate solution in the beaker.
- 5 Attach the stainless steel electrode to the positive power terminal. Do not allow it to touch the copper terminal.
- 6 Turn the power on for about 3 minutes.
- 7 Remove the copper and rinse with distilled water.

Questions

- 1 Compare the appearance of the copper before and after.
- 2 Construct a word equation for the reaction that occurred.

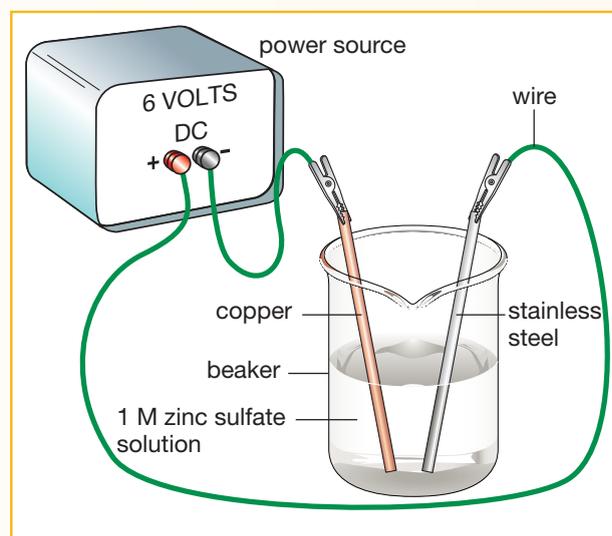


Fig 3.2.1 Apparatus set-up for investigating the displacement reaction associated with electroplating

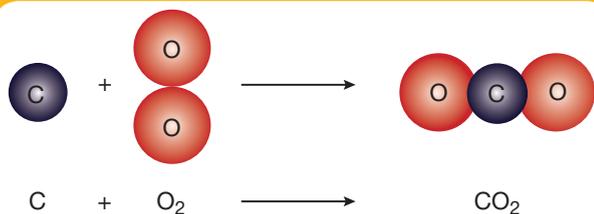


Fig 3.2.2 One atom of carbon combines with one molecule of oxygen to form one molecule of carbon dioxide.

Decomposition reactions

Decomposition reactions are the opposite of combination reactions. One substance breaks down to form two or more new substances. For substances that break down to form two new substances, the general equation can be written:



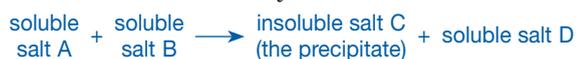
Examples are:



Fig 3.2.3 The deployment of an airbag during a crash is caused by a decomposition reaction.

Precipitation reactions

Precipitation reactions result in an insoluble solid (called a precipitate) being formed when two clear solutions are mixed. They can be written as:



Sometimes in chemical reactions subscripts are used to show what state the substances are in. A small (s) shows that the substance is solid, (l) shows that it is liquid and (g) shows that it is gas. The subscript (aq) is used to show aqueous solutions (from the Latin word *aqua*, meaning 'water'). These are substances that are dissolved in water. A precipitate is a solid, insoluble substance and therefore it too has the subscript (s).

Figure 3.2.4 shows the formation of silver chloride precipitate when solutions of the soluble salts silver nitrate and sodium chloride are mixed.

The word and chemical equations for this reaction are:



Fig 3.2.4 Silver chloride precipitation forming a white cloud at the centre of the test tube

The sodium and nitrate ions are left dissolved in solution.

Solubility rules help us to work out which substance in the mixture is precipitating. For example, in the above reaction, it cannot possibly be sodium nitrate because all sodium salts are soluble and all nitrate salts are soluble.

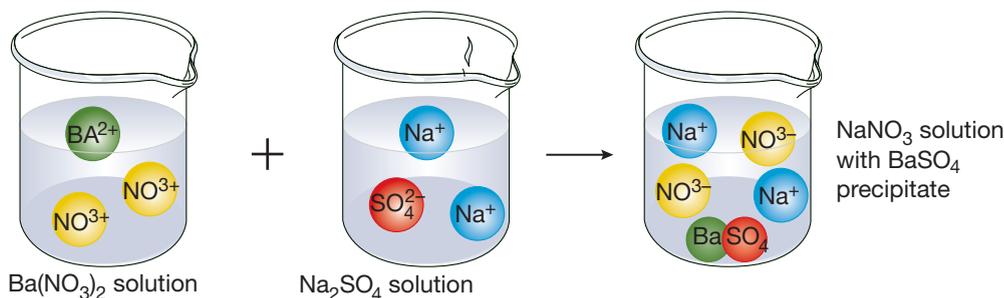


Fig 3.2.5 Mixing solutions of barium nitrate and sodium sulfate produces a precipitate of barium sulfate.

Solubility of common inorganic compounds in water

Negative ions (anions)	Positive ions (cations)	Compounds with solubility
Acetate CH_3COO^-	All	Soluble
All	Alkali ions, Li^+ , Na^+ , K^+ , Rb^+ , Cs^+ , Fr^+	Soluble
All	Ammonium ion NH_4^+	Soluble
All	Hydrogen ion $\text{H}^+(\text{aq})$	Soluble
Chloride Cl^-	Ag^+ , Pb^{2+} , Hg^{2+} , Cu^+ , Tl^+	Low solubility
Bromide Br^-	All others	Soluble
Iodide I^-	All others	Soluble
Hydroxide OH^-	Alkali ions, $\text{H}^+(\text{aq})$, NH_4^+ , Sr^{2+} , Ba^{2+} , Ra^{2+} , Tl^+	Soluble
	All others	Low solubility
Nitrate NO_3^-	All	Soluble
Phosphate PO_4^{3-}	Alkali ions, $\text{H}^+(\text{aq})$, NH_4^+	Soluble
Carbonate CO_3^{2-}	All others	Low solubility
Sulfate SO_4^{2-}	Ca^{2+} , Sr^{2+} , Ba^{2+} , Pb^{2+} , Ra^{2+}	Low solubility
	All others	Soluble
Sulfide S^{2-}	Alkali ions, $\text{H}^+(\text{aq})$, NH_4^+ , Be^{2+} , Mg^{2+} , Ca^{2+} , Sr^{2+} , Ba^{2+} , Ra^{2+}	Soluble
	All others	Low solubility

Neutralisation reactions

Neutralisation reactions occur when an acid is added to a base, forming water and other substances. A base is anything that can neutralise an acid, for example a metal hydroxide. These reactions can be written as:

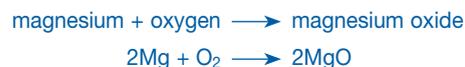
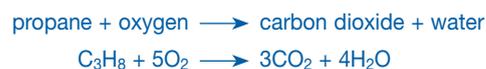


For example:



Combustion reactions

A combustion reaction is simply burning a substance in oxygen, so O_2 is always a reactant. The products will vary, depending on the substance that is burnt. Examples of combustion reactions are:



You can see that the combustion of magnesium is also an example of a combination reaction. Reactions can sometimes fall into more than one general category.

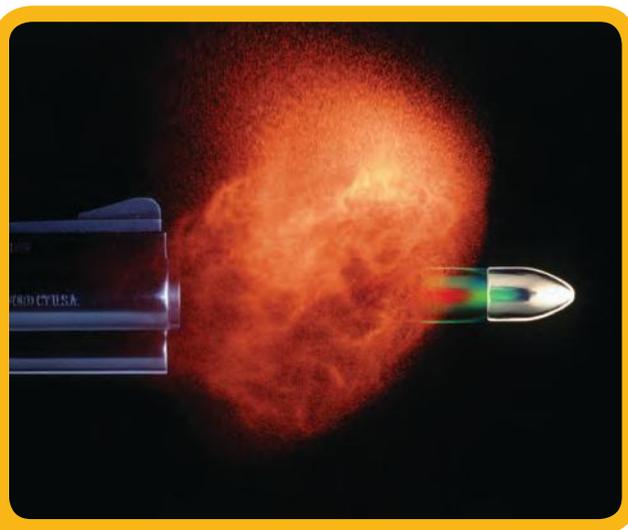


Fig 3.2.6 The combustion of a chemical propellant forces a bullet from a barrel.

Displacement reactions

Different metals have different degrees of reactivity. Some metals give up their outer shell electrons very easily and so are very reactive. The alkali metals are the most reactive metals. Other metals, such as gold and silver, are very unreactive. This means that they do not give up their electrons as easily. The activity series of metals shown in Figure 3.2.7 shows the metals listed in order from most reactive to least reactive.

most reactive	K	Potassium
	Na	Sodium
	Ca	Calcium
	Mg	Magnesium
	Al	Aluminium
	Zn	Zinc
	Fe	Iron
	Pb	Lead
	Cu	Copper
	Hg	Mercury
	Ag	Silver
	Pt	Platinum
least reactive	Au	Gold

Fig 3.2.7 The activity series of metals

When one metal deposits on (settles on top of) another, the reaction is known as a displacement reaction. This means that if you have a solution of a particular metal salt, and you place a solid piece of a more reactive metal in the solution, a reaction will take place. The electrons from the more reactive metal will be transferred to the ions of the less reactive metal, which will become solid and deposit on the surface of the more reactive metal. The basic rule is that 'a more reactive metal will displace a less reactive metal in solution' or, in other words, 'a less reactive metal in solution will deposit on a more reactive metal'.

Displacement reactions can be used to coat metals. For example, if you wanted to coat a piece of zinc with copper, you could simply dip it into a solution of copper sulfate. The copper ions would accept electrons from the zinc atoms on the surface, because copper is less reactive than zinc.

This reaction could be written as:



This would not produce a very even coating, however. Industrial plating is carried out quite differently. Electroplating is the name for the process that causes metal atoms to be deposited on the surface of a substance that acts as a conductor. By using electricity, reactions can be made to produce decorative or useful surfaces.



Fig 3.2.8 Solid copper (black) coats the zinc because the copper was replaced in solution by the more active zinc.



[Questions]

Checkpoint

Combination reactions

- 1 Describe a combination reaction and give an example.
- 2 Oxygen is written as O_2 in chemical reactions rather than just O. Explain why this is the case.

Decomposition reactions

- 3 Describe a decomposition reaction and give an example.
- 4 A gas is given off when calcium carbonate is heated. Identify this gas.

Precipitation reactions

- 5 Describe what observations may be made when a precipitation reaction occurs.
- 6 State the meaning of the subscripts (s), (l), (g) and (aq).

Neutralisation reactions

- 7 Describe what a neutralisation reaction is and give an example.
- 8 Identify the products formed when an acid is added to a metal hydroxide.

Combustion reactions

- 9 Describe what a combustion reaction is and give an example.

Displacement reactions

- 10 Describe what a displacement reaction is and give an example.

Think

- 11 Choose two reactions in the previous questions and write word equations for these.
- 12 Refer to the table of solubility rules on page 69. Assess which of the following substances would be soluble in water.
 - a $BaSO_4$
 - b $LiNO_3$
 - c $CaCO_3$
 - d $MgCl_2$

Analyse

- 13 Classify the following reactions.
 - a Hydrogen peroxide breaks down into hydrogen and oxygen gas.
 - b Phosphoric acid reacts with ammonia to form water and ammonium phosphate.
 - c Magnesium when placed in zinc chloride solution causes zinc metal to form.
 - d Sulfur reacts with iron to form iron sulfide.
- 14 Choose two reactions from Question 13 and construct word equations for these.

UNIT 3.3

The rate of chemical reactions and their importance in our daily lives

Introduction

Some reactions are slow. Others are fast. Some reactions are so fast that they explode! When solid potassium is added to water, large volumes of explosive hydrogen gas are quickly produced. Other reactions, such as iron rusting, a banana going brown or milk turning sour, are very slow. How quickly a reaction happens can make the difference between it being safe or dangerous. The rate of a reaction is important when producing chemicals.

Activity 3

Rates of reactions 1

Aim

To investigate how the surface area affects reaction rate

Equipment

Lab coat, safety glasses, gloves, marble chips (large and small), powdered calcium carbonate, dilute hydrochloric acid, stopwatch, spatula, 4 test tubes, test-tube rack, 10 mL measuring cylinder, electronic balance

Method

- 1 Using the equipment listed, design and perform an experiment to test the effect of surface area on the rate of reaction.
- 2 Construct a graph to display your results.

Questions

- 1 Use your results to deduce how surface area affects the rate of reaction.
- 2 Propose how your experiment could be improved.

Activity 4

Rates of reactions 2

Aim

To investigate the variables that affect reaction rates

Equipment

Lab coat, safety glasses, gloves, magnesium strips, ice, 1 M HCl, hydrogen peroxide solution, solid manganese dioxide, stopwatch, spatula, 4 test tubes, test-tube rack, 10 mL measuring cylinder, 2 × 100 mL beakers

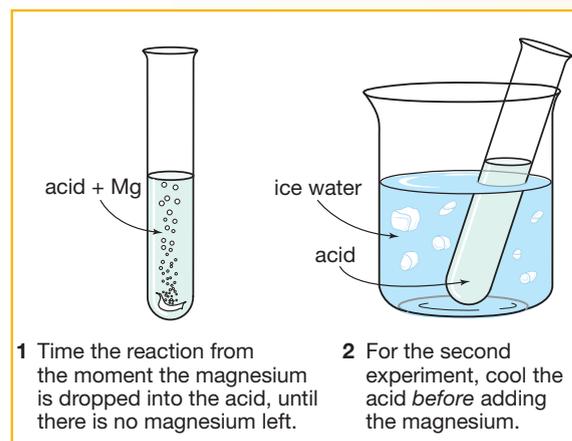


Fig 3.3.1 Apparatus set-up for investigating the variables that affect reaction rates

Method

- 1 Add a 2 cm strip of magnesium to a test tube.
- 2 Add 5 mL of acid and time how long it takes for the reaction to finish. The reaction is:



>>

- Place 5 mL of acid in the second test tube and sit it in a beaker of ice water.
- Once again, add a 2 cm strip of magnesium and time how long it takes for the reaction to finish.
- Add 2 mL of acid and 3 mL of water to a third test tube.
- Add a 2 cm strip of magnesium and time how long it takes for the reaction to finish.
- Add 5 mL of hydrogen peroxide solution to each of the two beakers. Hydrogen peroxide gradually breaks down according to the equation:



- To one beaker, add a very small amount of manganese dioxide.
- Compare the two beakers and record your observations.

Questions

- Identify factors that made the reactions proceed faster or slower.
- Predict the effect of heating the reactions.
- Identify the role of the manganese dioxide in the hydrogen peroxide reaction.

Factors influencing the rate of chemical reactions

Chemists often change the rates of chemical reactions, speeding up some and slowing down others. There are a number of factors that determine the rate of a chemical reaction. They are:

- concentration
- surface area
- temperature
- using a catalyst.

Concentration

Consider the reaction between magnesium and nitric acid:



When nitric acid dissolves in water, it breaks up into H^+ ions and NO_3^- ions. The nitrate ions do not react with magnesium, but the hydrogen ions do. Leaving out the unreactive NO_3^- 'spectator' ion, the above reaction may be written as:



In this reaction, H^+ ions must come into contact with the solid magnesium surface. Imagine that two experiments have been set up. In experiment A, the

acid is half the concentration of that in experiment B. Fewer H^+ ions in experiment A will result in a slower rate of reaction than in experiment B because the H^+ ions are meeting the surface of the magnesium less frequently. Thus, an increase in the reactant concentration results in an increase in the rate of reaction.

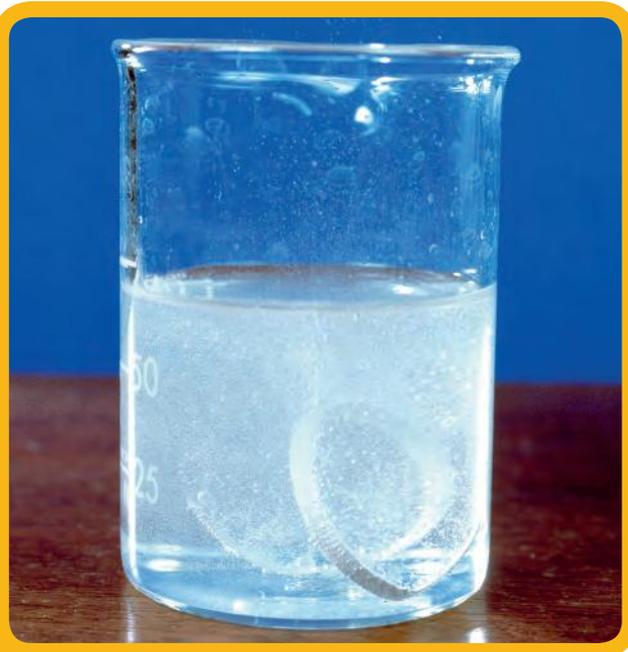


Fig 3.3.2 The reaction between magnesium and hydrochloric acid

Surface area

If you try to light a pile of sawdust it will not burn, but if you let a cloud of sawdust fall onto a candle, it will ignite. Similarly, a piece of iron does not burn, but powdered iron does. This is because a cloud of sawdust has greater surface area than a pile of sawdust and powdered iron has a greater surface area than a piece of iron. They ignite because their high surface area allows them to mix easily with oxygen in the air (the other reactant).

Powdering a solid reactant allows for a large increase in the surface area of the reactants and hence a dynamic increase in the rate of reaction.

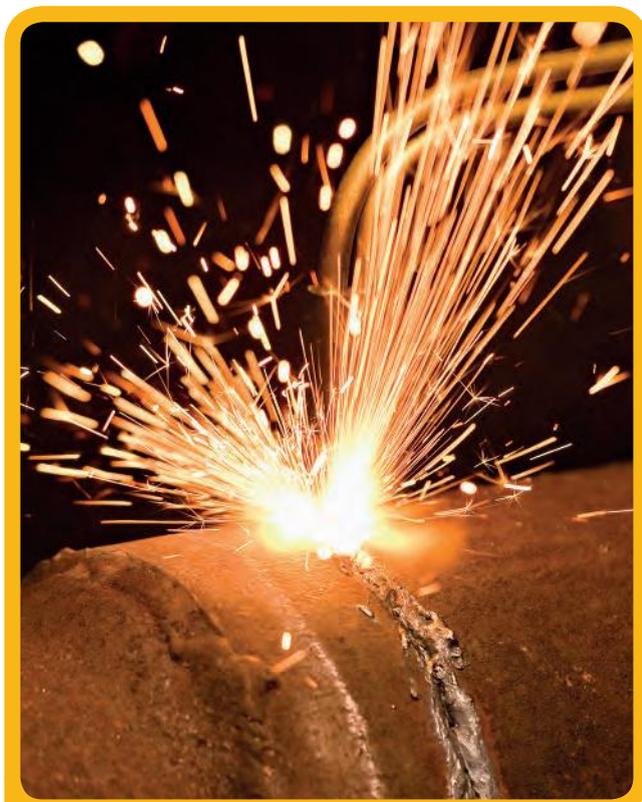


Fig 3.3.3 Iron ignites easily if it is mixed with a good supply of oxygen.

Temperature

One way to preserve food is by cooling it, for example keeping fish on ice inside in the esky. Cooling simply slows down the chemical reactions by which the food goes bad.

Kinetic energy is the energy of movement. When the temperature decreases, the kinetic energy of reactants decreases. When the temperature increases, the kinetic energy of reactants increases, and therefore increases the reaction rate.

Catalyst

A catalyst is a substance that changes the rate of a chemical reaction, but is not itself used up in the reaction. A homogeneous catalyst is in the same state as the reactants. A heterogeneous catalyst is in a different state from the reactants.

A catalyst may work in one of two ways.

- It may provide a surface to help the reaction proceed. For example, platinum metal is a heterogeneous catalyst that is very effective at catalysing gaseous reactions.
- It may participate in the chemical reaction, but is then re-formed at the end. One example of this is the use of a homogenous acid catalyst in the formation of esters.



Fig 3.3.5 Platinum metal is a very effective catalyst for reactions involving gases.

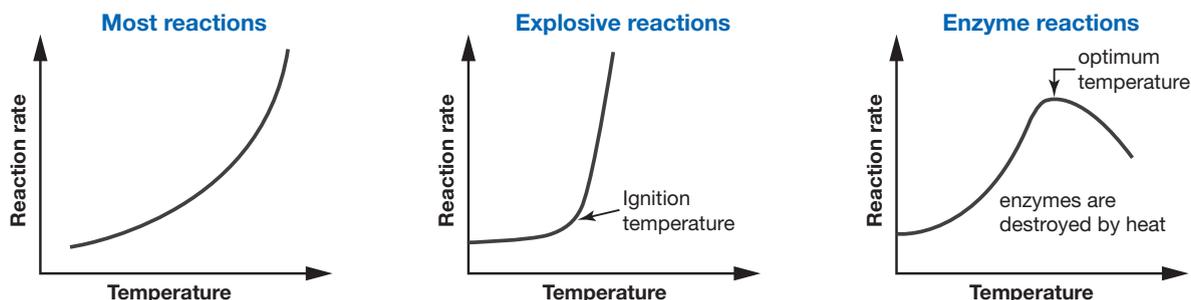


Fig 3.3.4 A change in temperature dramatically changes the rate of a chemical reaction.

Biological catalysts are called enzymes. The molecules are very specific and are capable of increasing the rate of reaction. Enzymes help your body to do important work such as producing energy and responding to stimuli, for example pulling your hand quickly away from hot object (stone or pot) as soon as you touch it.

The importance of chemical reactions

Chemical reactions are important in every aspect of our daily lives. They may be carried out in industry, or we may do them every day, or they may be happening around us.



Fig 3.3.6 The electrolytic refinement of copper produces copper bars like these.

Producing sulfuric acid

An example of an industrial process is the production of sulfuric acid, or H_2SO_4 , a chemical that is very important to our everyday lives. This process is called a contact process. It is a complicated process and you do not need to know it in detail at this stage. Figure 3.3.7 shows you how it is made.

Sulfuric acid is the cheapest bulk acid. It is produced in large quantities worldwide.

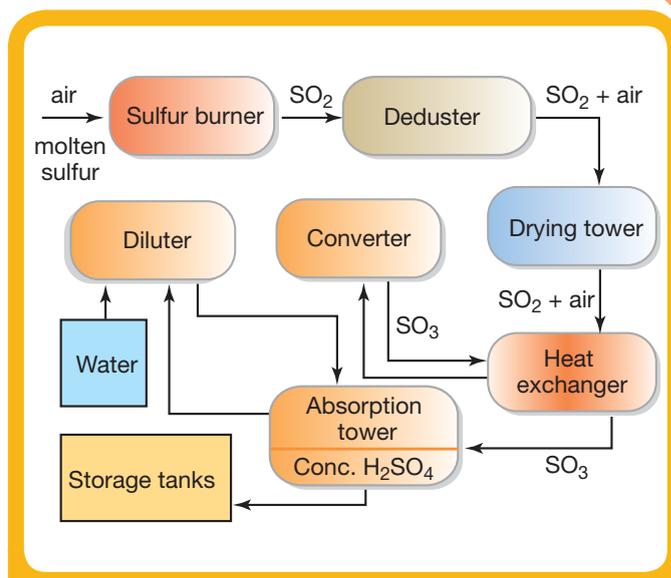


Fig 3.3.7 The contact process for the production of sulfuric acid

Uses of sulfuric acid

Sulfuric acid is used to make superphosphate, which is added to soil to increase the amount of phosphorus in the soil for plants to use. The current largest single use of sulfuric acid is in making fertilisers, both superphosphate and ammonium sulfate. It is also used to make many organic compounds, including ether, nitroglycerine and dyes, or colours. It is important in refining petroleum, making paints and pigments, processing metals and making rayon. It is found in car batteries and used in the superconductor industry for cleaning.

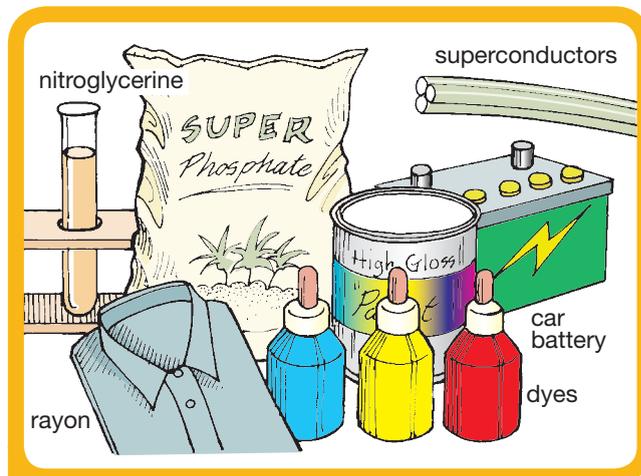


Fig 3.3.8 Some products made using sulfuric acid

Other chemical reactions

Other examples of chemical reactions that are important in our daily lives are:

- burning wood

This process is very important because it is used to cook food, and so provides a source of energy for your body to carry out its normal functions.

The word equation to describe this process is:



- plant photosynthesis

This is the process in which green plants manufacture their food by absorbing energy from the Sun. The word equation describing this process is:



Animals then eat the plants and take in oxygen in order to survive.

- respiration

This is the process by which a living organism breaks down the high-energy food content needed by its cells and tissues for normal functioning. This means that living organisms have enough energy to move and do work.

The word equation describing this process is:



- rusting
- fermentation to make alcohol, bread and cakes.

Chapter review

[Summary questions]

- 1 Describe the observations you might make if a chemical reaction occurs.
- 2 Is rain a physical change or a chemical change? Discuss.
- 3 Explain why some metals are more reactive than others.

[Thinking questions]

- 4 Define the term 'diatomic'. Give an example to illustrate your answer.

[Interpreting questions]

- 5 Identify the reaction type for each of the following equations:
 - a lithium + chlorine \longrightarrow lithium chloride
 - b sulfuric acid + barium carbonate \longrightarrow barium sulfate + carbon dioxide + water
- 6 State the type of reaction that could be used to coat a metal.
- 7 Deduce the products of the following neutralisation reactions:
 - a sodium carbonate + hydrochloric acid \longrightarrow
 - b calcium hydroxide + nitric acid \longrightarrow

3.3

[Questions]

Checkpoint

Chemical reactions

- 1 State an example of a product made through an industrial process.
- 2 Explain what is meant by the 'rate' of a reaction.
- 3 Describe two ways to obtain a faster reaction rate.

Producing sulfuric acid

- 4 State three uses of sulfuric acid.
- 5 State the formula for the following substances:
 - a sulfuric acid
 - b carbon dioxide
 - c glucose.

Skills

- 6 Identify the elements that make up sulfuric acid.

CHAPTER

4

Atmosphere, climate and weather

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

- identify from a diagram the different layers of the atmosphere: troposphere, stratosphere, mesosphere and ionosphere
- identify the main gases in the different layers of the atmosphere
- identify three essential gases for living organisms in the troposphere layer as oxygen, carbon dioxide and nitrogen
- use a diagram to describe the pattern of air movement
- describe the formation of a tropical cyclone and its pathway
- identify and explain on a world map different climatic zones caused by the patterns of heating and cooling of the Earth's surface
- measure daily temperature, rainfall, air pressure, wind speed and moisture in your area and other areas
- express the importance of water to you and other organisms
- express the importance of the water cycle.

- 1 Explain the word 'atmosphere'.
- 2 Name a scientist who studied the atmosphere.
- 3 What are the percentages of the three main gases in the atmosphere?
- 4 Identify the important processes that make up the water cycle.
- 5 What causes a cyclone to develop?

Specific learning outcomes

8.4.1.1, 8.4.2.1, 8.4.3.2, 8.4.4.1, 8.4.5.1, 8.4.6.1, 8.4.7.1,
8.4.8.1, 8.4.9.1, 8.4.9.2

Challenges



UNIT 4.1

The atmosphere

Introduction

A thick layer of gases surrounds the Earth. This layer is what we call 'air'. Scientists know the layer of gases as 'the atmosphere'. The atmosphere moves and twists about us, often quite violently, with winds, storms, cyclones and tornadoes. It stretches about 800 kilometres from the Earth's surface, providing us with oxygen to breathe and clean water to drink. It also protects us from the harmful radiation from the Sun and from stray meteorites. The atmosphere is very important to all of us, and without it we would not be here.

Activity 1

Layers of the atmosphere

Aim

To identify the layers of the atmosphere

Method

Refer to Figure 4.1.1 and answer the following questions.

Questions

You might need to read ahead to find the information to answer some of these questions.

- 1 List the layers of the atmosphere in order starting from the Earth's surface.
- 2 Identify any objects found in each layer.
- 3 In which layers do clouds and weather occur?

Layer upon layer

Although the atmosphere can be considered to be about 800 km high, it is very thin at the top and much heavier down where we live at the Earth's surface. Ninety-nine per cent of all the air in the atmosphere is found in the first 80 km from the surface, with little left for the remaining 720 km or so.

We live in the troposphere, the layer that touches the Earth's surface. This is where three-quarters of all air is found and where the clouds and weather occur. The troposphere has a height

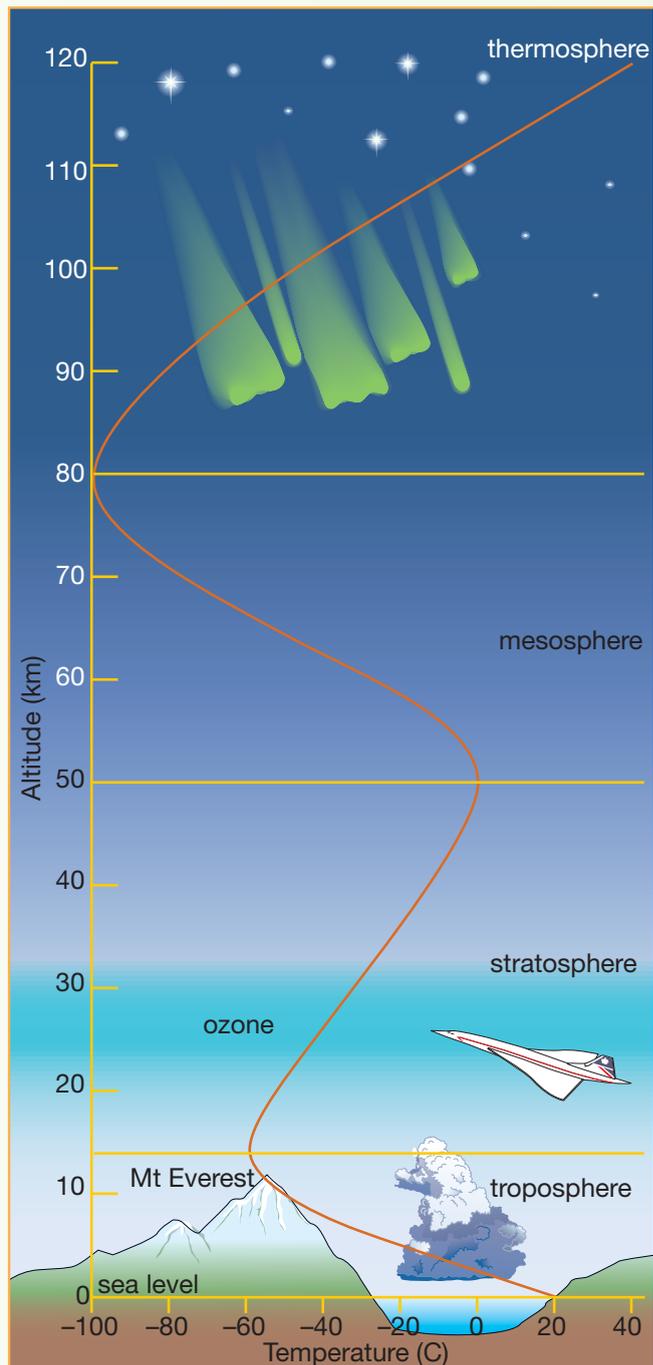


Fig 4.1.1 Layer upon layer—the Earth's atmosphere. The temperature at each level is shown by the solid curve.

of about 10 to 13 km, and as you climb higher the temperature drops from an average of 17°C to -52°C.

The stratosphere is the next layer and extends to 50 km high, with temperatures gradually increasing to -10°C at the top. It is a region of very low air pressure and fast jet-stream winds. Most commercial aircraft fly here. Within the stratosphere is the all-important ozone layer. This blocks out almost all harmful solar radiation, which, if allowed through, could injure or kill most living things.

Above the stratosphere is the mesosphere, which extends to about 80 km and where the temperature again falls to -93°C. At the outer limits of the atmosphere we find the largest of the layers, the thermosphere. This is a region of increasing temperature and few air particles.

The region called the ionosphere begins near the top of the stratosphere and extends through the mesosphere and thermosphere, but is most noticeable at heights above 80 km. The ionosphere is also where meteors begin to burn up and where harmful gamma rays from the Sun are screened out.

The final layer is the exosphere, which begins at about 600 km and extends out into space.



Fig 4.1.2 Space shuttle image of the clouds and weather patterns in the troposphere

What's in air?

The air we breathe is made up of more than ten different gases.

One of the most important gases in the air is oxygen (O₂). This is the gas that humans and all other animals breathe. Although only making up 21 per cent of the atmosphere, it is constantly being replaced by plants. Like animals, plants also use some of the oxygen in air to produce energy.

Only a tiny 0.03 per cent of the atmosphere is carbon dioxide (CO₂). It is important for plants because they use it to make their own food. CO₂ is also one of the gases that animals breathe out.

The amount of carbon dioxide in our atmosphere is increasing due to:

- forest depletion: trees use up carbon dioxide and every tree that is cut down increases the amount of this gas in the atmosphere by reducing the amount removed from the air
- fossil fuels: every time fossil fuels such as petrol, oil, gas and coal are burnt in car engines, factories, homes and power stations, carbon dioxide is produced
- rotting garbage in tips breaking down to release carbon dioxide.

At 78 per cent, nitrogen is the most abundant gas in the atmosphere. It seems to have little use except to dilute the oxygen gas to levels that animals can breathe without feeling ill. Pure oxygen can be poisonous to animals and plants.

In the middle level of the stratosphere lies a 15–20 km thick layer of ozone (O₃).

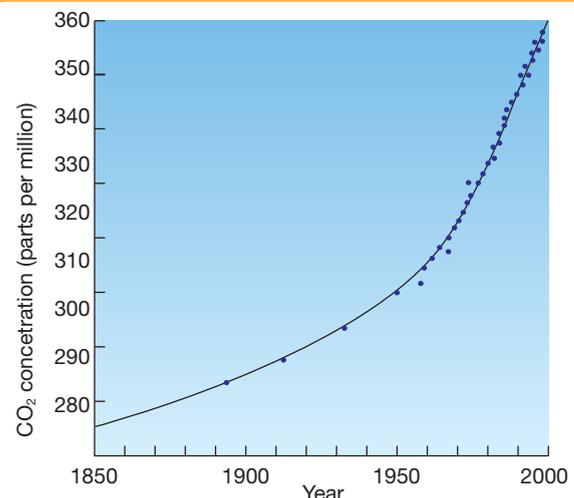


Fig 4.1.3 Carbon dioxide concentration is increasing.

4.1

UNIT

[Questions]

Checkpoint*Layer upon layer*

- 1 Copy the following into your workbook, changing any incorrect statements so they are true.
 - a Humans live in the ionosphere.
 - b Commercial aircraft travel in the stratosphere.
 - c Oxygen is the most common gas in the atmosphere.
 - d The ionosphere protects us from X-rays and gamma rays.
 - e The ozone layer is part of the stratosphere.
 - f Weather happens in the troposphere.
 - g Most of the air is in the ionosphere.
- 2 Identify the layers of the atmosphere that could be considered the:
 - a hottest
 - b coldest
 - c thickest.
- 3 Describe what happens to the air temperature as we go higher in the:
 - a troposphere
 - b stratosphere
 - c mesosphere
 - d thermosphere.

What's in air?

- 4 Identify the main gases in air and state the percentage of each.
- 5 Each gas in air has a purpose. Describe a purpose for each gas you listed for Question 4.

Think

- 6 Accurately draw a pie chart showing the percentage of each gas in the atmosphere.

Analyse

- 7 'The troposphere is the atmosphere of Earth.' Explain why:
 - a this statement is wrong
 - b this statement has some truth in it.

UNIT 4.2

Weather

Introduction

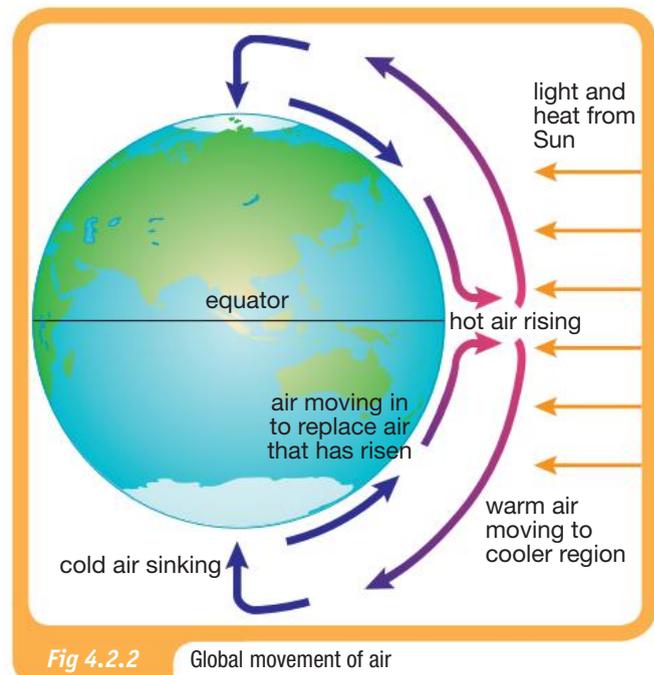
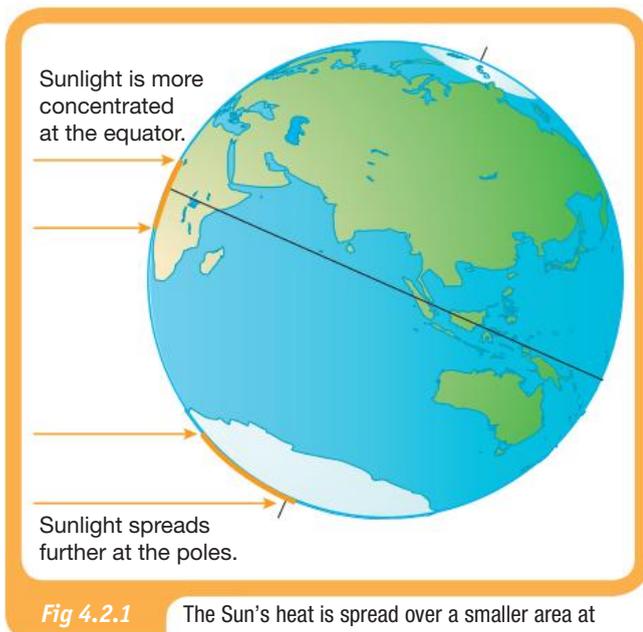
We often talk about the weather—‘It’s too hot’, ‘It’s too cold’ or sometimes ‘Today is perfect weather for ...’. Sometimes we like the wind, as it helps clothes dry and yachts race, but at other times it messes our hair or blows dust into our eyes. The weather affects our everyday decisions, such as what we wear, how we travel and where

we go. Extreme weather causes floods, drought and often destruction. It is therefore important to understand this most important part of our lives.

Wind

As air is heated, it expands and becomes ‘lighter’ and has lower pressure. Cold air is ‘heavier’ and has a higher pressure than warmer air. Because of this, hot air rises and cold air drops. This process is called convection and happens in our houses, the kitchen oven and the atmosphere.

The Earth’s equator receives more concentrated heat and light energy from the Sun than do the poles, causing the air over the equator to rise and the air over the poles to drop. Convection currents take warm air to the poles and cooler air back to the equator. The atmosphere is also swirled around by the spin of the Earth, creating a series of winds called trade winds.



In theory, this would cause winds that always blow roughly in the same direction, but winds do not actually do this. The Sun heats different materials at different rates. Land areas heat up more quickly than lakes, oceans and the seas. Dark colours increase in temperature faster than light colours. This means that bitumen roads, car parks, newly ploughed fields and dark-coloured rocks such as basalt heat faster than sand and marble, fields of crops and shiny metal roofs. Convection currents and winds are created because of differences in temperatures and air pressures in a small area.

Winds move from areas of high pressure to fill the 'gap' created in areas of low pressure.



Fig 4.2.3 Wind patterns over the Earth

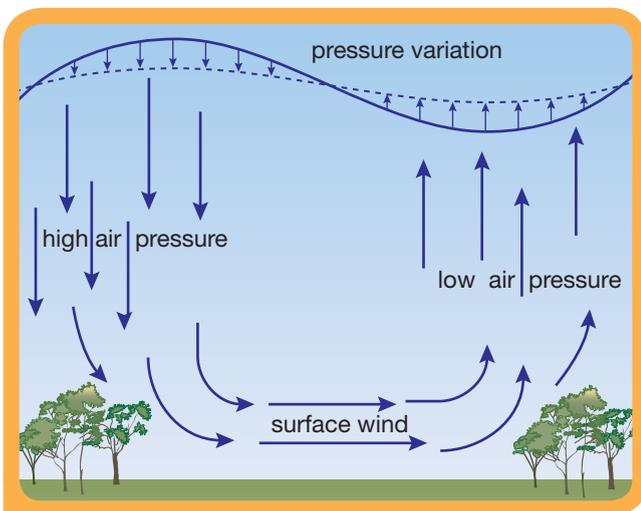


Fig 4.2.4 Local winds are caused by different heating rates and differences in air pressure.

Looks like rain!

Water is constantly evaporating from anything wet on Earth, whether it is a lake, the ocean, or the washing on a clothesline. More water evaporates from the oceans and seas than anywhere else. This warm water vapour rises, cooling as it gets into higher and colder levels of the atmosphere. When cold enough, it condenses back into liquid water, forming clumps of small droplets that we normally call clouds.

If the clouds cool further by being pushed upwards or over colder regions, the tiny droplets begin to join to make bigger drops that will fall as rain or, if cold enough, sleet or snow. Tiny specks of high floating dust often start the process. Sometimes it is cold enough for the water vapour to cool just above the land, forming fog.

Hail formation is still not fully understood. One explanation is that the supercooled raindrops freeze on the surface of dust particles or snow. These small hailstones are blown up and down inside the cloud by the storm's wind. They gradually gather more water and increase in size until they become too heavy and fall to the ground. Another explanation is that they grow in size as they fall through the storm cloud.

All this water evaporating and falling back as rain forms part of the water cycle, as shown in Figure 4.2.5.

The water cycle

Because H_2O contains only hydrogen and oxygen atoms it is classified as an inorganic compound. Of all the water on Earth, almost 98 per cent is found in the salt water of the oceans. Of the remaining 2 per cent, some is found in the form of atmospheric water vapour and as permanent ice deposits in various parts of the Earth. Less than 1 per cent is available as fresh water to the organisms that live on Earth. It is only because water is recycled that life on our planet has been able to exist for millions of years.

The Sun is the only source of energy that powers the essential process that we know as the water cycle. Heat energy from the Sun causes water molecules to evaporate from:

- moist soil surfaces

- living organisms such as plants (by transpiration) and animals (sweat)
- lakes, rivers and oceans.

Of these, evaporation from the oceans provides most of the water vapour present in our atmosphere. Water vapour is carried by air currents and much of it falls as either rain or snow when it reaches land. This water flows down through soil and porous rock until it reaches a layer of non-porous rock, which stops the water sinking any lower. The soil and rock immediately above this becomes saturated with water. This saturated layer is known as the water table. Eventually, the water finds its way back to the sea, allowing the cycle to continue.

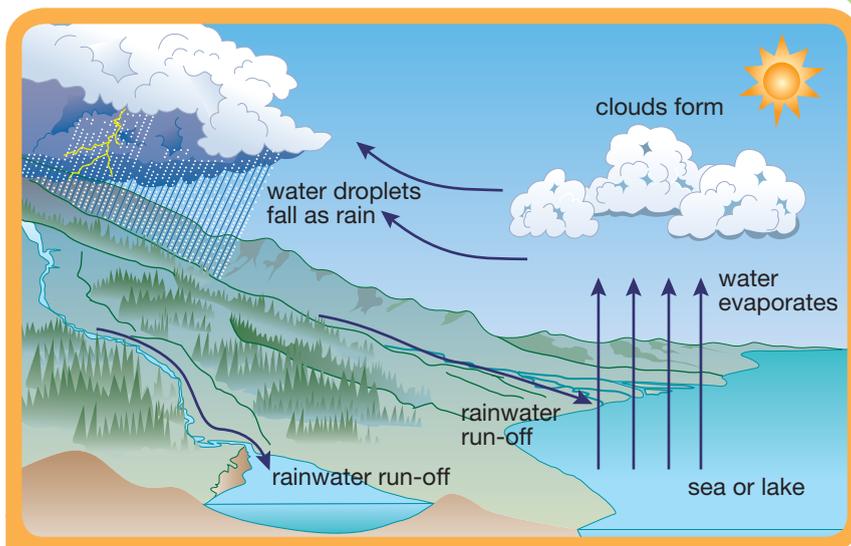


Fig 4.2.5

Clouds are cooled water vapour. This is called condensation. If the drops are heavy enough, they fall as rain. This flow of water from sea to clouds to rain, then run-off from land to sea, is called the 'water cycle'.



a Cumulus clouds do not produce rain.



b Altocumulus clouds produce light showers.



c Stratocumulus clouds produce drizzle.



d Cirrus clouds consist of ice crystals, and do not produce rain.



e Stratus clouds produce drizzle or fine rain. They may form fog at low levels.



f Cumulonimbus clouds produce thunderstorms with lightning.



g Nimbostratus clouds produce heavy rain or snow.



h Cirrocumulus clouds do not produce rain.

Fig 4.2.6

Different types of clouds

Activity 2

Making clouds

Aim

To determine what conditions are needed to make clouds

Equipment

400 mL beaker, ice cubes, evaporating dish, Bunsen burner, heat-proof mat, tripod, gauze mat and matches, safety glasses

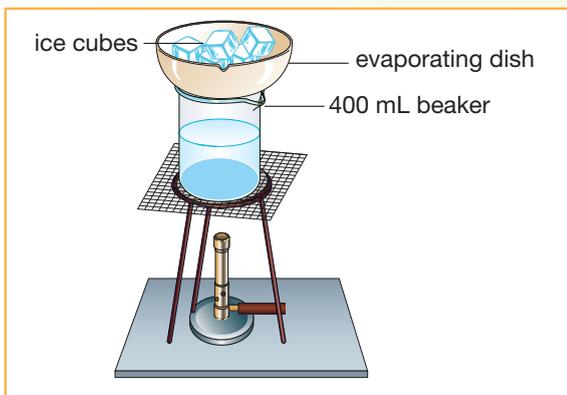


Fig 4.2.7 Apparatus set-up for determining the conditions necessary for cloud formation

Method

- 1 Heat about 100 mL of water in the beaker until boiling.
- 2 Turn off the gas and cover the beaker with an evaporating dish.
- 3 Observe and note in your results what happens.
- 4 Repeat the experiment but this time place ice cubes in the evaporating dish as shown in Figure 4.2.7.
- 5 Write down your observations in your results.

Questions

- 1 Explain what water vapour is.
- 2 Describe what happens to water vapour as it cools.
- 3 Explain how cooling water vapour could cause a cloud.

Too much movement ... storms

In the southern hemisphere, winds move in a clockwise direction around a region of low pressure (a low) on a weather map, and anticlockwise around a region of high pressure (a high).

A cyclone (known as a hurricane in the United States of America and a typhoon in Asia) begins as an intense low over a stretch of ocean, usually in the tropics. The warm, humid air begins to spiral

clockwise and upwards, cooling and condensing as it goes. Energy is released and the air is warmed again, forcing it to go even higher, reducing the air pressure at ground level even more. Air is sucked in from the seas around it, bringing high-speed winds and torrential rain. The cyclone usually keeps going until it passes over land and loses its supply of water and its energy.

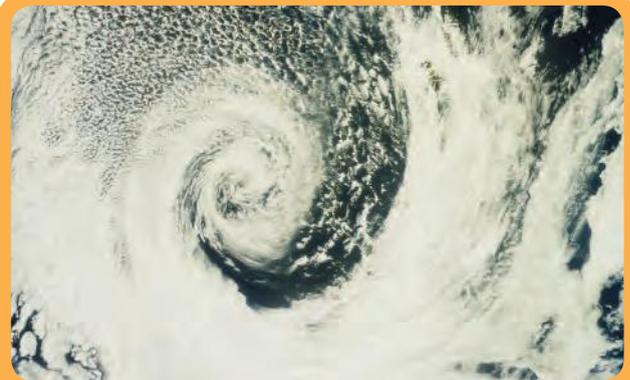


Fig 4.2.8

A satellite image of a low-pressure weather system off Australia's southern coast. Note that the winds spiral clockwise and move towards low pressure.

Activity 3

Cyclones

Aim

To identify what causes a cyclone

Questions

- 1 Briefly explain how a cyclone is formed.
- 2 Identify the other names for a cyclone.
- 3 What causes a cyclone to lose strength?

Career profile: Meteorologist

Meteorologists predict the weather and study the atmosphere to improve our understanding of the Earth's climate. Meteorologists can have a major effect on both society and the environment. Their weather predictions affect our society every day, especially when the prediction is inaccurate. Their advance warnings for dangerous weather can save both lives and property.

A meteorologist can be involved in:

- using different scientific instruments to forecast the weather

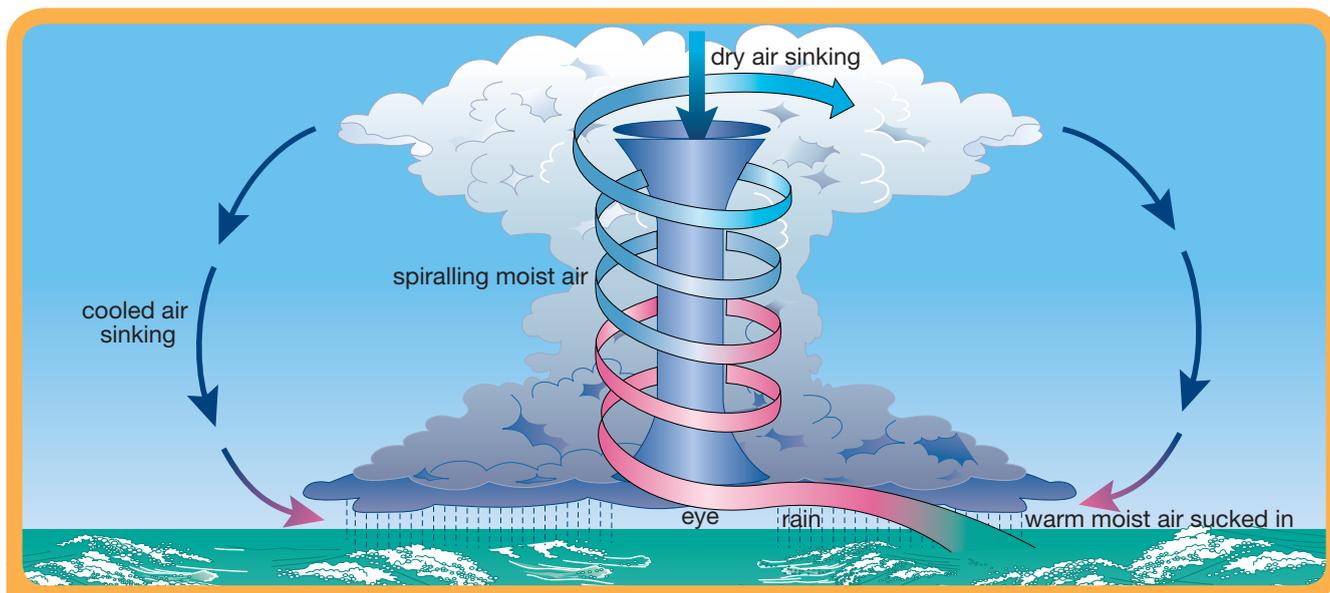


Fig 4.2.9 Tropical cyclones cause massive amounts of air to shift.

- examining satellite images of clouds for dangerous weather
 - preparing special reports for shipping, agriculture, fishing and flying
 - issuing warnings of cyclones, storms, floods, frosts, fire dangers and strong winds
 - reporting air pollution.
- A good meteorologist will be able to:
- record and analyse many different types of data
 - be part of a team
 - use different instruments to gather data in the field
 - write accurate reports.



Fig 4.2.10 A weather balloon measures the temperature and humidity of the atmosphere.

4.2 [Questions]

Checkpoint

Wind

- Copy the following and change any incorrect statements so they become true.
 - Hot air rises and cold air drops.
 - The equator receives more concentrated heat energy from the Sun than the poles do.
 - Hot air circulates away from the poles to the equator.
 - Trade winds are local winds.

Looks like rain!

- Identify these processes.
 - $\text{H}_2\text{O}(l) \longrightarrow \text{H}_2\text{O}(g)$
 - $\text{H}_2\text{O}(g) \longrightarrow \text{H}_2\text{O}(l)$
- Explain what is needed to cause a cloud to rain.
- Identify the types of clouds most likely to cause rain.

The water cycle

- In your own words, describe what the water cycle is.

Too much movement ... storms

- List the other names used for cyclones.
- Describe what causes a cyclone to begin.
- Identify what causes a cyclone to lose strength.

Think

- Explain why it is unwise to eat snow.
- Explain why the poles would be even colder if there were no convection currents.
- Predict whether the temperatures at the equator would be higher or lower if there were no convection currents.
- Plants are also involved in the water cycle. Describe how you think they fit in.
- In your own words, summarise the role of a meteorologist.

>>

Analyse

14 Predict the direction of the winds in the areas shown in Figure 4.2.11.

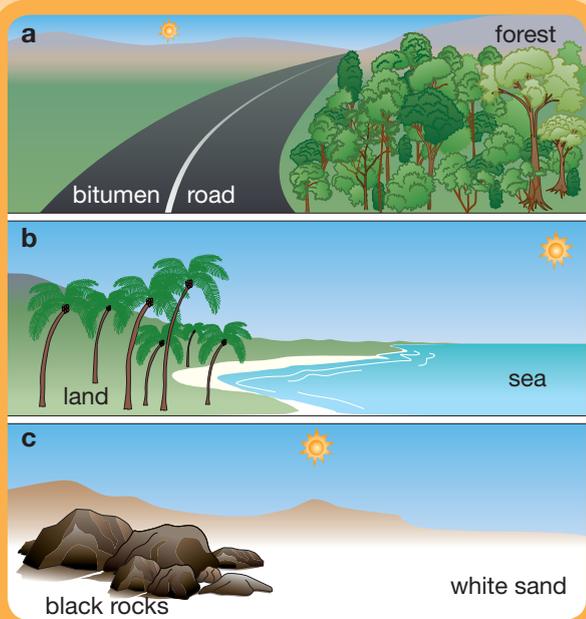


Fig 4.2.11

- 15 Gather weather maps from the newspaper for one week. Then use each map to do the following:
- Draw arrows on the maps to indicate the directions you would expect the winds to blow.
 - Shade areas where it would be warmer in red, and cooler in blue.
 - Draw water drops or snowflakes where you would expect rain or snow.

[Extension]

Investigate

- Keep a diary of the types of clouds you see over the next week and any rainfall (none, rain, drizzle, spitting) that occurs.

Action

- Construct a model of the water cycle using a fish tank with a lid on. Set up the inside of the tank to look like a part of the surface of the Earth. Attach labels to the outside of the glass to explain what is occurring in each part of the tank.

Chapter review

[Summary questions]

- True or false?
 - The layer of the atmosphere in which humans and animals live is called the stratosphere.
 - Winds move in a clockwise direction around a low.
 - Condensation is the name given when water turns from liquid to vapour.
 - Hot air is more dense than cold air.
 - Water heats up more quickly than rock.
 - The Sun heats up the atmosphere.
 - Clouds help trap heat in the atmosphere on cold nights.
- Draw a simplified diagram to demonstrate the water cycle.

[Thinking questions]

- List eight types of cloud in order from those most likely to give heavy rain to those that will not bring any rain.

[Interpreting questions]

- Copy and complete the following table to summarise the science career covered in this chapter.

Job title	Main tasks	Skills required
Meteorologist		

- Draw a diagram to demonstrate the wind direction around a low-pressure system.
- Make a sketch to demonstrate the air movement around a cyclone.
- List the layers of the atmosphere in the correct order, starting from the Earth's surface.

Plant processes and marine systems

Challenges

- 1 Do plants grow in pitch-black caves?
- 2 Very few plants grow at the bottom of deep water. Why?
- 3 Why are leaves usually green?
- 4 How can you tell the age of a tree that has been cut down?
- 5 Why do cacti have spikes?
- 6 Why do plants droop when they haven't been watered?
- 7 What are some marine ecosystems that you see in your coastal area?
- 8 How do coral reefs make their food?
- 9 How do fish take oxygen into their bodies?

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

- explain that photosynthesis occurs in the presence of chlorophyll in green leaves
- write the photosynthesis reaction in words
- demonstrate that plants have special vessels for food, nutrient and water transport
- write the word equation of and describe different stages in the process of respiration
- describe the different common marine ecosystems: mangrove, intertidal zone, coral reef and deep sea
- identify some marine organisms living in the different marine ecosystems
- identify some food sources from the different marine ecosystems
- investigate and compare species diversity and abundance in polluted and non-polluted marine ecosystems
- describe different local methods used to protect our marine resources
- describe some symbiotic relationships in the coral reef ecosystem
- dissect a fish
- identify, draw and label the external and internal parts of a fish
- describe methods of fishing in your community
- describe non-sustainable fishing in your community
- express the importance of sustainable fishing in your community.

Specific learning outcomes

8.5.1.1, 8.5.2.1, 8.5.2.2, 8.5.3.1, 8.5.4.1, 8.5.5.1, 8.5.6.1,
8.5.6.2, 8.5.6.3, 8.5.7.1, 8.5.8.1, 8.5.9.1, 8.5.10.1, 8.5.10.2,
8.5.11.1, 8.5.11.2, 8.5.12.1, 8.5.12.2, 8.5.13.1

UNIT 5.1

Plant transport systems

Introduction

Plants are essential to our lives. They are the producers that make the food that humans and all other organisms depend upon. We also use plant materials for other purposes. Wood is used in building and for making paper; flowers are used for decoration, and in making scents and some drugs and medicines; and cotton is used in clothing. Where would we be without plants?

Introducing photosynthesis

When exposed to sunlight, the leaves of plants convert carbon dioxide from the air and water from their surroundings into glucose and oxygen. They do this by using a special green chemical called chlorophyll. The process is called photosynthesis. This glucose produced is 'food' for plants and is transported around the plant in special pathways.

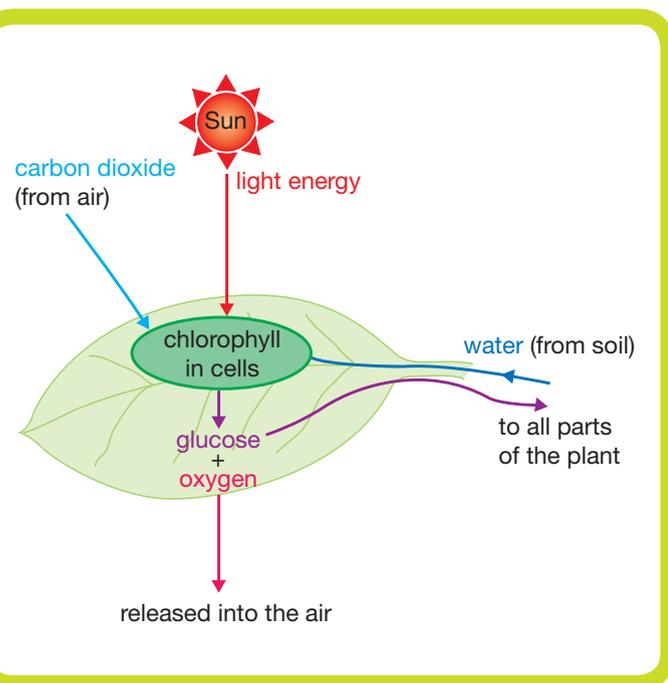


Fig 5.1.1

Water needs to be transported into a leaf for photosynthesis to happen. The glucose produced also needs to be transported out.

Activity 1

Water transport in celery

Aim

To observe the movement of water in the xylem of celery

Equipment

Celery stick with leaves, 2 beakers, razor blade, dye

Method

- 1 Arrange the apparatus as shown in Figure 5.1.2.
- 2 Leave it overnight and then observe the celery stalk closely.
- 3 Cut the celery stick lengthways and across the stalk, and note the presence of any dye.

Extension

Design a modification to this experiment to test the effect the leaves have on the movement of dye.

Questions

- 1 Describe the directions in which the dye travelled.
- 2 Construct diagrams of the horizontal slice and the vertical slice. In each diagram show where the dye travelled.
- 3 Explain why one half of the celery stalk was left in water with no dye.

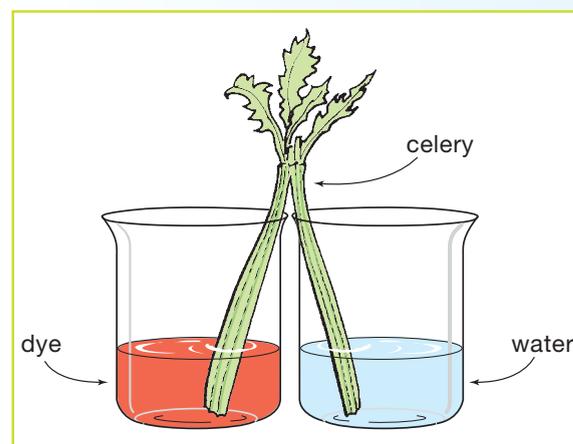


Fig 5.1.2 Apparatus set-up for observing movement of water in the xylem of celery

Plant pathways

In plants there are two types of transport tubes, which start in the roots and travel up the stem to the leaves. The roots anchor the plant and absorb water and nutrients from the soil. The xylem tubes in the roots carry water and minerals such as phosphorus, potassium, nitrogen, sulfur, calcium, iron and magnesium from the soil. Xylem tubes are made of dead cells strengthened with a woody substance. Unlike an animal, a plant does not have a heart to pump liquid through its tubes—instead, pressure in the roots pushes water upwards. Evaporation through tiny holes in the leaves (called stomata) further assists the flow by sucking water upwards.

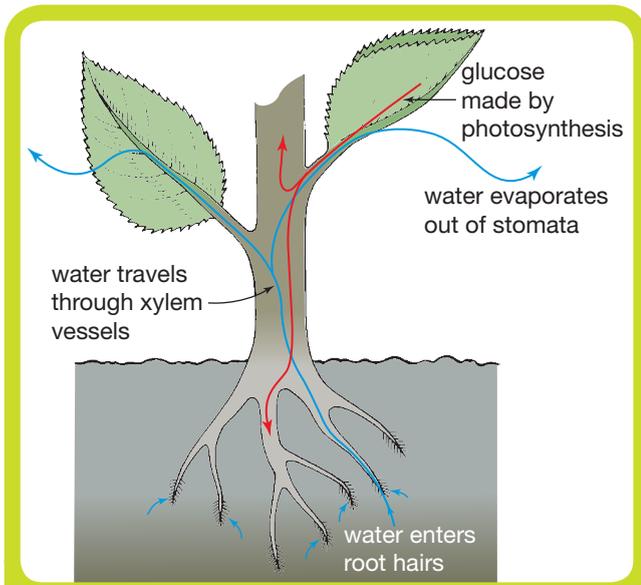


Fig 5.1.3 Water and glucose flow through a plant.

Phloem tubes are made from living cells. Their function is to transport the food (glucose) that is produced by photosynthesis in the leaves to the stem and roots. Some plants store glucose directly for use when required (eg to produce new buds in spring). Glucose is stored in the leaves of the lettuce, the stem of the celery plant and the tuber of the carrot plant. In other plants the food is stored in the form of starch, such as in the potato—which explains why potatoes are not as sweet as carrots and other vegetables.

Xylem and phloem tubes are grouped together in vascular bundles, separated by a layer of cambium cells. Cambium cells are able to become either new xylem or new phloem cells as required.



Fig 5.1.4 Root hairs increase the surface area through which water is absorbed into a plant.

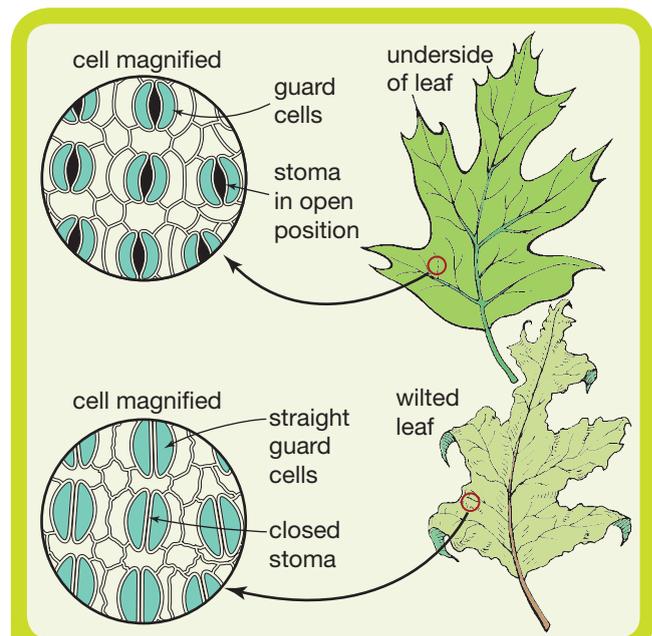


Fig 5.1.5 Stomata (singular: stoma) control the flow of oxygen and water vapour out of a leaf, and also control carbon dioxide intake.

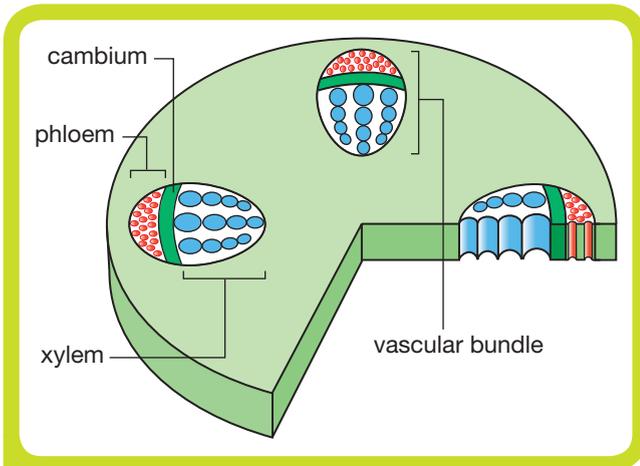


Fig 5.1.6 Cross-section of a stem, showing vascular bundles

Ringbarking removes the layer of phloem cells and will quickly kill a tree. Each year a new layer of xylem cells is produced, and the inner layers of old xylem cells combine with other plant substances to form wood. A cut cross-section of a tree trunk can reveal these yearly rings of growth.



Fig 5.1.7 Growth rings in a mature tree

Firm or floppy

The soft parts of plants are supported by water in its cells. The plant will be upright and its cells firm (turgid) if enough water is present. The plant's stem and leaves may droop and become flaccid if the water content in the cells falls.

Wood

Trees are just big plants and so they too contain xylem and phloem cells. Vascular bundles in the stem eventually link up to form a vascular cylinder. Phloem cells stay in the outer layer of a tree, just under the bark. These phloem cells are the pathways by which nutrients reach all parts of a tree.

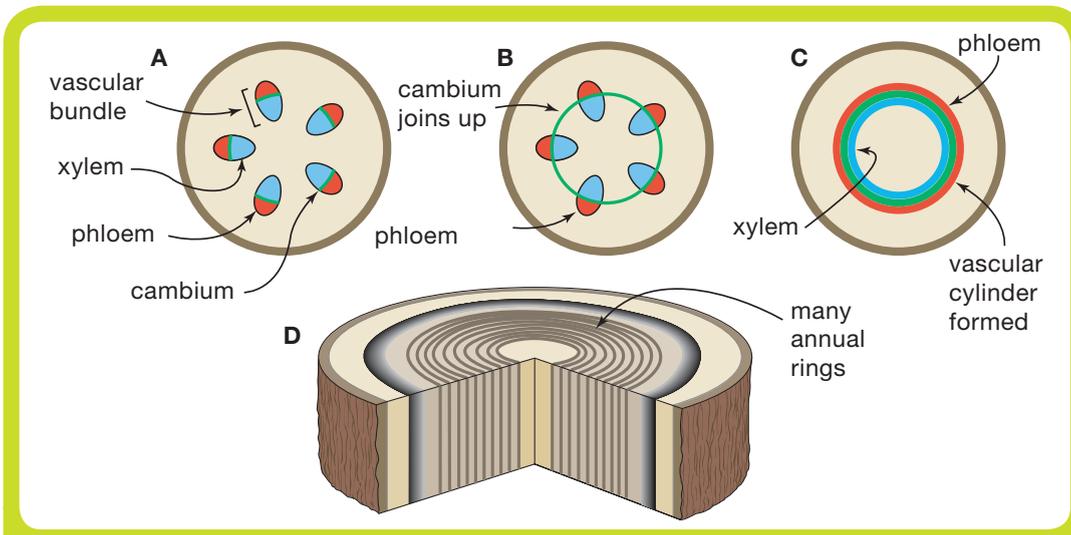


Fig 5.1.8 Formation of a growth ring in a tree

[Questions]

Checkpoint**Introducing photosynthesis**

- 1 Outline what is needed for photosynthesis and what is produced.
- 2 Figure 5.1.1 shows the function of the leaf in photosynthesis. Outline ways in which the leaf assists in photosynthesis.

Plant pathways

- 3 State whether the following statements are true or false.
 - a Water is conducted up and down the plant stem through the xylem.
 - b Water is transported around the plant in the phloem.
 - c Xylem and phloem are grouped together in the cambium.
 - d Dead xylem and phloem cells turn into cambium.
- 4 Identify which tubes in plants carry:
 - a nutrients
 - b water and minerals.
- 5 Explain how water moves through a plant.

Firm or floppy

- 6 Outline what happens to a plant when it is 'flaccid'.
- 7 Describe what is required for plants to remain 'turgid'.

Wood

- 8 Ringbarking a tree may kill it. Explain why this occurs.
- 9 Identify which cells turn into wood.

Think

- 10 Plants contain a large amount of carbon. Identify where this carbon comes from.
- 11 Flowers are usually placed in water in a vase to keep them looking good. Explain how this stops them going flaccid.
- 12 The flat surface of most leaves faces the Sun. Propose a reason for this plant behaviour.
- 13 Eucalyptus leaves droop so that their flat surfaces are vertical. Explain how this adaptation would help eucalypts survive in a hot climate.
- 14 The leaves from a plant are removed. Explain how this will affect the plant.
- 15 Cactus plants often have needle-like leaves. Propose a reason for this adaptation.

Analyse

- 16 Use Figure 5.1.1 to construct a word equation for photosynthesis.
- 17 Growth rings are produced because trees grow at different rates during a year, producing different patterns within the tree. Evaluate the age of the tree trunk shown in Figure 5.1.7.
- 18 Account for the presence of a large network of root hairs on a plant like that shown in Figure 5.1.4.

[Extension]

Investigate

- 1 Research information about the manufacturing of paper from wood. Construct a poster that shows a diagram of each step in the process and a brief description.

Action

- 2 Place some radish seeds on moist cotton wool and observe the roots that develop over a few days. Contrast your observations with those predicted by pulling a plant out of the ground.

UNIT 5.2

Photosynthesis and respiration

Introduction

Humans and other animals depend on glucose as their source of energy, and on a steady supply of oxygen to burn the glucose. However, animals cannot make their own glucose, and cannot replenish the oxygen in the air. Only plants have this ability. They do it in the process of photosynthesis. Ultimately, all life on Earth depends on photosynthesis, a process by which plants trap and use light energy from the Sun.

Activity 2

A product of photosynthesis

Aim

To investigate the products of photosynthesis

Equipment

2 × 600 mL beakers, 2 glass funnels, 2 test tubes, sodium hydrogen carbonate solution (0.5 per cent), 2 pieces of actively growing *Elodea* (Canadian pond weed), light source, wooden splint, safety goggles

Method

- 1 Half-fill each beaker with sodium hydrogen carbonate solution.
- 2 Place a piece of plant in each beaker and cover the plant with a funnel.
- 3 Invert a test tube full of water over the stem of each funnel.
- 4 Place one beaker in the dark, the other in continuous light for several days.
- 5 Describe any changes in appearance that have developed in each set-up.
- 6 Test any gas collected. To do this, lift the test tube off the funnel and gently remove it from the water. Quickly insert a glowing wooden splint into the test tube, making sure not to touch the sides of the wet test tube.
- 7 Record the results of the gas test.

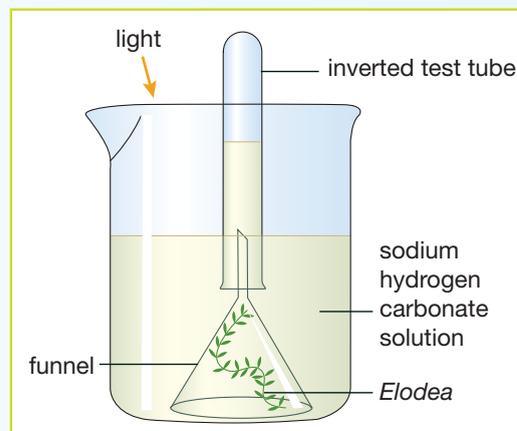


Fig 5.2.1 Apparatus set-up for testing for a product of photosynthesis

Questions

- 1 State the purpose of the sodium hydrogen carbonate solution.
- 2 Identify any gas given off.
- 3 Explain any differences you observe in the two set-ups in the experiment.

Photosynthesis

The search for the secret of plant growth has a long history. The first careful experiments were conducted around 400 years ago by Jan Baptist van Helmont. He grew a willow tree in a tub after carefully weighing the plant and the soil. He watered the plant regularly and after 5 years reweighed the plant and the soil. The mass of the plant had increased by 74.5 kg, but the mass of soil had not changed. He concluded that the plant had converted water to wood and leaves. In the 1770s, Joseph Priestley demonstrated the importance of oxygen, and its production by plants. Jan Ingenhousz then showed that light was necessary for this production. Jean Senebier in 1782 found



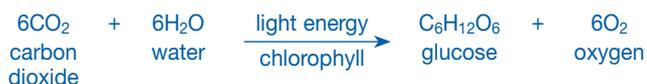
Fig 5.2.2 The Sun is the source of energy for all living things on Earth.

that plants absorb carbon dioxide from the air. In 1804, Nicolas de Saussure showed that water was chemically involved in plant growth.

The basic facts of the process of plant growth that we now know as photosynthesis were therefore known by the early 1800s. Although hundreds of scientists have conducted many experiments on different aspects of photosynthesis, the process is still not fully understood. For example, scientists have not yet been able to duplicate photosynthesis outside a living cell.

Photosynthesis—a chemical reaction

Photosynthesis (from Greek: *photo* = light, *syn* = with, *thesis* = to make) can be represented by the chemical equation:



This equation gives only a general idea of what happens. The equation indicates that chlorophyll, the green pigment in plants, is necessary for the reaction to occur. However, if carbon dioxide, water and chlorophyll are placed in a test tube in sunlight nothing happens! The explanation is that this 'single' reaction is in fact a complex chain of smaller reactions.



Fig 5.2.3 Single-celled organisms called diatoms come in a variety of shapes. They are important photosynthetic organisms in the ocean. A litre of sea water may contain as many as 450 000 diatoms.

Photosynthesis is essentially a two-stage process.

- Stage 1 is called the light reaction. In this stage, light energy is trapped and changed into chemical energy. At the same time, enzymes split water into oxygen and hydrogen. Enzymes are protein molecules that act as catalysts. A catalyst is something that speeds up a chemical reaction without being used up in the reaction. Enzymes help reactions occur faster.
- Stage 2 is the dark reaction, a series of enzyme-controlled reactions in which carbon dioxide and hydrogen from water combine to form glucose. Light energy is not needed in this stage.

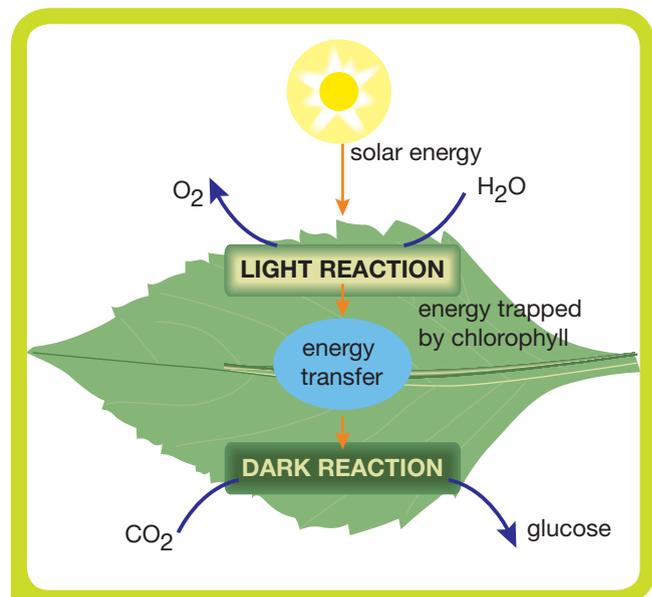


Fig 5.2.4 Energy changes during the two stages of photosynthesis

The key to the process is chloroplasts, which are found within the cells of plants. Chloroplasts contain the green pigment chlorophyll, which acts something like a solar cell, trapping light energy and converting it to another form. Chloroplasts act as 'factories' for the production of glucose. One plant leaf contains tens of thousands of cells, each containing forty to fifty chloroplasts.



Fig 5.2.5 A chloroplast (green) in a leaf cell. In the centre is a starch granule (blue).

What happens to the glucose produced during photosynthesis? The plant may use the glucose directly for energy through respiration. However, on a sunny day photosynthesis can occur ten times faster than respiration. The excess glucose must be 'used' in other ways. Most is converted to starch for temporary storage in the leaf. At night this starch is reconverted to glucose, a process known as destarching.

Glucose may be converted to:

- cellulose to build plant cell walls
 - sugars for transport to various parts of the plant
- or
- substances used for producing plant oils and proteins.

The rate of photosynthesis

The rate of photosynthesis depends mainly on the availability of carbon dioxide and light. In general, an increase in either carbon dioxide or light causes an increase in the rate of photosynthesis. The effect is shown in Figure 5.2.6, a graph of the rate of

photosynthesis versus light intensity. The rate rises quickly as light intensity increases, because more energy is available. Once the light energy reaches a certain point, no further rise occurs. At this point, carbon dioxide begins to limit the reaction: carbon dioxide levels determine the maximum rate of photosynthesis.

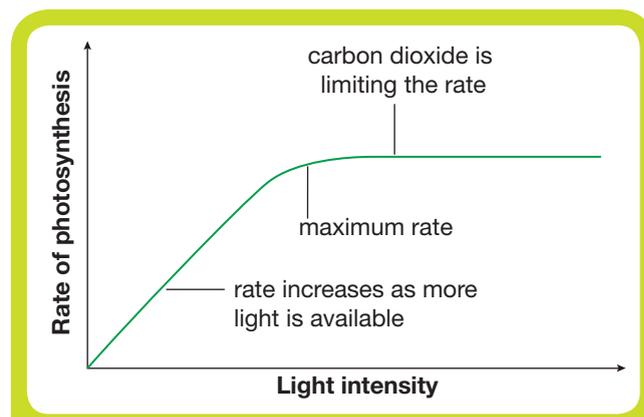


Fig 5.2.6 Effect of light intensity on the rate of photosynthesis

Like most chemical reactions, the rate of photosynthesis increases with increasing temperature. The rate of photosynthesis increases up to a temperature of about 30°C, then decreases. At these higher temperatures the enzymes are affected and no longer function correctly.

Activity 3

Green leaves and photosynthesis: Teacher demonstration

Aim

To examine where the products of photosynthesis are stored in leaves

WARNING: Ethanol is highly flammable. At no stage should the test tube containing ethanol be placed near a flame.

Equipment

Potted plant with variegated leaves, potted plant of the same species with completely green leaves (a hibiscus plant would be suitable), 3 beakers of boiling water (these should ONLY be heated using

>>

an electric hot plate), 2 large test tubes containing ethanol or methylated spirits, iodine solution, forceps, scissors, 2 watch-glasses or 2 glass petri dishes, safety goggles

Method

- 1 Cut a leaf from each plant. Cut a small nick in the edge of the variegated leaf so it can be identified later.
- 2 Sketch two outlines of the variegated leaf side by side. Do the same for the green leaf.
- 3 Drop both leaves into a beaker of boiling water for a few minutes. This kills the leaf cells so that no further reactions can occur.
- 4 Using the forceps, remove the leaves and place one in each test tube of ethanol.
- 5 Stand both test tubes in the second beaker of boiling water. The ethanol will start to boil, and the green colour will be dissolved from the leaves. After around 10 minutes the leaves should look quite pale.
- 6 Using the forceps, remove the leaf from one test tube and dip it into the third beaker of boiling water for a few seconds. This removes the ethanol and softens the leaf. Place the leaf on a watch-glass or petri dish. Repeat this step for the other leaf.

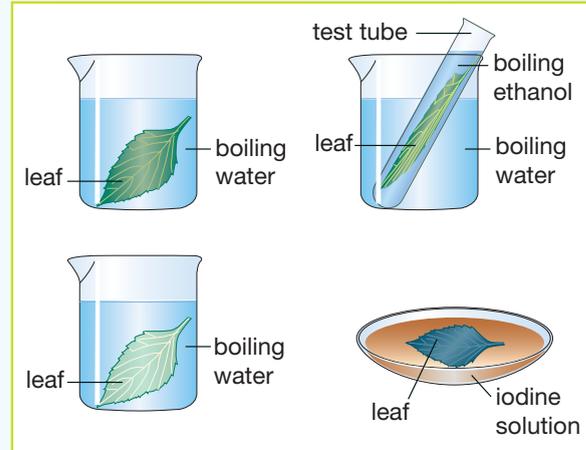


Fig 5.2.7 Apparatus set-up for testing a leaf for starch

- 7 Add iodine solution to each leaf. Allow it to stand for a minute.
- 8 Dispose of all solutions as instructed by your teacher.
- 9 On the outlines prepared in step 2, draw and colour in the areas stained blue-black on each leaf.

Questions

- 1 State the name of the substance identified by the blue-black colour obtained with iodine.
- 2 Explain why the leaves were boiled in ethanol.
- 3 Describe any relationship between the presence of green in the leaves, and areas that were stained blue-black.
- 4 Explain why the stained areas of the leaf show where photosynthesis is likely to occur.

Respiration

The process by which organisms release energy from food is called respiration. This energy is available to cells for their many activities. These include growth of cells, and transport of substances into and out of cells. Some of the energy released during respiration is given out as heat. For most organisms this process needs oxygen, so it is called aerobic respiration. We can show aerobic respiration using the following chemical equation:



Respiration occurs in the cells of all living things. Glucose can also be burnt in air: its reaction is rapid and uncontrolled, releasing heat and light. If such a process occurred in cells, the heat would destroy the cell. Instead, the reaction is gradual and controlled, releasing energy in small amounts. Just how the cell manages this process is still not completely understood. It is known that this 'single' reaction occurs as a sequence of at least thirty different reactions arranged in a complicated chain. The keys to all these reactions are those amazing molecules called enzymes.

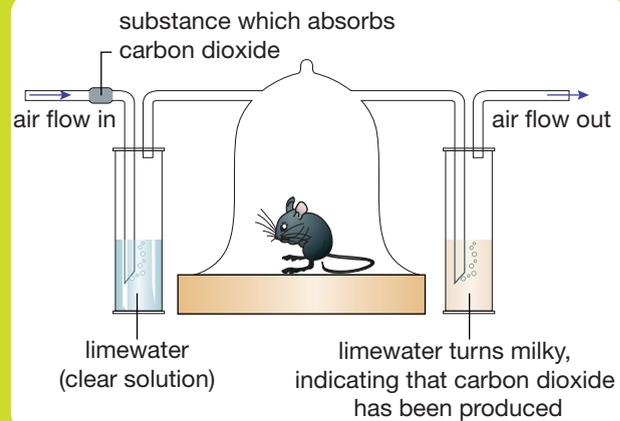


Fig 5.2.8

An experiment to show that carbon dioxide is produced by a mouse

Enzymes act as catalysts, speeding up chemical reactions without being used up in the reaction. Enzymes are very efficient at speeding up reactions. They can increase reaction speed by as much as ten billion times. That is like taking a minute to do a task that would otherwise take 18 000 years!

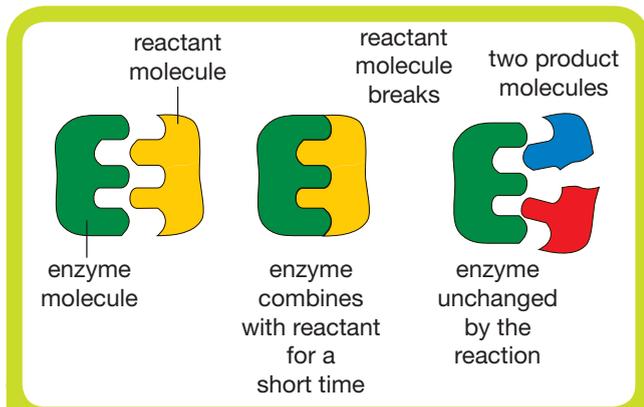


Fig 5.2.9 The 'lock and key' model that explains enzyme action

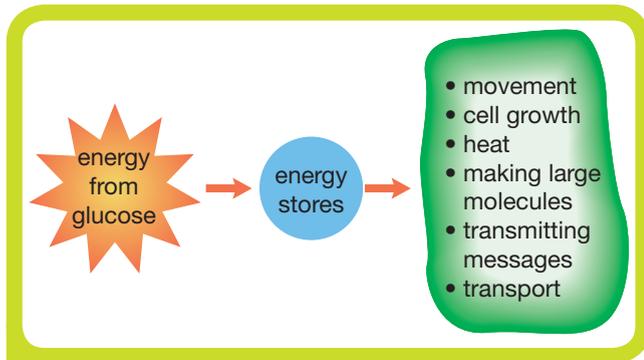


Fig 5.2.10 The flow of energy in cells

Activity 4

A product of respiration

Aim

To investigate the products of respiration

Equipment

Flasks and glassware as shown in Figure 5.2.11, filter pump, sodium hydroxide solution, limewater, potted plant, several insects or earthworms, plastic bag, black paper

Method

- 1 Set up the apparatus as shown in Figure 5.2.11.
- 2 Slowly draw air through the apparatus by means of the filter pump.
- 3 Record any changes in the colour of the limewater in flasks B and D.

Questions

- 1 Sodium hydroxide absorbs carbon dioxide from the air. Carbon dioxide dissolves in limewater to form a milky solution. Explain the purpose of flasks A and B.
- 2 Explain the purpose of flask D.
- 3 Justify the use of the:
 - a plastic bag
 - b black paper.
- 4 Explain any changes observed in the limewater during the experiment.
- 5
 - a Modify the experiment, using an animal (eg an earthworm) in place of the potted plant in flask C.
 - b Compare and contrast the results of the two experiments.

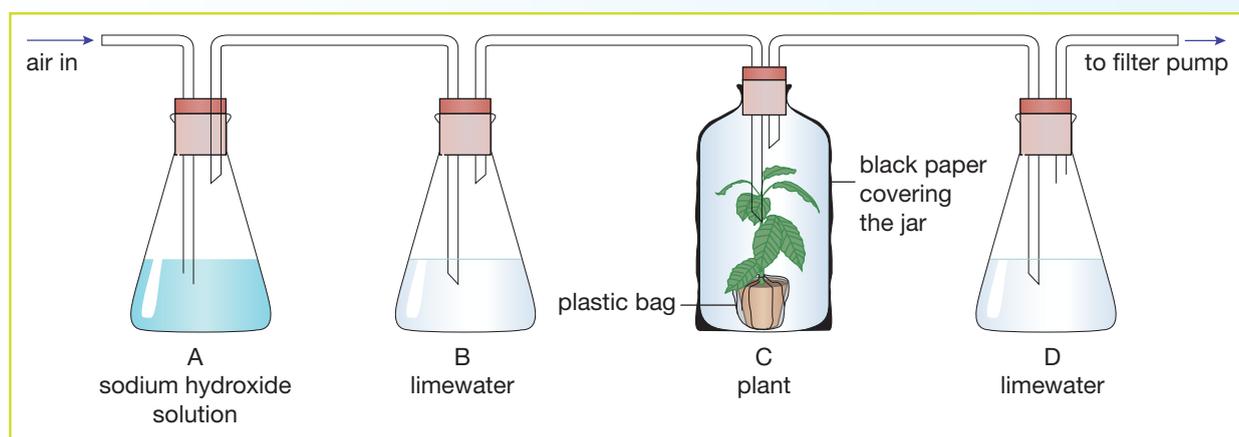


Fig 5.2.11 Apparatus set-up for testing for the products of respiration

Activity 5

Light intensity and photosynthesis

Design an experiment to investigate the effect of light intensity on the rate of photosynthesis. The apparatus shown in Figure 5.2.12 should give you some ideas to get started with. Variables that may be changed include distance of light from test tube, power of the light globe and temperature of the water.

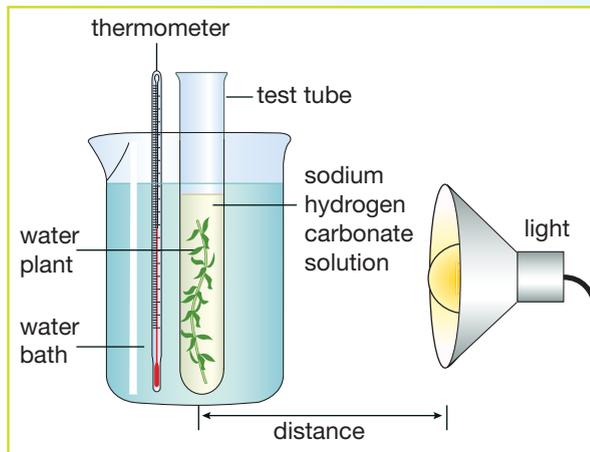


Fig 5.2.12 Apparatus set-up for investigating light intensity and photosynthesis

Comparing photosynthesis and respiration

For almost everything, chloroplasts and photosynthesis are directly or indirectly the basis of life, providing the essential requirements for respiration. The equations for respiration and photosynthesis are the reverse of each other.

Respiration:



Photosynthesis:



This is true if we look only at the overall equations. However, we have seen that the two processes are more complex than the equations suggest. They use different steps and different enzymes, and occur in different locations.

Activity 6

Energy production in respiration

Aim

To determine the heat energy produced by respiration in plant seeds

Equipment

2 wide-mouth thermos flasks, 2 thermometers, cotton wool, pea seeds, boiling water, mild disinfectant

Method

- 1 Divide the seeds into two equal batches.
- 2 Place one batch in boiling water to kill the seeds.
- 3 Soak these killed seeds in the disinfectant.
- 4 Set up the apparatus as shown in Figure 5.2.13.
- 5 Record the temperature in each flask.
- 6 After several hours record the temperature in each flask again.

Questions

- 1 Explain any observed changes in temperature.
- 2 Explain the purpose of the flask containing killed seeds.
- 3 Explain the purpose of the disinfectant.

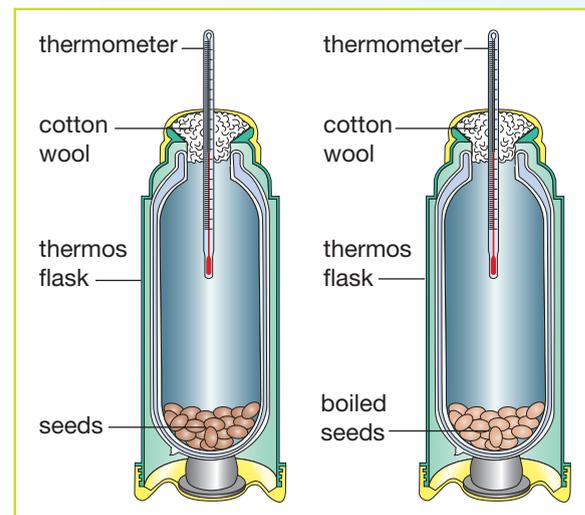


Fig 5.2.13 Testing for energy release in respiration

Comparison of photosynthesis and respiration

	Photosynthesis	Respiration
Occurrence	Plant cells containing chlorophyll	All living cells
Cell structures used	Chloroplasts	Mitochondria
Reactants	Carbon dioxide and water	Glucose (or other fuel) and oxygen
Products	Glucose and oxygen	Carbon dioxide and water
Type of process	A building process leading to increased mass	Breakdown process leading to decreased mass
Energy changes	Light energy changed to chemical energy	Chemical energy changed to heat, energy of movement and other forms
Light requirement	Essential—provides energy	Not required

Respiration

- Outline the purpose of respiration.
- List the products of respiration.

Comparing photosynthesis and respiration

- Outline how photosynthesis and respiration complement each other by working together.
- Identify the cell components in which photosynthesis and respiration occur.

Think

- Photosynthesis does not occur if chlorophyll, water and carbon dioxide are placed in a test tube in sunlight. Explain why it does not occur.
- Propose two ways in which the glucose formed during photosynthesis may be used by the plant.

Analyse

- A leaf was picked from a plant that had been kept in the dark for two days. The leaf was placed in water and the apparatus shown in Figure 5.2.14 was used to carry out an experiment. The apparatus was placed in sunlight. The sodium hydroxide removed carbon dioxide from the air. After some time the leaf was placed in boiling water, then boiling alcohol, then boiling water again. A few drops of iodine solution were then added to the leaf.
 - State the name of the substance being tested for with the iodine.
 - Outline the expected result of the iodine test.
 - Explain why it was necessary to keep the plant in the dark for two days.

5.2 UNIT

Questions

Checkpoint

Photosynthesis

- Several scientists helped discover the basic features of photosynthesis. Identify the correct discovery for each scientist.

Scientists	Discoveries
Priestley	Light is necessary
de Saussure	Oxygen is used
Ingenhousz	Carbon dioxide is used
Senebier	Water is produced

- State whether the following statements are true or false.
 - Photosynthesis can be duplicated outside a living cell.
 - Photosynthesis is completely understood.
 - Water is involved in photosynthesis.
 - Photosynthesis occurs during the night.

Photosynthesis—a chemical reaction

- Explain why chlorophyll is necessary for photosynthesis.
- Describe the energy change that occurs during photosynthesis.
- Photosynthesis is essential for all living things. Explain why.
- List the two reactants in photosynthesis.
 - Identify what else is needed for photosynthesis to occur.
 - List the two products of photosynthesis.

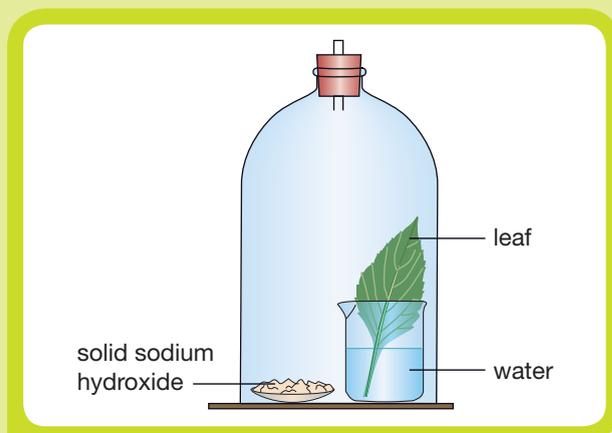


Fig 5.2.14

Skills

- 14 Photosynthesis may be thought of as a two-stage process.
- Use a simple equation to demonstrate what happens in the first stage.
 - Use a simple equation to demonstrate what happens in the second stage.
 - Identify which stage requires light.
- 15 The graph in Figure 5.2.15 shows the amount of oxygen produced by a plant as light intensity was increased under two different sets of conditions.

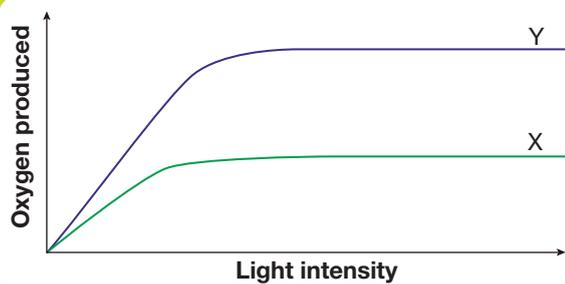


Fig 5.2.15

- Identify the process that produces the oxygen.
 - Explain why the amount of oxygen increases as the light intensity increases.
 - Propose two possible changes that could be made to the experiment to produce graph Y.
- 16 a Increasing the temperature usually increases the rate of photosynthesis. Explain why.

- At temperatures above approximately 30°C, increasing the temperature slows the rate of photosynthesis until it stops altogether. Explain why this occurs.
- 17 An experiment was conducted using the set-up shown in Figure 5.2.16. The set-up was placed in sunlight.
- State the name of the gas produced during the experiment.
 - Describe how you would test to find out the type of gas produced.
 - Use a chemical equation to demonstrate the production of the gas.
 - The experiment was repeated for the same length of time, but using a larger mass of plant. Explain how this would alter the volume of gas produced.

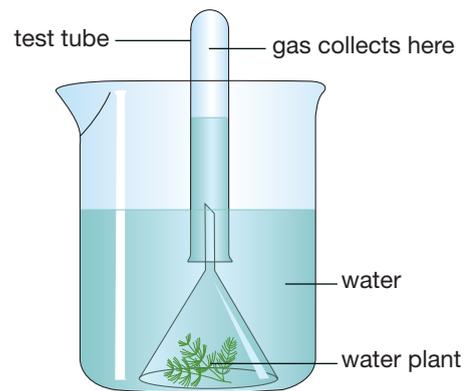


Fig 5.2.16

[**Extension**]

Investigate

- 1 Construct a timeline to demonstrate the main stages in the discovery of photosynthesis. Include major areas of recent research on your timeline.

Action

- Design a controlled experiment to investigate the effects of fertilisers on plant growth.
 - Account for observations made in terms of effect on photosynthesis.

UNIT 5.3

Marine systems

Introduction

A marine system is made up of a number of ecosystems. These ecosystems are found from the seashore to the depths of the ocean. Within these ecosystems are millions of different organisms. These organisms range from very small to very large. Marine systems are bountiful with food supplies. They supply us with our daily protein requirements. As coastal dwellers, many of us find that marine systems also provide us with ways of earning money.

Marine ecosystems are home to a large number of different species, ranging from tiny planktonic organisms to large marine mammals such as whales, manatees, sharks, turtles and dolphins. They are also home to many of the fin fish and shellfish we eat.

In Solomon Islands, the sea is used for recreational purposes, as well as a source of food. Children and adults often take time out to swim and enjoy a relaxing time in the sea. Therefore it is important to keep our waters clean from wastes.

Activity 7

Threats to marine ecosystems

- 1 Walk to a nearby beach, reef, mangrove area or stream. (Do not forget to take a notebook with you.)
- 2 Collect and record details of all the litter that you find on the beach, among the mangroves, on the reef or in the stream.
- 3 Find out what kind of litter is most common. List the different types of litter in order of most to the least abundant.
- 4 Where does the litter come from?
- 5 What is the effect of the litter on the marine ecosystem?
- 6 How can we help look after our marine ecosystems?

Marine ecosystems

Marine ecosystems are a part of the largest ecosystem on the planet, as oceans cover over 70 per cent of the Earth's surface. Marine ecosystems range from the productive near-shore regions to the ocean floor. Examples of important marine ecosystems are coral reefs, mangroves, oceans and coastal areas. Coastal areas consist of lagoons, the intertidal zone and the muddy, sandy and rocky shores.



Fig 5.3.1

In Solomon Islands, the sea is used for recreational purposes as well as a source of food.

Coral reefs

Corals are colonies of tiny living animals found in marine waters. Most coral reefs are built from stony corals, and are formed by polyps that live together in groups. The polyps secrete a hard carbonate exoskeleton, a hard outer structure that provides support and protection for the body of each polyp. Reefs grow best in warm, shallow, clear and sunny waters.

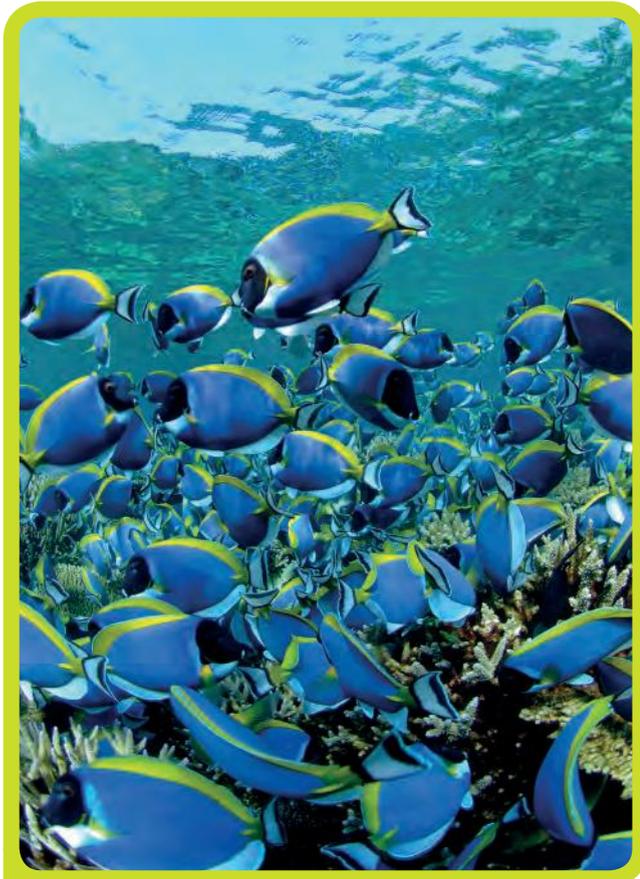


Fig 5.3.2 A coral reef ecosystem is home to many fin fish species.

Coral reefs form some of the most diverse ecosystems on Earth. They provide a home for a large number of marine species. Coral reefs are most commonly found at shallow depths in tropical waters, particularly in the Pacific Ocean, but deep water and cold water corals also exist on smaller scales.

Coral reefs provide many ecosystem services that support human populations economically and culturally. They are beautiful to look at. They also provide ecological support for other ecosystems such as seagrass beds and mangroves.

Types of coral reefs

There are three main reef types: fringing reefs, barrier reefs and atolls.

Fringing reefs are simply reefs that grow attached to the shoreline of islands. Fringing reefs begin growth in shallow water close to shore and tend to spread outward.

Barrier reefs typically grow along the outer edges of continental shelves, separated from the mainland by open water. They are actually made up of many separate small reefs separated by channels.

Atolls are circular reefs enclosing lagoons. Atolls begin by colonising sea mounts or volcanoes, and then grow upward as the sea mount sinks and/or the sea level rises. Eventually, the sea mount sinks below the sea surface, while the coral reef continues to grow upward, resulting in the characteristic doughnut-shaped reef enclosing a central lagoon.

Threats to our coral reefs

Coral reefs are fragile ecosystems, partly because they are very sensitive to water temperature.

Despite the benefits of maintaining healthy coral reefs, many have been seriously degraded due to overuse and abuse by human activities such as over-harvesting of fish and other reef resources, destructive fishing practices, coastal development and poor landuse practices. Coral reefs are also vulnerable to high temperatures, which cause corals and their symbiotic algae to die in a process called coral bleaching.

A global threat to coral reefs is ocean acidification, or a lowering of ocean pH (below pH 7) due to the increased uptake of atmospheric carbon dioxide and the subsequent formation of carbonic acid. Increasing levels of carbon dioxide levels in the atmosphere accelerate this effect. Ocean acidification has been shown to decrease the rate at which corals and coralline algae secrete their calcium carbonate skeletons.

In Solomon Islands, corals that were once found on the shores of many of our coastal urban areas, such as Honiara (including Ranandi area), Gizo, Auki and Tulagi, have either been wiped out already or are slowly dying. This is due mainly to industrial waste such as oil or fuel from ships or nearby industries, or untreated sewage directly disposed of at many of our shores. Gaining in popularity is the removal of corals to burn into lime used for chewing betel nut.



Of major concern is erosion due to bad logging practices. For example, in Marovo lagoon, where some of our most beautiful reefs are found, many of the coral reefs are dying as a result of increased land erosion. This is due to logging on the land. Forests (trees) that hold the soil together have been cut down by logging companies. This means that soil is washed down into the reefs during rainy seasons. This results in corals being smothered, and then coral bleaching. What this means is that corals are suffocated and die. Corals have a relationship with organisms called zooxanthellae, which provide food and enable the corals to grow. Without these small organisms, the corals cannot survive. When the soil is washed into the reefs, it covers the corals, eventually killing these small organisms.



Fig 5.3.3 Killing of corals would result in the loss of some of the most beautiful coral lagoons in the world (Marovo lagoon).

Intertidal zone

The intertidal zone is the shore area between the low and high water marks. This zone is subject to changes in the tide. The zone is covered with water at high tide, and exposed to air at low tide. The land in this zone can be rocky, sandy or muddy. This area can include many different types of habitats, including rocky cliffs, sandy beaches and mudflats.

Environmental conditions in the intertidal zone

Organisms in the intertidal zone are adapted to an environment of harsh extremes. Water is available regularly with the tides, but varies from fresh, when there is with rain, to highly saline and dry between tidal flooding. Animals and plants found in the intertidal zone are subject to changes in tide. Such changes have some advantages for marine animals. They enable fish to search for food in areas of high availability and also allow marine plants to come in direct contact with sunlight. They also allow humans to walk freely to search for seafood at low tide.

The range of sea animals found in this zone includes juveniles and large fish, such as barracuda (ono), mamula, parrot fish, mullet and even sharks, turtles and dugong. This zone is also rich with a variety of edible shellfish.



Fig 5.3.4 The shoreline is part of the intertidal zone.

Mangroves

Activity 8

Richness and diversity of a marine ecosystem

If your school is near the coast or close to a mangrove area, your teacher will arrange a field study trip for you.

Aim

To determine the number of different organisms and how many of each are present in different habitats in a marine ecosystem

Equipment

Clipboard, activity sheet, metre rule, magnifying glass, pen, pencils, extra sheets of paper

Precautions

- 1 Wear shoes or slippers when you walk on the reef.
- 2 Do not touch any shell, fish or any organisms without seeking advice from your teacher.
- 3 Do not collect or disturb organisms in their natural habitat unless told to do so.

Method

- 1 Your teacher will organise you into small groups of four to five students.
- 2 Choose a person in your group to take notes and write down your findings.
- 3 When you are at a marine ecosystem chosen by your teacher, you will sample different habitats within the ecosystem. Some examples of habitats in the intertidal zone are rocks, sand, logs, corals, sea grass or sea weeds. Some examples of habitats in a mangrove ecosystem are muddy spots, mangrove trees, shrubs, rotten logs, water.
- 4 Select different habitats for sampling and, using a metre rule, measure out an area 1 m × 1 m.
- 5 Identify different marine species and also determine how many (quantity) of each is present.
- 6 Use local names to identify the marine organisms (animals, shells, plants, prawns etc).

- 7 Sample a habitat once and move on to a new habitat. For example, if you sampled a coral in an intertidal zone ecosystem, do not sample another coral habitat.
- 8 Record your finding on a sheet provided by your teacher.
- 9 Present your result to the class later.

Questions

- 1 What organisms were present in the marine ecosystems you studied?
- 2 List the organisms you found in the following order:
 - a organism present in the highest number
 - b organism present in the least (lowest) number
 - c organisms that are edible (you can eat them).
- 3 Suggest why some organisms are very low in numbers from your results.

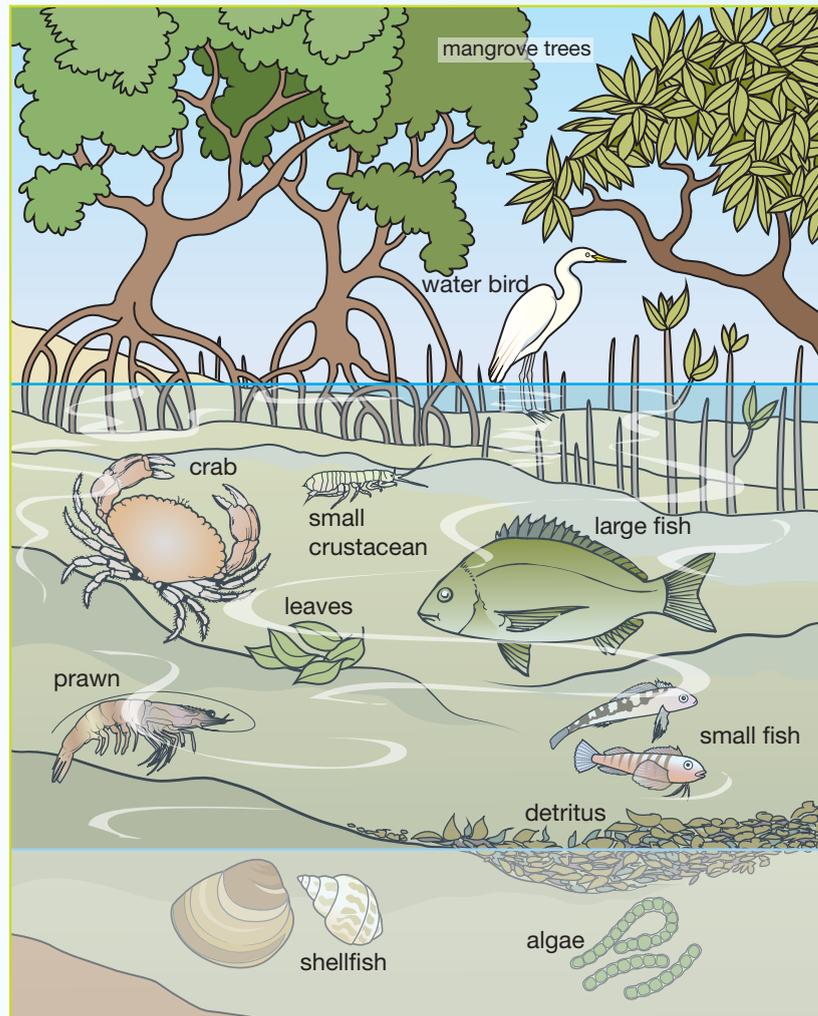


Fig 5.3.5 Mangrove ecosystems are very rich in organisms.



Mangroves in Solomon Islands

Solomon Islands is home to thirteen families and twenty-six species of mangrove. Solomon Islands is rich in mangrove species compared with other neighbouring countries, except for Papua New Guinea. The estimated area covered by mangroves in Solomon Islands is 64 200 hectares.

Mangrove species of Solomon Islands

Family	Species
Acanthaceae	<i>Acanthus ebracteatus</i>
	<i>Acanthus ilicifolius</i>
Avicenniaceae	<i>Avicennia alba</i>
	<i>Avicennia eucalyptifolia</i>
	<i>Avicennia marina</i>
	<i>Avicennia officinalis</i>
Combretaceae	<i>Lumnitzera littorea</i>
Euphorbiaceae	<i>Excoecaria agallocha</i>
Leguminosae	<i>Cynometra ramiflora</i>
Meliaceae	<i>Xylocarpus granatum</i>
	<i>Xylocarpus moluccensis</i>
Myrsinaceae	<i>Aegiceras corniculatum</i>
Myrtaceae	<i>Osbornia octodonta</i>
Palmae	<i>Nypa fruticans</i>
Rhizophoraceae	<i>Bruguiera gymnorhiza</i>
	<i>Bruguiera parviflora</i>
	<i>Bruguiera sexangula</i>
	<i>Ceriops tagal</i>
	<i>Rhizophora apiculata</i>
	<i>Rhizophora mucronata</i>
	<i>Rhizophora stylosa</i>
	<i>Scyphiphora h.</i>
Rubiaceae	<i>Sonneratia alba</i>
	<i>Sonneratia caseolaris</i>
	<i>Sonneratia ovata</i>
Sterculiaceae	<i>Heritiera littoralis</i>

Value of mangroves to Solomon Islands

Many Solomon Islanders use mangroves extensively. For example, mangrove trees are used for house posts and rafters, fishing tools, medicine and firewood. Some people also eat the mangrove fruit. The *Avicennia alba* (koa) is eaten by many Solomon Islanders.

Threats to mangrove ecosystems

Destruction of mangrove ecosystems is a global concern.

In Solomon Islands, mangroves are under increasing threat from activities such as logging, mining, reclamation for human settlement, waste disposal and over-exploitation by traditional users. In many parts of the country, the mangrove tree has become the major source of firewood for households (domestic use) and for drying bêche-de-mer, cocoa and copra. It is being reported that mangrove trees are being logged in Marau Sound (Guadalcanal), Langa Langa Lagoon (Malaita) and possibly elsewhere in the country. Mangrove areas are increasingly being used for settlement as villages grow, as a result of the increasing growth of coastal populations of the country. The mangrove resources of Solomon Islands will have to be utilised in a sustainable way or they will be wiped out in the near future.

Fish

Fish are fascinating animals that come in an amazing variety of shapes and sizes. All fish are vertebrates (have a backbone) and most breathe through gills and have fins and scales. Fish make up about half of all known vertebrate species.



Fig 5.3.6

Fish come in a vast range of different shapes, sizes and colours (Gizo market).



Fig 5.3.7 The giant whale shark is the world largest fish.

External and internal parts of a fish

The external and internal parts of a fish are labelled in Figures 5.3.8 and 5.3.9.

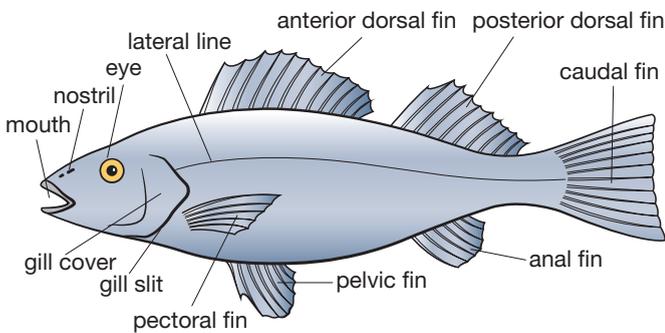


Fig 5.3.8 The external parts of a fish

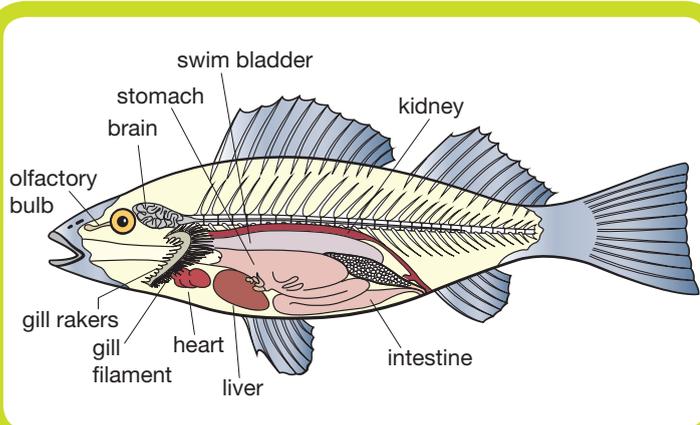


Fig 5.3.9 The internal parts of a fish

Activity 9

Internal and external parts of a fish

Aim

To investigate and identify the main parts of a common fish

Equipment

A sharp knife, a fish just caught or kept in the freezer

Method

- 1 Place the fish on a flat cutting board or just a clean flat surface.
- 2 Identify the external parts of the fish.
- 3 Section through the fish to reveal its internal organs.
- 4 Identify the internal organs.
- 5 Compare your result with the diagram in Figure 5.3.10.

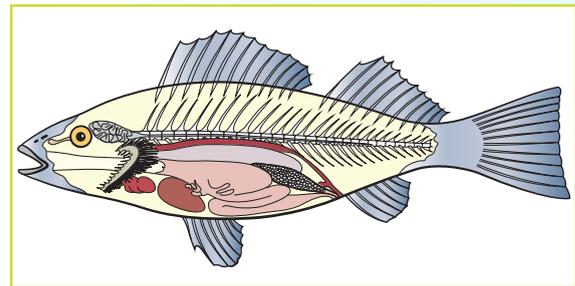


Fig 5.3.10 A fish sectioned to reveal its internal organs

Questions

- 1 What part of the fish is used for breathing?
- 2 Determine the function of two of the internal parts of the fish that you identified in step 4 above.
- 3 In your opinion, are some of the parts you identified present in other animals (eg pigs or birds)?

Respiratory systems in fish

Most fish exchange gases using gills on both sides. Gills consist of thread-like structures called filaments. Each filament contains a capillary network that provides a large surface area for exchanging oxygen and carbon dioxide. Fish exchange gases by drawing oxygen-rich water through their mouths and pumping it over their gills. The gills push the oxygen-poor water out through openings in the sides of the pharynx. Some fish, such as sharks and lampreys, possess multiple gill openings. However, most fish have a single gill opening on each side. This opening is hidden beneath a protective bony cover called an operculum.



Reproduction in fish

The methods of reproduction in fish are varied, but most fish lay a large number of small eggs, which are fertilised and scattered outside the body. The eggs of open-sea fish usually remain suspended in the open water. Many shore and freshwater fish lay eggs on the sea bottom or among plants. Some use corals, mangroves or seagrasses. The mortality of the young, and especially of the eggs, is very high, and often only a few individuals grow to maturity out of hundreds, thousands, and in some cases millions of eggs laid.

Two common methods of reproduction in fish are heterosexual and hermaphroditic. In the most common form, heterosexual reproduction, both a male and a female are involved. During reproduction, a male will shed its sperm, usually as a milky white substance called milt, onto the eggs already laid by the female in the surrounding waters.

In hermaphroditic reproduction, a single fish is both male and female, produces both eggs and sperm, and mates with other similar hermaphroditic fishes. External self-fertilisation occurs in one hermaphroditic fish, which sheds egg and sperm simultaneously. In certain fish there is a time sequence of hermaphroditism, young fish reversing their sex as they grow older. They are born and start their life as females, actively reproducing for 2 to 3 years, and then change their sex to become male fish in the later stage of their lives.

In bony fish, a sperm duct leads from each testis to an opening behind the vent or anus. In the females, the eggs are formed in two ovaries (sometimes only one) and pass through the ovaries to the opening and to the outside.

In some fish, the eggs are fertilised internally but shed before development takes place. Members of about a dozen families of bony fish and sharks bear live young. Many skates and rays also bear live young.

Some fish, such as salmon, undergo long migrations from the ocean and up large rivers to spawn in gravel beds where they themselves hatched. Others undertake shorter migrations from lakes into streams or spawning habitats that they do not ordinarily occupy.

Common fish types

Almost all bony fish are edible. However, different regions and places tend to prefer certain type of fish species. In Solomon Islands, the deep sea fish commonly eaten by locals are tuna, kingfish, sailfish, rainbow and deep sea snapper. Common reef fish are coral trout and groupers (ulafu), parrot fish, surgeon fish, mamula and barracuda (ono). Figure 5.3.11 shows some common fish that we eat in Solomon Islands.



Fig 5.3.11

Barracuda (ono), northern blue tuna, giant grouper, parrot fish

The body shape and mouth parts of a fish tell many things about the lifestyle and behaviour of that fish, such as how it lives, what it eats and its speed. For example, a fish such as the parrot fish is almost round in shape, with a parrot-like beak mouth parts. It is easy to tell that it is a slow-moving fish and eats corals and algae. It feeds by grazing on algae or rocks. On the other hand, a fish such as barracuda is streamlined, thin and long, with strong jaws and sharp teeth, indicating that it is a speedy (fast) and meat-eating fish.

Threat to our fish stock

Overfishing is a major threat to edible fishes such as cod and tuna. Overfishing eventually causes fish stocks (populations) to become depleted or reduced because the fish that survive cannot reproduce enough young to replace those removed.

Some methods of fishing, such as the use of gill nets and explosives (dynamite), are very destructive methods of fishing. They kill all the fish within the area. This type of fishing must be stopped. Our fish stock is also being reduced by habitat loss. For example, if we destroy a coral reef or a mangrove area, we are destroying the breeding ground of our fish stock. This will result in the fish stock depletion as well.

Economic importance of fish

Apart from supplying us with protein, our fish stock is important for us economically. Our country earns money by selling our tuna stock to foreign countries. This is done in two ways:

- Local companies catch tuna then process and sell it as canned tuna or frozen tuna.
- Solomon Islands collects fees from foreign fishing boats that fish for tuna in our waters.

Other fish species in our reefs have the potential to earn big money for us as well. Local fishermen and women support their families by selling their catches at the markets. The demand for fish is very high, so people can earn lots of money by selling their catches.

Photosynthesis in the marine system

Just as the terrestrial (land) plants carry out photosynthesis for their energy requirements, marine plants and other organisms also carry out photosynthesis. The product of the photosynthesis process (that is, carbon dioxide + water → carbohydrate + oxygen) supplies carbohydrate

(food) and oxygen for many animals in the marine environment. This process, however, cannot occur without the presence of sunlight.

In the marine environment, oxygen is absorbed through the gills of many fin fish and through other organs in many other marine organisms.

Marine organisms such as corals, seagrasses and seaweeds carry out photosynthesis. As sunlight is important for the process of photosynthesis, corals, seagrasses and seaweeds are found growing close to the surface, mostly in shallow waters such as on the reefs and in the intertidal zone, where they can receive enough sunlight. They do not grow in the very deep oceans, where sunlight does not penetrate.

While seaweeds and seagrasses use the structures in their bodies to carry out photosynthesis, corals conduct photosynthesis with the help of single-celled algae called zooxanthellae. Zooxanthellae grow on the corals, giving them the beautiful colours we see. Zooxanthellae develop a mutualistic relationship with corals by carrying out photosynthesis, in which the product of the process is used by the corals for their energy requirements. The corals provide home and protection to the zooxanthellae.

Another marine organism that uses zooxanthellae to carry out photosynthesis is the giant clam shell. Zooxanthellae are found on the mantle of the giant clam. As with the corals, they trap sunlight and use it to convert carbon dioxide and water into carbohydrate and oxygen. The carbohydrate and oxygen are used by the clam. The clam in turn provides protection and a home to the zooxanthellae.



Fig 5.3.12

Sunlight is important for the process of photosynthesis in coral, seagrasses and seaweeds.



Fig 5.3.13 Corals tend to grow more in shallow waters.

Endangered marine animals

Worldwide, a number of marine animals are listed as endangered species. This means that these species are slowly disappearing from the world's marine ecosystems, and that they will disappear from the face of our planet. They will become like the dinosaurs.

Some marine organisms in Solomon Islands are listed as threatened species. These include the leatherback turtle, the hawksbill turtle and the greenback turtle. Another animal whose population is decreasing in our marine waters is the dugong.

Protecting endangered organisms

There are a number of ways in which countries, governments, communities and individuals can protect their marine resources. In Solomon Islands, the Nature Conservancy (TNC) works with the communities of Kia (Isabel) and the communities of Choiseul to protect our turtles. By protecting the Annavon Islands from people who harvest turtles, the islands have become a breeding ground for turtles.

Communities can also take their own initiative to conserve their marine resources. An example of this can be seen in the Tetepari. The land owners have decided to protect their marine resources from any forms of destructive fishing. Turtles are also protected.

One form of protecting our marine resources on the local level is the use of Marine Protected Areas (MPAs). Communities can decide to protect a reef in their area from fishing and the harvesting of any marine resources for a certain period. This may be for up to a year or so. The community can later lift the ban and allow people to fish again. But by doing this, the populations of our fish stocks and other marine resources will increase, allowing us to continue to enjoy our marine resources for a long time. Many communities in Solomon Islands are taking this approach and are protecting their reefs, such as Biche in Marovo, Marau in East Guadalcanal and Natagera in Santa Ana (Makira Province).

5.3 UNIT

[Questions]

Checkpoint

Marine ecosystems

- 1 Why are marine ecosystems important to us?
- 2 Identify the marine ecosystems found between the shoreline and the deeper waters.
- 3 Take one marine ecosystem and:
 - a list the number of organisms that are found in that ecosystem
 - b identify the organisms that are edible (can be eaten by humans).

Coral reefs

- 4 Explain how corals are able to feed themselves.
- 5 Name another organism that also relies on the algae used by the corals to produce its food.
- 6 Name the three types of coral reefs and explain how they are formed.
- 7 Explain how corals are killed in our waters.
- 8 In Solomon Islands, which practices are having the most damaging effect on our corals?

Intertidal zone

- 9 Outline the physical factors that organisms in the intertidal zone are subject to.

Mangroves

- 10 Discuss the threats to our mangroves.



Fish

- 11 Using your local names, list the types of fish you or your community eat.
- 12 Provide examples of forms of fishing that may threaten our fish stocks.
- 13 In what ways can we obtain money from our fish as individuals and as a country?
- 14 The leatherback turtle is an endangered marine species in Solomon Islands. Explain what this means.

Think

- 15 Consider a parrot fish and a barracuda fish in terms of their body shape and mouth parts.
 - a Using the shape of their body, describe their movement (speed).
 - b Using their mouth parts, describe their eating habits. (What does each eat?)
 - c Why does a barracuda need to be a fast-moving fish while a parrot fish does not?

Analysis

- 16 A logging operation in Marovo occurs upland. Right down on the coastal area is pristine (undisturbed or unspoiled) coral reef.

- a Identify the risks to corals of the logging operation.
- b Outline the stages that lead to the death of the coral.
- c Identify organisms that live in corals and suggest what would happen to them if the corals die.
- d In what other ways do Solomon Islanders kill corals?

Skills

- 17 Photosynthesis is an important process in all living things, whether they are land or marine organisms. In marine systems, the process of photosynthesis makes available carbohydrates and oxygen required by many marine organisms.
 - a Identify the organisms that carry out photosynthesis in a marine ecosystem.
 - b Describe how fin fish take oxygen into their body.
 - c Why is it that corals are not found in deeper waters?
- 18 What traditional management or conservation methods are used by your community to conserve the following marine resources in your area?
 - a fish stocks
 - b mangroves
 - c corals
 - d shells

Chapter review

[Summary questions]

- 1
 - a The process of photosynthesis can be represented by an equation. Write this equation.
 - b Clarify the importance of photosynthesis to living things.
- 2 Recall which cells result in growth rings in a tree.
- 3
 - a List three factors that affect the rate of photosynthesis.
 - b Explain how each of these factors affects the rate.
- 4 Outline two uses of the glucose produced by plants during photosynthesis.
- 5 A student incorrectly wrote that 'plants photosynthesise during the day and respire at night'. Change the sentence to make it correct.
- 6
 - a The glucose produced during photosynthesis may be stored by the plant for later use. State the form of storage of the glucose.
 - b State the form of storage of excess glucose in plants.
- 7
 - a List some organisms that are found in marine ecosystems.
 - b Identify the organisms that are edible (can be eaten by humans).

[Thinking questions]

- 8 Compare and contrast xylem and phloem tissue.
- 9 The chemical equation for photosynthesis is the reverse of that for respiration. Propose two reasons why it is not correct to say that photosynthesis is simply the reverse of respiration.
- 10 Construct a table to compare photosynthesis and respiration. Your table should include reactants, products, conditions and energy changes.
- 11 Outline an experiment that can be conducted to demonstrate that leaves contain starch.
- 12 Contrast the types of leaves found on tropical plants with those in desert regions.
- 13 Compare and contrast photosynthesis and respiration.
- 14 Is fresh tuna sold in your province? If so, where does the fresh tuna come from?

>>

[Interpreting questions]

15 An experiment was conducted using the flasks shown in Figure 5.4.1.

All flasks contained water, were at the same temperature and were in sunlight. After two hours the carbon dioxide and oxygen levels in each flask were measured.

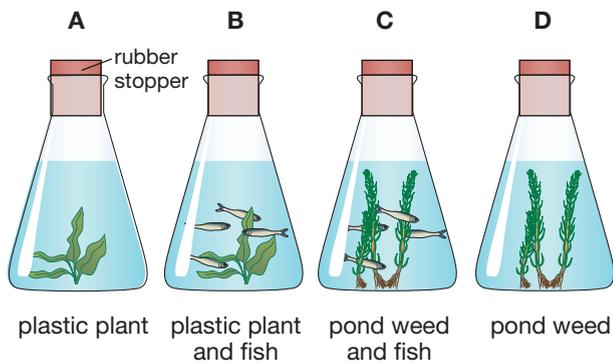


Fig 5.4.1

a Identify the flask or flasks in which photosynthesis would occur.

b Identify the flask or flasks in which respiration would occur.

c Predict which flask would have the highest carbon dioxide level after the two hours.

d Predict which flask would have the highest oxygen level after the two hours.

16 An experiment was conducted using three potted plants. Each plant was exposed to continuous light of the same intensity but different colour. Plants and colours used were: plant A—green light; plant B—yellow light; plant C—red light.

a List three factors that must be kept constant for all plants in this experiment.

b Identify the plant (A to C) that would produce the most glucose in a given time.

CHAPTER

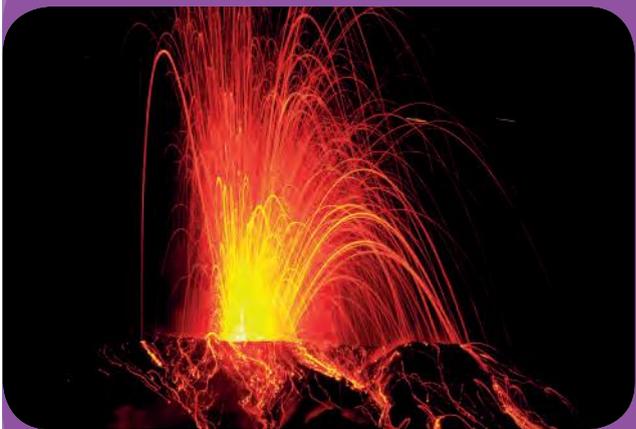
6

Heat and sound

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

- state that heat is caused by movement of atoms or molecules in the material
- explain that heat energy is transferred by conduction, convection and radiation
- explain land and sea breezes by reference to concepts of gas expansion, convection and heating
- demonstrate heat transfer by conduction, convection and radiation
- demonstrate expansion and contraction of metallic materials when heated or cooled
- explain how the particles of materials take up more space when they are heated
- list ways in which heat energy is used in your life
- explain that sound is caused by vibrating particles
- state that sound has pitch and loudness
- state that sound needs a medium in which to travel: solid, liquid or gas
- state that sound moves as a wave, formed by compression and rarefaction of particles
- identify the hearing range of your ears
- describe the speed of sound in solids, liquids and gases
- demonstrate using different media how sound travels
- identify and label the main parts of a human ear
- describe the function of the main parts of the ear
- recognise the ways in which sound affects your life.

- 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 soup hot all day long?
- 4 Describe three devices that use energy.
- 5 When is a sound dangerous?



8.6.1.1, 8.6.2.1, 8.6.3.1, 8.6.4.1, 8.6.4.2, 8.6.5.1, 8.6.6.1,
8.6.6.2, 8.6.6.3, 8.6.6.4, 8.6.6.5, 8.6.7.1, 8.6.8.1, 8.6.9.1,
8.6.10.1, 8.6.11.1, 8.6.12.1

Specific learning outcomes

Challenges

UNIT 6.1

Heat

Introduction

On a sunny day you can feel the Sun's heat warming you up. You have to take off layers of clothing to stay cool. On a cold day you increase the amount of clothing you wear to stop the cold air from cooling you down. We also use heat for many purposes such as cooking food and drying clothes. Heat is a very common form of energy that affects us every day.

Heat and temperature

Heat energy can increase the temperature of a substance. Do not confuse heat and temperature—they are not the same thing. Heat is a form of energy, but temperature is not. To understand the difference, consider two Bunsen burners set on a blue flame, one heating a beaker half-filled with water and the other heating a beaker filled with water. After one minute, both beakers will have been supplied the same amount of heat energy, but the full beaker will be at a lower temperature.

Activity 1

Conduction in metal rods

Aim

To compare the heat conductivity of different metals

Equipment

Three rods made of different metals (eg iron, copper, brass), candle, tripod, Bunsen burner, heat-proof mat, timer

Method

- 1 Assemble the apparatus as shown in Figure 6.1.1. Melt a piece of candle wax at regular intervals along each rod. (Alternatively, use a temperature probe to monitor the temperature at the end of each rod for a given time.)
- 2 Begin heating the non-waxed ends of each rod, and time how long it takes each blob of candle wax to melt.
- 3 Stop heating after 5 minutes, if not before.

Questions

- 1 List the rods in order from best to worst conductor.
- 2 Present your results as a graph.

When an object is hot, its particles vibrate more rapidly. Temperature measures how much these particles are vibrating.

Heat will move from one area to any other area that is at a lower temperature. Heat moves in three ways—by conduction, convection and radiation.

Activity 2

Conduction in water

Aim

To investigate the ability of water to conduct heat

CAUTION: The test tube may crack during this experiment. Make sure you wear safety glasses. Use great care in heating the test tube, moving the tube continually in the flame.

Equipment

Bunsen burner, heat-proof mat, test tube, small ice-blocks, steel wool, safety glasses, test-tube holder

Method

- 1 Heat a test tube containing ice, water and steel wool as shown, moving the tube continuously. Use the steel wool to hold the ice at the bottom of the tube. Make sure you heat the middle of the test tube, above the steel wool, as shown in Figure 6.1.2.

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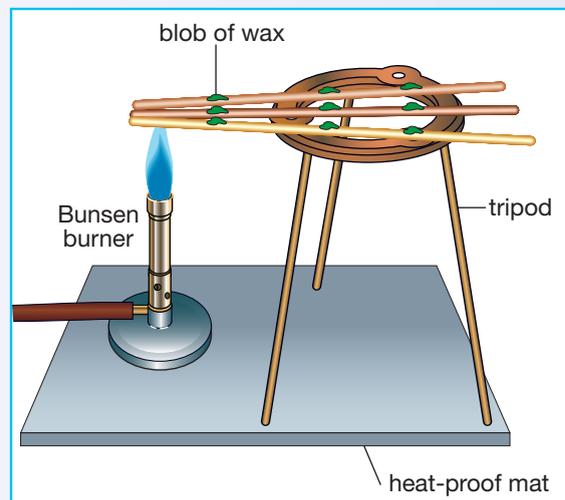


Fig 6.1.1 Apparatus set-up for comparing the heat conductivity of different metals

2 Heat the water until it begins to boil.

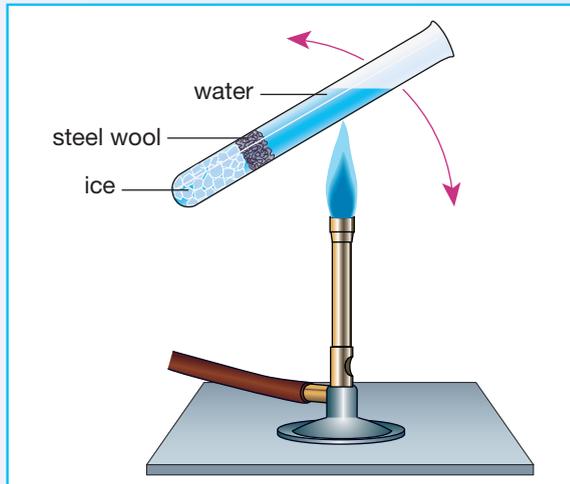


Fig 6.1.2 Apparatus set-up for testing the heat conductivity of water

Questions

- 1 State whether the ice melts completely before the water boils.
- 2 Describe what this experiment tells you about the heat-conducting ability of water.

Conduction

You may have experienced conduction when washing the dishes or running a bath. Have you ever felt one part of an object (eg a plate or metal tray) get hot when another part is held under hot water, or been burnt by touching a metal tap that has had hot water running from it? These are both examples of conduction.

Conduction occurs when the particles in one part of an object vibrate more, and these vibrations are passed on from particle to particle through the object. The particles do not actually move along the length of the object; they merely pass along the increased vibrations.

Have you ever walked barefoot across a tiled floor and felt that the floor was quite cold, even though it must have been at the same temperature as the rest of the room? Meanwhile the rest of your body did not feel cold. The reason is that the tiled floor is a better conductor than the air surrounding the rest of your body, and conducts heat away from your feet, leaving the particles in them vibrating less and feeling cold.

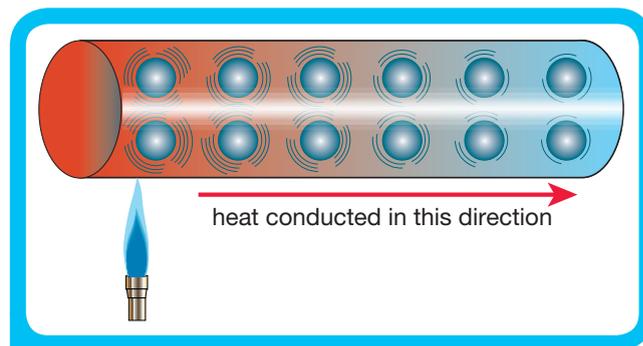


Fig 6.1.3 Conduction—vibrations pass along from particle to particle away from the heat source.

Different substances conduct heat at different rates. Metals are generally good conductors of heat, whereas non-metals such as paper, wood and plastics are not. Among the metals, copper and gold are particularly good conductors. Compare the water tap in the laboratory with the desktop or your book. Which feels the coldest? Solids are better conductors than liquids because the particles in a solid are packed closer together. Gases are less efficient conductors than liquids, as the particles in a gas are spread out much more.

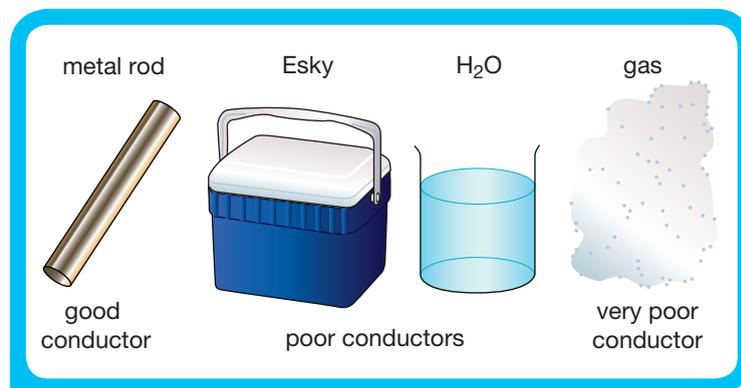


Fig 6.1.4 Different substances have different conducting abilities.

Poor conductors are called insulators. The reason many substances are poor conductors (insulators) is that they contain trapped air, which is a gas and a very poor conductor.

Activity 3

Insulators

Aim

To compare the insulating properties of different materials

Equipment

Two soft-drink cans or small metal containers, insulating materials (eg cloth, cotton wool, foam, rubber, newspaper, carpet scraps, fibreglass insulation), thermometer or temperature probe, hot water, beaker, timer

Method

- 1 Surround one can or container with a layer of one of the insulating materials. Leave the other can uncovered. This can is called a control.
- 2 Use a beaker to measure a certain amount (eg 100 mL) of hot water into both. (Note: you will need hot water of the same temperature later in this experiment.)
- 3 Place a thermometer or temperature probe in the cans and record the temperature every minute for 10 minutes.
- 4 Repeat steps 1 to 3 for each of the other insulating materials, making sure the hot water is at the same temperature as that used previously.

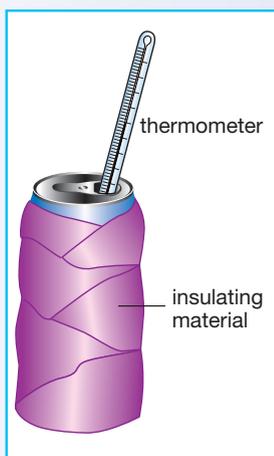


Fig 6.1.5 Apparatus set-up for comparing the insulating properties of different materials

Extension

- 5 Try different thicknesses (number of layers) of a particular material.
- 6 Repeat the experiment, but instead of using hot water, use cold water, and attempt to heat the containers using sunlight or other suitable heating sources.

Questions

- 1 Present your results in a table.
- 2 Draw a line graph for each container on the same set of axes. Put time along the horizontal or x-axis. Label each graph.
- 3 Identify which material is the:
 - a best insulator
 - b worst insulator.
- 4 Explain why one container was left uncovered.

Useful insulation

Many animals make use of the poor conducting ability of air by having thick fur coats or feathers that trap air and insulate them against harsh, cold conditions. Some animals even grow a thicker 'winter coat'. Jumpers, blankets and sleeping bags contain fibres (hair or feathers) that trap air and insulate against the cold.



Fig 6.1.6

Fur and feathers provide good insulation by trapping air.

There are many examples where insulators are useful in the kitchen. Saucepan handles, oven mitts and pot stands are all made of poor conductors to prevent burns to people or surfaces.

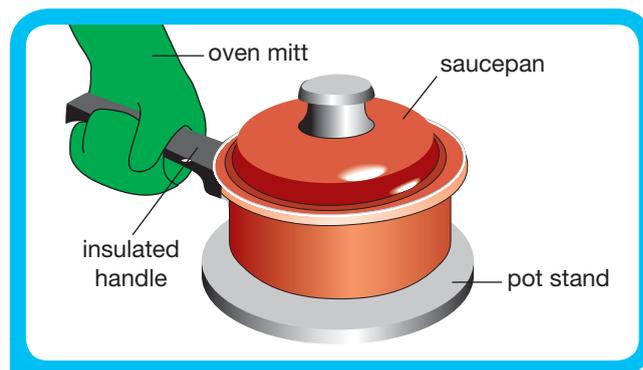


Fig 6.1.7

Insulation in action in the kitchen

The walls and ceilings of many buildings contain fibreglass insulation batts that trap air within fibreglass fibres.

Double-glazed windows have two layers of glass (instead of the conventional one sheet) with an insulating layer of air trapped in between.

A space shuttle's surface is protected by tiles made of insulating material to protect against the heat generated on re-entry to the Earth's atmosphere. When these tiles are damaged the effect can be disastrous, as happened on 1 February 2003, when the space shuttle *Colombia* broke up on re-entry, killing all seven of its astronauts.

R ratings

Insulation batts are often given 'R' ratings. The R stands for resistance to heat flow. The R ratings for 2.5 cm thicknesses of some materials are given below.

Material	R rating
Insulation batt	4.0
Polystyrene foam	4.5
Chipboard	2.0
Wood	2.3
Window (single glazing)	0.9
Window (double glazing)	1.6



Fig 6.1.8 Insulation batts being installed in a house

Activity 4

Purple convection currents

Aim

To observe convection currents in water

Equipment

A single crystal of potassium permanganate, a 250 mL beaker, Bunsen burner, tripod, gauze mat, heat-proof mat, glass tube or straw

Method

- 1 Assemble the apparatus as shown in Figure 6.1.9, except for the crystal of potassium permanganate.

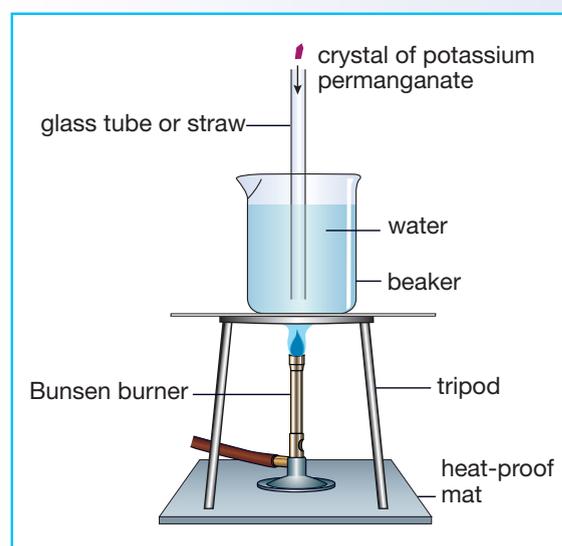


Fig 6.1.9 Apparatus set-up for observing convection currents in water

- 2 Use a glass tube or straw to gently place the crystal at the bottom of the beaker. (You could try several small pieces of paper instead of potassium permanganate.)
- 3 Heat the beaker and observe what happens.

Questions

- 1 Sketch the pattern formed by the moving potassium permanganate particles at several stages of the experiment.
- 2 Explain why the particles moved in the path they did.
- 3 Explain where you would find similar convection currents in the home or in industry.

Convection

In liquids and gases, more heat is transferred by convection than by conduction. The particles in a solid have fixed positions and can only vibrate, whereas the particles in liquids and gases can actually move about. They can easily carry their heat energy with them, spreading the heat to other parts of the substance. The spread of heat due to the movement of particles in liquids and gases is called convection. When a liquid or gas is heated, the particles in the heated region become more spread out, or less dense. Liquid or gas that is less dense than the rest of the substance will rise, taking heat with it. You may be familiar with the expression ‘hot air rises’—hot air balloons rise due to the less dense hot air within the balloon. Smoke and air rise above a fire for the same reason.

Conversely, colder liquid or gas will sink. When the door of an upright freezer is opened, you may feel the cold air as it falls onto your feet. Supermarket freezers that are upright have doors, while the ‘tub’ type do not, and so the cold air cannot spill out as easily.

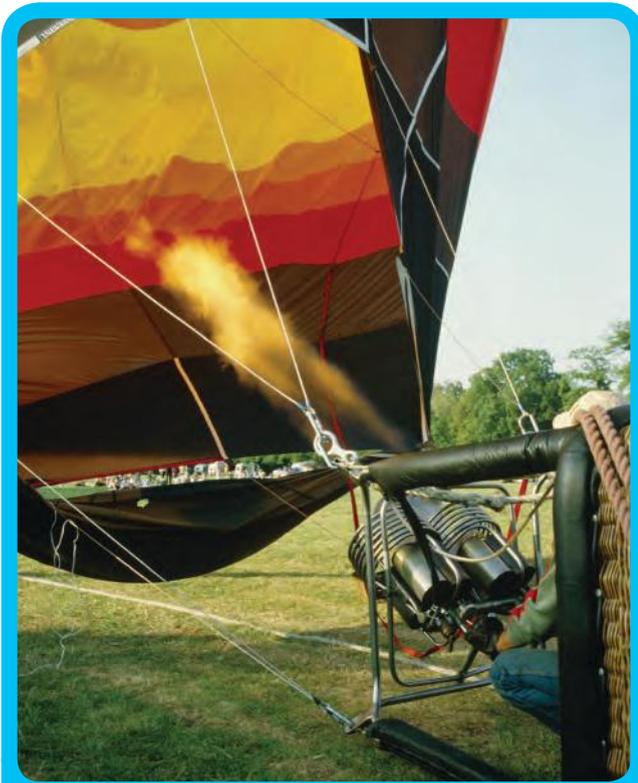


Fig 6.1.10 Hot air rises.

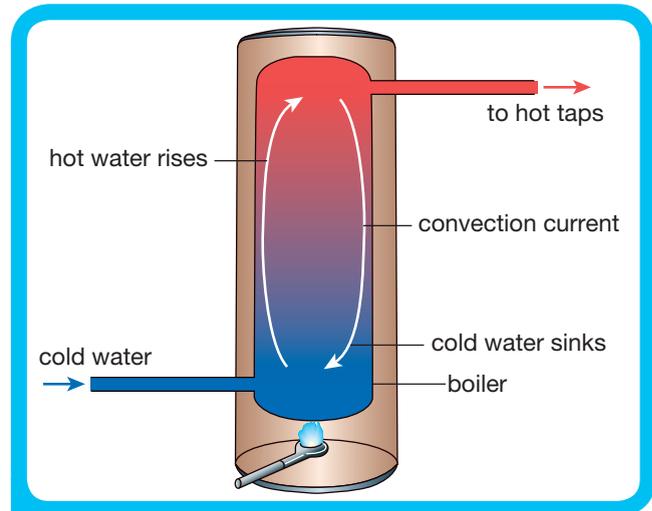


Fig 6.1.11 A basic hot water system showing the movement of water by convection

Hot water systems have heating elements or flames at the bottom of the tank because convection will cause the heated water to naturally rise and mix with the remaining colder water. Central heating vents are usually in the floor, as the hot air will rise to warm higher regions. The roof cavity of a home will often be noticeably warmer than floor level for the same reason.

When warmer air rises, cooler, denser air moves in to fill the space left behind, resulting in convection currents.

Solar hot water systems also make use of convection as shown in Figure 6.1.12.

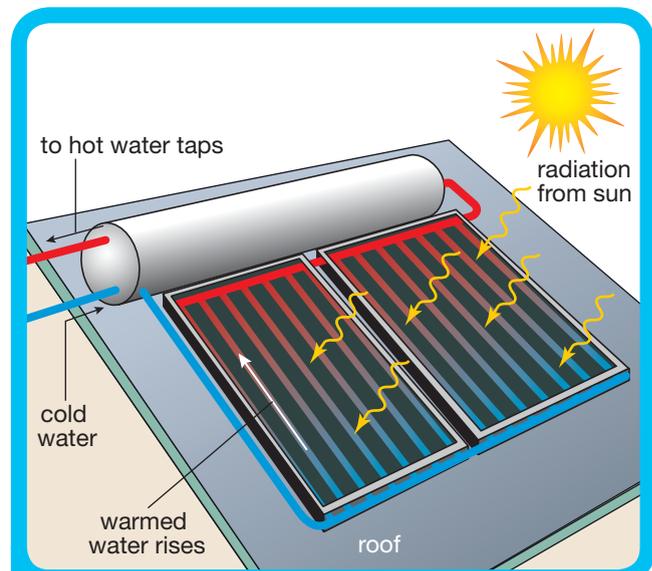


Fig 6.1.12 A solar hot water system

Wind and sea breezes

Wind is caused by hot air in one region rising and its place being taken by colder air coming in from another region. For example, air at the equator is hotter than air at the poles, causing global winds.

During the day a sea breeze occurs because the land warms up more quickly than the sea. As warm air rises above land, cooler air moves in from just above the sea to replace it. The opposite occurs at night, when the land loses heat more quickly than the sea.

Radiation

When you step outside into bright sunlight, you often feel the warmth of the Sun on your skin.

Heat from the Sun cannot reach us by conduction or convection because space is a vacuum. There are no particles between the Sun and Earth to pass along vibrations or move in convection currents. How then does heat transfer from the Sun to the Earth?

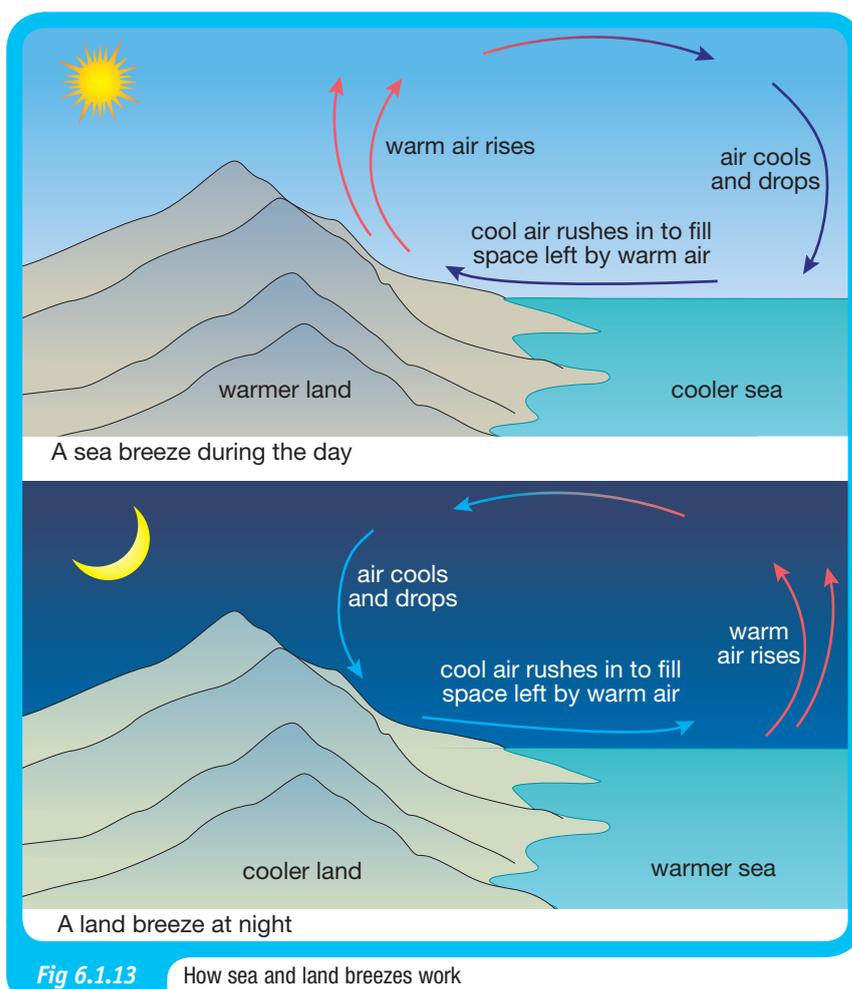


Fig 6.1.13

How sea and land breezes work

Activity 5

Radiation emission

Aim

To find what colour best radiates heat energy

Equipment

Two cans (one black and one silver or white), measuring cylinder or beaker, two thermometers or temperature probes, hot water, beaker, timer

Method

- 1 Fill each can with an equal amount of hot water at the same temperature.
- 2 Place a thermometer (or a temperature probe) in each container and record the temperature every minute for 20 minutes.
- 3 Record your results in a table.

Questions

- 1 Draw a line graph for each container on the one set of axes.
- 2 Identify which colour is the better radiator of heat.
- 3 It was important that the water in each can was at the same temperature at the start. Explain why.

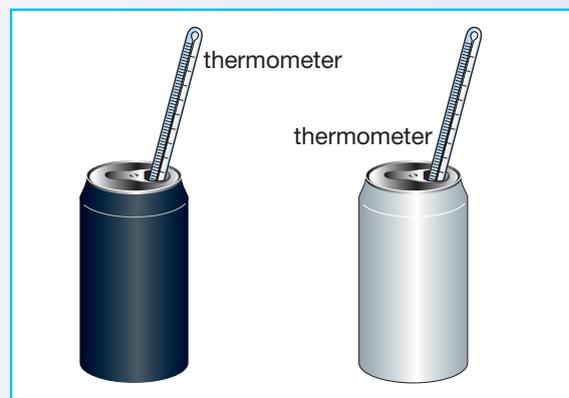


Fig 6.1.14 Apparatus set-up for observing what colour best radiates heat energy

The answer is radiation. Radiation is the transfer of heat energy by invisible waves and does not need a material to travel through.

Heat radiation is sometimes referred to as infra-red radiation and travels at the speed of light. In fact, infra-red radiation and visible light are both types of electromagnetic waves. You will learn more about these and other waves later on in Science.

All objects give out heat radiation—the hotter an object is, the more heat it radiates. Dark objects tend to give out more radiation than shiny or light-coloured objects at the same temperature.

Another good example of radiated heat is an open fire. Red-hot coals give out a great deal of radiation. If someone stands between you and the glowing embers, you notice the loss of radiated heat immediately! An electric radiator gives the same effect.

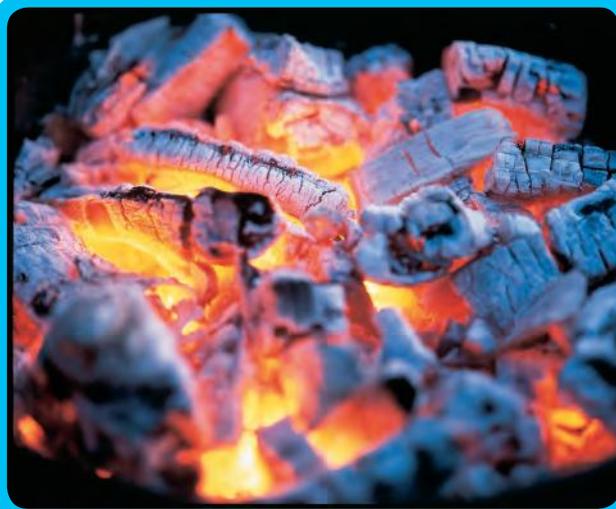


Fig 6.1.15 One source of radiation

Activity 6

Radiation absorption

Aim

To find what colour best absorbs heat energy

Equipment

Two thermometers or temperature probes, black card, white card, two retort stands with clamps, a 100 W light globe, heat-proof mat

Method

- 1 Attach the black card to the bulb of one thermometer, and the white card to the other as shown in Figure 6.1.16. (Alternatively, use a temperature probe and study one surface at a time.) Ensure the cards are the same size.

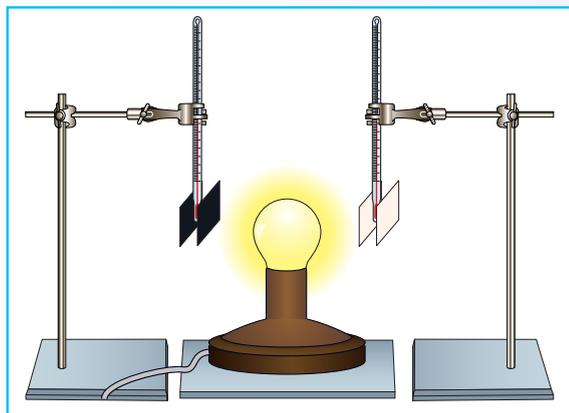


Fig 6.1.16 Apparatus set-up for observing what colour best absorbs heat energy

- 2 Clamp the thermometers and place them on either side of the light globe.
- 3 Measure and record the distance between the globe and the card. Ensure the globe is placed exactly between the two thermometers.
- 4 Connect the light globe to a power point and switch on.
- 5 Record the temperature on each thermometer in a table like the one below.
- 6 Repeat steps 3 to 5 with the cards and thermometers twice the distance from the globe.

Time (minutes)	1	2	3	4	5	6	7	8	9	10
Temperature (°C) (black)										
Temperature (°C) (white)										

Questions

- 1 Identify which colour card absorbed heat the best.
- 2 In this experiment the light globe must not be closer to one thermometer than the other. Explain why.
- 3 Explain why the same-sized card should be used on each thermometer.
- 4 State what happened to the temperature when the cards were twice the distance away. Propose a reason for this observation.

Absorption, reflection and transmission

Infra-red radiation may be absorbed, reflected or transmitted when it hits an object (in reality, a combination of all three). You may have noticed coils of black hose on the roofs of some houses. These may be connected to hot water systems or swimming pool heaters. Black is used as dark objects are good absorbers of radiation. Black cars tend to heat up more than lighter-coloured ones, and people in hot climates wear light-coloured clothing to reduce the amount of radiation they absorb, and therefore stay cooler. Windows are good transmitters of radiation.

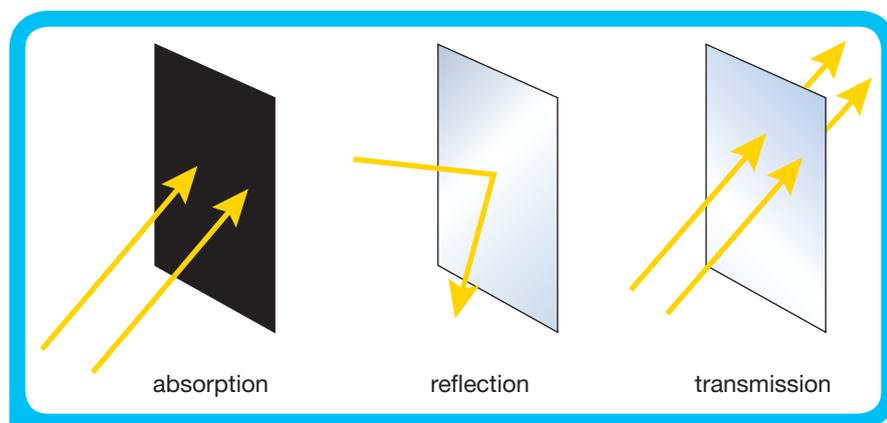


Fig 6.1.17 When radiated heat meets an object, three things may happen.

The thermos flask

The thermos flask is constructed to minimise all three possible ways of losing heat.

The walls of the flask are made of two thin layers of glass with a vacuum between to prevent heat loss due to conduction and convection. The glass walls have a silvered coating to reduce emitted radiation.

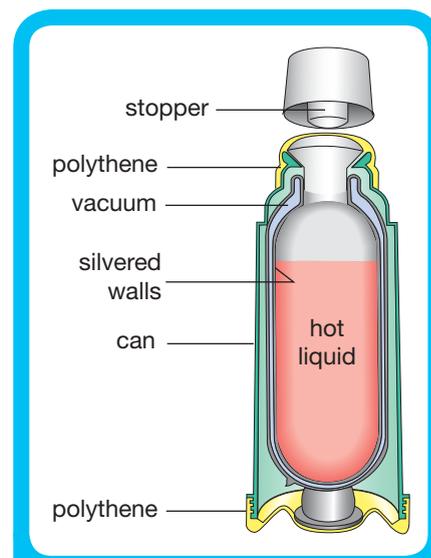


Fig 6.1.18 A vacuum flask prevents heat loss by all three methods of heat transfer.

6.1 [Questions]

Checkpoint

Heat and temperature

- 1 Identify three sources of heat.
- 2 Explain the difference between temperature and heat.
- 3 Give three examples of how heat can move from one place to another.

Conduction

- 4 Explain how conduction occurs in terms of particles.
- 5 For heat to conduct from one solid to another, two things must happen. Explain what these two things are.
- 6 Draw a particle diagram to demonstrate conduction in a metal rod.
- 7 List the following in order from best to worst heat conductor: water, air, copper, outer space.
- 8 State another name for a poor conductor. Give an example.

Summary

Heat may be transferred by:

- conduction—the passing of vibrations from particle to particle
- convection—the movement of particles from one place to another
- radiation—where no substance is required to aid the transfer.

- 9 Explain how a fur coat insulates the person who wears it.
- 10 Describe what double glazing is and when it is used.

Convection

- 11 There are many differences between convection and conduction. Explain some of these.
- 12 Draw a diagram to demonstrate convection currents in a beaker of water being heated from underneath by a Bunsen burner.
- 13 Draw a diagram to demonstrate how a sea breeze works.

>>



Radiation

- 14 Identify a household device that gives out both light and radiated heat.
- 15 Explain why cloudy nights are usually not as cold as nights when the sky is clear.

Think

- 16 Explain how some supermarket freezers can be open at the top without losing too much cold air.
- 17 Explain why you often feel a draught when someone leaves a door open on a cold night.
- 18 Explain why heat cannot reach Earth from the Sun by conduction or convection.
- 19 Propose the best colour for the following things (and explain each choice you have made).
 - a solar heating panels
 - b the outside of a house in a hot country
 - c a car radiator, where heat is required to be lost
 - d a fire-fighter's uniform
- 20 Identify the type of heat transfer that applies in each case below.
 - a No material is required.
 - b Particles vibrate.
 - c Particles move through a material.
- 21 Identify the correct statement and copy it into your workbook.
 - A Black objects are better emitters but poorer absorbers of heat than white objects.
 - B Black objects are better emitters and better absorbers of heat than white objects.
 - C Black objects are worse emitters and better absorbers of heat than white objects.
 - D Black objects are worse emitters and worse absorbers of heat than white objects.
 - E The colour of an object does not affect how it emits or absorbs heat.
- 22 Identify an example of each type of heat transfer.

- 23 Explain how a thermos keeps food hot by reducing all three types of heat loss.
- 24 a Identify four devices or inventions that have something to do with heat energy.
 - b Evaluate the importance of each device to society.

Analyse

- 25 Propose why the outside of a kettle is often shiny.
- 26 A saucepan full of water is heated on an electric hotplate. Explain the different types of heat transfer happening.
- 27 An open fire in a lounge room is an inefficient way to heat a house, while an enclosed wood heater is good for heating a house. Explain why.
- 28 In cooler climates, some buildings have central heating systems that release hot air into rooms through vents. Sometimes vents are placed near the ceiling. Explain why this is poor design.

Skills

- 29 Construct a column graph to display the R values for the table on page 115.

[Extension]

Investigate

- 1 Investigate how radiation is involved in the greenhouse effect.
- 2 List the ways your house uses or prevents heat transfer.
- 3 Investigate how dinosaurs such as dimetrodon were able to absorb and emit heat. Are there animals today that use similar methods to absorb and emit heat?



Activity 8

Heat and glass

Aim

To observe the effect of boiling water on glass

Equipment

Glass beaker, watch-glass, tripod stand, Bunsen burner, gauze mat, heat-proof mat

Method

- 1 Half-fill a glass beaker with water.
- 2 Place a watch-glass on top of the beaker of water.
- 3 Heat the beaker until the water boils.
- 4 Observe the watch-glass when the water is boiling.

Questions

- 1 Describe what happened to the watch-glass as the water heated up.
- 2 Describe what happened to the watch-glass when the water was boiling.

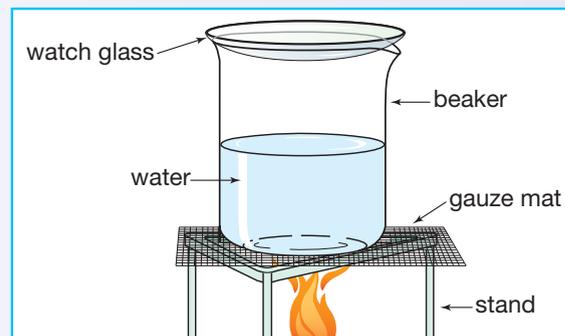


Fig 6.2.1 Apparatus set-up for observing the effect of boiling water on glass

Activity 9

Heating an empty tin

Aim

To observe the effect of heat on metal

Equipment

Empty Milo or milk tin and lid

Method

- 1 Gently place the lid on the empty tin, making sure the lid is not on tight.
- 2 Heat the empty tin.
- 3 Observe what happens.

Question

What change or changes did you observe when the tin was heated?

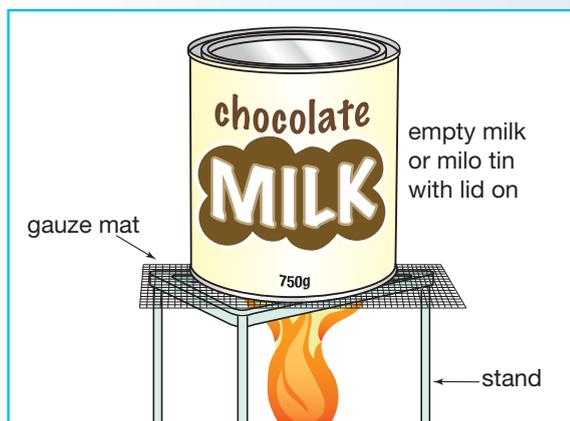


Fig 6.2.2 Apparatus set-up for observing the effect of heat on metal

Activity 10

Expansion of solid

Aim

To observe the expansion of a metal rod

Equipment

Cardboard box, brick, candle and stand, coconut leaf midrib, books and paper pointer, Blu-Tack

Method

- 1 Set up the experiment as shown in Figure 6.2.3.
- 2 Light the candle and heat up the iron rod.
- 3 Observe the movement of the paper pointer from the starter mark.
- 4 Determine how far the paper point moves.

Questions

Why did the paper point move from its original position?



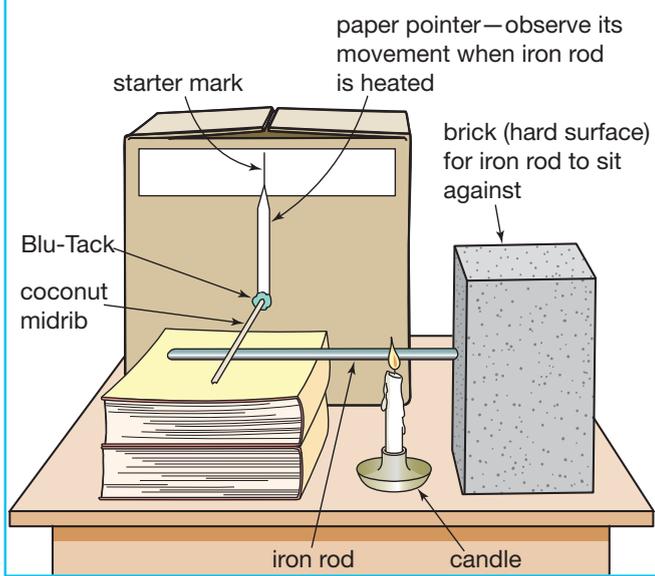


Fig 6.2.3 Apparatus set-up for observing the expansion of a metal rod

Expansion of solids

Different solids expand at different rates. The following table above shows how much a 1-metre length of particular solids will expand when the temperature is increased by 1, 10 and 100°C.

1-metre length expansion table

Temperature rise	1°C	10°C	100°C
Solid	Expansion amount in millimetres		
Invar (nickel/steel mixture)	0.001	0.01	0.1
Wood (oak)	0.003	0.03	0.3
Pyrex	0.003	0.03	0.3
Glass	0.009	0.09	0.9
Platinum	0.009	0.09	0.9
Steel	0.011	0.11	1.1
Concrete	0.011	0.11	1.1
Iron	0.012	0.12	1.2
Brass	0.019	0.19	1.9
Aluminium	0.025	0.25	2.5

Notice that steel and concrete expand at the same rate. This is why steel is used as reinforcement for concrete; there is no risk of cracking caused by one material expanding at a different rate from the other. Consider what would happen if aluminium bars were used instead of steel.

Activity 11

Ball and hoop

Aim

To investigate the expansion of metals on heating

Equipment

Brass ball and hoop apparatus, tongs, Bunsen burner, heat-proof mat

Method

- 1 Check that the ball fits through the hoop when both are at room temperature.

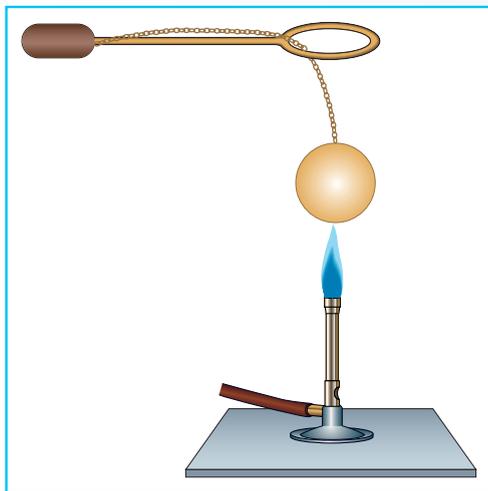


Fig 6.2.4 Apparatus set-up for investigating the expansion of metals on heating

- 2 Heat the ball over a Bunsen burner (blue flame) for a minute or so. DO NOT HEAT THE CHAIN.
- 3 Use the tongs to carefully place the ball on the hoop. Does it still fit through?
- 4 Place the equipment onto the heat-proof mat to cool. The brass will remain hot for a long time. BE VERY CAREFUL.

Questions

- 1 Identify the scientific idea or concept that this activity demonstrates.
- 2 A different ball did not fit through the hoop at room temperature. Explain what you would do to make it fit.

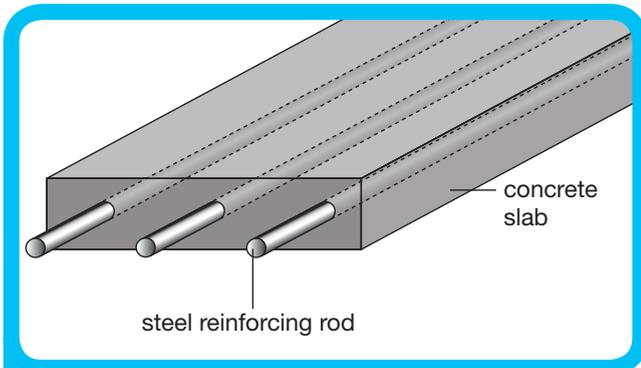


Fig 6.2.5 Reinforced concrete has steel rods to allow it to contract and expand without cracking and to give it more strength.

Expansion gaps must be left in bridges. You may also have noticed that power lines sag more on hot days due to expansion.

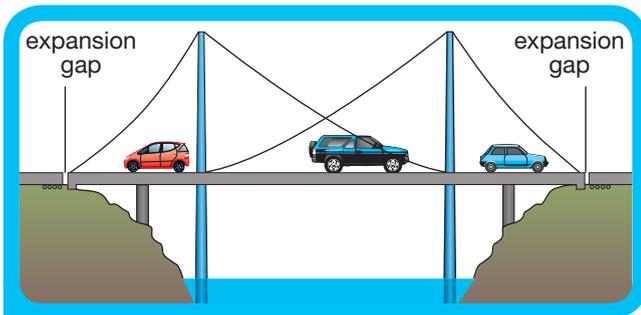


Fig 6.2.6 Expansion gap in a bridge

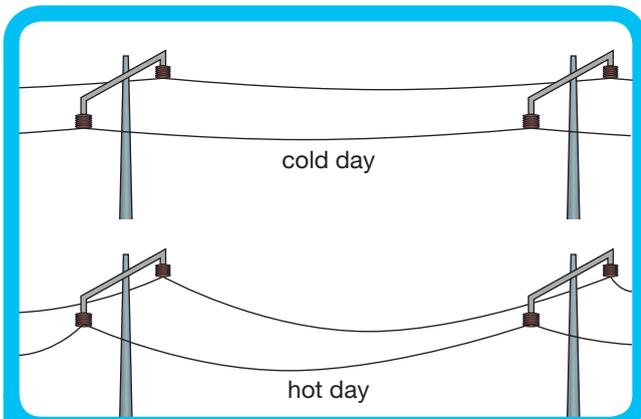


Fig 6.2.7 Why are power lines strung with some sagging?

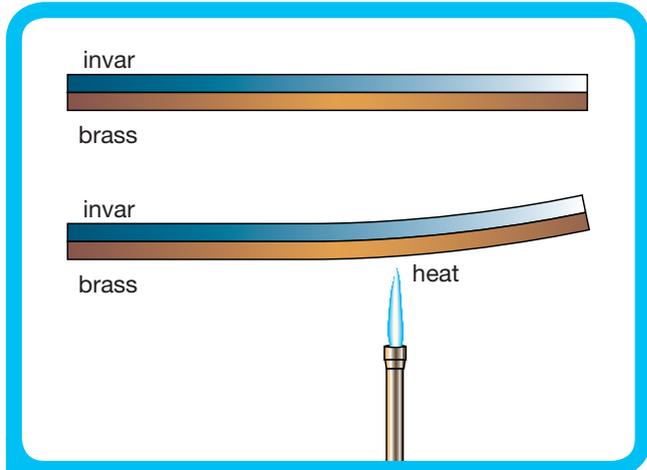


Fig 6.2.8 Brass expands more than invar (nickel-iron alloy) when heated, so how many ways could this bimetallic strip bend?

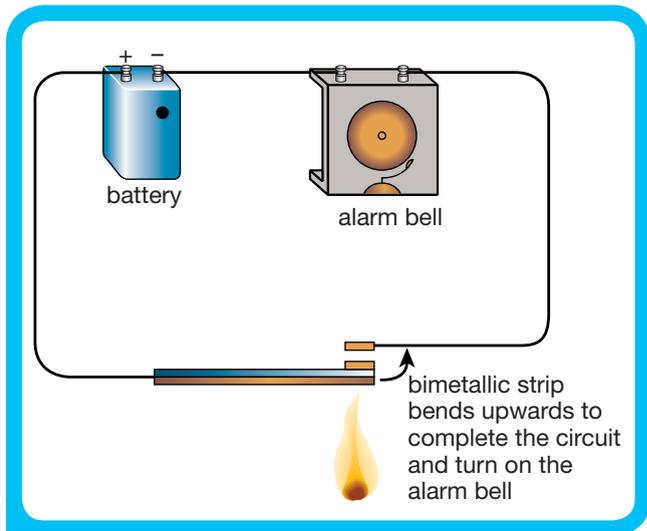


Fig 6.2.9 A bimetallic strip used in a fire alarm

By applying the expansion theory we can loosen tight-fitting jar lids. Look at the expansion differences between glass and steel in the expansion table. Notice that steel will expand more than glass when we raise the temperature by 100°C . The ends of a garden hose pipe may be heated by placing them in hot water so they expand and are more easily joined. When the hose ends cool down, they contract and fit together more tightly.

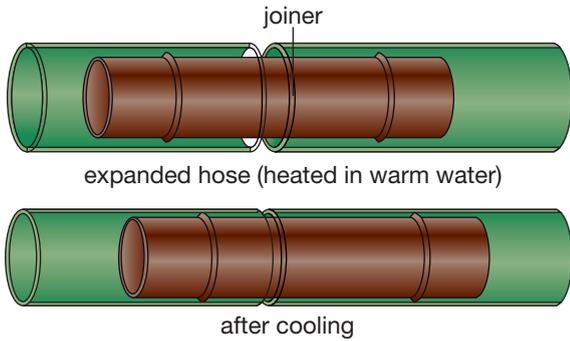


Fig 6.2.10 Expansion and contraction can be useful when joining two plastic garden hoses.

Expansion of liquids

In general, liquids expand much more than solids when heated. Care must be taken to leave space for liquids to expand into, when filling containers such as petrol and liquid petroleum gas (called LPG) tanks. A car radiator contains water that is used to cool the engine. This water expands when it absorbs engine heat, and may overflow into an expansion chamber.

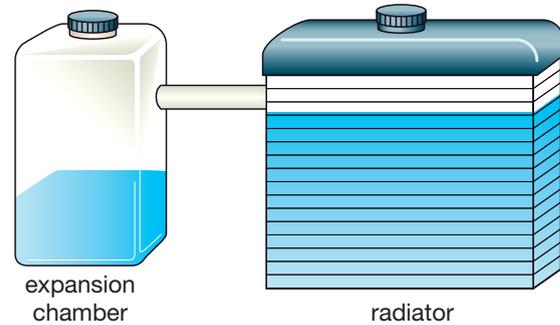


Fig 6.2.12 Any further expansion of water in the radiator will cause an overflow into the expansion chamber.

Activity 12

An expansion gauge

Aim

To evaluate an apparatus for comparing the expansion of different metals

Equipment

Metal rod, retort stand, clamps, pivot, ruler, Bunsen burner, splint, heat-proof mat

Method

- 1 Assemble the apparatus as shown.
- 2 Use a Bunsen burner to apply heat to the metal rod.
- 3 Repeat using a rod made from a different metal.

Questions

- 1 Explain why a long splint is better than a short one.
- 2 Describe what you should do to ensure a fair comparison of different metals using this apparatus.

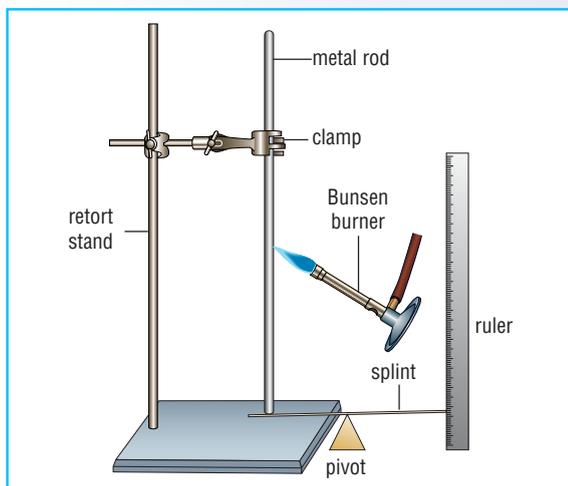


Fig 6.2.11 Apparatus set-up for comparing the expansion of different metals

Thermometers are used to measure temperature. They contain a liquid—mercury or coloured alcohol—in a bulb connected to a narrow tube that makes the liquid rise noticeably when heated. Thermometers used by doctors and nurses to measure the temperature of a sick person are called clinical thermometers. Clinical thermometers also contain mercury. The mercury expands when it gains heat energy from a sick person with a high temperature.

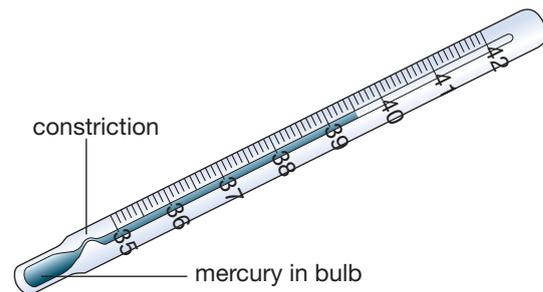


Fig 6.2.13 A clinical thermometer

The unusual behaviour of water

Water at 4°C or above will expand like other substances if heated. Water or ice at 0°C will contract like other substances when cooled. Between 0°C and 4°C, however, water behaves quite strangely: it contracts rather than expands. When a substance contracts, its particles become more closely or densely packed together. So, water is densest at 4°C and will sink through liquid layers at other temperatures.

Water at 4°C sinks to the bottom of lakes and ponds when they freeze in winter. This enables fish and other animals living in the lake to survive. By sinking below the ice layer, water at 4°C is protected from the surroundings by the ice layer. It does not freeze as easily.

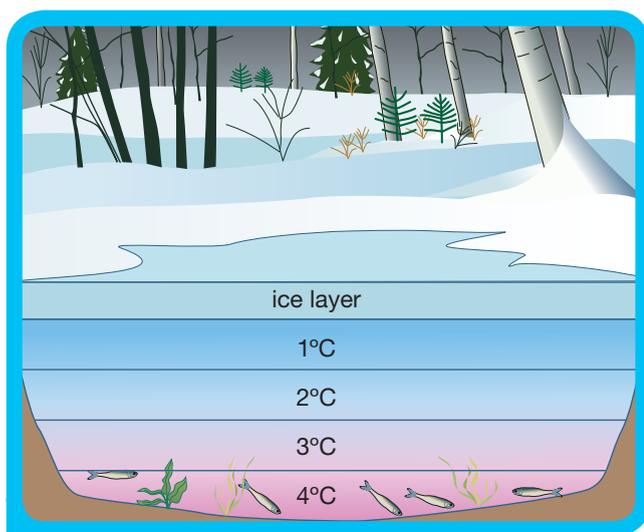


Fig 6.2.14 Fish in ponds prone to freezing survive because ponds freeze from the top down, not the bottom up.

Expansion of gases

Gases react to changes in temperature more than solids and liquids do. A gas will try to expand if heated, but may be prevented from doing so by its container.

As the particles of a gas will diffuse to completely fill a container, it is not always quite correct to say that gases contract to take up less space. Instead we say that a gas exerts less pressure when it is cooled or more pressure when it is heated in a container.

Hot air balloons rise to great heights. They make use of the fact that hot, expanded gas is less dense than cooler gas.



Fig 6.2.15 Hot, expanded, low-density air makes this balloon rise.

6.2

[Questions]

Checkpoint

Expansion and particles

- Copy and complete: Substances generally _____ when heated and _____ when cooled.
- Explain what the particles in a substance do when heated to take up more space.

Expansion of solids

- Describe what happens to the movement of the particles in a solid as it is heated.
- Figure 6.2.16 shows a solid in terms of the particle model. Identify whether Figure 6.2.17, 6.2.18 or 6.2.19 best shows the solid after heating.

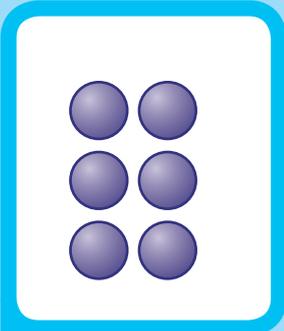


Fig 6.2.16 Before heating

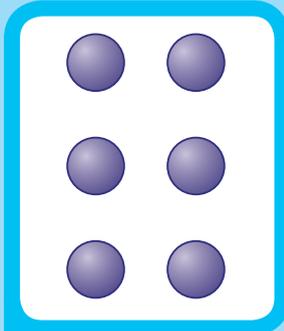


Fig 6.2.17

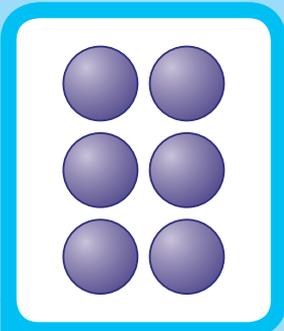


Fig 6.2.18

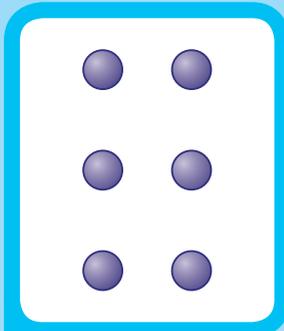


Fig 6.2.19

Expansion of liquids

- State whether liquids expand more or less than solids when heated. Give a reason for your answer.
- Describe two uses of expanding liquids.

Expansion of gases

- Identify what may be used to prevent a gas expanding when heated.
- State what happens to the pressure as gas is heated inside a container.

Think

- Copy and complete: A gas trapped in a container that is heated will exert more _____ on the walls than in a cold container.
- State why you think mercury or coloured alcohol is used in thermometers instead of coloured water.
- Explain why it is more important to have a constriction in a clinical thermometer than in a laboratory one.
- Describe why a clinical thermometer is usually shaken after use.

Analyse

- Explain what the particles in a gas are doing to cause pressure.
- Identify which type of bimetallic strip would bend most when heated—one made of iron and brass, or one made of iron and aluminium.
- List the following in order from least to greatest expansion when heated: concrete, pyrex, brass, platinum.

Skills

- Draw a bar graph comparing the expansion of different substances using the information in the table on page 123.

[Extension]

Investigate

Investigate the expansion of air using an apparatus similar to the one shown in Figure 6.2.20.

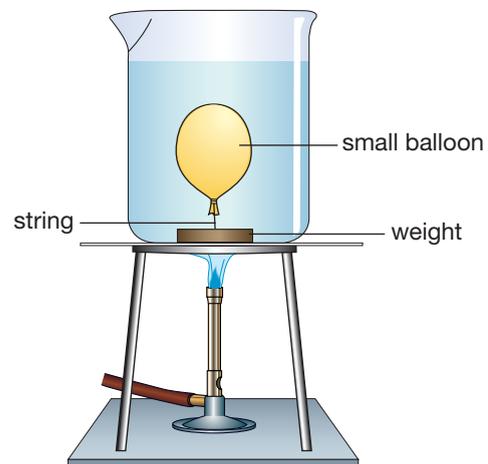


Fig 6.2.20

UNIT 6.3

Sound

Introduction

Sound, like light and heat, is a form of energy. We use sound to communicate, for entertainment such as music, and in medical applications such as ultrasound, to inspect unborn babies, and in industrial applications, such as fish finders. As we shall see in this unit, using sound has made many

tasks more entertaining and easier. Unlike light, sound needs something to travel in. It cannot travel through a vacuum.

Activity 13

A sound cannon

Aim

To make a sound cannon that will blow out a candle

Equipment

A cardboard tube (eg a poster tube), cling wrap, masking tape or rubber bands, a match

Method

- 1 Place the cling wrap over each end of the tube, stretch it taut and hold it tight with tape or rubber bands.
- 2 Make a small hole in one end using a pin or compass end.

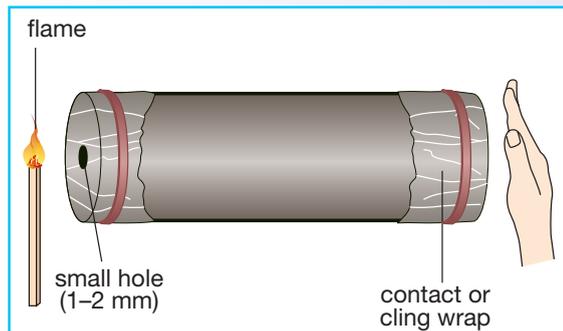


Fig 6.3.1 Sound cannon

- 3 Hold a lit match a few centimetres in front of the hole and sharply tap the other end.

Questions

- 1 Explain what happened to the flame when you tapped the end of the tube.
- 2 Explain why it is important to seal both ends of the tube, and for the cling wrap to be tight.
- 3 Why was the small hole necessary?

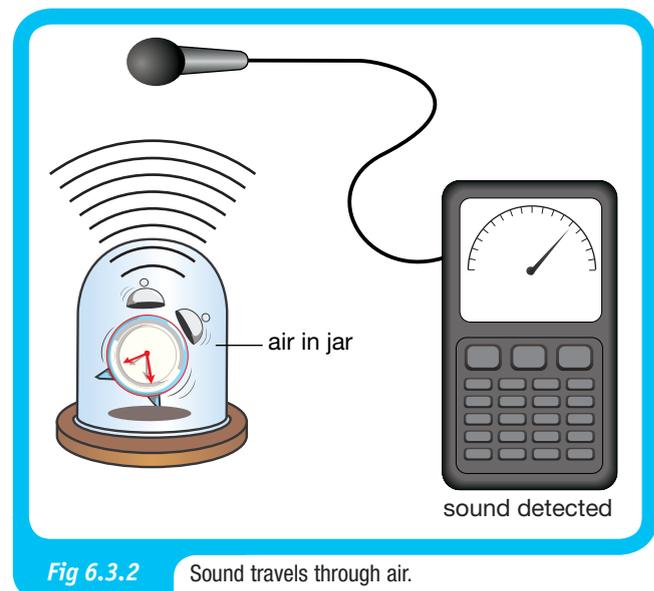


Fig 6.3.2 Sound travels through air.

Transmission of sound

We hear sounds because something has caused our eardrums to vibrate. Eardrums are small flaps of tissue inside the ear that pass on messages via special bones and nerve impulses to the brain.

But how do vibrations reach our eardrums?

Sound is produced when an object vibrates and passes these vibrations to the particles in air. Layers of air particles vibrate in turn, passing the sound energy through the air in a series of compressions and rarefactions that we call a sound wave. When the wave reaches our ears, our eardrums also begin to vibrate.

In the case of a musical drum, a thin membrane vibrates when struck. Our vocal cords produce vibrations when we speak.

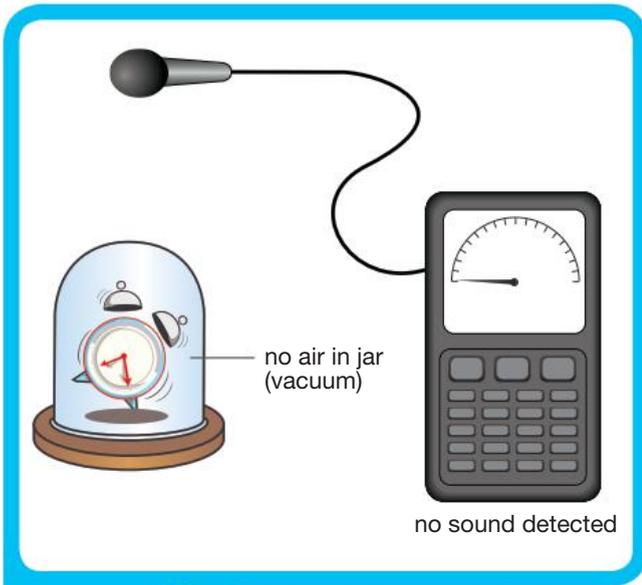


Fig 6.3.3 Sound cannot travel if there is no air present.

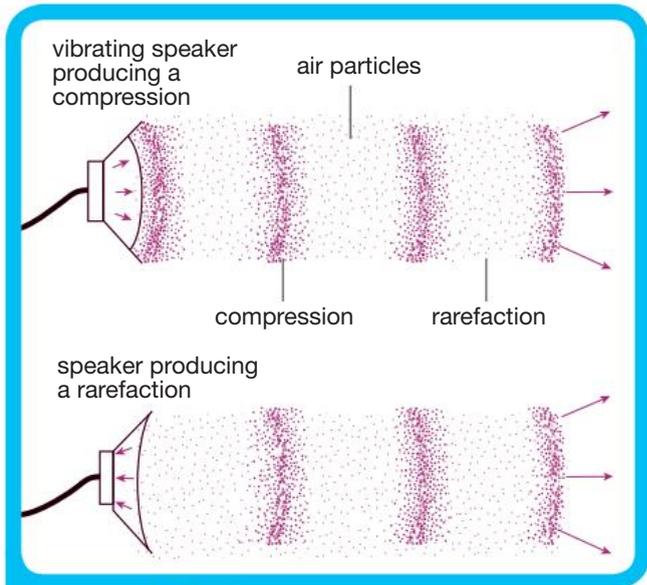


Fig 6.3.4 A sound wave is a series of compressions and rarefactions.

The vibration associated with a sound can be demonstrated by placing the prongs of a struck tuning fork into a beaker of water.

A similar effect may be observed if several coils of a slinky are compressed. When the compressions are released they travel from one end of the slinky to the other.

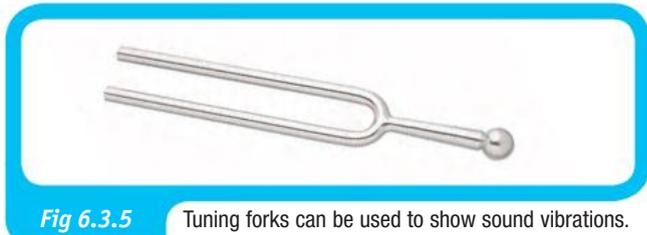


Fig 6.3.5 Tuning forks can be used to show sound vibrations.

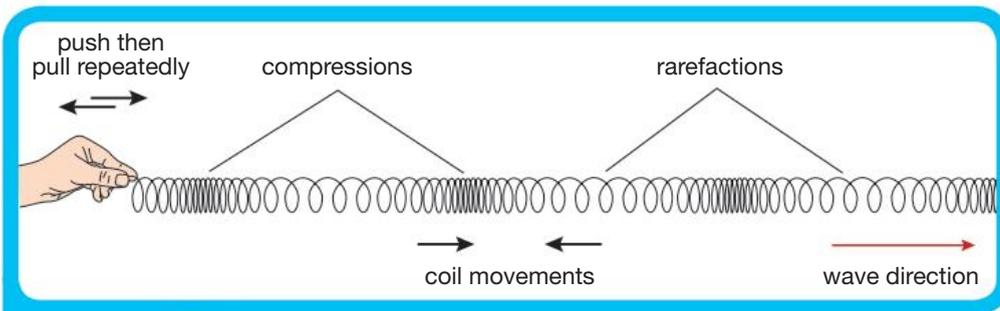


Fig 6.3.6 A longitudinal wave in a slinky

Sound waves and waves such as the one in the slinky in Figure 6.3.6 are called longitudinal waves, as the particles vibrate in the same direction as that of the sound.

Another type of wave is the transverse wave shown in Figure 6.3.7, in which the particles vibrate at right angles to the direction of the wave. Transverse waves may be produced by shaking a slinky sideways rather than releasing compressions.

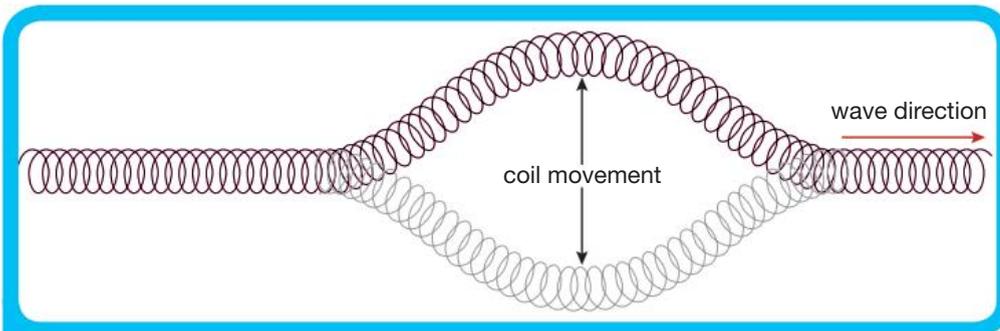


Fig 6.3.7 A transverse wave in a slinky

Activity 14

The speed of sound

Aim

To compare the speeds of sound and light

Equipment

A teacher with a starting pistol, a long tape measure or trundle wheel for measuring 100–300 m, a stopwatch

Method

- 1 Measure a straight distance of between 100 and 300 metres with a clear view from the start to the finish.
- 2 Your teacher should stand at the start with the starting pistol.
- 3 Several students should stand at the finish with stopwatches.
- 4 The teacher fires the starting pistol. The students start their watches when they see a wisp of smoke rise from the starting pistol, and stop them when they hear the sound of the pistol. (Alternatively, use a sound detector to determine the time taken for the sound to reach you.)
- 5 Calculate an average of the times recorded.

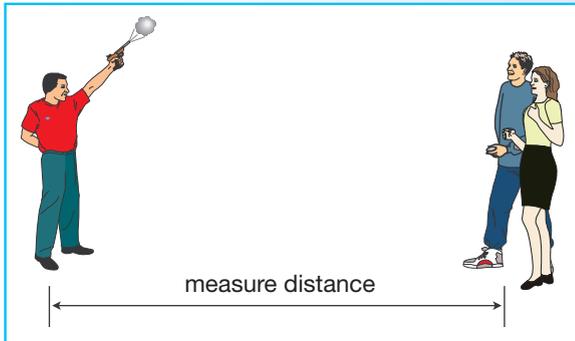


Fig 6.3.8 Comparing the speeds of heat and light

Questions

- 1 The people with stopwatches started timing when light from the smoke reached their eyes. Explain whether the time this takes is a significant factor.
- 2 Explain the advantage of calculating an average.
- 3 Use your average to calculate the speed of sound. To do this, divide the distance (in metres) by the time (in seconds).

The speed of sound

Sound travels at 343 m per second in air at 20°C. You may have noticed a delay between seeing a cricketer hit a ball, and hearing the accompanying sound. This is because light sends a message to our eyes at 300 000 000 metres per second! If you were sitting 343 m from the action, the sound would take 1 second to reach your ears, but the light would take only 0.000001 seconds to reach your eyes!

Just as a wave travels faster in a slinky made of a stiffer spring, sound travels more quickly in liquids and solids than in air because the particles are packed more closely together. The following table shows the approximate speed of sound in some different materials.

Material	Approximate speed of sound in the material (metres per second)
Air at 0°C	330
Air at 20°C	340
Air at 30°C	350
Water	1400
Wood	4500
Steel	5000

Activity 15

Reflection and absorption of sound

Aim

To determine the reflecting and absorbing capacities of different materials

Equipment

A sound-level meter or sound probe, various materials to test as reflectors and absorbers of sound

Method

Design an experiment to test and compare the reflecting and absorbing qualities of various materials (eg cardboard, glass, wood, plasterboard, fabric).

Questions

- 1 Which materials (eg cardboard, glass, wood, plasterboard, fabric) reflected sound the best?
- 2 List the materials you tested in order from those that absorbed sound the best to those that absorbed sound the least.

Echoes

Sound striking a hard wall will reflect back, or echo, towards the source. Echoes can be used to calculate the speed of sound. For example, if the person in Figure 6.3.9 finds that it takes 1 second after making a sound to hear its echo, the sound must have travelled 2×150 m or 300 m in 1 second. Hence the speed of sound for the experiment was 300 m per second.

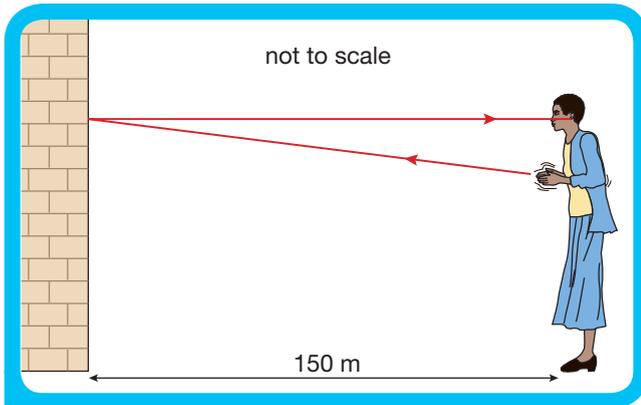


Fig 6.3.9 Using echoes to calculate the speed of sound

If the speed of sound is known, it can be used to calculate distance or depth. If it takes 1 second for a sound vibration to return to a ship after bouncing off a shoal of fish, then the sound has travelled 1400 m (from the table on page 130, sound travels 1400 m per second in water), so the distance to the fish is 700 m. Sonar on ships and fishing vessels uses ultrasonic sound waves. These are waves travelling faster than sound that humans can hear. This technique is called echolocation.

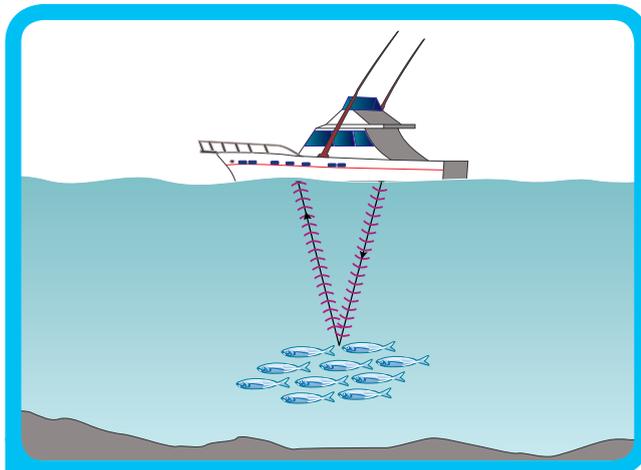


Fig 6.3.10 Ultrasonic waves are used in echolocation.

Some animals use echolocation to avoid obstacles or detect food or objects. Dolphins, piranhas and bats are examples.



Fig 6.3.11 Bats use echolocation to locate objects.

Radar uses a similar process to echolocation, except that radio waves are used instead of ultrasound to locate, direct and track various objects over long distances.

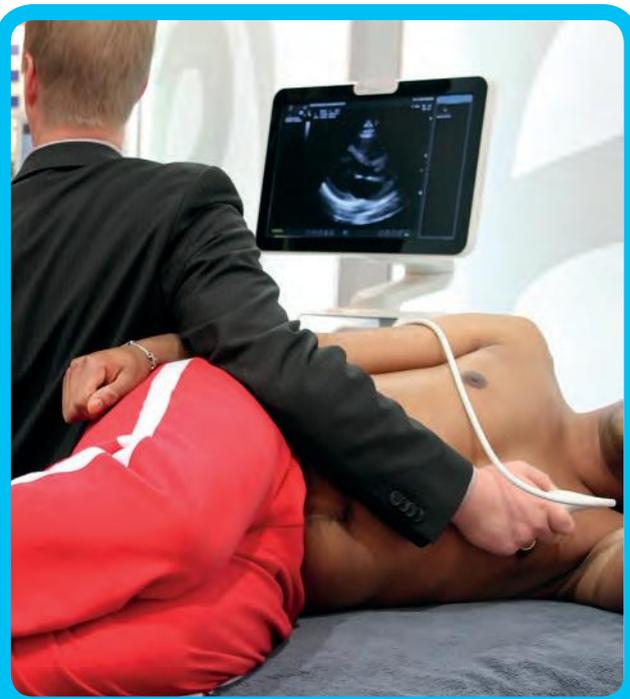


Fig 6.3.12 Ultrasound technology is used to study patients' organs, muscles and heart, and, in pregnant women, the developing baby. The ultrasound machine sends out high-frequency sound waves and the reflected sounds are recorded to create an image.

Reverberation

If you yell out in an empty hall, the echo time is too short for you to detect a distinct second sound.

The echo partly overlaps with the original sound, producing a sound that lasts longer.

We call this effect reverberation, and it may take some time to die out as echoes become weaker and weaker. Soft materials such as carpet and curtains absorb the sound energy rather than reflecting it to produce echoes. Concert halls use special sound-absorbing panels to reduce reverberation.

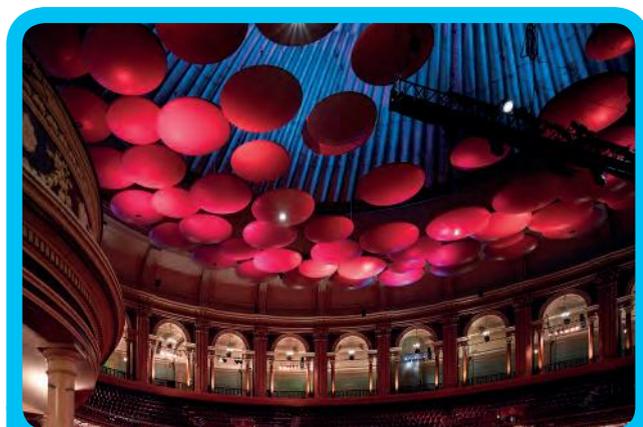


Fig 6.3.13 Note the sound-absorbing panels on the ceiling of this concert hall.

Sound graphs

Sound waves may be detected by a microphone and displayed on a cathode ray oscilloscope (CRO for short), a device that converts the pressure variations caused by vibrating layers of air into electrical impulses. The wave displayed on the CRO in Figure 6.3.14 is not a 'picture' of the sound produced by the tuning fork; it is a graph showing how the pressure is changing as compressions move through the air near the microphone.

The number of compressions that pass a point (eg the microphone) each second is called the frequency of the sound. A high frequency produces a high-pitched sound.

The CRO displays for some other sounds are shown in Figures 6.3.15 and 6.3.16.

When spoken, different words and letters produce different sound graphs. These can then be used by voice recognition software to convert spoken words into text on a computer.

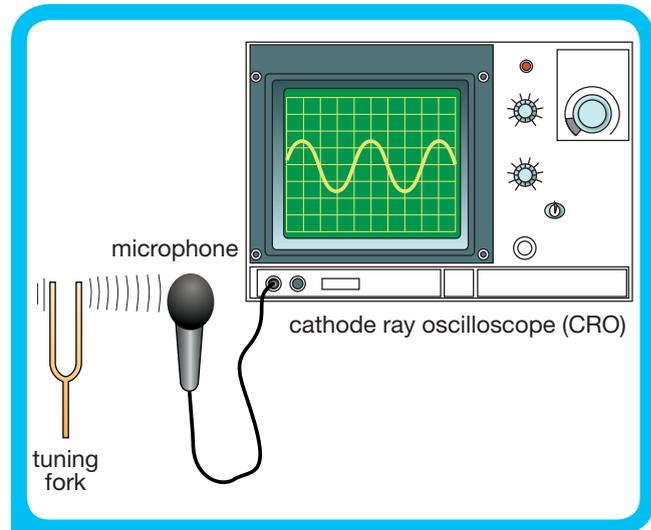


Fig 6.3.14 A CRO produces a 'graph' of a sound, showing pressure at different times.

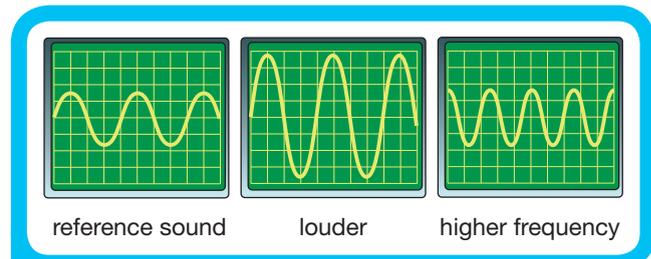


Fig 6.3.15 The height of a sound graph indicates loudness. Its horizontal spacing indicates its frequency.

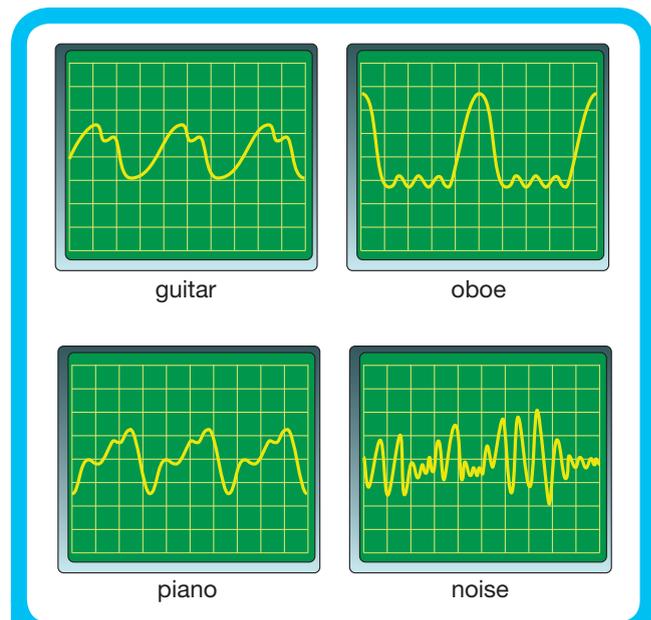


Fig 6.3.16 CRO displays for a guitar, oboe and piano note, which show a repeating, smooth pattern. Noise shows a much messier pattern.

The sound of music

A plucked guitar string produces sound by passing vibrations into the air.

When played, a clarinet may be thought of as a column of vibrating air particles that also passes vibrations into the surrounding air.

A string or air column has a natural frequency that depends on its length. We say the string or column resonates at this frequency. Resonance can be observed when a vibrating object causes another nearby object to vibrate at the same rate. The thin wood of a guitar resonates in response to the vibrating strings.

The frequencies of sounds produced by a guitar may be varied by altering the length of the string (by holding the strings at different points) or by tightening or loosening the strings.

A clarinet has keys that open or close holes in the column. This changes the length of the air column and the resulting sound.

Activity 16

Measuring cylinder resonance

Aim

To examine resonance in a measuring cylinder

Equipment

250 mL measuring cylinder,
tuning fork

Method

- 1 Strike a tuning fork and hold it at the top of the measuring cylinder. (If a sound detector is available, you may wish to use one to measure the intensity of the sound produced.)
- 2 Add a small amount of water to change the length of the air column in the measuring cylinder, and repeat step 1. Note whether the sound produced is louder or not.
- 3 Keep adding water and testing the sound produced when a struck tuning fork is held at the top of the cylinder.

Questions

- 1 Determine the length of air column that has a resonant frequency equal to that of the tuning fork.
- 2 Explain why water is added in small amounts.

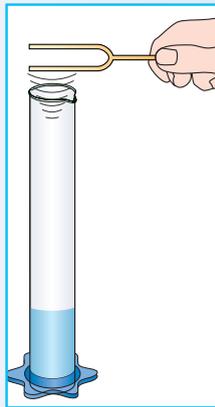


Fig 6.3.17 Set-up for measuring resonance in a cylinder

Sound levels

The decibel scale is used to measure sound and noise levels. We use the abbreviation dB for decibels. Figure 6.3.18 shows the decibel levels of a variety of sounds.

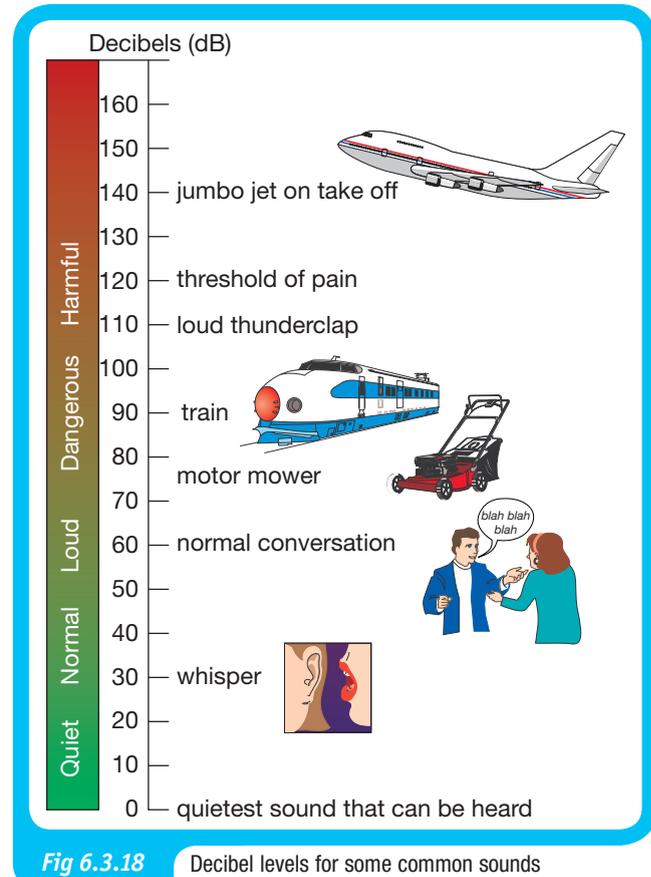


Fig 6.3.18 Decibel levels for some common sounds

For every increase of 10 decibels, we perceive the loudness to have doubled.

Noise-producing machinery may be given decibel ratings; for example, a motor mower may be rated at 75 dB. Sounds levels of 120 dB or more can be painful and result in permanent loss of hearing with continued exposure.

Earmuffs and sound-proof walls contain material that absorbs sound energy and so protects against high-decibel sounds.

Audible sound

Sounds within the range of human hearing are called audible sound. Sounds above the range of human hearing are called ultrasonic sounds, or ultrasound.

6.3

[Questions]

UNIT

Checkpoint**Transmission of sound**

- A sound is transmitted from Person X to Person Y by:
 - air particles which travel from X to Y
 - air particles passing vibrations from X to Y
 - infra-red waves in the same way as radiated heat
 - heated air particles which transmit heat by conduction from X to Y
 - none of the above.
- List five sources of sound.
- Sketch a longitudinal wave.
- Clarify the following terms by providing a definition for each.
 - compression
 - rarefaction

The speed of sound

- State the speed of sound in air at 20°C.
- State how far sound would travel (in air at 20°C) in 3 seconds.
- State how many seconds it would take sound (in air at 20°C) to travel 1 km.
- From the following list, identify the substance in which sound travels the fastest: air at 30°C, water or steel.

Echoes

- Identify an example of a useful and a not-so-useful echo.
- Identify two animals that use echolocation.
- Explain an advantage of ultrasound.
- Explain the term 'reverberation'.

Sound graphs

- True or false?
 - CRO is short for 'cathode ray oscilloscope'.
 - A CRO shows what sound waves would actually look like if air were visible.
 - A CRO can display a graph of pressure at different times as a sound wave passes.

The sound of music

- Explain what is meant by the following terms.
 - frequency
 - resonance
- Explain how the frequency of the sound from a guitar string can be changed.

Sound levels

- State the level at which sound becomes dangerous.
- Identify an example of a machine that may produce dangerous sound levels.

Think

- A student stands at the end of a road and yells towards a house some distance away. If she hears an echo 2 seconds later, how far is she from the house?
- There is an old expression: 'Keep your ear to the ground'. What do you think it means? Suggest where it might have come from.
- Explain how pushing someone on a swing is similar to resonance in a guitar.
- Identify which of the displays in Figure 6.3.19 was caused by the loudest sound.

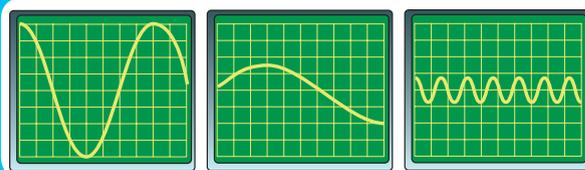


Fig 6.3.19

- Copy Figure 6.3.18, which shows various decibel levels, and add the following where you think they best fit.
 - a noisy class
 - an idling car engine
 - a telephone ringing
 - a rock concert
 - a person shouting

[Extension]**Investigate**

- Investigate how vocal cords work.
- Select a photograph of an aeroplane going through the sound barrier and, using this example, explain what a sonic boom is.
- Using diagrams and a short piece of writing, describe how a piano produces so many different sounds.

UNIT 6.4

Hearing

Introduction

When we cross a road, our ears can warn us of approaching traffic before we see it. In sport, sound helps players decide who to pass a ball to when their eyes are directed elsewhere on the field. Our ears work by detecting sound waves. They also sense the position of our head, helping us to keep balance. The ears are thus really two sense organs in one.

Activity 17

Hearing tests 1

Aim

To examine the directional ability of our ears in detecting sounds

Method

Seat one of your group and blindfold them. Ensure they are facing straight ahead. Develop a test that will indicate how well they can detect a sound coming from various directions. Test what effect changing distance and blocking one ear have on your results.

Questions

- 1 Describe how the distance of the sound source affects results.
- 2 Describe what happens if the person covers one ear.
- 3 Evaluate the need for two ears.

Sound

Sound travels through air at about 340 m per second, in waves of vibrating air particles. When the sound wave reaches our ears, the vibrations travel through the auditory canal and in turn cause the eardrum to vibrate. The various parts of the ear then convert the sound energy into electrical impulses that are sent via nerves to the brain for interpretation. The loudness of sound is measured in decibels (dB).

Activity 18

Hearing tests 2

Aim

To listen to different sounds from around the school grounds

Method

Go outside onto the lawn. Describe the sounds you hear and write down where you think each one comes from.

Questions

- 1 What source gave the loudest sound?
- 2 What source gave the highest frequency sound?
- 3 What source gave the most melodious sound?
- 4 What source gave the lowest frequency sound?

Parts of the ear

The ear consists of three main sections: the outer, middle and inner ear. The outer and middle ear are filled with air, and the inner ear is filled with fluid.

The outer ear consists of the highly visible pinna, which helps to collect sounds and funnel them into the auditory canal. The auditory canal connects the outer ear with the eardrum or tympanic membrane. The eardrum is the beginning of the middle ear and is made of a thin sheet of muscle and skin that vibrates in response to sounds. Vibrations are passed to a set of three tiny bones: the hammer, anvil and stirrup. This group of three bones is known as the ossicles. By the time the sound reaches the stirrup, it has been amplified to about thirty times louder than at the eardrum.

The stirrup vibrates against a section called the oval window at the boundary between the middle ear and inner ear, causing vibrations to pass into a coiled, fluid-filled tube called the cochlea. This fluid passes vibrations to a layer of tiny hairs connected to auditory nerves. These send messages to the brain, where they are interpreted as sounds.

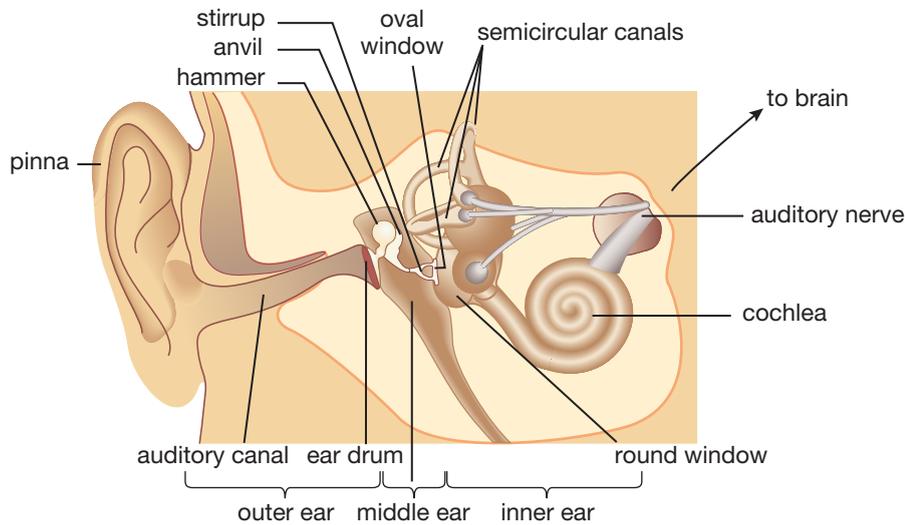


Fig 6.4.1 The human ear

Above the cochlea are the semicircular canals. There are three sections, each perpendicular to the others (like two walls and a floor that meet at the corner of a room). These contain fluid that moves when we do. Nerves send messages to the brain, which in turn signals muscles to help us keep our balance.

Why two ears?

Two ears help us determine the direction of a sound. If a sound reaches both ears at the same time, our brain interprets this to tell us that the source of the sound is directly in front of, behind or above us. If a sound reaches, say, the left ear before the right ear, the brain tells us that the source of the sound is to our left.

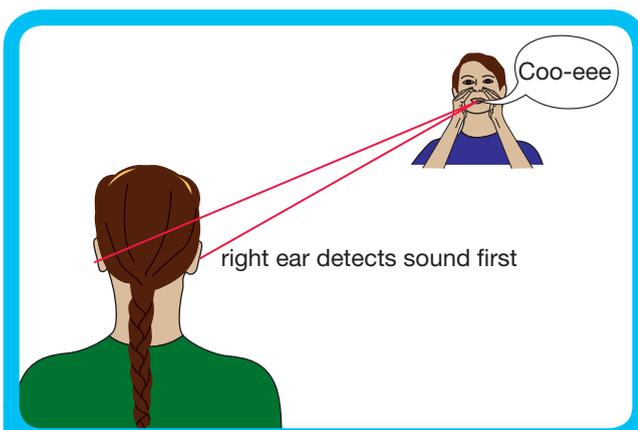


Fig 6.4.2 Two ears help us locate the direction of a sound.

Ear problems

Prolonged exposure to loud sounds can flatten the hairs of the cochlea. Hence when leaving a loud rock concert, the hairs have been flattened by the intensity of the noise. Most of the flattened hairs take some time but do recover. This gives partial deafness and ringing in the ears. As these hairs recover so does the hearing, but not completely. Some hairs are flattened permanently and destroyed. Repeated rock concerts will

destroy more hairs, leading to more permanent deafness.

A blow to the head or a very loud sound (eg an explosion) could rip the eardrum. A small tear in the eardrum may heal itself but usually leaves permanent scarring. This interferes with its vibration, so the hearing impairment is also permanent. Damage to the nerves cannot be repaired, and results in permanent hearing loss.

Deafness and partial deafness can be due to a number of things. Wax is produced in the auditory canal to help prevent entry of dust and bacteria. A build-up of wax can stop the eardrum from vibrating correctly, causing temporary deafness. A doctor can easily cure this by flushing out the excess wax with warm water.

The ossicles may get jammed together due to exposure to loud sounds or infection, so that vibrations are not passed on to the cochlea.

Some people are born with ear defects that reduce the amount of vibration reaching the auditory nerves. Hearing aids work by amplifying sounds and transmitting them to the auditory canal. If the cochlea is damaged, however, hearing aids may not be as effective, since unclear signals to the brain are produced, even if they are amplified.

An Australian invention known as the cochlear implant, or bionic ear, can restore a degree of hearing to some people. The bionic ear replaces a non-functioning inner ear. It consists of a microphone that sends information to a small



Fig 6.4.3 A hearing aid amplifies sound.

speech processor worn behind the ear or attached to a belt. The speech processor sorts out which information is important for understanding speech, transmitting it to a receiver–stimulator implanted in the mastoid bone. The receiver–stimulator then produces electrical signals in probes embedded near the cochlea. These are detected by the nerves and transmitted to the brain.

Ear protection



Fig 6.4.5 Ears should be protected from exposure to loud sounds.

If you operate noisy machinery, mow the lawn or use power tools, your ears may be in for prolonged exposure to loud sounds. The use of small earplugs or earmuffs will protect your ears and prevent ringing in your ears, which can last for several hours. Any ringing in your ears after exposure to loud sound means that some permanent damage has been done to your hearing.

Tinnitus, a condition in which a person hears a permanent ringing in the ears even when there is no sound, can be caused by exposure to loud sounds over a long period of time.

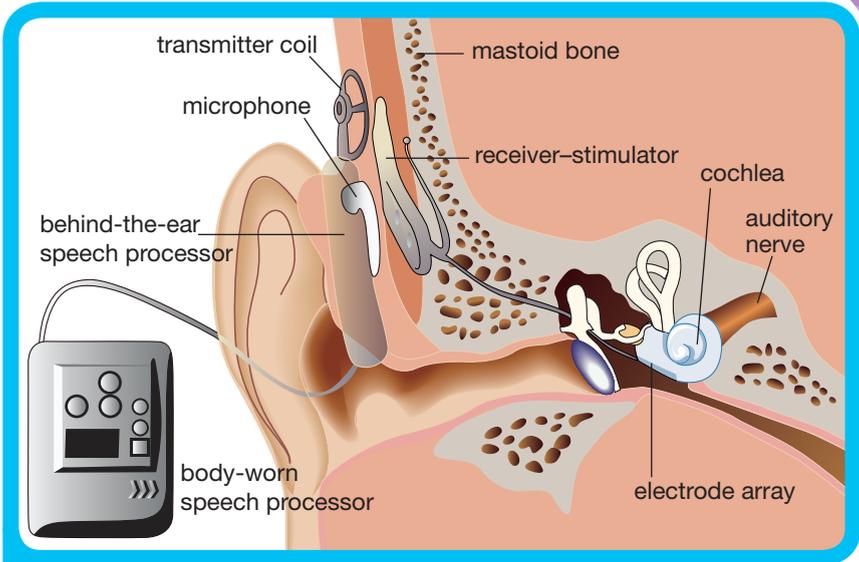


Fig 6.4.4 A bionic ear has several components.

6.4 [Questions]

Checkpoint

Sound

- 1 State the word that best describes the movement of air, fluid and bones within the ear when a sound passes through it.
- 2 Identify the unit used to measure the loudness of sound.

Parts of the ear

- 3 Copy and complete the table below to summarise each part of the ear described in this section.

Part	Description/function
Pinna	Fleshy ear flap, collects sound

- 4 Identify the part of the ear that is filled with fluid.
- 5 Identify the three small bones in the middle ear and state the name for them as a group.
- 6 Identify the part of the ear to which the auditory nerve is attached.
- 7 State where most sound amplification happens in the ear.

Why two ears?

- 8 A sound arrives at your right ear just before it reaches the left. State which direction the sound came from.
- 9 Sounds from directly in front arrive at both ears at the same time and so do sounds from directly behind. Suggest how we know which direction it is coming from.



Ear problems

- 10 Propose a reason why there are three semicircular canals instead of just one.
- 11 Describe how ear wax may be:
 - a useful
 - b a hindrance.
- 12 Describe two ways in which damage can be done to your hearing.
- 13 Explain what happens to your hearing after a loud rock concert.

Ear protection

- 14 Identify three common situations in which some form of ear protection is advisable.
- 15 Use Figure 6.3.18 on page 133 to identify some sounds that can be:
 - a dangerous
 - b harmful
 - c quiet.
- 16 State the sound level in decibels at which sound becomes hazardous to your hearing.

Think

- 17 Identify a task that involves mainly hearing.
- 18 Propose a reason why animals such as rabbits, deer and zebras have large ears.
- 19 Evaluate whether two ears are more valuable than one for survival.
- 20 Explain why an ear infection may upset your sense of balance.
- 21 Caleb and Sarah both have hearing difficulties. Speaking louder to Caleb makes it easier for him to hear, but it makes no difference to Sarah's hearing. Suggest reasons for this.
- 22 For each of the following sounds, state the approximate decibel level, and whether the sound will damage the ear. Use Figure 6.3.18 on page 133 to help you decide.
 - a motor mower
 - b large truck passing by
 - c helicopter up close
 - d person shouting at 1 metre away
 - e formula one racing car from the side of the track
 - f normal level of music through headphones
 - g normal classroom chatter

[Extension]**Investigate**

- 1 Investigate how a stethoscope works.
- 2 Investigate the bionic ear. Illustrate the important parts of the bionic ear to show how it functions. Who was the first recipient of a bionic ear?

Create

- 3 Construct a model ear to demonstrate how the ear works, labelling the important parts. Demonstrate the path of sound energy through the ear and the energy transformations that occur.

Action

- 4 **a** Design an experiment in which a sound level meter measures the sound levels produced by different MP3 or CD players. Record your results in an appropriate table and column graph.
 - b** Evaluate your results to determine whether the levels at which you regularly listen are harmful to your hearing.

Chapter review**[Summary questions]**

- 1 Identify the three ways in which heat may be transferred.
- 2 Classify the following as either heat insulators or heat conductors: nail, foam esky, wooden table, plastic cup, barbecue grill, frypan handle, woollen garment, metal oven tray.
- 3 **a** Identify whether water or air is the better conductor of heat.
 - b** Explain why.
- 4 Copy and complete the following sentence: A sea breeze is an example of ____.
- 5 Identify an example of radiated heat.

>>

- 6 State whether light- or dark-coloured objects best absorb and emit heat.
- 7 State the kind of wave that sound waves are.

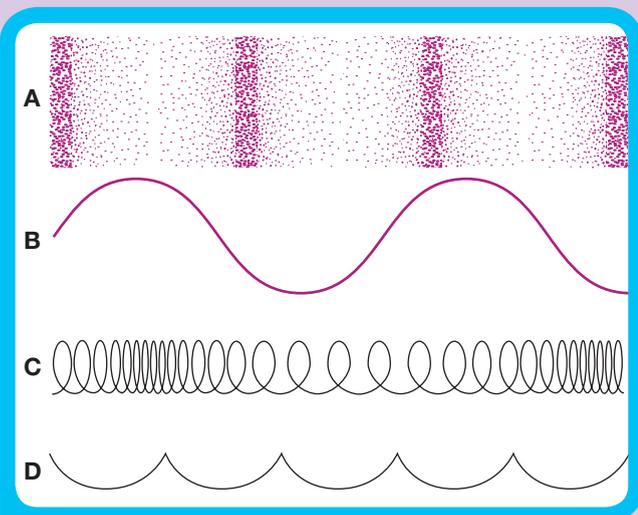


Fig 6.5.1

- 8 Identify which diagram in Figure 6.5.1 best represents an actual sound wave.

- 9 True or false?
 a Sound needs a material to travel through.
 b Light needs a material to travel through.
- 10 Many applications and uses of science in everyday life were introduced in this chapter. Copy and complete the table below to summarise some of these applications.

Interpreting questions

- 11 Identify the type of heat transfer that does not require a material.
- 12 Explain the difference between an echo and a reverberation.
- 13 A person standing 160 m from a wall hears an echo from it 1 second after calling out. State the speed of sound based on this information.
- 14 A boat is using echolocation to find fish. The signal is sent down into the water and returns to the boat after 1 second. The speed of sound in water is 1400 m/s.
 a Calculate how deep the fish are.
 b If the sound returned in 0.5 seconds, how deep would the fish be?
- 15 A vibrating tuning fork placed on a tabletop causes the tabletop to vibrate at the same frequency. What do we call this?

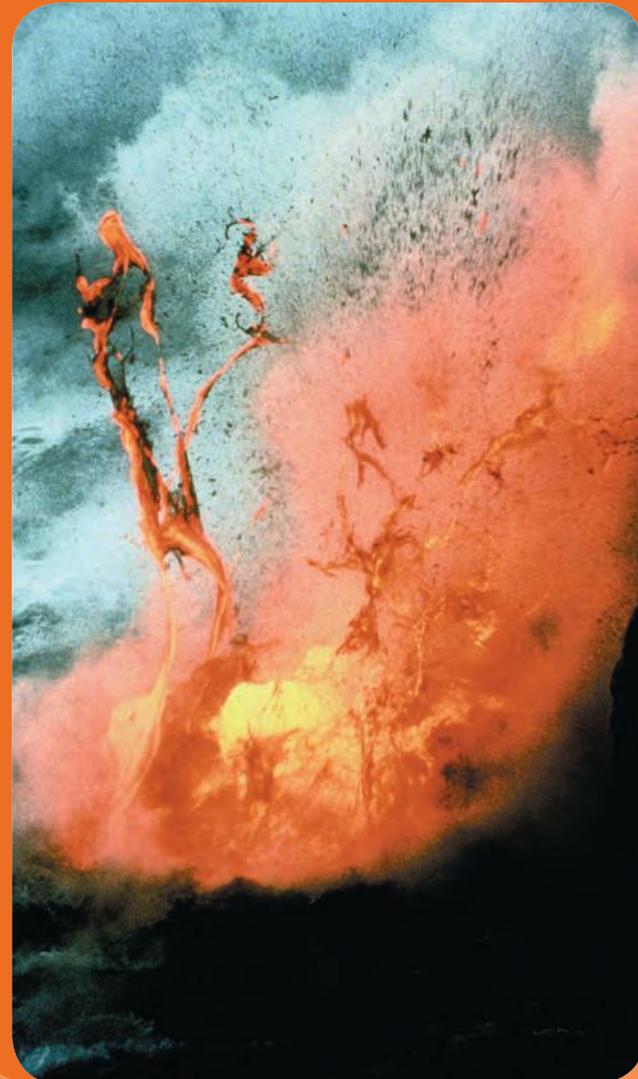
Technology	Use of technology	Type of energy	How it works
Ultrasound	Viewing unborn baby	Sound	Sound waves are sent into the body and reflected back from bones, tissue etc. The reflected sound is changed into an image on a screen.
Fish finder (echolocation)			
Guitar			
Solar hot water system			
Insulation batt			

The fragile crust

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

- 1 describe Earth's main layers: crust, mantle and core
- 2 understand that the lithosphere is made of solid rock (plates) that continues to move
- 3 explain the movement of Earth's plates
- 4 construct models to demonstrate plate tectonics
- 5 describe the geological features that are result of tectonic activities
- 6 identify the level on the Richter and Mercalli scales that show the strength of earthquakes
- 7 draw and label a cross-section of an erupting volcano
- 8 make a visit to a geology office close to your school
- 9 display in class pictures of earthquakes and volcanoes in Solomon Islands
- 10 describe the geological time scale of Earth
- 11 describe fossils and their uses to determine the ages of rocks.

- 1 Australia is moving northwards. True or false?
- 2 Los Angeles and San Francisco are 1200 km apart, yet one day they could be neighbouring suburbs. Why?
- 3 Australia does not have many earthquakes or volcanoes but New Zealand does. Why?
- 4 What is the biggest mountain on Earth and why is it in the Pacific Ocean?



UNIT 7.1

Plate tectonics

Introduction If you look at a map of the world, it appears that some coastlines could fit neatly together. A man called Francis Bacon first noticed it in 1620: the eastern coast of America had just been mapped and seemed to fit the coasts of Africa and Europe like pieces in a jigsaw. This observation seems to suggest something amazing—that these continents were once joined and have since moved apart!

The planet Splatter

Aim

To reconstruct a supercontinent

Equipment

A4 photocopy of the map in Figure 7.1.1, scissors, blank A4 paper, paper glue

Splattonianians think that the continents on their planet move and were once the supercontinent Squidgewana. Evidence comes from shape, magnetic fields and fossil remains of the golden splattered slug and the squidgian tinea fern.

Method

- 1 Cut out the continents and arrange them to rebuild Squidgewana.
- 2 Paste the map in your workbook.

Questions

- 1 Explain how each piece of evidence suggests that a supercontinent once existed.
- 2 Determine whether there are any other ways in which the supercontinent could be arranged.

Continents that move!

In 1915, Alfred Wegener proposed a radical theory. He suggested that there was once a supercontinent called Pangaea, which split to form the continents. These then drifted into their current positions. Although Wegener had lots of evidence to support his ideas about drifting continents, geologists did not take his work seriously. This was because Wegener was not a trained geologist but an astronomer and meteorologist.

Activity 1

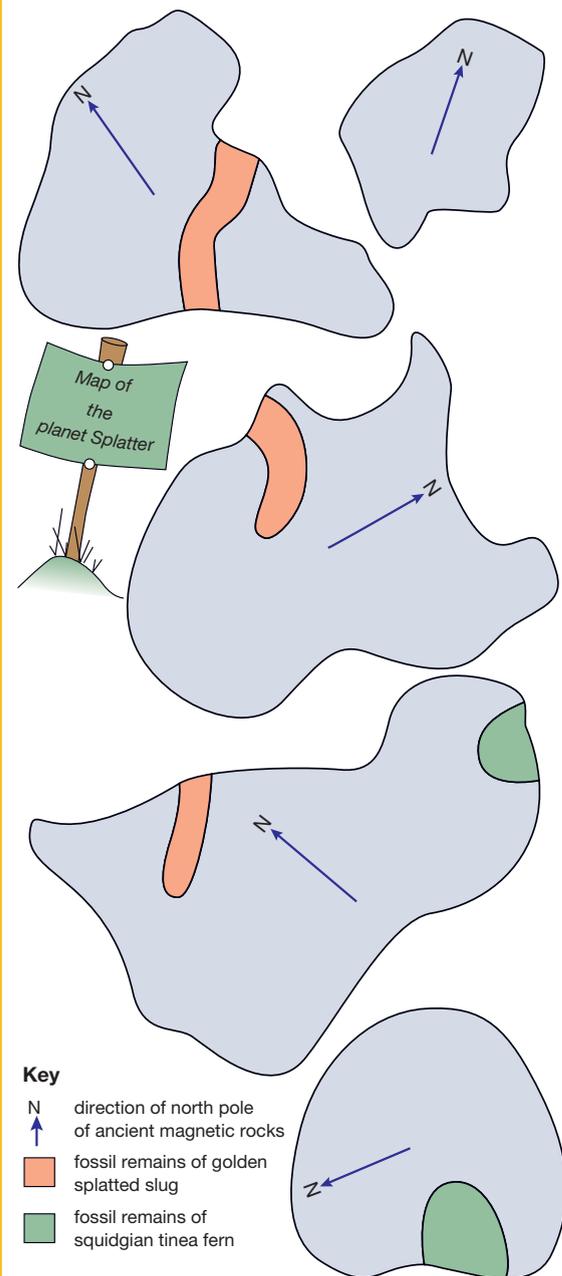


Fig 7.1.1 Map of the planet Splatter



Fig 7.1.2 Alfred Wegener

The evidence Wegener used in forming his theory included the following information:

- Two hundred million year old fossils of the same fern-like plant (*Glossopteris*) and Triassic reptiles were found across the southern continents, as shown in Figure 7.1.3. They all seem to have started on a single continent. They were then spread around the world when it split and the pieces drifted apart.
- The structure and rock composition of mountains in eastern North America can be matched to those of mountains across north-western Europe, as shown in Figure 7.1.4. Africa seems to be matched with South America.

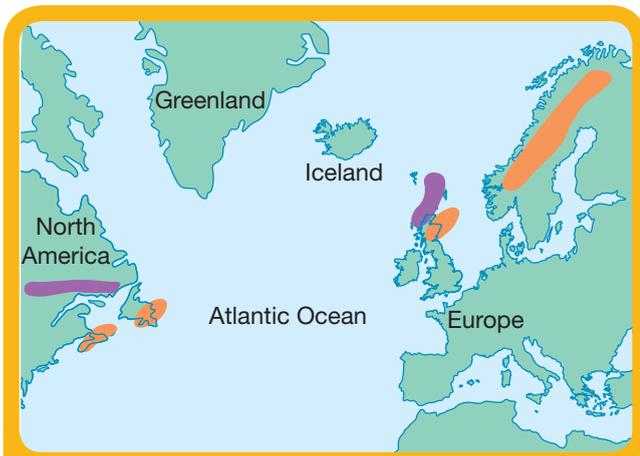


Fig 7.1.4 The mountain ranges in eastern North America and north-western Europe can be matched in detail for structure and rock composition.

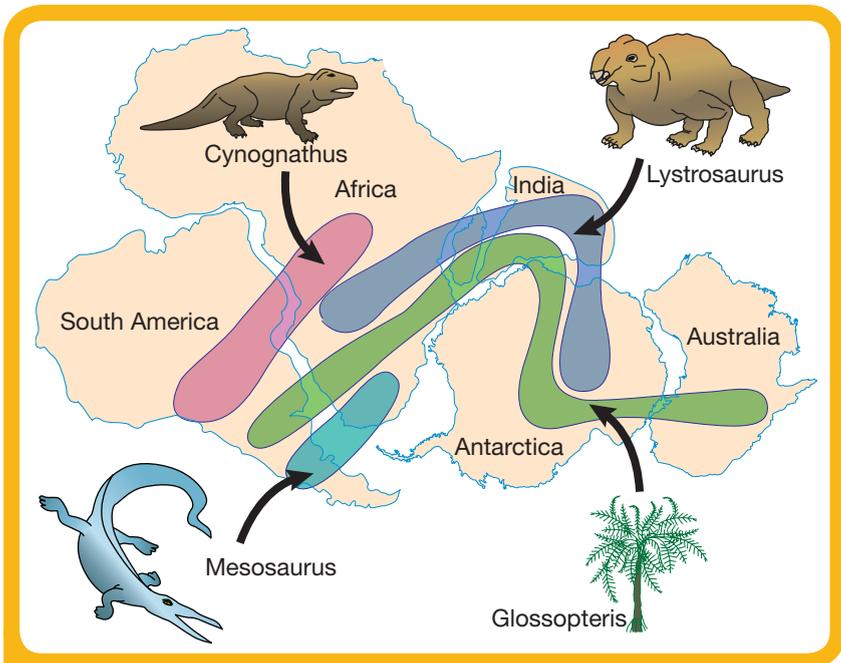


Fig 7.1.3

The migration of Triassic reptiles could have happened only if the continents were joined. The reptiles could not possibly have swum across the large distances between the continents and the spores (seeds) of ancient ferns could not have survived in the sea.

- Ancient glaciers have left valleys and debris across many continents. Some of these continents are now too warm to produce glaciers. These continents seem to have moved from a colder climate.
- Coal has been found above the Arctic Circle. Coal comes from decomposed plants and it is far too cold there now for plants to grow. These regions seem to have shifted from a warmer climate where plants could grow.
- As lava from a volcano cools, it adopts the magnetism of the Earth at that moment. Three hundred million year old magnetic rocks in South and North America have been found with their north poles pointed in different directions. The continents seem to have shifted so that these mini-magnets point in mismatched directions. If the continents are put together, however, the mini-magnets all point in the same direction, as shown in Figure 7.1.5.

It was later suggested that Pangaea split first into two smaller supercontinents before breaking again. These supercontinents were Gondwana (Australia, Antarctica, South America, Africa and India) and Laurasia (North America, Europe and most of Asia).

The idea of continental drift was not understood at the time, because it was generally thought that the Earth was solid rock. How could continents move across solid rock, and what pushed them?

Evidence from below!

During World War II, the military needed accurate maps of the seabed. They also needed to find underwater reserves of fossil fuels to assist the war effort. Using the newly developed technology of sonar, some surprising results were found:

- Huge underwater volcanic mountain ranges run down the centre of the oceans. The longest one is the Mid-Atlantic Ridge, with a length of 16 000 km.
- The rocks of the ocean floor vary in age from brand-new to 200 million years old, far younger than the rock of the continents.
- Very deep ocean trenches exist. The deepest one is over 11 km deep.
- The rock of the continents is less dense than that of the ocean floor and seems to ‘float’ on it.
- The rocks of the ocean floor have magnetic ‘stripes’, which are parallel with the underwater ridges. The magnetic field of the Earth has changed many times in its history, with the

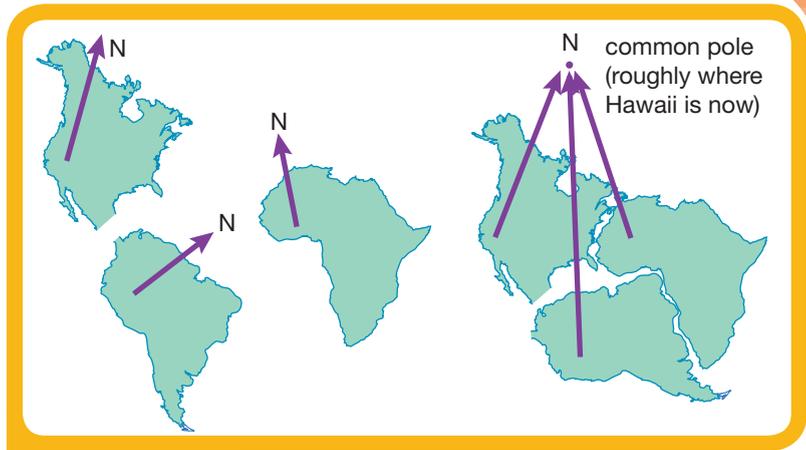


Fig 7.1.5

The magnetic alignments of ancient igneous rocks are scattered. If the continents are joined, the magnetic poles all point to the same spot.

north pole becoming south and vice versa.

The stripes show this reversal and indicate that the youngest rock is next to the ridges and the oldest next to the trenches. The magnetic stripes of the ocean floor south of Australia are shown in Figure 7.1.6.

All this evidence suggests that the new crust is born at mid-ocean ridges. The molten rock cools as it hits the water. This builds new mountains and pushes old ones out of their way. The ocean floor acts like a conveyor belt that carries everything towards the trenches.

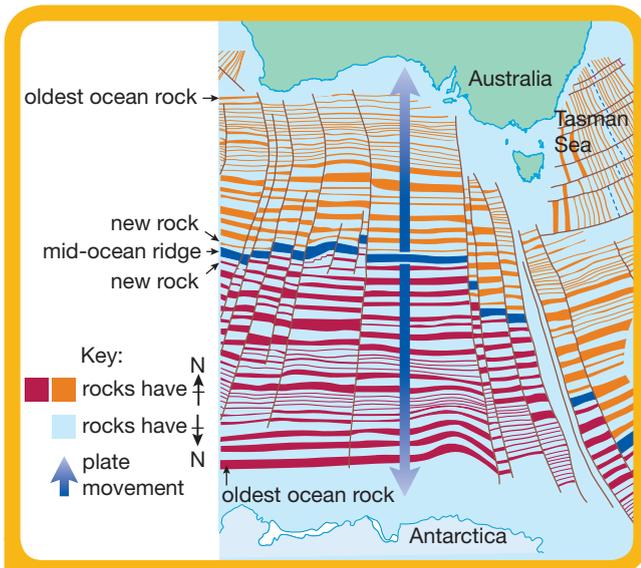


Fig 7.1.6

Magnetic stripes show that the rocks of the ocean floor vary in age and are moving away from a mid-ocean ridge.

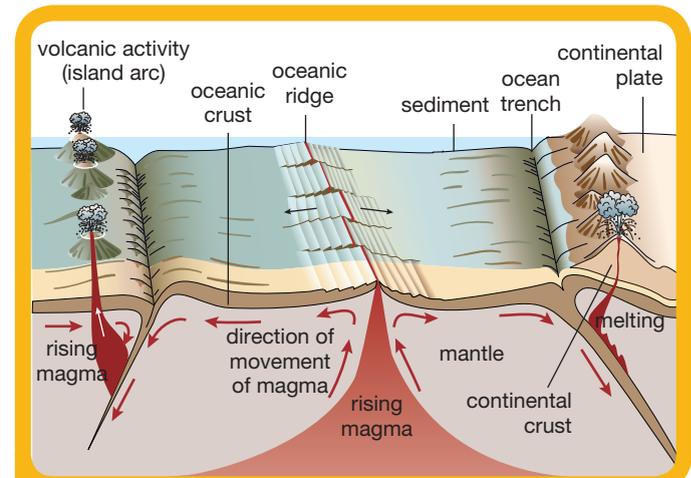


Fig 7.1.7

The ocean floor is like a conveyor belt, dragging new rock from mid-ocean ridges into the ocean trenches.

Convection currents

Aim

To investigate the movement of convection currents

Equipment

Large beaker (500 mL), medium beaker (200 mL), small bottle, two-holed stopper that can fit well into a small bottle—with two glass tubes inserted, tripod stand, Bunsen burner, gauze mat, heat-proof mat, box of matches, food colouring or pop drink sachet, Blu-Tack or plasticine

Method

- 1 Ask your teacher to insert the two glass tubes into the stopper. You must not do it by yourself.

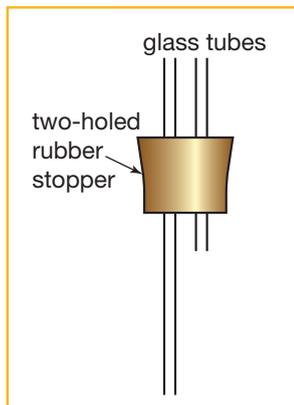


Fig 7.1.8a Apparatus set-up for step 1

- 2 Fill the 500 mL beaker with cold water and put it aside. You will need it later.
- 3 Half-fill the 200 mL beaker with cold water and heat it gently over a Bunsen burner flame. Do not heat the water to boiling.

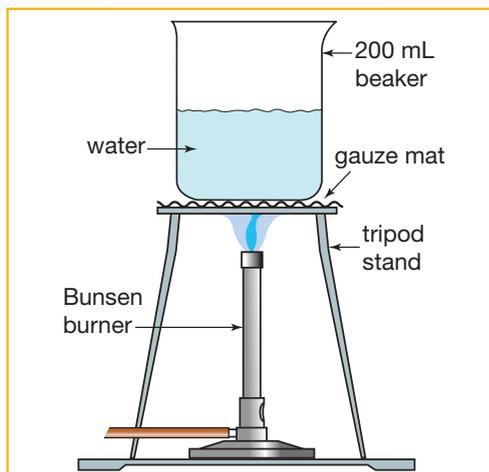


Fig 7.1.8b Apparatus set-up for step 3

- 4 Add a few drops of food colouring (or pop drink powder) to the water while it is heated.
- 5 Transfer the hot coloured water from the beaker into a small bottle. Close the bottle with the stopper (with two glass tubes). Ensure that one tube almost touches the bottom of the bottle.

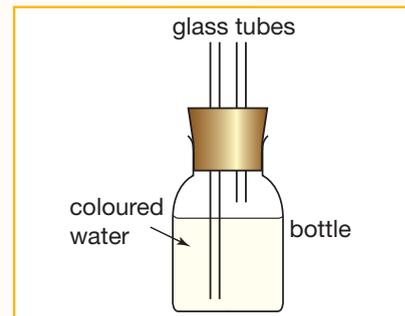


Fig 7.1.8c Apparatus set-up for step 5

- 6 Plug the ends of the glass tubes with Blu-Tack or Plasticine, and carefully lower the small bottle into the cold water in the 500 mL beaker (see Figure 7.1.8d). Take the Blu-Tack or plasticine out of the tubes when you have placed the bottle at the bottom of the beaker.
Note: You may need to prevent the bottle from floating by pressing down on the rubber stopper with your fingers.

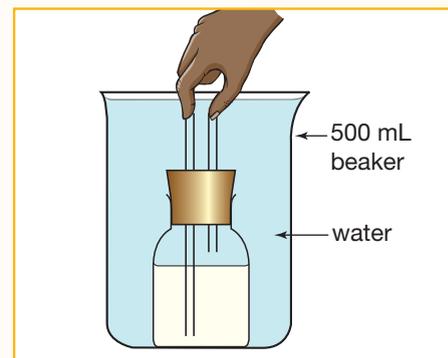


Fig 7.1.8d Apparatus set-up for step 6

Questions

You might need to read ahead to find the information to answer some of these questions.

- 1 Observe carefully how the convection currents are formed. In which direction did the heat flow?
- 2 Explain what causes convection currents.
- 3 Explain in terms of particles of the coloured water how heat flows in liquids.
- 4 What is the purpose of the two glass tubes?
- 5 Why do you think it was necessary to colour the water in the small bottle?

Floating plates

Earth is made of layers. We live on the crust, which varies in thickness from about 11 km under the ocean to an average of about 33 km under the continents.

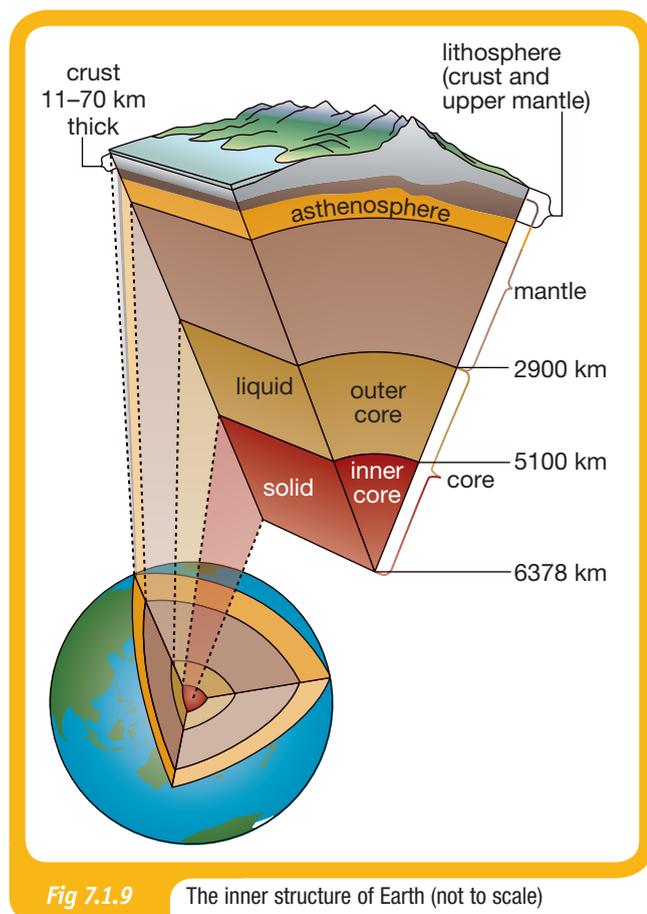


Fig 7.1.9 The inner structure of Earth (not to scale)

Next is the 2900 km thick mantle. The mantle is unusual in that the upper mantle is solid, just like the crust. The upper mantle and crust form a rigid layer of rock called the lithosphere. Below the lithosphere is a narrow, mobile layer of fluid-like rock called the asthenosphere. The rock here is under extreme heat and pressure and behaves like soft, thick, slow-moving mud. The rigid slabs of lithosphere, called tectonic plates, float on the slowly moving asthenosphere. The continents sit on the plates and move with them. Imagine the asthenosphere as a bowl of thick, hot soup and the tectonic plates as pieces of toast floating on the soup. The toast will move whenever the soup is stirred. Some pieces will crash against each other, some will ride on top of others, and others will sink.

The idea of moving plates is called the theory of plate tectonics. It was first developed in 1962 by the American Harry Hess.

Although scientists now agree that the plates are moving, nobody is quite sure why. The most commonly accepted theory is convection currents. Hot air and liquids rise and so does hot molten rock. In the same way, 'cool' rock sinks. Heat from deep within the Earth causes the molten rock of the mantle to move upwards. When this hot mantle rock comes into contact with the relatively cold crust, it cools and sinks. Convection currents in the mantle are the result.

7.1 [Questions]

Checkpoint

Continents that move!

- Outline any two pieces of evidence that suggest the continents were once joined.
- Identify the land masses thought to have made up:
 - Gondwana
 - Laurasia

Evidence from below!

- List any two surprising facts discovered when the ocean floor was first mapped.

- Refer to the diagram in Figure 7.1.6 and identify the locations of the oldest and youngest rocks on the ocean floor.

Floating plates

- Define the following terms:
 - tectonic plate
 - mantle
 - crust.
- State how thick the crust is.
- Explain the theory of plate tectonics.
- Discuss what causes convection currents and identify where they are thought to occur.



Think

- 9 Copy the following and change any incorrect statements so they become true.
 - a Triassic reptiles could have swum the distances required to populate different continents.
 - b There are similar mountain ranges in the United States of America and Africa, and also in Europe and South America.
 - c Continents that do not have glaciers now have always been too warm to have them.
 - d Coal deposits above the Arctic Circle suggest that the land floated there from warmer climates.
- 10 Temperatures along the ridges are higher than elsewhere in the ocean. Suggest why.
- 11 Draw a diagram to illustrate the convection currents in an oven.
- 12 Explain what keeps the mantle from cooling down and becoming solid.
- 13 Assess what would happen to the plates if the asthenosphere below them cooled and became solid.

[Extension]

Investigate

- 1 The plate on which Australia sits is moving northwards at a rate of about 5 cm per year. Calculate how far will it move in an average person's lifetime.
- 2 Investigate what Alfred Wegener contributed to the development of the theories of continental drift and plate tectonics.
- 3 Research what sonar is and how it measures depth. Illustrate your findings with examples.

UNIT 7.2

At the edges

Introduction

The tectonic plates move at about the rate at which our fingernails grow. For this movement to continue, new crust must be made and old crust destroyed. All this action happens at the edges or boundaries of the plates. It creates the basic landscape of our world, including its volcanoes and earthquakes.

Plates that separate (mid-ocean ridges)

Aim

To model the mid-ocean spreading of tectonic plates

Equipment

Cardboard box, A3 sheet of paper, coloured pencils or highlighters, scissors, sticky tape, pegs

Method

- 1 Cut a very thin lengthwise slot in the centre of the cardboard box.
- 2 Cut the sheet of paper lengthwise and tape the pieces together to make a long strip.
- 3 Fold and push both free ends of the paper up through the slot in the box.
- 4 As the paper emerges from the gap, brush it down with your hand so that the paper follows the top of the box.
- 5 As each 5 cm emerges, colour or decorate each new strip of paper.

Questions

- 1 Explain how this activity relates to the spreading at the mid-ocean ridges.
- 2 Identify what in your model represents each of the following:
 - a ocean floor or plate
 - b the water
 - c the lava flow
 - d gravity
 - e mid-ocean ridge
 - f the magnetic strips found in rocks parallel to the mid-ocean ridges.

Activity 3

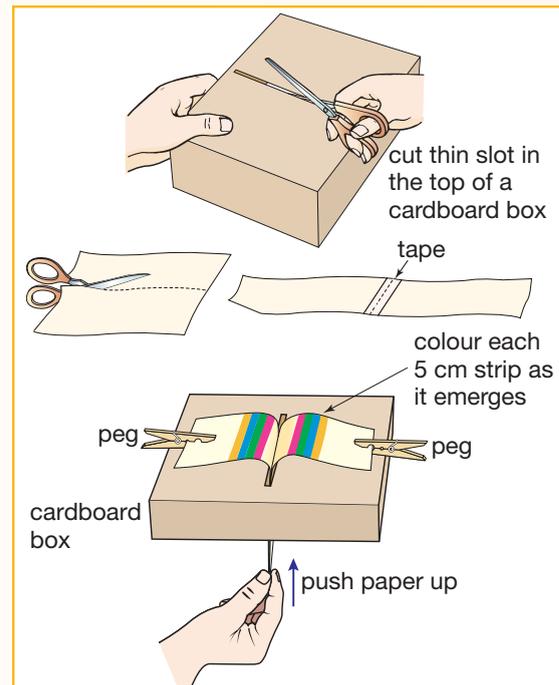


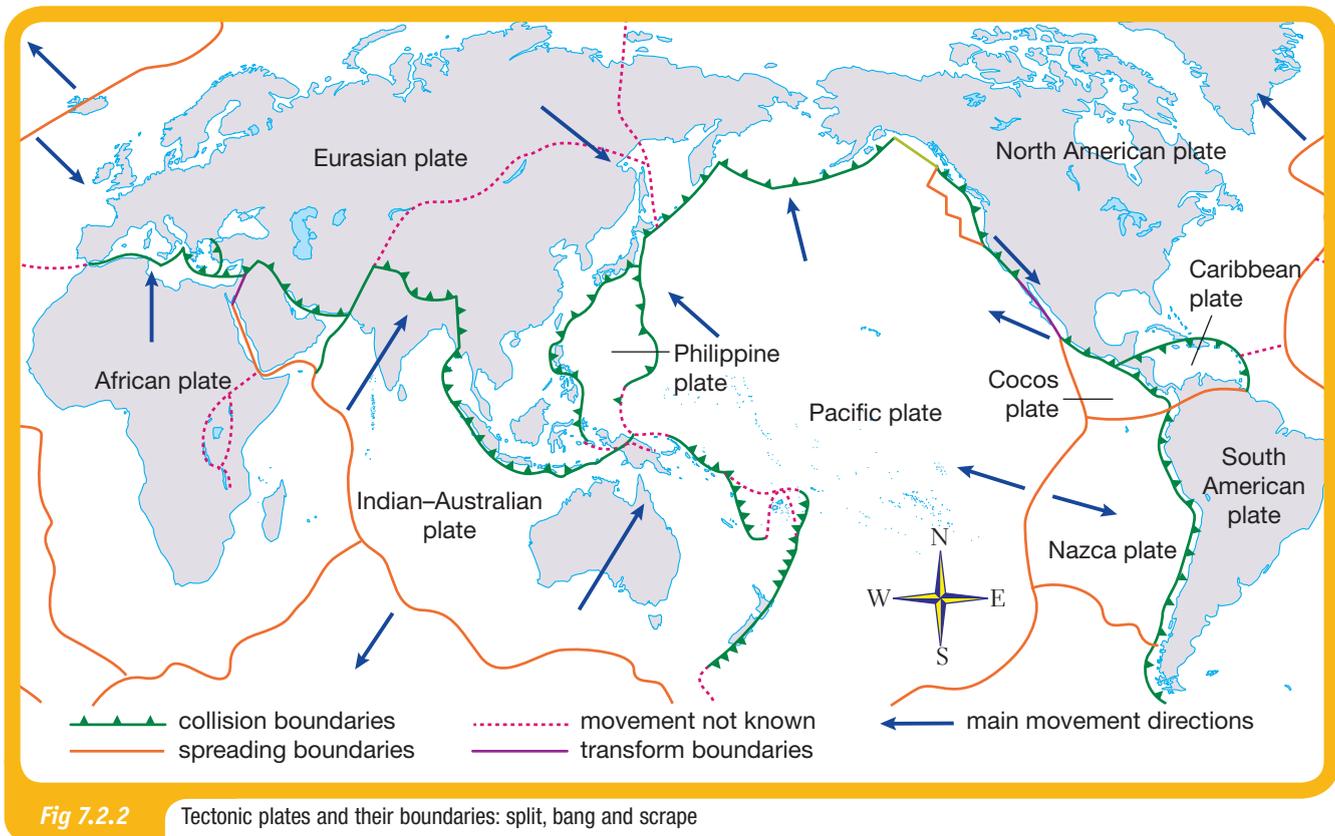
Fig 7.2.1 Modelling spreading plates

- 3 Describe what you noticed about the height of the paper as it emerged from the gap compared to the paper further out.
- 4 Identify which of the strips you coloured would be the 'oldest' rock and which the 'youngest' rock.
- 5 Identify which of these strips would be the first to be 'swallowed' by an ocean trench.

Plate boundaries

There are three types of plate boundaries:

- Spreading boundaries are where plates move apart. They are also known as constructive boundaries, since new rock is being made on the ocean floor.
- Collision boundaries are where one plate collides with another. These are destructive boundaries, since rock is melted here and is returned to the mantle for recycling.



- Transform or scraping boundaries are where plates scrape along each other. They are conservative boundaries, since they conserve rock. They do not create or destroy it.

A broken scab: spreading plates

Mapping of the ocean floor shows that some plates are moving apart at a rate of up to 20 cm a year. A weakened line (called a fault) in the crust causes a huge crack or rift valley to form and hot liquid magma forces its way up from the mantle to fill it. The magma cools and solidifies as it hits the water, and creates underwater mountain ranges like those observed in the Atlantic and Pacific Oceans. This is brand-new oceanic lithosphere. Older rocks crack and are squeezed out of the way as more magma moves upwards. New magma then fills the crack and the process repeats itself. It's like a wound: a scab begins to repair the wound but any stress cracks it, allowing blood to ooze again. The scab then needs to re-form.

Most rift valleys are under water but a few are on the surface. The largest is the East African Rift Valley, which is filled in some parts with lakes, and in other parts with huge volcanoes such as Mt Kilimanjaro.

A rift valley passes through the Dead Sea (at 400 m below sea level (this is the lowest point on Earth not under an ocean) and the Sea of Galilee (209 m below sea level). This rift valley continues into the Red Sea. This indicates that it will widen and become an ocean in the future.

Another rift valley is gradually splitting Iceland in two. Although Iceland is a relatively small island, it provides more than one-fifth of the total lava output from all volcanoes around the Earth. It is located on a spreading boundary. This is where the mid-Atlantic ridge is exposed as land.



Fig 7.2.3 The Sea of Galilee and the Dead Sea lie in a giant rift valley that joins with the Red Sea.

Activity 4

Colliding plates

Aim

To model what happens when two tectonic plates collide

Equipment

A stack of about 30 A4 pages (recycle: use scrap paper!), a textbook

Method

- 1 Split the stack of A4 paper into two smaller stacks of about fifteen sheets each.
- 2 Place each on the desk and slide them slowly into one another.
- 3 Observe what happens to the layers as they collide. Repeat four times to confirm your observations. Sketch what usually happened.
- 4 Now hold the end of one stack to keep it still. Push the other stack into it. Observe which layer climbs on top of the other. Repeat for confirmation and draw what happened.
- 5 Finally, place a textbook on the desk and push a stack of thirty sheets into it. Observe which goes under.

Questions

You might need to read ahead to find the information to answer some of these questions.

- 1 Compare the above tests with plate tectonics.
- 2 The stack of paper had obvious layers. Assess whether rock has layers, and if so, explain why.
- 3 State which tests simulated the following collisions:
 - a an oceanic plate with a continental plate
 - b a continental plate with another continental plate
 - c an oceanic plate with another oceanic plate.
- 4 Identify a place on Earth where each of these collision types occurs.

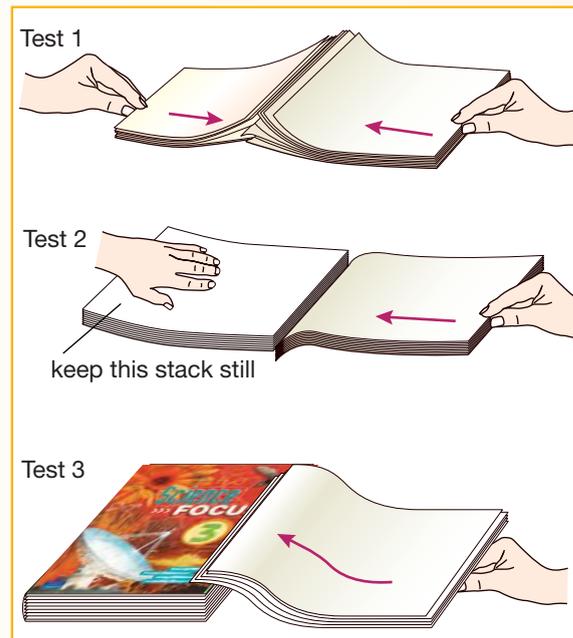


Fig 7.2.4 Modelling plate collisions

Collision boundaries

Going under: subduction zones



Fig 7.2.5 The Helgafjell volcano in Iceland began its life in 1973.

As the oceanic plates move away from the mid-ocean ridges they collide with other oceanic plates or with continental plates. Continental plates can also hit other continental plates. Each collision creates something different.

The rock of the oceanic plates is denser than the plates that the continents sit on. When they hit, the heavier oceanic plate is forced under the continental plate at an angle of 20° to 60° to the surface. This angled dive is called a subduction zone. Meanwhile, the upper plate gets crushed, thickens and forms folded mountains along its edge. By the time the ocean plate has reached a depth of about 200 km it has melted and become part of the asthenosphere once more.

The two plates do not slide easily over each other due to friction between them. When they do slip, it is sudden and an earthquake results.

The friction also generates heat, which produces magma along the top of the oceanic plate as it submerges. The magma will try to force its way back to the surface, perhaps to burst out as a ridge of volcanoes. The Andes Mountains were formed in this way.

Parallel to them is the Peru–Chile trench. Ocean trenches form where the oceanic plate drops below the continental plate. Although some of these trenches are filled with sediment, many are

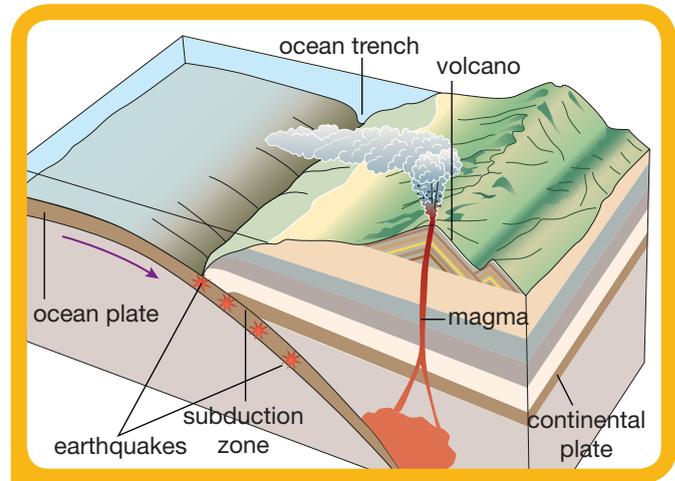


Fig 7.2.6 Volcanoes and trenches come from collisions between an oceanic plate and a continental plate.

incredibly deep. The Mariana Trench, in the western Pacific, was discovered in 1951 by the British survey ship *Challenger*. Its depth is about 11 033 m from the sea level. Mt Everest could easily sit in it and still leave plenty of room.

Going up: island chains

If an oceanic plate hits another oceanic plate and their densities are the same, the fastest plate sinks in the collision.

Once again a subduction zone is created. The upper plate gets thicker and volcanoes form, some of which push out of the water to form islands and island chains. Examples are the islands of Japan, Indonesia, the Philippines, the Caribbean and the Aleutians.

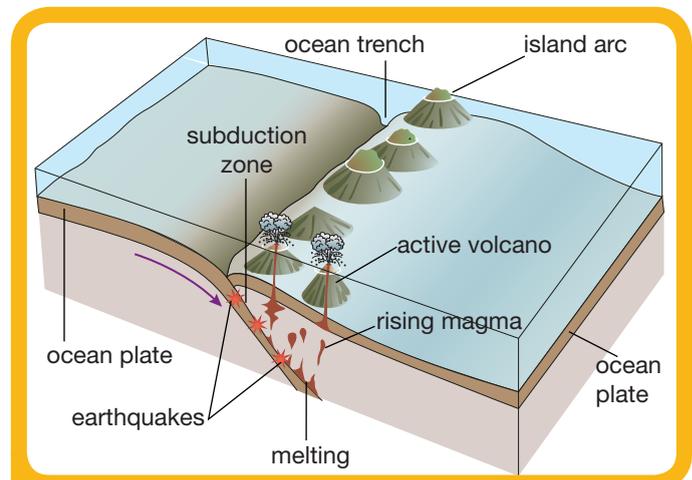


Fig 7.2.7 When an oceanic plate meets another oceanic plate, a chain of islands forms.

Really big mountains

When two continental plates collide, they crumple and fold. Intense heat from the collision also melts some rock and forms a solid 'mountain root' that resists weathering. The Himalayas are the tallest mountains on Earth, with Mt Everest the biggest at 8854 metres. These were formed when the plate that carries India collided head-on with the plate that carries the bulk of Asia. Both plates have similar densities and neither can push the other underneath. Instead the plates crumple, fold and push up.

The collision of plates is still happening, so the Himalayas are still rising about 1 cm every year. Current mountaineers now need to climb 0.5 m more than the first successful climbers, Sir Edmund Hillary and Tenzing Norgay, in 1953.

Plates that scrape: transform boundaries

Plates scrape along each other along a transform boundary. This does not make mountains or volcanoes but does produce lots of earthquakes, some very strong. Although most transform boundaries are under water, some are on land. The most important of these is the San Andreas Fault. It runs 1300 km through California in the United States of America, directly under San Francisco and close to Los Angeles. The coastline of California slips 5 cm along it every year, moving Los Angeles north and closer to San Francisco.

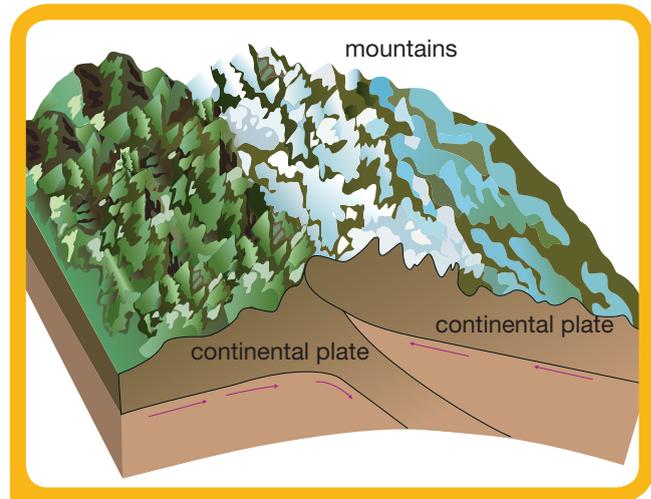


Fig 7.2.8

Massive folded mountains form when continent collides with continent.



Fig 7.2.9

The San Andreas Fault has nearly separated Point Reyes from the rest of California. It is an example of a transform fault.

7.2 [Questions]

Checkpoint

Plate boundaries

- Identify the three types of plate boundaries.
 - Describe what happens to the plates at each boundary.

A broken scab: spreading plates

- A mid-ocean ridge can be compared to a scab. Explain why.

Collision boundaries

- Describe what happens in a subduction zone.
- Determine which is more likely to sink when the two hit each other:
 - the fast or the slow oceanic plate

- the heavy or the light plate
- the continental plate or the oceanic plate.

Plates that scrape: transform boundaries

- Describe what occurs at a transform boundary.

Think

- Describe boundaries that:
 - form rift valleys
 - dive into the mantle
 - cause trenches
 - cause huge, folded mountains.

>>



- 7** Identify the type of boundary on which these places are situated:
- Iceland
 - the San Andreas Fault
 - Mt Everest
 - the Dead Sea.
- 8** Illustrate the following with a labelled diagram:
- spreading plate boundaries
 - oceanic plate meets continental plate
 - oceanic plate meets oceanic plate
 - continental plate meets continental plate
 - transform plate boundaries.
- 9** Identify the two plates that created the:
- Himalayas
 - Mid-Atlantic Ridge
 - Mariana Trench
 - San Andreas Fault.
- 10** A plate often gets thicker when another plate is forced under it. Explain why.

Skills

- 11 a** The Himalayas are growing about 1 cm per year. Calculate how much they will grow in an average lifetime.
- b** Calculate how long it will take for them to grow a further:
- 10 m
 - 100 m
 - 1 km.
- 12** Currently the Red Sea is about 240 km wide and widening at a rate of about 20 cm per year. Calculate the time it will take for it to become the same width as the Mediterranean Sea (about 500 km)

UNIT 7.3

Earthquakes

Introduction

We have seen that tectonic plates separate, collide and scrape over each other. None of this movement is smooth, because the plates must build pressure to overcome the strong friction forces that causes them to 'stick'. The plates are constantly trying to move, so the release of pressure is frequent. More than one million earthquakes occur per year, although most are so small or so remote that they are not noticed and cause little damage.

Now imagine bending a branch. It bends fairly easily up to a point, then suddenly snaps. The vibrations you feel through your hands are the release of the stored energy in the branch. This is what happens with an earthquake. The pressure release is sudden, explosive and often disastrous. Major earthquakes can destroy buildings, roads, services and lives. In the process they also devastate the community they hit, making many homeless and destroying the economic structure of the community.

Activity 5

Slinky springs: transverse and longitudinal waves

Aim

To model the movement of P and S waves

Equipment

Slinky spring, dense smaller-diameter slinky, string, paper, sticky tape

Method

- 1 Tape a small piece of paper to the slinky.

PART A: Transverse waves

- 2 Lie the slinky along the floor. Hold the spring at both ends, stretching it lightly. One person should hold their end still at all times.
- 3 Move one end sideways so that a ripple-like wave moves down the spring.
- 4 Construct a diagram showing the movement of the paper and in which direction it moves down the spring.
- 5 Test bigger and smaller waves. Compare their speeds and 'height' or amplitude.

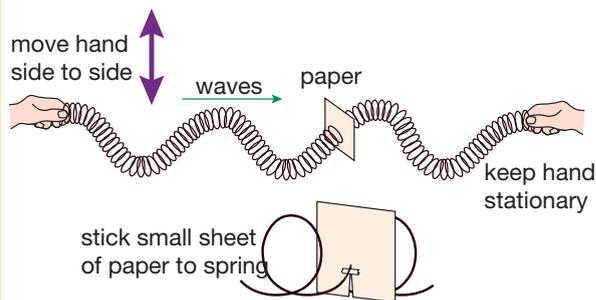
PART B: Longitudinal waves

- 6 Quickly move one end of the spring in and out about 30 cm. A compression should move down the spring. Describe what happened to the paper.

PART C: Waves in different densities

- 7 Attach the heavy, smaller slinky to the bigger one and repeat the above experiments. Compare your observations on speed and size when the wave travels from big to small diameters and vice versa.

Set-up A: Transverse waves (movement of S waves)



Set-up B: Longitudinal waves (movement of P waves)

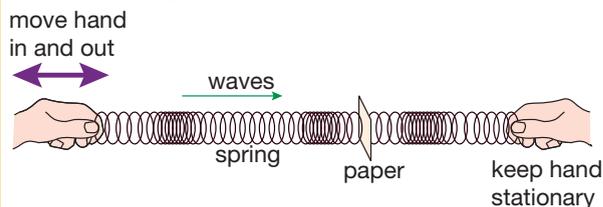


Fig 7.3.1 Making waves

- 8 Repeat, but attach a piece of string instead of the smaller-diameter spring.

Questions

- 1 Identify the direction of movement of the paper in the slinky when:
 - a a transverse wave moved along it
 - b a longitudinal wave moved along it.
- 2 Imagine you are an ant standing on the piece of paper in each case. Describe what you would feel.

>>

- 3 Identify which part of the experiment (A, B or C) best represents:
- a P wave
 - an S wave.



Fig 7.3.2 Damage caused by the 2011 Christchurch earthquake

Focus and epicentre

The focus of an earthquake is the point where it begins. It is where the plates slip and is on a fault line usually at the plate edges. The focus can be very close to the surface or it can be as deep as 200 km. This is the depth at which the oceanic plate finally melts into the asthenosphere.

The size of an earthquake does not depend on the focus depth.

The epicentre is the point on the Earth's surface that is directly above the focus and will suffer the most damage.

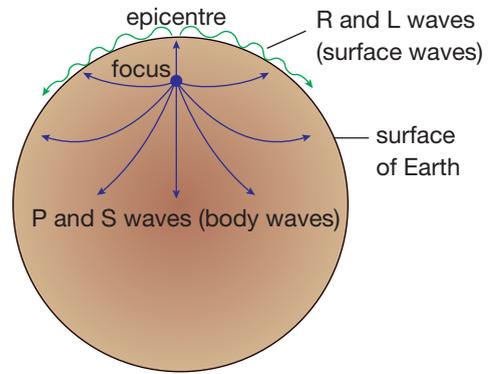


Fig 7.3.3 The focus is where the earthquake starts. Seismic waves spread from here to the epicentre and beyond.

Seismic waves

Earthquakes release energy in the form of vibrations, called seismic waves, which travel through and around the Earth. An instrument called a seismometer detects all these waves. The recorded seismograph gives the time delay of the arrival of each different wave type. It also shows the level of their energy. The greater the energy, the higher the amplitude (width of the squiggle) of the trace on the seismogram.

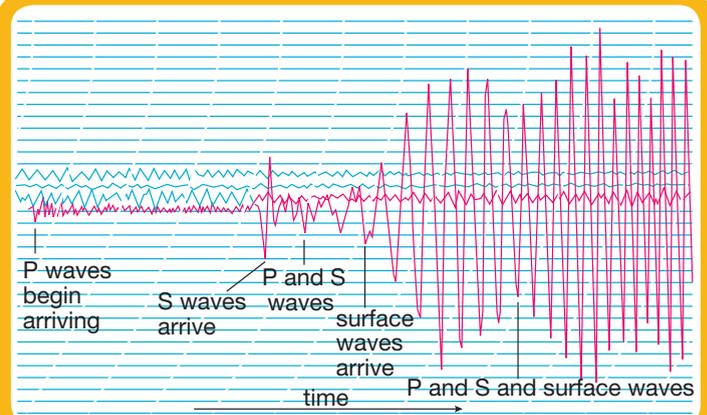


Fig 7.3.4 A typical seismograph, showing P, S and surface waves

- Seismic waves can be split into two categories:
- body waves—these travel through the body of the Earth and can be either primary (P) or secondary (S)
 - surface waves—these travel on the surface of the Earth and are either Rayleigh (R) or Love (L).

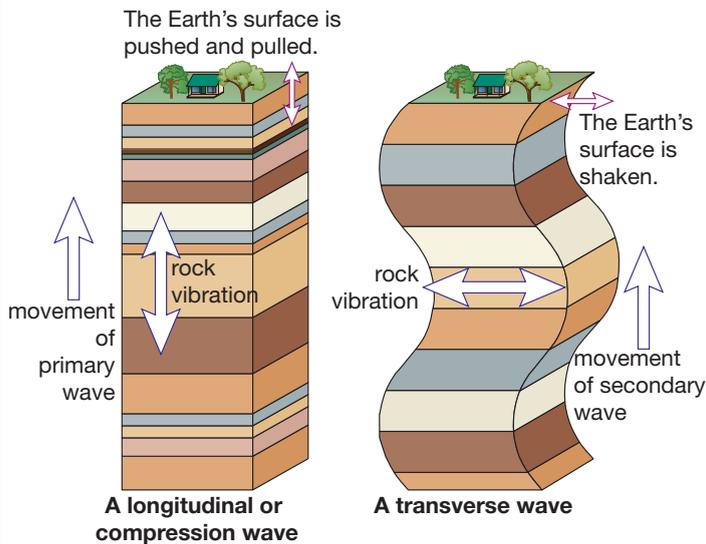


Fig 7.3.5 Body waves: P and S

Body waves

Primary waves move fastest and are the first to be recorded. They are an example of longitudinal or compression waves that push and pull. They do not behave in the up-and-down motion of water waves that we are used to. Sound is another example of a longitudinal wave.

P waves can travel through both solid and liquid rock. They subject the rocks to an alternating push-pull motion, hitting the surface with an up-and-down motion.

S waves are slower than P waves and are the next to be recorded. They are transverse waves and have an up-and-down movement just like water waves. S waves travel only through solid rock. Molten rock blocks them. S waves hit the surface with a shaking or side-to-side motion.

Earthquake shadows

The speeds of P and S waves depend on what they are travelling through. The denser the rock, the faster they go. The waves change speed as they pass into rock of different density. They also change direction. This is called refraction and happens to all types of waves as they change speed on passing from one material to another. Water waves do it and so do light and sound waves.

When an earthquake happens, seismometers around the world record all the waves that reach

Activity 6

Building a seismometer

Aim

To construct a working model of a seismometer

Equipment

Retort stand, bosshead and clamp, spring, heavy weight, adhesive tape, felt pen

Method

- 1 Set up the apparatus as shown in Figure 7.3.6.
- 2 Slowly pull the paper while creating 'earthquakes' by thumping the bench on top and at the end.

Questions

- 1 Identify which movements caused the seismographs to work.
- 2 Explain why the graph did not stop after the earthquake did.

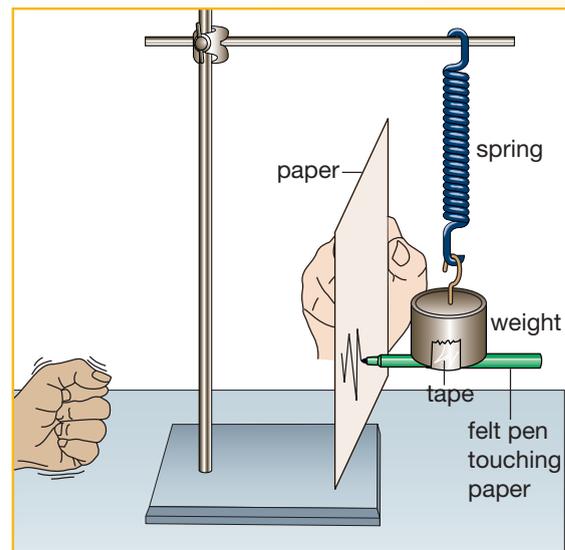


Fig 7.3.6 Modelling a seismometer

them. When all the seismographs are analysed, a pattern showing the spread of waves is produced.

The bending of the waves and the fact that S waves will not travel through liquids causes some seismometers to record different combinations of body waves. Figure 7.3.7 shows how this happens.

- There is an area directly opposite the epicentre of an earthquake where S waves are not recorded. The outer core is blocking the S waves. Why? It must be liquid rock since S waves cannot travel through liquid.

- The paths of S and P waves are not straight. They are bent or refracted by the changes in density and temperature of the different layers of the Earth. This causes two 'shadow zones', as shown in Figure 7.3.7, where P and S waves are not recorded.

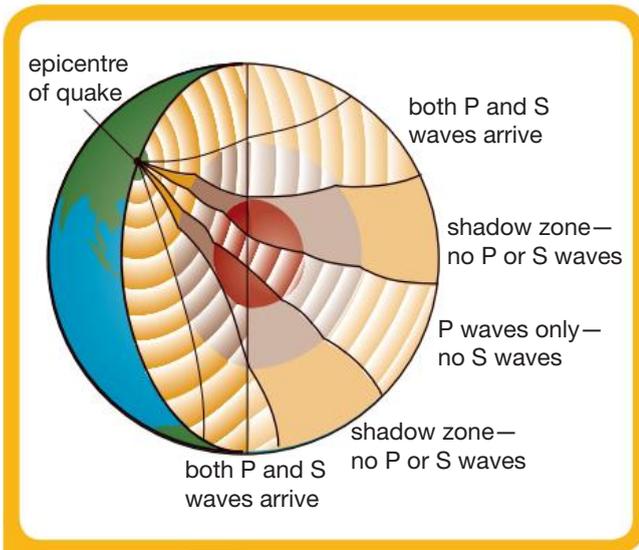


Fig 7.3.7 Refraction of P and S waves and 'shadows' where they do not arrive

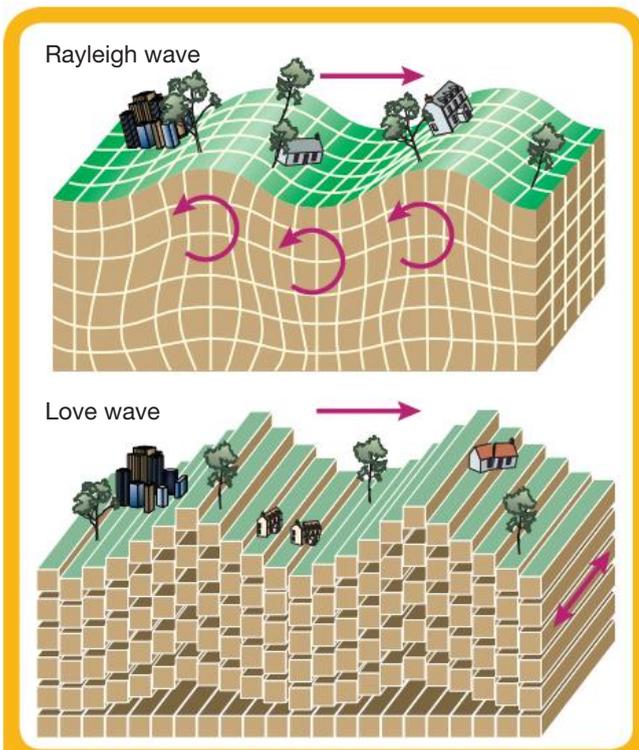


Fig 7.3.8 Rayleigh and Love waves travel across the surface and are very dangerous.

Surface waves

Rayleigh (R) and Love (L) waves travel around the Earth, not through it. They have a longer distance to go than P and S waves and therefore arrive after them. They are more dangerous than P and S waves because their effect on the surface is more disastrous. Their energy radiates from the epicentre like ripples on a pond from where a stone has been dropped.

R waves are rolling waves, like breakers at a surf beach. They are the slowest of the seismic waves but often the largest and most destructive.

L waves are faster than R surface waves and have a side-to-side motion, like a moving snake. Figure 7.3.8 shows the dramatic effects of R and L surface waves.

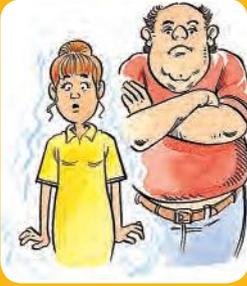
Measuring earthquakes

Richter and Mercalli scales

Scientists can use seismographs to estimate the energy of an earthquake at its epicentre.

An earthquake's strength is measured on a scale devised by American Charles Richter in 1935. It is an open-ended scale that starts at 0. No known earthquake has ever exceeded 9 on the scale. On the Richter scale an increase of one unit represents a ten times increase in the size of the earthquake and a thirty times increase in the energy released by it. This means that an earthquake of magnitude 8 is ten times the size of an earthquake of magnitude 7 and has thirty times its energy. Any earthquake above 7 on the Richter scale must be considered dangerous, since major damage can be expected. Such serious earthquakes are rare.

The Richter scale gives no indication of the damage caused by an earthquake. Damage depends on the location of the epicentre, environment of the region, density of the population, construction and design of the buildings and length of time of the earthquake. The Mercalli scale gives a better indication of an earthquake's effects because it is based on actual observations. Giuseppe Mercalli developed the Mercalli scale in the 1890s before seismometers were in use. It measures the intensity (strength) of the earthquake rather than its magnitude (size).

a Richter 2–3
Mercalli I–II**b** Richter 4–5
Mercalli IV–V**c** Richter 5–6
Mercalli VI**d** Richter 6–7
Mercalli VII–VIII**e** Richter 7–8
Mercalli IX–X**Fig 7.3.9**

Earthquake damage levels **a** Very feeble—noticed only by sensitive people **b** Moderate—felt by people who are moving about **c** Strong—slight damage to buildings **d** Destructive—chimneys fall **e** Disastrous—many buildings are destroyed

Damage caused	Richter	Mercalli	Average number per year
Felt by seismographs only	1–2	I	More than 500 000
Felt by very few people	2–3	I–II	100 000 to 500 000
Felt by people in tall buildings; hanging objects swing, some damage	3–4	II–III	10 000 to 100 000
Felt and heard by most; parked cars rock, crockery rattles, walls crack	4–5	IV–V	1000 to 10 000
Felt by all; some panic, furniture moves, difficult to walk	5–6	VI	200 to 1000
Some panic, difficult to stand; chimneys and some buildings collapse; cracks in the ground	6–7	VII–VIII	20 to 200
General panic; deep cracks in the ground, most buildings collapse, rail lines twist, dams break	7–8	IX–X	10 to 20
Total destruction; few buildings survive, valleys fill with mud from landslides and flood	8–9	XI–XII	0 to 10

Related earthquake disasters

Aftershocks

Large earthquakes have the power to move large slabs of crust and rock around. These slabs take some time to settle down. This can cause smaller earthquakes called aftershocks. Although these are usually smaller than the first earthquake, they can be extremely dangerous. This is particularly true if buildings were made unstable by the first earthquake.

Fire

Gas pipes can easily be broken in an earthquake. One spark or flame can turn the wreckage of a large earthquake into a furnace. In 1906, San Francisco in the United States of America was hit by an earthquake estimated at 8.3 on the Richter scale. Sixty per cent of the damaged city (520 city blocks!) was then burnt to the ground in the days that followed.

Tsunami

An earthquake with its epicentre under the ocean floor can cause a wave to be formed. Although it may start at only 2 m high, it travels at great speeds and increases dramatically in height as it enters shallow water. This wave is called a tsunami (pronounced *soon-army*). Tsunamis can travel at 800 km/h and reach heights of 35 m when they hit land and crash onto the shore. They sweep everything out of their path. People in low-lying areas receive little warning because the first waves caused by the earthquake are the same as normal surf. The first real warning is when water rapidly gets sucked out to sea, with the main wave crashing in soon after. The sea can then die down. Survivors often move in to help search for victims and can be swept away by another large wave that follows up to an hour later.

In 2007, an underwater earthquake of 7.8 on the Richter scale caused a tsunami in the western Solomons. It killed about sixty people and destroyed many coastal villages and buildings in G120, Vellala Vella and Choiseul Islands. On an even larger scale, a tsunami hit countries in the Indian Ocean on Boxing Day in 2004, killing more than 200 000 people. The worst-affected countries were Indonesia, India, Sri Lanka and Thailand. In 2011, a tsunami hit Japan, killing more than 15 000 people.



Fig 7.3.10 Damage in Banda Aceh, Indonesia after the 2004 Boxing Day tsunami

7.3
TIME

[Questions]

Checkpoint

Focus and epicentre

- 1 Explain why friction exists at plate boundaries.
- 2 Use friction to explain what causes an earthquake.

Seismic waves

- 3 Identify the main types of seismic waves.

Body waves

- 4 Identify examples of:
 - a a longitudinal wave
 - b a transverse wave

Earthquake shadows

- 5 Define the term 'refraction'.
- 6 Describe what causes refraction of P and S waves.
- 7 Outline the evidence that suggests that the Earth's core is liquid.

Surface waves

- 8 Contrast L waves and R waves.

Measuring earthquakes

- 9 List two reasons why most earthquakes are not felt.
- 10 At what value on the Richter scale would you call an earthquake 'serious'? Explain why you chose this number.

Related earthquake disasters

- 11 Describe what aftershocks are and what causes them.
- 12 Aftershocks are often more dangerous than the first earthquake. Explain why this is the case.
- 13 Explain what causes a tsunami to form.

- 14 There are almost no videos or photographs anywhere of tsunamis. Suggest an explanation for this.

Think

- 15 Australia has few earthquakes, while Solomon Islands, Papua New Guinea and New Zealand have many. Use the theory of plate tectonics to explain why.
- 16 Distinguish between:
 - a body and surface waves
 - b a longitudinal and a transverse wave.
- 17 Determine which of the seismic waves P, S, R or L:
 - a are the most dangerous
 - b are up-down waves
 - c are compression waves
 - d pass through the Earth.
- 18 Copy the following and change any incorrect statements so they become true.
 - a Aftershocks are huge waves caused by earthquakes.
 - b An earthquake of strength 5 on the Richter scale is double the strength of a 4.
 - c Earthquakes are caused by plates slipping.
 - d The focus of an earthquake is the exact point where an earthquake starts.
 - e Tsunamis are huge when in deep water.
- 19 A tremor is an earthquake that can be felt but does little damage. State what its value would probably be on both the Richter and Mercalli scales.
- 20 Superquakes are earthquakes that are more than 8 on the Richter scale.
 - a Evaluate the damage that can be expected when superquakes hit.
 - b State how often they occur per year.

[Extension]

Investigate

Research what you should do if an earthquake hits. Present your findings in an illustrated poster.

UNIT 7.4

Volcanoes

Introduction

What could cause a noise so loud that it could be heard clearly 5000 km away and causes pain to people who were 50 km from it?

What could completely destroy an island and produce waves 40 km high that would travel inland for 16 km and kill 36 000 people? The cause of this disaster was the eruption of a small volcanic island called Krakatoa, located west of Java. It erupted in 1883 and caused the largest explosion ever experienced in recorded human history.



Fig 7.4.1

In the 130 years since Krakatoa destroyed itself, pressure from below has steadily built a new island of Krakatoa. The new island (pictured here) has small, regular eruptions.

Volcanic clouds

Aim

To investigate the formation of volcanic clouds

Equipment

Large beaker, pneumatic trough or transparent jar, 100 mL flask, rubber stopper with hole, food dye or pop-drink sachet

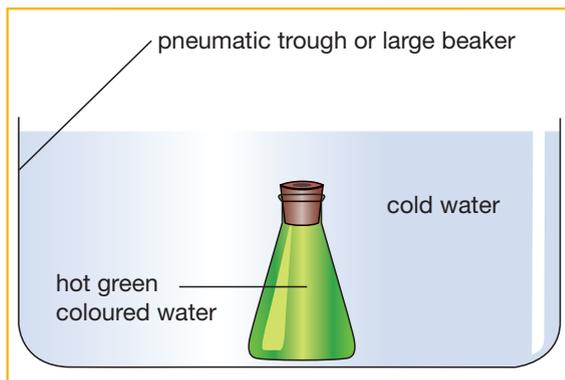


Fig 7.4.2 Modelling hot volcanic ash rising

Method

- 1 Three-quarter fill the large beaker or container with cold water.
- 2 Put 2–3 drops of food dye or pop-drink powder in the 100 mL flask.
- 3 Fill the flask to the very top with hot water (the hotter the better, but take care).
- 4 Seal the flask with the stopper.

- 5 Place your finger over the hole and lower the flask carefully into the container of cold water until it is completely submerged.
- 6 Carefully remove your finger and observe the motion of the hot coloured water.

Questions

- 1 Construct a diagram of what you saw.
- 2 State whether hot water rises or falls when it mixes with cold water.
- 3 Identify what the coloured and clear waters represent in this model of a volcano.
- 4 Predict what you think would happen when hot ash from a volcano mixes with cold air.
- 5 Propose a likely reason for this.

Volcanoes everywhere

There are about 1500 potentially active volcanoes around the world, with some erupting each day. Eruptions are often not noticed, however, as many of these active volcanoes lie under water. The eruptions produce about three-quarters of the total lava erupting from volcanoes each year.

All volcanoes can be classified as either active, dormant or dead (extinct). Active volcanoes erupt regularly. Dormant volcanoes are sleeping; that is, volcanic activity is present but it has been more than 5000 years since there was an eruption.



Dead volcanoes are those that cannot erupt. They are often classified as extinct and have not erupted in the last 25 000 years. Some volcanoes in Solomon Islands are situated along the boundary of the Indian–Australian Plate and the Pacific Plate. This collision plate boundary runs from the Western Province, through the Central Province and right up to the Tremont Province in the Eastern Province. The volcanoes are Tinakula in the Tremont Province, Seuss in the Central Province and Simbo and Kavachi (underwater volcano) in the Western Province. Tinakula, Simbo and Kavachi can be described as active volcanoes, while Seuss is dormant.

Formation of volcanoes

Most volcanoes occur at the edges of the tectonic plates. Pressure from gases in the mantle squeezes the molten rock upwards. The surface of the Earth can swell like a big pimple until it cannot take any more pressure. It then explodes with lava, ash and steam bursting through the surface.

Eruptions may come from a single vent, or from a group of vents. Some take place from long cracks called fissures.



Fig 7.4.3 The ash cloud from the 1980 eruption of Mt St Helens, USA. The Mt St Helens blast ripped the trees from all the surrounding hills and devastated more than 400 square kilometres.



Fig 7.4.4 Hot lava and ash spurts from this erupting volcano. You can use the table to determine the temperature of the lava.

Colour of lava	Temperature
White	Above 1150°C
Yellow	1000–1150°C
Orange	900–1000°C
Red	500–900°C
Black	Less than 500°C

Volcanic material

Magma is molten rock that forms in a magma chamber deep under the surface. It is lighter than the surrounding rock because it is full of gas. The pressure pushes it up until it bursts out from a vent.

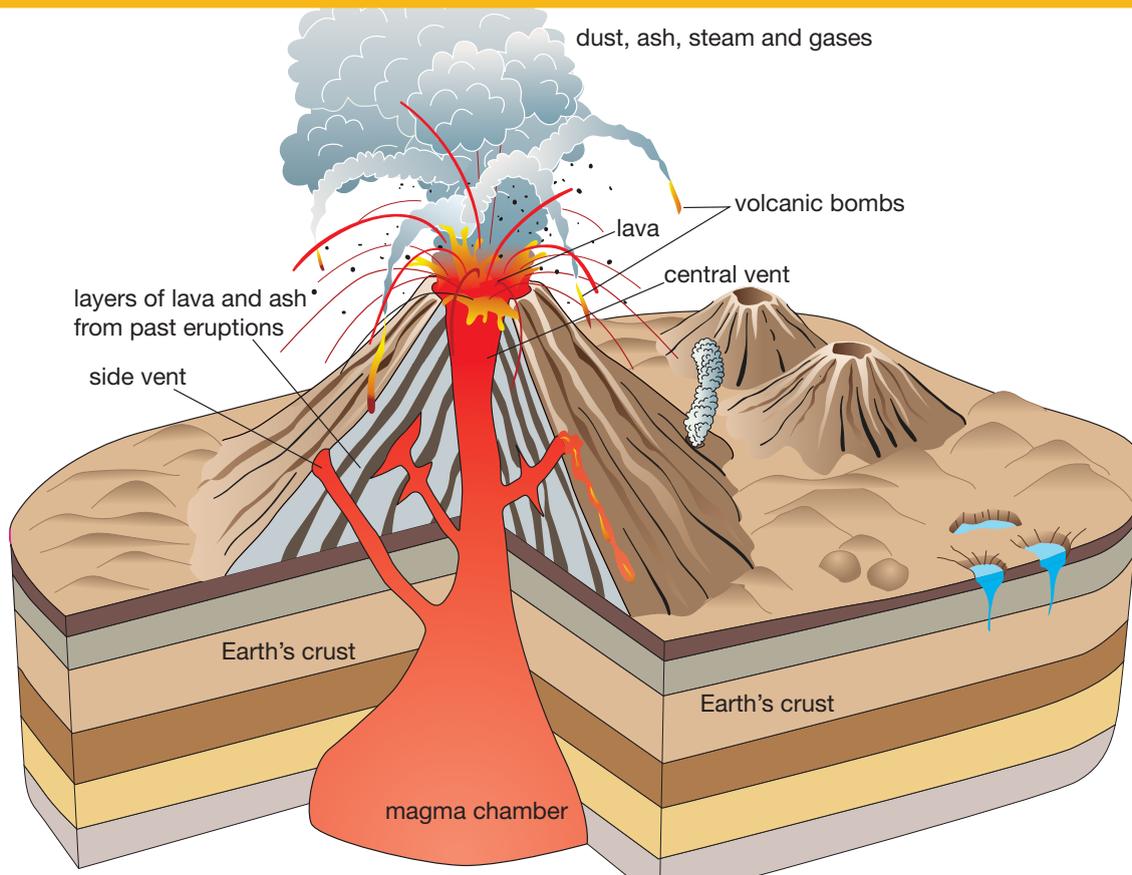


Fig 7.4.5 Cross-section of an erupting volcano



Fig 7.4.6 Lava flowing from a volcano

What emerges is called lava. This is made up of magma and gases such as hydrogen sulfide (rotten egg gas) and steam. Lava flows down the volcano at speeds of less than 10 km/h and will later cool to form solid rock.

Hot volcanic ash, steam and gases form a fast-moving (often 200 km/h) cloud that can reach incredible heights. In 1982, a British Airways Boeing 747 that was on its way to Australia from Malaysia flew through an ash cloud from the eruption of Mt Galunggung in Java, Indonesia. The dust jammed all four engines and the aircraft dropped without any power for many minutes before they could be re-started. The volcano ash is not visible to radar so pilots have little warning. The ash from the 1994 eruption of Mt Tavurvur in Papua New Guinea crushed the nearby town of Rabaul. More recently, the eruption of a volcano in Iceland in 2010 sent thousands of tonnes of ash into the skies across northern Europe, disrupting air travel for over two weeks. In 79 AD the people of Pompeii, Italy, suffocated in the ash from Mt Vesuvius and were then buried by it! Ash from Mt St Helens landed up to 500 km away.

Rain often then turns the ash into a lahar, which is a river of mud that can destroy anything downstream from it.

Volcanic ash can also travel the planet in the jet-stream winds that exist 30 km up. Here the ash blocks the Sun, making the planet cooler and producing spectacular sunsets. Ash from the 1991 eruption of Mt Pinatubo in the Philippines is thought to have blocked 4 per cent of the sunlight reaching Earth that year, and the dust from Krakatoa changed the colour of the sky in England, 10 000 km away!

Gas explosions can destroy parts of the volcano itself, with large pieces blown out as solid rock, called volcanic bombs. Volcanic bombs also form when hot lava is thrown into the air, landing great distances from the crater. The rock can also block the vent until the gases build enough pressure to clear it once more with another large explosion.

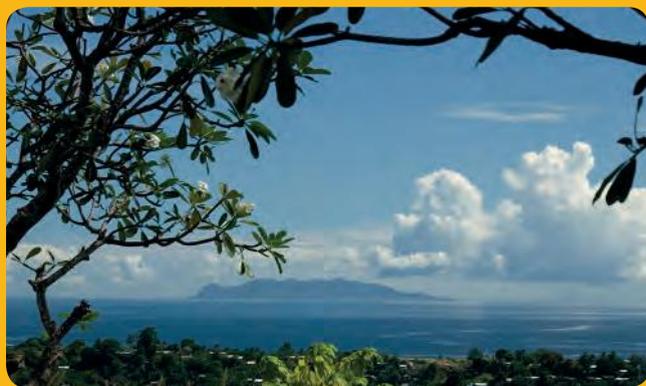


Fig 7.4.7 Gases produced by an active volcano

UNIT 7.4

[Questions]

Checkpoint

Volcanoes everywhere

- 1 State what Krakatoa was famous for.
- 2 Explain why erupting volcanoes are sometimes not able to be seen.
- 3 State the location of a volcano on Solomon Islands that is probably dormant (sleeping).

Formation of volcanoes

- 4 Distinguish between a fissure and a vent.
- 5 Explain why volcanoes are more likely to be found at the edges of tectonic plates than in the middle of them.

Volcanic material

- 6 Identify five different volcanic materials.
- 7 **a** Explain why volcanic ash clouds rise.
b Identify three different situations in which volcanic ash can be dangerous.
- 8 Define the following terms:
a lava **b** the magma chamber **c** lahar.

- 9 Explain what a volcanic bomb is and name one way it can form.

Think

- 10 Copy the following and change any incorrect statements so they become true.
 - a** Lava is not the same as magma.
 - b** A dormant volcano is a live volcano.
 - c** Volcanic ash moves more slowly than lava.
 - d** White lava is hotter than red lava.
 - e** Ash clouds do not travel far.
- 11 Identify what causes the smell that is always around volcanoes and hot springs.
- 12 The edge around the Pacific is often called the 'Ring of Fire'. Suggest a reason for this.
- 13 Explain why volcanic areas are also areas of great earthquake activity.
- 14 The sound of the Krakatoa explosion took four hours to travel 5000 km across the Indian Ocean. From this information calculate the speed of sound.
(Remember: speed = distance/time)

UNIT 7.5

Faults and folds

Introduction The Earth's crust is built up in layers. The oldest rock is the deepest, and the youngest rock and sediment from erosion are on the very top. These layers were originally flat and horizontal. The movement of the plates then results in faults (cracks) and folds. Weathering and erosion further shape the landscape to form the land we live on today.

Activity 8

Faults and folds

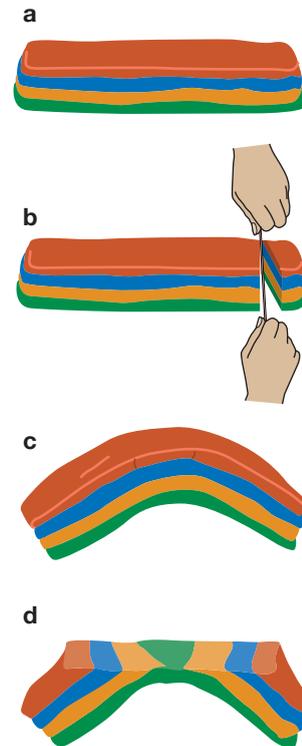


Fig 7.5.1 Making faults, folds and erosion

Geological feature	What to build	Before erosion	After erosion	Aerial view after erosion
Syncline (downward fold)				
Anticline (upwards fold)				
Overfold				
Normal fault				
Transcurrent fault				
Horst and graben				

Aim

To model faults and folds in the land

Equipment

Plasticine in four colours, a rolling pin, fine wire or a hacksaw blade

Method

- 1 Roll the plasticine flat into 1 cm layers.
- 2 Make a layered 'cake' with the plasticine.
- 3 Copy the table on the left into your workbook.
- 4 Model each feature shown in the table. To make faults, cut the cake in the direction of the arrows with the hacksaw, or hold the wire tightly with two hands and cut down through it.

>>

- 5 Use the hacksaw blade or wire to cut in the direction shown by the arrows in each diagram in Figure 7.5.1. This is our 'erosion'.
- 6 For each feature, draw a cross-section or side view after 'erosion'. Colour the layers appropriately.
- 7 Look down on the feature as if you are travelling over it in an aircraft. Draw what you see.

Question

Identify which geological feature created the layers when seen from the air as shown in Figure 7.5.2.



Fig 7.5.2

Faulty landscaping!

Faults are fractures, or cracks, in the Earth's crust. They are caused by the extreme forces from the slow movement of rock in the asthenosphere.

Faults can be:

- normal
- reverse
- transcurrent.

Normal and reverse faults

These faults are roughly vertical and are formed by forces pulling the crust apart (normal fault) or by compressing the crust (reverse fault). Movement along them is roughly up-down, creating a fault scarp, or a line of natural cliffs. If the rock is hard and weathering is slow, a cliff will form. If the rock is soft, erosion will wear it down to a gentle rise.

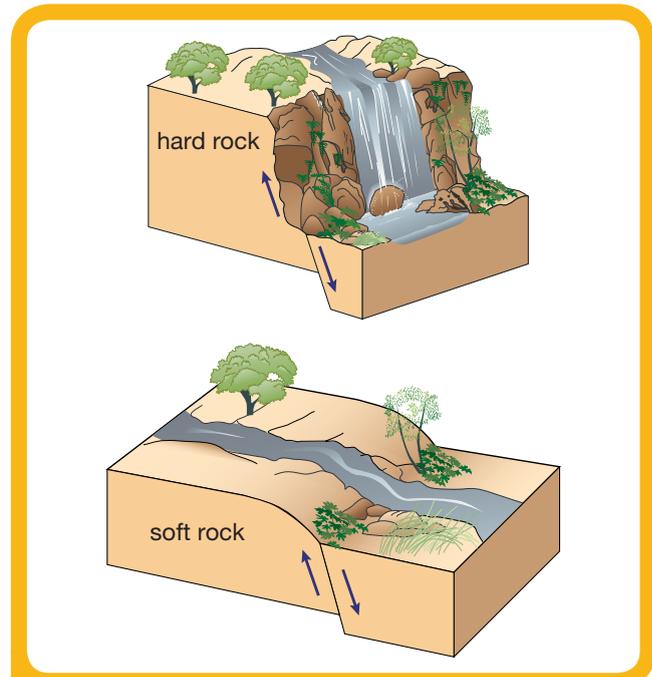


Fig 7.5.4

Normal faults can erode into different landscapes depending on how hard the rock is.

Sometimes two faults allow a block of rock to thrust up to form a horst or sink down to form graben or rift valleys. Erosion sometimes moulds them into parallel mountain ranges, as seen in Figure 7.5.5.

Transcurrent faults

Transcurrent faults are horizontal, and movement along them is in a sideways direction. No mountains are formed but the movement shatters rock along the fault. Smaller rock is easier to weather than larger rock, so heavy erosion creates troughs that often fill with water to form lakes and inlets, or low narrow openings.

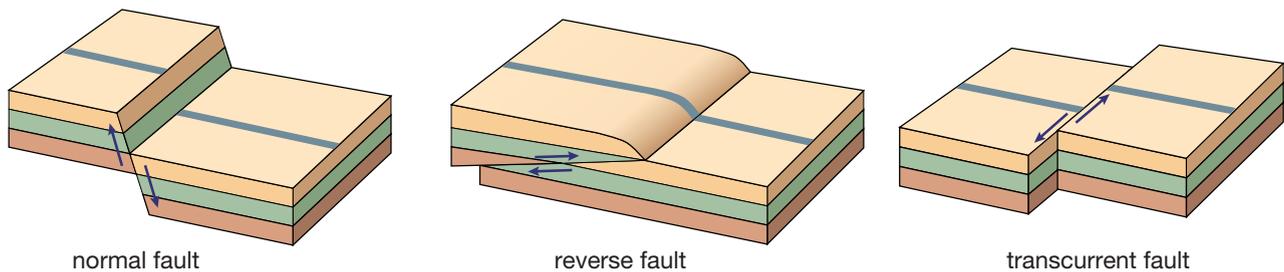


Fig 7.5.3

Faults are fractures, or cracks, along lines of weakness in the Earth's crust. The arrows show the direction of likely movement.

Folding

When continental plates collide, the rock of the Earth's crust is subjected to extreme pressure both horizontally and vertically. Under these conditions rock acts like plasticine and begins to bend (curve) and fold without breaking (scientists call this 'plastic behaviour'). The rock can fold to build mountain ranges or hills. The folded rock can form an arch (called an anticline) or a trough (a syncline), or may even fold over another fold (an overfold), as shown in Figure 7.5.7.

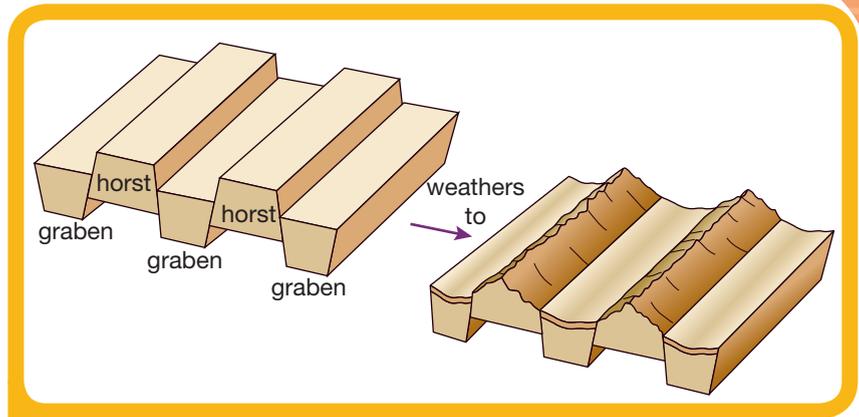


Fig 7.5.5 Horsts and graben are blocks of rock with faults on two sides.



Fig 7.5.6 A transcurrent fault nearly splits Scotland in two. It is partly filled with water and includes the very deep and mysterious lake, Loch Ness.

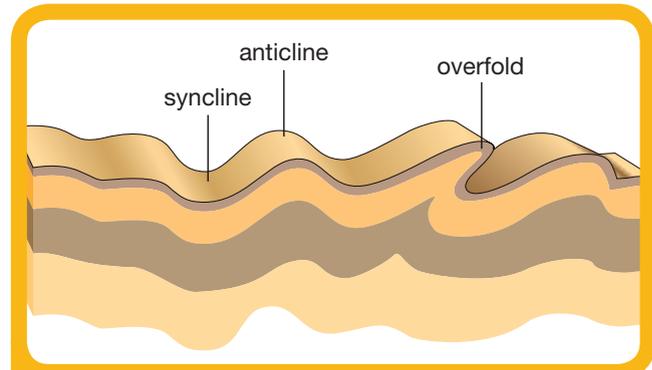


Fig 7.5.8 Synclines, anticlines and overfolds can occur when rock buckles under intense pressure and high temperature.

Erosion can wear away exposed soft rock or can level the folded layers. When new sediments are laid down on top of these old and eroded folds, layers of folds are formed that do not match each other. This creates an unconformity, as shown in Figure 7.5.9.

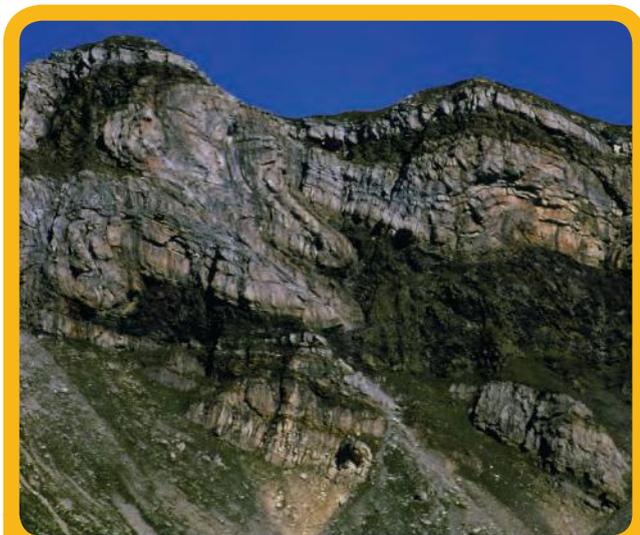


Fig 7.5.7 The rocks of the European alps have undergone intense folding due to the collision of continental plates.

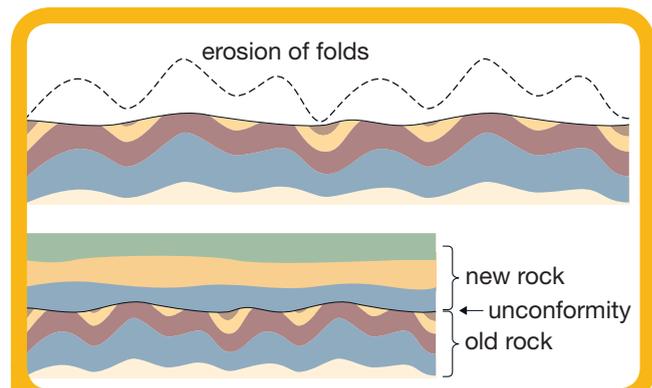


Fig 7.5.9 Erosion exposes layers of folded rock and allows new layers to be laid on top.

7.5

[Questions]

UNIT

Checkpoint

Faulty landscaping!

- 1 Identify the three basic types of faults.
- 2 Fault scarps are often very rounded, not sharp like cliffs. Explain why.

Folding

- 3 State the properties of something that shows plastic behaviour.
- 4 Describe what conditions are needed to make rock act in a plastic way.

Think

- 5 Use diagrams to distinguish between:
 - a a normal and a transcurrent fault
 - b a fault and a fold
 - c a syncline and an anticline.

Analyse

- 6 Identify and label the faults, anticlines, synclines and unconformities in the landforms in Figure 7.5.10.

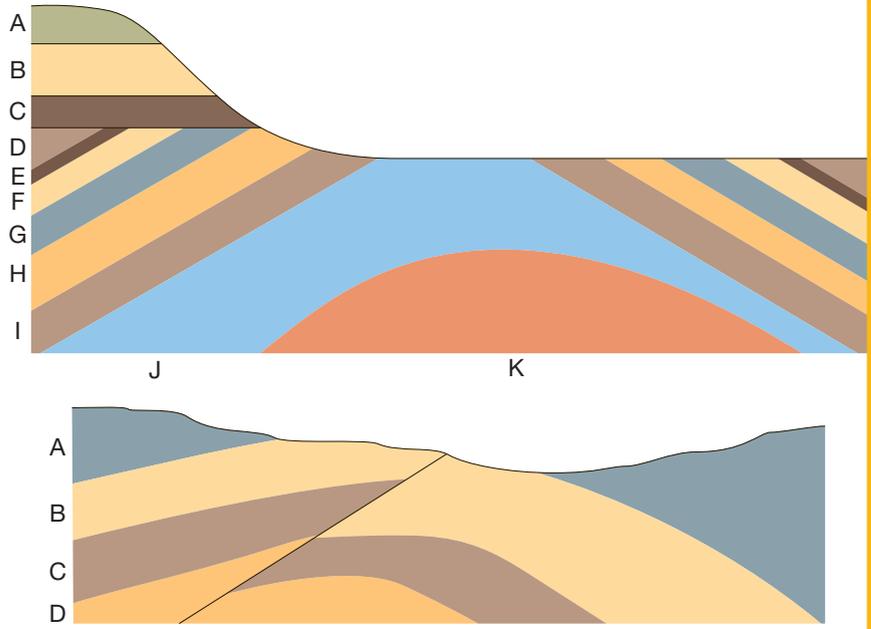


Fig 7.5.10

UNIT 7.6

Geological time

Introduction

How old is the Earth? How has it changed over time? For centuries, people have tried to answer these questions. Biblical records suggested that the Earth was created in about 4000 BC. Growth rings in trees may be used to trace back further than this, but, more recently, other methods have been used to estimate the ages of rocks in the Earth's crust.

Activity 9

Dinosaur fossils

Aim

To make a fossil of a dinosaur

Equipment

Clay or plasticine (to make a mould), a pin, a probe or blunt pencil, tracing paper or photocopy of the skeleton below, rolling pin or piece of dowel, cardboard or shoe-box lid, plaster mix, water

Method

- 1 Trace the skeleton shown in Figure 7.6.1 (your teacher may provide a photocopy).
- 2 Roll out a layer of plasticine about half a centimetre thick, large enough for a copy of the skeleton.
- 3 Transfer a copy of the skeleton to the plasticine by pushing a pin through the copy at key points to mark the shape and use a probe or blunt pencil to form an impression of the skeleton.
- 4 Place the plasticine in a shallow cardboard tray or shoe-box lid that is at least 3 cm deep.
- 5 Mix up a thick plaster paste, fill the impression in the plasticine with it and allow it to dry overnight.
- 6 Carefully remove the cast of the 'fossil'.

Questions

- 1 If this was a real fossil, suggest what you would use instead of the plasticine/plaster mix.
- 2 You have actually made two types of artificial fossil. Describe each one.

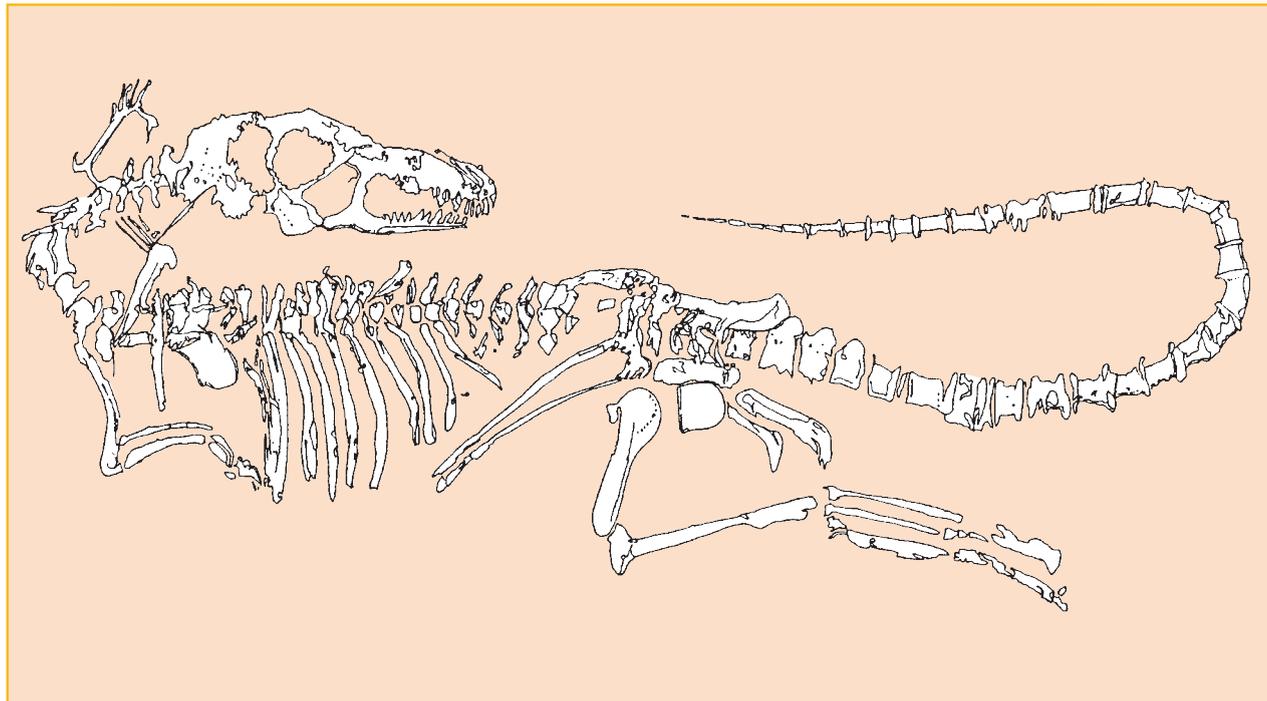


Fig 7.6.1 Sketch of a dinosaur fossil

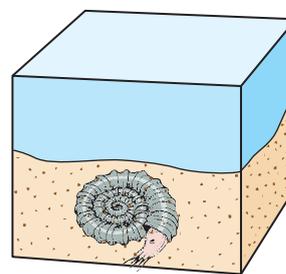
Fossils

Palaeontologists study fossils to add to our knowledge of Earth's history. A fossil is evidence of past life found in a rock or other material. This evidence may be the remains of a plant or an animal, or a mark such as a footprint. In rare cases, a complete animal may be preserved—for example, an insect trapped in amber (a hard yellowish-brown substance used to make jewellery), or a woolly mammoth preserved in frozen Siberian soil. Fossils can be created when the remains of an animal or plant are covered by sediments (dust, sand or mud) and become part of the sedimentary rock that is formed. Most remains are crushed or decay too quickly for them to be preserved. Sometimes, however, they are preserved as shells or skeletons, as moulds, or as quartz or limestone. They may also exist in opal (a white stone with changing colours in it). The general steps in the formation of fossils are shown in Figure 7.6.3.

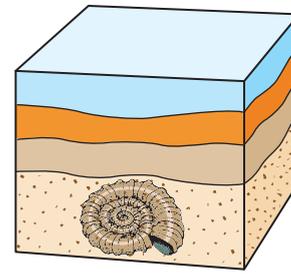


Fig 7.6.2 The bones of a dinosaur (*Ichthyosaurus*) have been replaced by minerals to form this fossil.

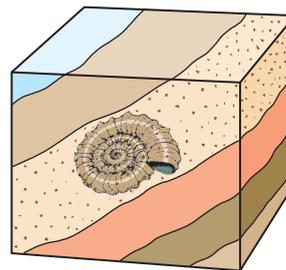
Generally, the lower the layer, the older the fossils. Fossils that lived over a comparatively short period of time and were widespread are called index fossils, and can help determine the age of a layer of rock. For example, the presence of different species of ammonite can be used to date various layers of rock around the world to within a million years or so. The presence of more primitive ammonites indicates that a region is older than one containing more evolved ammonites.



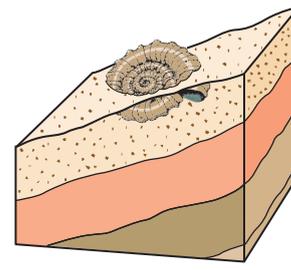
a An ammonite dies and falls to the bottom of the sea where it is covered by sediments and protected from being eaten by other animals. The soft parts of its body decay, leaving just the shell.



b More and more sediment covers and squeezes the shell. The shell may remain or be replaced with minerals such as quartz or limestone that seep into it in solution before the original shell dissolves.



c After millions of years, movement in the Earth's crust may thrust the layer of sedimentary rock containing the fossil upwards to form part of a mountain range.



d Weathering and erosion may eventually wear away some of the rock to expose part of the fossil. Fossils are often found in road cuttings or quarries.

Fig 7.6.3 Fossil formation

Radioactive dating

Rocks contain radioactive substances that gradually change or decay into other substances over a long period of time. For example, uranium is a radioactive substance found in many rocks, and slowly changes into lead over time. By comparing the amount of uranium and lead in a rock, the age of the rock may be determined. This type of radioactive dating is used to determine the ages of fossils more than 100 million years old. Using this technique, tiny sand grains found in Western Australia have been estimated to be 4.25 billion years old.

Activity 10

'Radioactive' cubes

Aim

To model the radioactive decay of uranium

Equipment

50 or more small wooden cubes, with one face marked (eg with a dot), a cup, graph paper

Method

- 1 Make sure one face of each cube has a distinctive mark (eg a dot or a '6').
- 2 Imagine that each cube represents an atom of radioactive uranium. These atoms emit invisible particles as they change into lead. Shake the 'uranium' cubes in a cup and tip them carefully onto a desk.
- 3 Cubes that land with the distinctive face uppermost are said to have 'decayed' into lead. Remove these from the pile and put them to one side.
Count how many 'uranium' cubes are left (eg subtract the number of 'lead' cubes that were removed).
- 4 Collect the remaining 'uranium' cubes and repeat steps 2 and 3 until no 'uranium' cubes remain.

Questions

- 1 Plot a graph showing the number of 'uranium atoms' left after each toss. Draw a smooth curve like the one in Figure 7.6.6 through the middle of the group of plotted points. This is called a 'curve of best fit'.

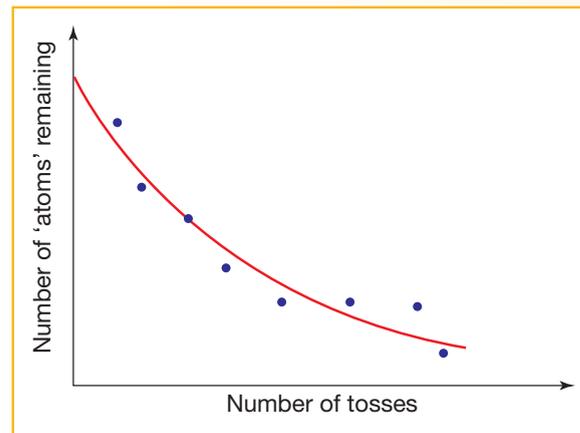


Fig 7.6.6 An example of a 'curve of best fit'

- 2 Use your curve of best fit to determine the number of tosses taken for the original number of 'uranium atoms' to halve. This is called the 'half-life'.
- 3 Compare the half-life for your experiment with that obtained by other groups.
- 4 Try to find out the actual half-life of radioactive uranium.



Fig 7.6.4 Ammonite fossils that formed about 100 millions years ago



Fig 7.6.5 A human fossil plaster cast—this unfortunate person died under a layer of volcanic ash after Mount Vesuvius erupted in 79 AD.

A radioactive form of carbon found in plants and animals may also be used to date fossils less than 70 000 years old.

The geological time scale

Scientists now believe the Earth to be about 4.5 billion years old. If the complete history of the Earth were condensed into a year, modern humans (*Homo sapiens*) would have appeared only in the

last five minutes of the year. It is no wonder there is still much to be learnt about the past! Despite this, rocks and fossil records have enabled scientists to piece together a history of the Earth in various stages, called eras. Each era is divided into periods.

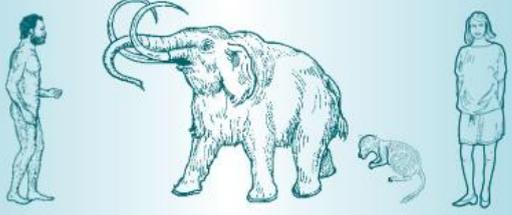
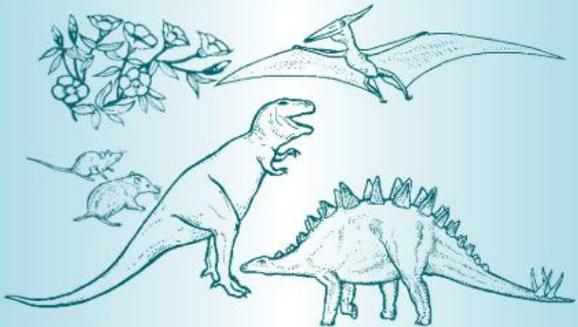
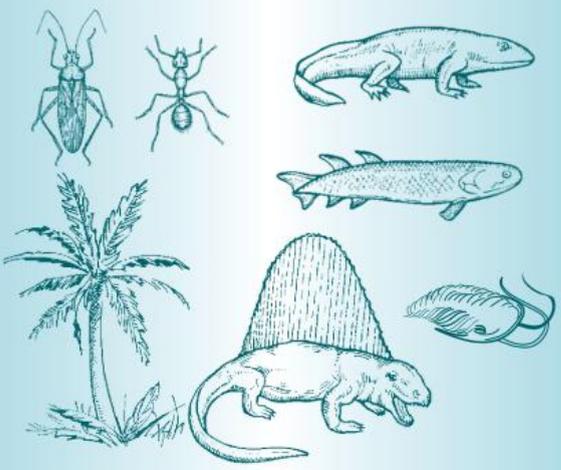
Era	Period	Millions of years ago (mya)	Life/comments	
Cenozoic (recent life)	Quaternary	0–2	Humans (<i>Homo sapiens</i>)	
	Tertiary	2–65	Mammals and birds become dominant after extinction of the dinosaurs.	
Mesozoic (middle life)	Cretaceous	65–144	Final period for dinosaurs. Small mammals, flowering plants. <i>Tyrannosaurus</i> lived around 65–68 mya.	
	Jurassic	144–208	Plant-eating dinosaurs abundant, flying reptiles, first birds. <i>Apatosaurus</i> (formerly <i>Brontosaurus</i>) lived about 150–156 mya.	
	Triassic	208–248	Dinosaurs. Tiny mammals.	
Palaeozoic (ancient life)	Permian	248–290	Modern insects. New mountains, deserts.	
	Carboniferous	290–362	Reptiles evolve from amphibians.	
	Devonian	362–408	Many types of fish, first land animals, amphibians, tree-sized land plants.	
	Silurian	408–438	Early simple land plants, first insects.	
	Ordovician	438–505	Fish, corals, molluscs.	
Cambrian	505–570	Worm-like creatures, first vertebrates—eel-like animals, animals with shells (eg trilobites).		
Proterozoic (earlier life)	Precambrian	570–2700	Single-celled animals, early sea plants, fungi.	
Archaean (primitive life)		2700–3500	First signs of life—algae and bacteria.	
Azoic (without life)		3500–4600	No life. Earth still cooling.	



Fig 7.6.7 This trilobite fossil is 5 cm long and between 250 and 400 million years old.



Fig 7.6.8 The horseshoe crab of today is thought to be a distant relative of the trilobite.

Many of the animals that evolved over the ages no longer exist—dinosaurs are perhaps the most famous example. There have been several times when mass extinctions have occurred in a relatively short space of time, allowing other species to emerge and dominate their environment. For example, about 250 million years ago, the trilobites died out and crustaceans became abundant—today there are over 30 000 species of crustaceans. One, the horseshoe crab, bears some resemblance to the trilobite.

- 4 a Identify which radioactive substance may be used to date plant and animal fossils.
- b Evaluate whether it could be used to date a 100 000-year old-fossil.

The geological time scale

- 5 Arrange the following eras in order, starting with the most recent: Palaeozoic, Archaeozoic, Cenozoic, Azoic.
- 6 List the periods that make up the Mesozoic era.
- 7 Propose two reasons why a species may become extinct.

Think

- 8 Explain what an index fossil is and how it is useful.
- 9 State how old scientists currently believe the Earth to be.
- 10 Copy and complete this table.

Period	Span (millions of years)
Quaternary	2
Tertiary	63

- 11 Identify the period in which:
 - a reptiles evolved
 - b *Tyrannosaurus* lived
 - c land plants appeared
 - d bacteria evolved from a 'chemical soup' in the oceans
 - e birds appeared
 - f fish appeared on Earth
 - g sea plants appeared
 - h flying reptiles first existed
 - i dinosaurs last lived.
- 12 Older fossils can sometimes be found in rock above newer fossils. Justify how this can be.
- 13 Rocks containing fossils of sea life can be found in areas far from the ocean. Explain how this can happen.

Analyse

- 14 Suggest what may have happened long ago to produce the tracks in Figure 7.6.9.



7.6 [Questions]

Checkpoint

Fossils

- 1 Define the term 'fossil'.
- 2 Copy the following statements into your workbook, changing any incorrect statements so they are true.
 - a A dinosaur footprint is not a fossil.
 - b Minerals may replace the shell or bone of an animal to make a fossil.
 - c Soft-bodied animals are less likely to form fossils than animals with shells or skeletons.
 - d Fossils are found only under oceans or other bodies of water.
 - e Generally speaking, lower layers of rock in a region contain older fossils.
 - f Fossils of complete animals do not exist.

Radioactive dating

- 3 Identify what uranium decays to over time.

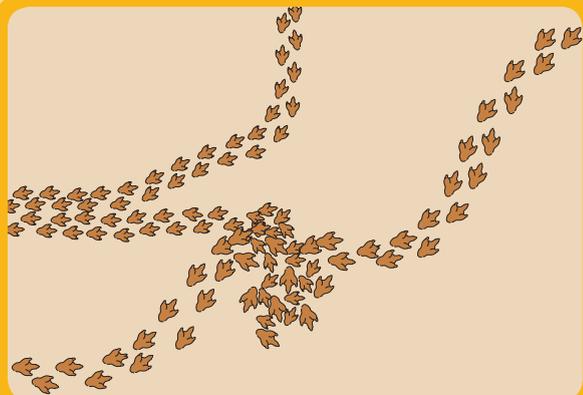


Fig 7.6.9

Chapter review

[Summary questions]

- 1 Explain why the Earth's plates are like toast on soup.
- 2 'Pangaea' is Greek for 'all the lands'. Justify why this is a good name for the original supercontinent and identify the names of its 'babies'.
- 3 Describe how magnetism in rocks suggests that:
 - a the continents were once joined
 - b the ocean floor is spreading.
- 4 Explain the theory of plate tectonics.
- 5 Describe how convection pushes tectonic plates around.
- 6 Explain why earthquakes occur mainly at plate boundaries.
- 7 State at what depth the subduction zone is completely molten and returns to the asthenosphere.
- 8 Identify the waves detected by a seismometer and in what order they will be detected.
- 9 Construct a drawing of a transverse wave.
- 10 Identify which seismic waves produce these motions at the Earth's surface:
 - a side-to-side
 - b up-and-down
 - c rolling.

- 11 Describe one way in which mountain ranges can form.
- 12 Distinguish between a fault and a fold.
- 13 True or false?
 - a The mantle is where most volcanic and earthquake activity occurs.
 - b The crust is thickest under the continents.
 - c Scientists who study earthquakes are called seismologists.
 - d A seismograph shows where an earthquake is.
 - e A tsunami is a wave caused when the epicentre is under the ocean.
 - f Magma rises because it is full of gas.
 - g A dead volcano will never erupt again.
- 14 a Identify which types of animals are more likely to form fossils.
b Explain why this is the case.
- 15 State what scientists measure to tell the approximate age of a rock.
- 16 Identify the eras in which the following periods occurred:
 - a Silurian
 - b Cambrian
 - c Tertiary
 - d Jurassic.
- 17 Identify a life form that existed in each of the following periods:
 - a Devonian
 - b Archaeozoic
 - c Quaternary.

[Thinking questions]

- 18 Determine why the mysteries of the ocean floor were not discovered until the late twentieth century.
- 19 A map of the world in the future will be different to the one we know now. Explain how.
- 20 Analyse how the upper mantle can be solid but still able to move.
- 21 The ocean floor has been likened to a conveyor belt. Explain why.
- 22 Analyse how density affects the movement of plates.
- 23 Explain how slipping plates cause earthquakes
- 24 Explain what magma is and why it gets squeezed to the surface.

>>

[Interpreting questions]

- 25 Explain why the temperature near the ceiling of a room is always hotter than that at floor level.
- 26 Explain why magma rises.
- 27 Explain why volcanic ash rises in the atmosphere.
- 28 Describe any volcanic material visible in the picture below.



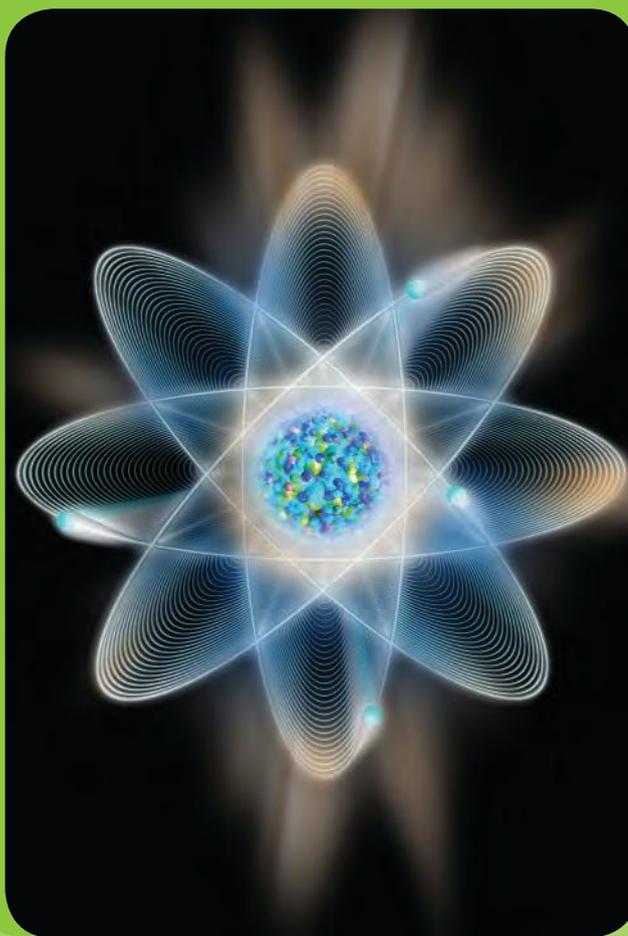
Fig 7.7.1

Small particles of matter

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

- give examples of elements (first twenty elements in the periodic table and the common elements such as silver, zinc, lead, mercury copper and iron)
- write the symbols of the first twenty elements and the common elements, such as silver, zinc, lead, mercury copper and iron
- identify common elements, such as aluminium foil, iron nail, gold medal, silver medal
- use common everyday materials to construct a model of an atom
- name scientists and their contributions to the understanding of atoms and elements.

- 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?



UNIT 8.1

Elements

Introduction

An element is a pure chemical substance consisting of one type of atom. All substances found on Earth, whether occurring naturally or created by humans, are made from about 118 elements. The different combinations of these elements give rise to the millions of compounds that have been found and produced. The periodic table is a table that shows the elements arranged in order. Elements can be metals, metalloids or non-metals.

The periodic table

The table below lists the first twenty elements of the periodic table and their symbols.

The first elements

No.	Element	Symbols
1	Hydrogen	H
2	Helium	He
3	Lithium	Li
4	Beryllium	Be
5	Boron	B
6	Carbon	C
7	Nitrogen	N
8	Oxygen	O
9	Fluorine	F
10	Neon	Ne
11	Sodium	Na
12	Magnesium	Mg
13	Aluminium	Al
14	Silicon	Si
15	Phosphorus	P
16	Sulfur	S
17	Chlorine	Cl
18	Argon	Ar
19	Potassium	K
20	Calcium	Ca



fluorine



sodium



aluminium



sulfur

Fig 8.1.1

Some of the first twenty elements as found in nature: fluorine, sodium, aluminium and sulfur



gold



silver



mercury



iron

Fig 8.1.2

Some of the elements: gold, silver, mercury and iron

Common elements often used by us

No.	Element	Symbols
1	Zinc	Zn
2	Gold	Au
3	Silver	Ag
4	Mercury	Hg
5	Iron	Fe
6	Lead	Pb
7	Tin	Sn

Activity 1

Solid, liquid or gas?

Copy the following table into your workbook. Complete the table by writing down in the last column whether each element is a solid, liquid or gas at room temperature. You will need to refer to the periodic table on page 208.

No	Element	Symbol	State at room temperature
1	Hydrogen	H	
2	Helium	He	
3	Lithium	Li	
4	Beryllium	Be	
5	Boron	B	
6	Carbon	C	
7	Nitrogen	N	
8	Oxygen	O	
9	Fluorine	F	
10	Neon	Ne	
11	Sodium	Na	
12	Magnesium	Mg	
13	Aluminium	Al	
14	Silicon	Si	
15	Phosphorus	P	
16	Sulfur	S	
17	Chlorine	Cl	
18	Argon	Ar	
19	Potassium	K	
20	Calcium	Ca	

8.1

UNIT

[Questions]

Checkpoint

- Describe what is an element?
- List the first twenty elements in order.
- Write the symbols of the following elements:
 - sodium
 - magnesium
 - copper
 - hydrogen
 - lithium.

Think

- Which of the following elements would you say is common?
 - silicon
 - hydrogen
 - sulfur
 - carbon
- We have only 118 elements on Earth. Why do we have so many substances and compounds?

[Extension]

- Explain why atoms are said to be just empty spaces.
 - Look at the material inside your pencil and write down the name of the element that it is made from.
- Research information about the use of the following elements:
 - helium
 - boron
 - nitrogen.

UNIT 8.2

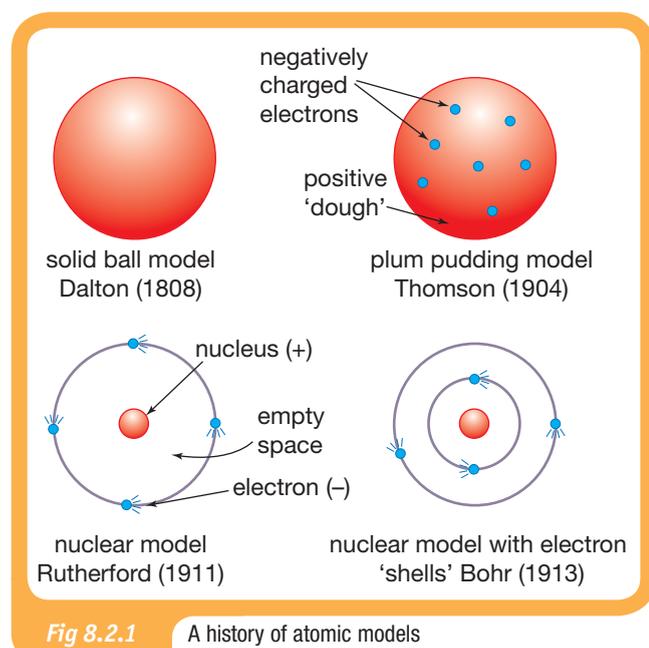
Inside atoms

Introduction

The original idea of a small particle called the atom came from the ancient Greeks, some 2000 years ago. Over the last two hundred years scientists have been discovering what is in these atoms and how they came into being. Their aim is still the same as that of the ancient Greeks—to find simple patterns that explain the complexity of nature.

Atomic history

There have been a number of theories about the structure of atoms. Here are some key dates.



- about 350 BC The ancient Greeks believe that atoms are solid balls of matter.
- 1800
- 1808 John Dalton (an English chemist) supports the idea of atoms as solid balls.
- 1890
- 1897 Sir Joseph John Thomson (Britain) discovers electrons. The electron is the first known particle that is smaller than an atom.
- 1900
- 1903 Thomson proposes the 'plum pudding' model of a positively charged 'dough' with negatively charged electrons embedded in it.
- 1908 New Zealand born physicist and student of Thomson, Ernest Rutherford, wins the Nobel Prize for Chemistry 'for investigations into the disintegration of the elements, and the chemistry of radioactive substances'.
- 1910
- 1911 Rutherford proposes a nuclear model in which negatively charged electrons orbit a positive nucleus, with most of the atom being empty space. This was discovered in his famous gold foil experiment.
- 1913 Rutherford discovers that hydrogen is the smallest atom. Niels Bohr, a Danish physicist and assistant to Rutherford, extends Rutherford's model to include electron shells—regions in which a given number of electrons may move.
- 1920
- 1914 Rutherford discovers the proton, although he did not name it until 1920.
- 1920 Rutherford proposes the existence of a 'neutron'.
- 1922 Bohr wins Nobel Prize for Physics 'for investigations of the structure of the atoms and their radiation'.
- 1930
- 1932 James Chadwick (Britain) discovers neutrons.

Atoms are mainly empty space!

Working with two other scientists, Hans Geiger and Ernest Marsden, Ernest Rutherford experimented with firing tiny positively charged particles (called alpha particles) at thin gold foil. Amazingly, many of the alpha particles went straight through the gold foil, some not even moving from their path! This suggested to Rutherford that most of an atom was empty space, allowing the alpha particles to go straight through. Some of the alpha particles were scattered, however, and Rutherford suggested that this was because they were repelled by a concentration of positive charges in the centre of an atom. In 1911, he presented his theory of the atom as consisting of a small, dense positively charged nucleus with negatively charged electrons orbiting the nucleus.

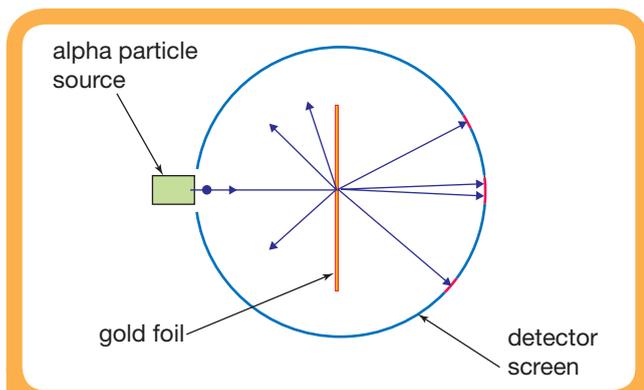


Fig 8.2.2 Rutherford's alpha particles and gold foil experiment



Fig 8.2.3 This scanning tunnelling micrograph shows carbon nanotubes. It is hoped that these could be used as conducting wires for heat or electricity. They are one-billionth the thickness of a human hair. Individual atoms can be seen as bumps on the surface of the tubes.

Atomic structure

The model of the atom used today is the Rutherford–Bohr model. This model has a central nucleus made up of positively charged particles, known as protons, and particles that are neutral (no charge), known as neutrons. This nucleus is orbited at high speed by much smaller negatively charged particles known as electrons. Protons and neutrons have about the same mass, while electrons have about 1/1800th the mass of protons and neutrons.

Though the protons (+) and electrons (–) have opposite charges, the size of the charge is the same for each. An atom has an equal number of protons and electrons, so the positive and negative charges balance each other to produce a neutral atom (one with no overall charge).

The simplest atom is the hydrogen atom, whose nucleus contains only a single proton, orbited by one electron.

Diagrams of the next three simplest atoms are shown in Figure 8.2.5.

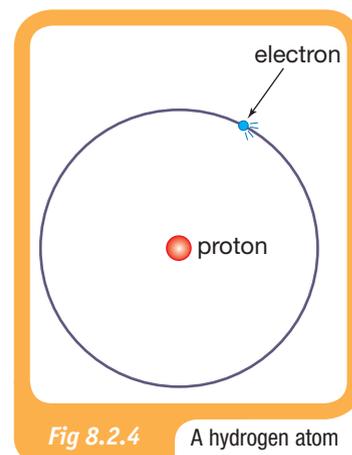


Fig 8.2.4 A hydrogen atom

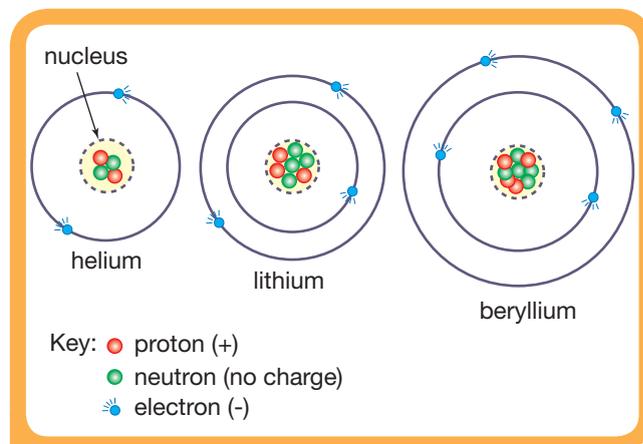


Fig 8.2.5 Helium, lithium and beryllium atoms

Electron shells

Bohr improved Rutherford's model of the atom by explaining how electrons orbit around the nucleus. He suggested that they orbit in special regions, or shells, around the nucleus. Only two electrons can fit in the innermost shell of any atom, then up to eight in each of the next two shells for elements up to atomic number 20. The shells closest to the nucleus are 'filled' first.

This may be compared to filling spaces on a bookshelf—you might fill the bottom shelf first, then only move up as each lower shelf is filled.

The sodium atom in Figure 8.2.6 has eleven electrons. Two of these electrons orbit in the inner shell and eight in the next shell, leaving one electron to orbit in the third shell.

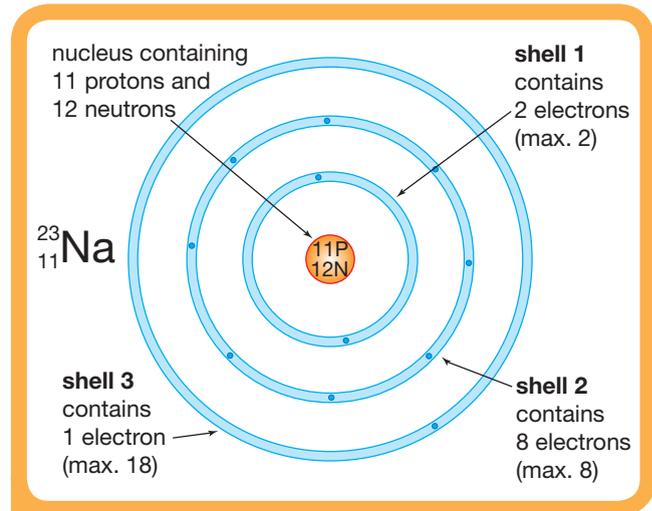


Fig 8.2.6

Three electron shells in a sodium atom—the inner two are filled to capacity

8.2

UNIT

[Questions]

Checkpoint

Atomic history

- Starting with the earliest atomic theory, list the following in date order: Rutherford, Dalton, Thomson, Bohr.
- Name two Nobel Prize winners involved in developing atomic theory.
- Explain what the dough represents in the 'plum pudding' model.
- Explain what the sultanas and raisins would represent in the 'plum pudding' model.
- Name the date of discovery of each of the following subatomic particles:
 - protons
 - neutrons
 - electrons.

Atoms are mainly empty space!

- Describe the evidence that led Rutherford to believe there was positive charge at the centre of the atom.

Atomic structure

- State which particles contribute most to the mass of an atom.
- State the charge on the following subatomic particles:
 - an electron
 - a neutron
 - a proton.

Think

- Atoms are described as being made up mainly of empty space. Evaluate how correct this statement is by outlining the structure of an atom.

[Extension]

Investigate

Construct a timeline of key events in the development of the atomic model.

Chapter review

[Summary questions]

- 1 Recall the symbols for the following elements:
 - a carbon
 - b aluminium
 - c gold
 - d tin.
- 2 Recall the names of the elements that have these symbols:
 - a N
 - b P
 - c K
 - d B.
- 3 Describe the charge and relative size of subatomic particles found in the atom.

- 4 State whether the following statements are true or false.
 - a The nucleus is the central region of an atom.
 - b Any number of electrons can orbit in the innermost shell of an atom.
 - c Only two protons may orbit in the innermost shell surrounding an atom.
 - d Electrons are incredibly small compared to neutrons and protons.

[Interpreting questions]

- 5 Copy the following diagram and identify the parts of the helium atom.

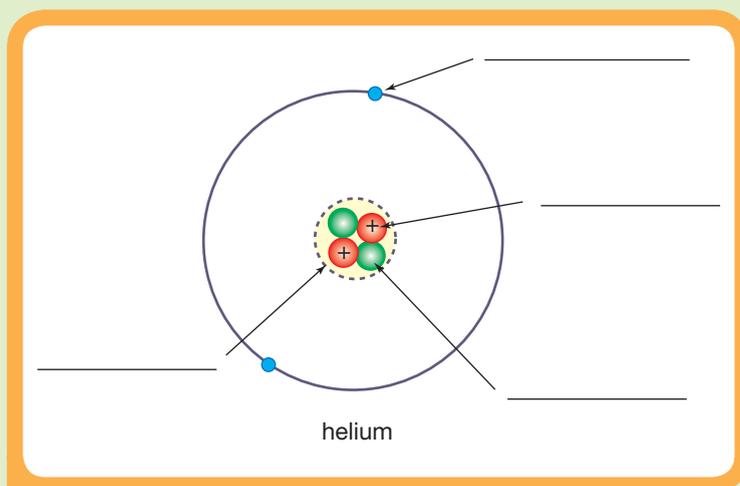


Fig 8.3.1

Microbes

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

- identify examples of the five types microbes: bacteria, fungi, protists, viruses and algae
- demonstrate the correct use of a microscope
- use a microscope to observe microbes in prepared slides and from water samples from a pond
- explain different methods of microbe reproduction
- identify two examples of harmful bacteria, viruses, protists and fungi, and state the diseases they cause
- identify two useful bacteria.

Specific learning outcomes

8.9.1.1, 8.9.2.1, 8.9.2.2, 8.9.2.3, 8.9.3.1, 8.9.4.1, 8.9.4.2,
8.9.4.3, 8.9.5.1, 8.9.6.1, 8.9.7.1



- 1 What is your idea of a 'germ'?
- 2 What has the fewer germs, your computer mouse or your toilet?
- 3 Bacteria are found in yogurt. Does that mean the yogurt is 'off'?
- 4 Mouldy bread provided the first antibiotic. True or false?
- 5 Why are you unlikely to catch chicken pox twice?
- 6 Why does food go bad and why do we get sick from it?

Challenges

UNIT 9.1

What is a microbe?

Introduction

When you think of 'germs' you probably only think of something invisible that can make you sick. Germs, however, are living things: they need food and somewhere to live, they reproduce and eventually they die. Scientists have developed ways of studying and classifying germs.

New and improved microscopes have led to many exciting discoveries about these invisible organisms, which can be both our friends and our enemies.

Activity 1

Fun with fomites

Aim

To observe microbes found on fomites (a fomite is a non-living object such as a pin that can carry disease-causing microbes)

Equipment

Sterile petri dishes containing nutrient agar, sticky tape, permanent markers, cotton buds, antibacterial soap

Method

- 1 Discuss and select a range of appropriate fomite samples. Use only everyday objects such as pens, door knobs, seats, desk tops and hand rails.
Warning: Do not take samples from a toilet, your mouth, other body parts or unhygienic places as this could lead to the growth of dangerous bacteria that can cause serious illness.
- 2 Expose the agar on the petri dishes to a variety of everyday objects. This may be done by leaving the lid off for a period of time, wiping a cotton bud on an object and then onto the agar, or pressing an object such as a leaf onto the agar.
- 3 Place the lid on the petri dish and seal with sticky tape immediately.
- 4 Write your name, the fomite tested and the date around the edge of the underside of the petri dish.
- 5 Leave samples overnight, upside down in a dry place.
- 6 Observe samples without opening the petri dishes.
Warning: Lids must not be removed.
- 7 Record results using a table and labelled diagrams.

Questions

- 1 Compare and contrast results for the range of non-living objects sampled.
- 2 Evaluate whether non-living objects are 'germ' free.

Microbes

The scientifically correct term for 'germs' is microorganisms, which is often shortened to microbes. Microbes are single-celled organisms that are usually too small to be seen with the naked eye. Figure 9.1.1 shows rod-shaped bacterial microbes sitting on the tip of a pin. A non-living object such as a pin that can carry disease-causing microbes is called a fomite.

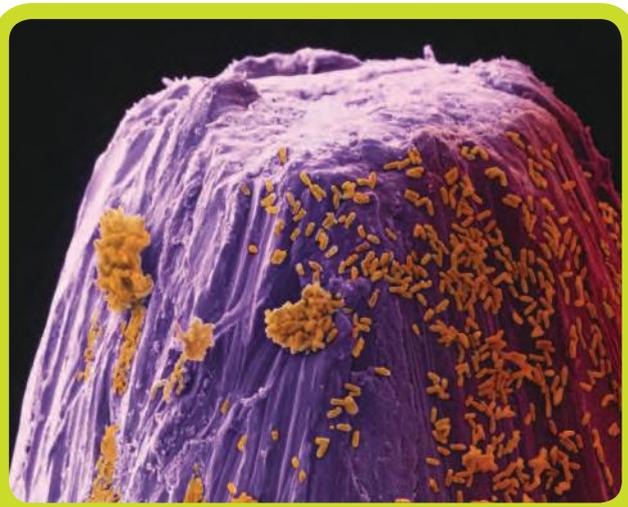


Fig 9.1.1

Coloured scanning electron micrograph of rod-shaped bacteria on the tip of a household pin

There is a large variety of microorganisms. In this unit you will learn about bacteria, fungi, protozoa and viruses.

Observing microbes

Scientists who study microorganisms are known as microbiologists. They carry out a wide range of tasks using specialised equipment and simple experimental techniques.

Microbes are very, very small. Normal units such as the metre and even the millimetre are far too big to measure them. Instead, other smaller units based on the metre are used. To understand these units, you need to know their conversions:

Metric units of length

Metric unit	Meaning of prefix	Metric equivalent
	k = kilo = 1000	1000 m
1 metre (m)	no prefix needed	Standard unit of length
1 centimetre (cm)	c = centi = 1/100	0.01 m
1 millimetre (mm)	m = milli = 1/1000	0.001 m
1 micrometre (µm)	µ = micro = 1/1 000 000	0.000 001 m
1 nanometre (nm)	n = nano = 1/1 000 000 000	0.000 000 001 m

The comparative sizes of a range of items are shown in the table below. Different types of microbes are shaded.

Relationship between sizes of various objects and microbes

Object	Size	Method of viewing
Puddy grass	1 metre (m)	Human eye
Red algae	10 centimetre (cm)	Human eye
Fungal hyphae	1 centimetre (cm)	Human eye
Fungal spore	1 millimetre (mm)	Human eye
Protozoa	100 micrometre (µm)	Light microscope
Bacteria	1 micrometre (µm)	Light microscope
Virus	100 nanometre (nm)	Electron microscope
Large molecules	1 nanometre (nm)	Electron microscope

Microbes range in size from a tiny 0.000 001 metre (1 micrometre) for a protozoa to an even tinier 0.000 000 1 metre (100 nanometres) for a virus. Although fungi are microbes too, many, such as mushrooms, are large enough to be seen easily with the naked eye.

Microscopes

There are many types of modern microscopes that can be used to view microbes. Figure 9.1.2 shows a typical light microscope that is capable of magnifying 40 times using low power or 400 times using high power.

Electron microscopes are used to view objects that are smaller than 0.2 millimetres, such as viruses or cell organelles. They magnify in the range of 10 000 to 100 000 times. The only problem

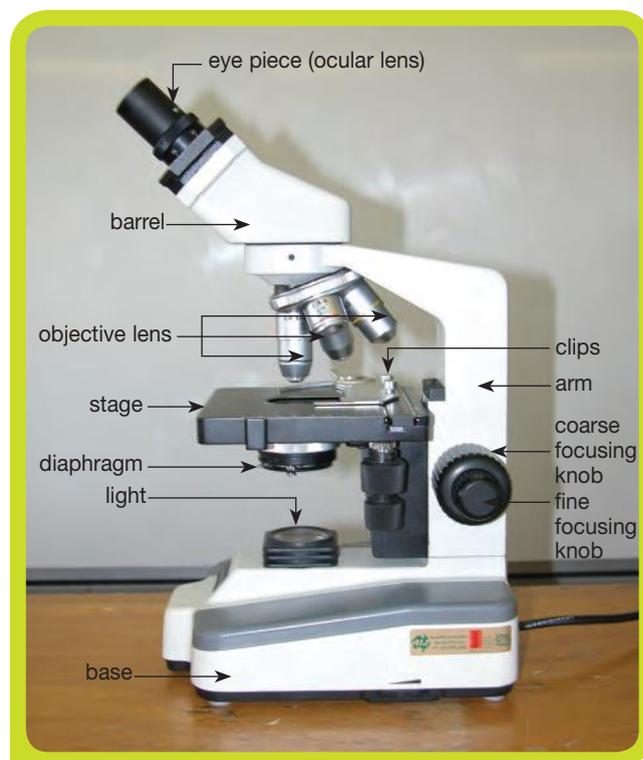


Fig 9.1.2 Parts of a light microscope

is that the images made are black and white, and live specimens cannot be viewed. Sometimes the images are coloured to highlight different parts.

Bacteria

A bacterium is a simple cell that is made up of a cell wall, cell membrane and cytoplasm. Bacteria do not have a nucleus like animal and plant cells. Some bacteria have tails, known as flagella (singular: flagellum), for movement.

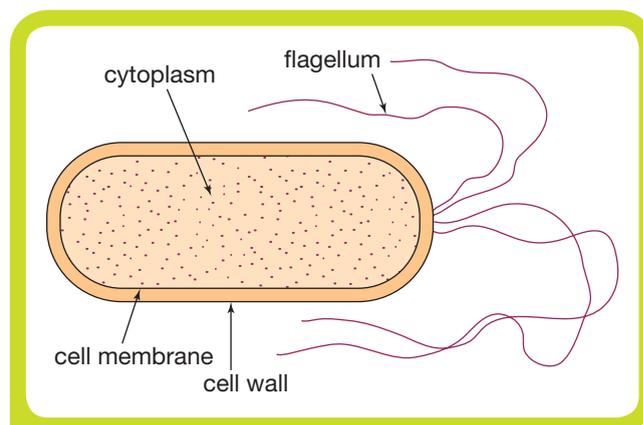


Fig 9.1.3 A typical bacterial cell



The human body is home to many bacteria. Bacteria live in your nose, on your skin, in your blood and intestines. Many of these bacteria do not cause you any harm and actually help you stay healthy. They help stop other harmful bacteria entering your body by taking up the available space. Other bacteria are less friendly. Those under your arms cause body odour and those in your mouth can cause bad breath.



Fig 9.1.4 Pimples are caused by bacteria entering the skin.

Bacteria come in many sizes and shapes. The three basic shapes are cocci (spherical), bacillus (rod-shaped) and spirilla (spiral).

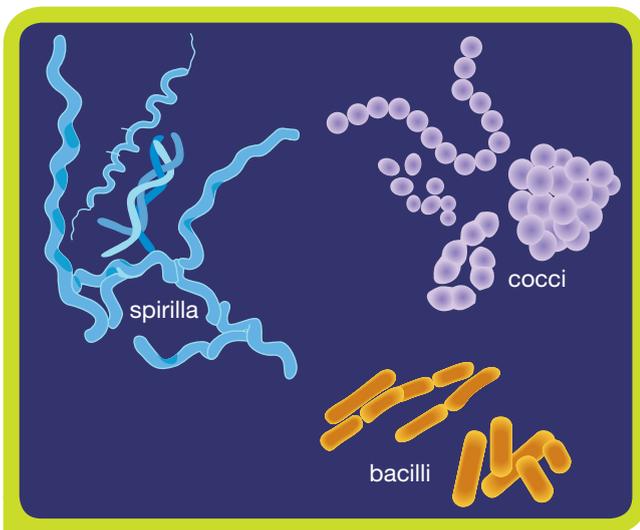


Fig 9.1.5 Common shapes of bacteria



Fig 9.1.6 This spiral bacterium (shown in blue) is normally found attached to the wall of a person's intestine (pink).



Fig 9.1.7 Clover showing the root nodules that contain nitrifying bacteria

Activity 2

Bacteria and fungi under the microscope

Aim

To observe bacteria and fungi using a microscope

Equipment

Mouldy bread, agar plates from the previous activity, stereo microscope, microscope lamp if needed, forceps

Method

- 1 Set up a microscope to focus on low power.
- 2 Use forceps to place a small piece of mould on a glass slide.
- 3 Observe the mould under the microscope and draw your observations. Record the magnification used on your diagram.
- 4 Observe the agar plates from Activity 1 under the microscope.

Warning: Lids must not be removed from agar plates.

Questions

- 1 Contrast bacterial and fungal specimens on the agar plates.
- 2 Compare your observations of bread mould and any fungus on the agar plates.

Activity 3

Observing fungi

Aim

To observe a variety of fungi

Equipment

Various types of fungi (mushrooms, food mould), yeast solution, microscope, microscope slides, hand lens

Method

- 1 View mushrooms and mould using a microscope and hand lens.
- 2 View yeast on a microscope slide using a microscope.
- 3 Draw diagrams of all specimens observed and label any features you can identify.

Questions

- 1 Contrast each of the different types of fungus observed.
- 2 Describe the structural features of mould.

Fungi

There is a huge variety of fungi that you come across in your daily life. Mushrooms and toadstools are probably the best known fungi and come in many colours, shapes and sizes. Some are edible while others are poisonous. Moulds grow on rotten food and damp surfaces such as bathroom walls. We use yeast to make foods and drinks such as bread, cereals, wine and beer.



Fig 9.1.8

Different types of fungi: **a** fungi on a rotting log; **b** toadstool; **c** mould on a lemon; **d** bread mould close up

Although fungi often look like plants, they are not. They feed on dead and decaying material, helping to return nutrients to the natural cycles of the environment.

Protists

Protists (sometimes called protozoa) are single-celled organisms that live in water and areas of high moisture. If you look at a drop of pond water under the microscope you are likely to see some amazing protists. Some protists, such as *Euglena*, are plant-like because they contain chlorophyll and make their own food. *Euglena* move rapidly using their whip-like tails or flagella.

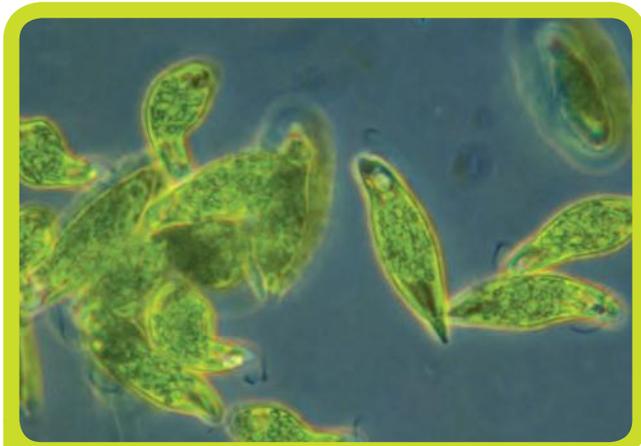


Fig 9.1.9 *Euglena* are plant protists. These are magnified $\times 90$ under a light microscope. Note the green chloroplasts in their cells and the flagella they use for movement.

Amoeba and *Paramecium* are examples of single-celled animals. They catch their food from the water around them. *Paramecium* have tiny hair-like tails on their outside that beat back and forth, allowing them to move. Amoeba have no definite shape. An amoeba extends a part of its cell body outward in the direction in which it wants to move. The cell contents flow into this part of the cell. The part of the cell that extends outwards is called a false foot or pseudopod.

Giardia and cryptosporidium are two protists that can cause diarrhoea, vomiting and severe illness. They are commonly tested for in drinking water. The results are recorded as the number of microorganisms found in each 100 litres of water. Chlorine kills these protists and chlorine levels are increased in drinking water if these microbes are discovered.

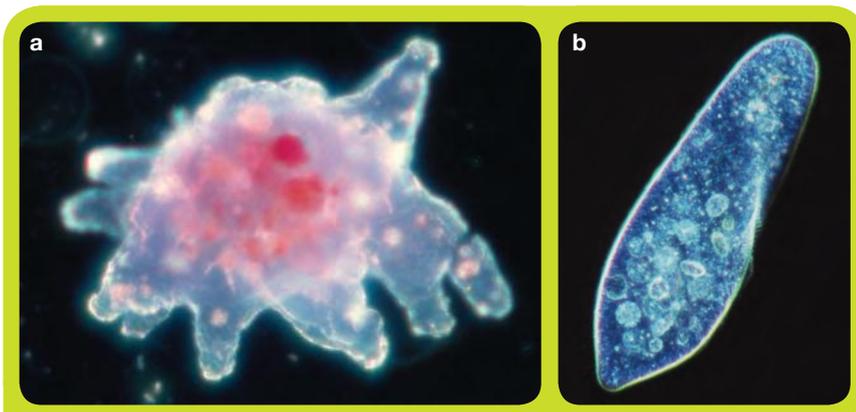


Fig 9.1.10 Animal protists under a light microscope: **a** amoeba at $\times 85$ showing the false feet; **b** *Paramecium*

Activity 4

Pond life

Aim

To observe and identify some protists present in pond water

Equipment

Pond water, droppers, microscope slides, cover slips, monocular microscope, probes, gelatin (3 g in 100 mL water), neutral red or methylene blue stain

Method

- 1 Place a drop of pond water on a slide and lower the cover slip using a probe.
- 2 Observe protists under low power on the microscope.
- 3 Record your observations using labelled diagrams.
- 4 To aid observation, a drop of gelatin solution can be added to the slide to slow down the movement of the protists. To enhance the visibility of structures a drop of neutral red or methylene blue stain can be placed on a slide, left to dry, and then a drop of pond water added.

Questions

- 1 Describe any features you observe that help the protists to move.
- 2 Given the observations made of the pond water when viewed under a microscope, evaluate the suitability of pond water for human consumption.
- 3 Propose a method for measuring the size of the protists observed in the experiment.

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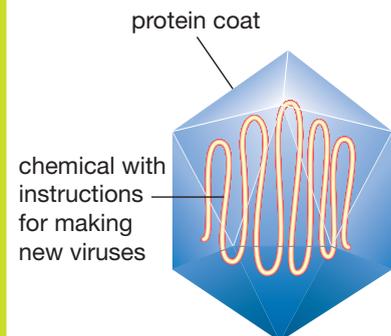


Fig 9.1.11 A typical virus

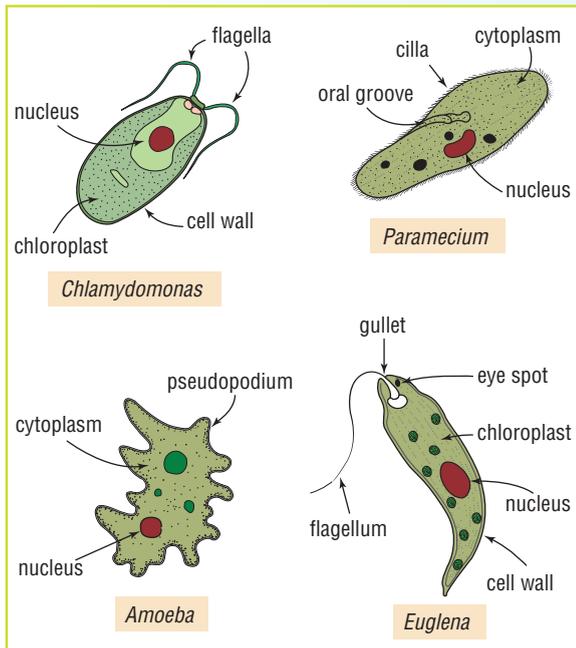


Fig 9.1.12 Some common protists that you may see in pond water

Viruses

Virus is the Latin word for poison. Viruses cause many illnesses. Viruses are much smaller than other microbes and must be viewed under the electron microscope. Viruses are unlike other living things. Their structure consists of a protein coat surrounding a chemical that contains the instructions for building a new virus. This chemical is commonly known as deoxyribonucleic acid (DNA) or ribonucleic acid (RNA). The protein coat is able to take on many shapes. The polyhedral shape shown in Figure 9.1.11 is very common.

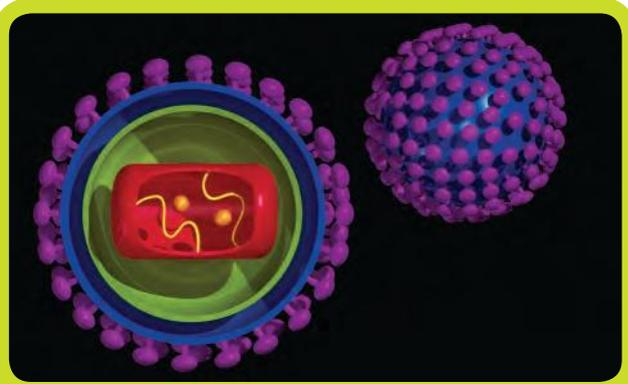


Fig 9.1.13 A model of the virus that causes AIDS, showing its inner structure

Questions

Checkpoint

Microbes

- 1 Define the term 'microbe'.
- 2 State whether the following statements are true or false.
 - a All microbes cause disease.
 - b Microbes cannot be seen with the naked eye.
 - c All non-living objects are free of microbes.

Observing microbes

- 3 In order to observe most microbes special instruments are needed. Identify two suitable instruments.
- 4 State which groups of microbes are visible with the human eye and which groups are not.

Microscopes

- 5 Identify the main parts of the microscope in Figure 9.1.14.
- 6 What magnification can be achieved by the electron microscope?

Bacteria

- 7 Modify the following statements so that they are correct.
 - a Bacteria consist of a cell wall, cell membrane and nucleus.
 - b All bacteria cause disease.
 - c Bacteria have only one basic shape.
- 8 List three types of bacteria, based on shape.

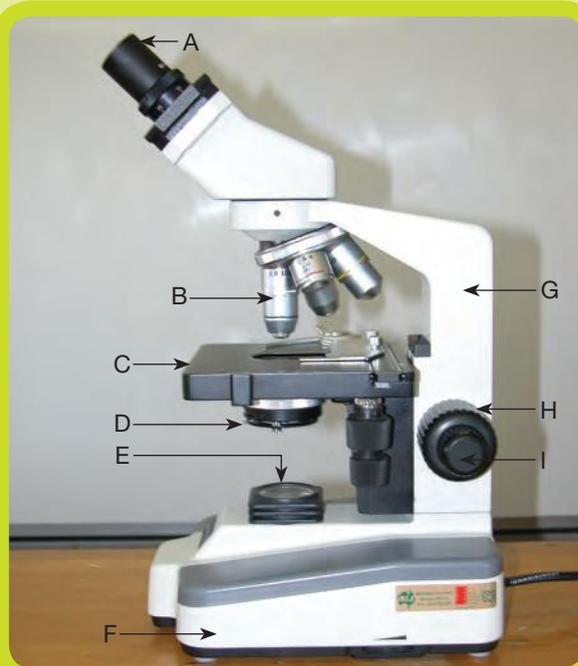


Fig 9.1.14

Fungi

- 9 List three different types of fungi, giving an example of each.
- 10 Outline how fungi obtain their nutrients.

Protists

- 11 Define the term 'protist'.
- 12 Describe three ways by which protists may move.
- 13 Identify two protists that are monitored in drinking water.

Viruses

- 14 State whether the following statements are true or false.
 - a Viruses contain instructions for building new viruses.
 - b Like bacteria, viruses have cell walls.
 - c The word 'virus' is a Latin word that means 'helpful to humans'.
- 15 Outline two features that make a virus different from other microbes.

Think

- 16 Contrast the characteristics of a bacterium with those of a protist.
- 17 It is difficult to classify viruses as living organisms. Propose some reasons why they may be considered living organisms.
- 18 Identify the type of microscope used to observe:
 - a live cells of a *Paramecium*
 - b a virus
 - c bacteria.
- 19 Propose reasons why a telephone handset, a computer keyboard and a computer mouse often carry far more bacteria than the toilet bowl at home.
- 20 Explain why you should wash your hands after going to the toilet.

Skills

- 21 Three different surfaces in a classroom were wiped with sterilised damp cotton buds. The cotton buds were wiped over agar jelly in petri dishes. The diagram below shows the results after the petri dishes were incubated for three days.

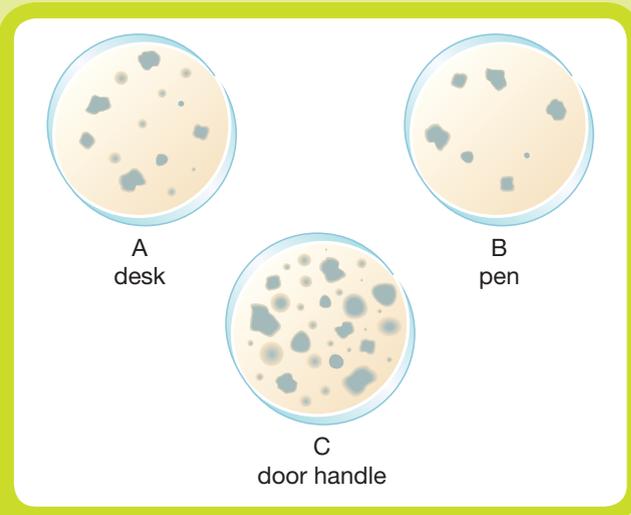


Fig 9.1.15

- a Compare the three sets of results.
 - b Draw a conclusion for the experiment.
- 22 Copy the following incomplete equations into your workbook. Calculate the correct answers to fill in the blank spaces.
 - a $1 \text{ mm} = \underline{\hspace{2cm}} \text{ m}$
 - b $1 \text{ mm} = \underline{\hspace{2cm}} \text{ nm}$

[Extension]

Investigate

- 1 a Construct an illustrated timeline showing the main events in the discovery of the microscope and electron microscope.
 - b Outline the impact of each discovery on the understanding of microbes.
- 2 Construct a poster using diagrams to explain how a light microscope magnifies.

UNIT 9.2

Reproduction in microbes

Introduction

Remember the last time you got sick? You were probably feeling okay one day and very bad the next. It is amazing how fast illness can occur once a microbe has entered your body. It is all to do with how microbes reproduce. In only a few hours a single bacterium can become millions! The more bacteria there are, the sicker you get. And just to make it more difficult for you, the microbes making you sick don't want to leave because your body is the perfect home for them. It is warm and comfortable and has lots of food.

Bacterial reproduction

Bacteria reproduce by cell division or binary fission. This kind of reproduction does not need females and males. Instead, a parent cell divides to become two identical daughter cells. Figure 9.2.1 shows the stages involved in binary fission as well as a scanning electron micrograph of a single bacterium dividing.

Some bacteria can undergo binary fission in as little as 20 minutes, but most take between one and three hours to reproduce. The daughter cells divide just as quickly. If the time for reproduction is every 20 minutes, then at this rate a single bacterium will become a colony of over one million in seven hours, making you very sick!

Bacteria grow and reproduce very rapidly only when the conditions are right. All bacteria need moist and warm environments. Many find the core temperature of 37°C of the human body ideal. These simple growth conditions also mean that we can grow bacteria very easily in the laboratory for our own use. We also need to supply the correct food source.

Your body has ways to fight bacteria and overcome infection. Sometimes, if an infection is quite bad, extra help will be needed. This is when you need to take antibiotics. Antibiotics are chemicals or drugs that kill bacteria, usually by destroying their cell walls. Any bacteria that survive, however, will probably be resistant to the antibiotic. They will then start to breed and the infection will continue. The antibiotic is then not effective any more and a new drug-resistant 'strong' strain of bacteria will have developed.

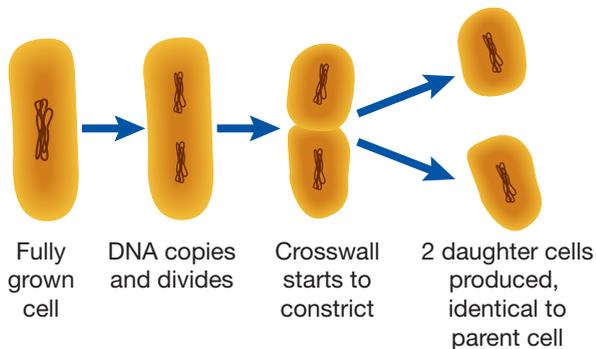


Fig 9.2.1 Bacteria dividing by binary fission

Activity 5

Fungal reproduction

Aim

To observe the stages of fungal reproduction

Equipment

Samples of mould, forceps, glass slides, stereo-microscopes, disinfectant

Method

- 1 Using forceps, place small samples of mould on a microscope slide. A cover slip will not be required.
- Warning: Avoid inhaling or skin contact with moulds as they can cause allergies and/or disease.**
- 2 Using a stereo-microscope, examine the mould for evidence of spores and mycelia.
- 3 Draw a diagram that shows as much of the structure of fungi as possible.
- 4 Clean your hands and working area with disinfectant.

Questions

You might need to read ahead to find the information to answer these questions.

- 1 Use your results to explain the stages in fungal reproduction.
- 2 Outline the advantages of this type of reproduction.

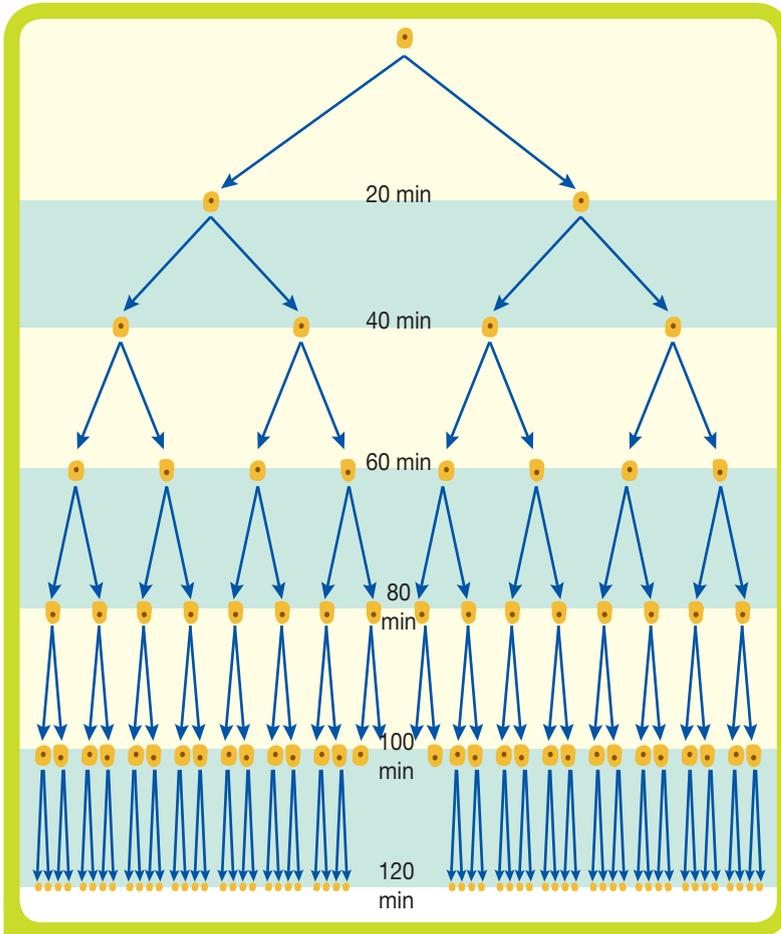


Fig 9.2.2 The number of bacteria can increase very quickly through binary fission, even after only a few generations.

A fungi way to reproduce

Fungi such as mushrooms are moulds. They are made up of thread-like structures that have a furry appearance. In mushrooms, these threads grow underneath the mushroom and into the ground, so you usually do not see them. The threads are known as hyphae. Hyphae grow into the food and digest nutrients for further growth.

Fungi such as mushrooms and moulds have two ways of reproducing.

- 1 A piece of fungus made up of hyphae breaks off and begins to grow.
- 2 The hyphae produce spores. These spores form in a capsule called a sporangium that grows upwards from the hyphae. When mature the sporangium bursts open, releasing the spores into the air. Spores are able to exist for long periods of time until they find the right place

to grow. They are much like the seeds of a plant. The part of the mushroom that you eat is really just a big sporangium, preparing its spores to release into the air.

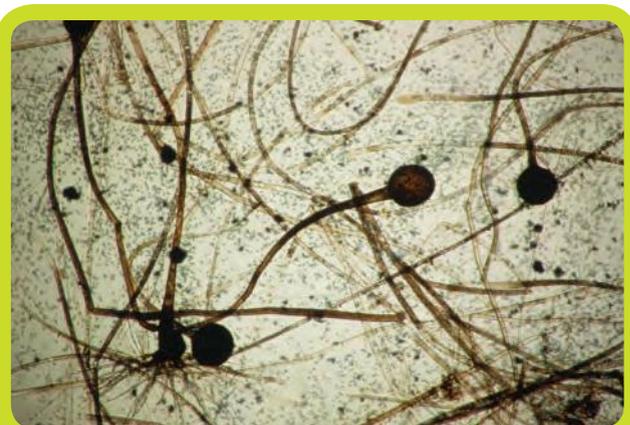


Fig 9.2.3 Under the light microscope it is easy to see the sporangia and hyphae of bread mould.

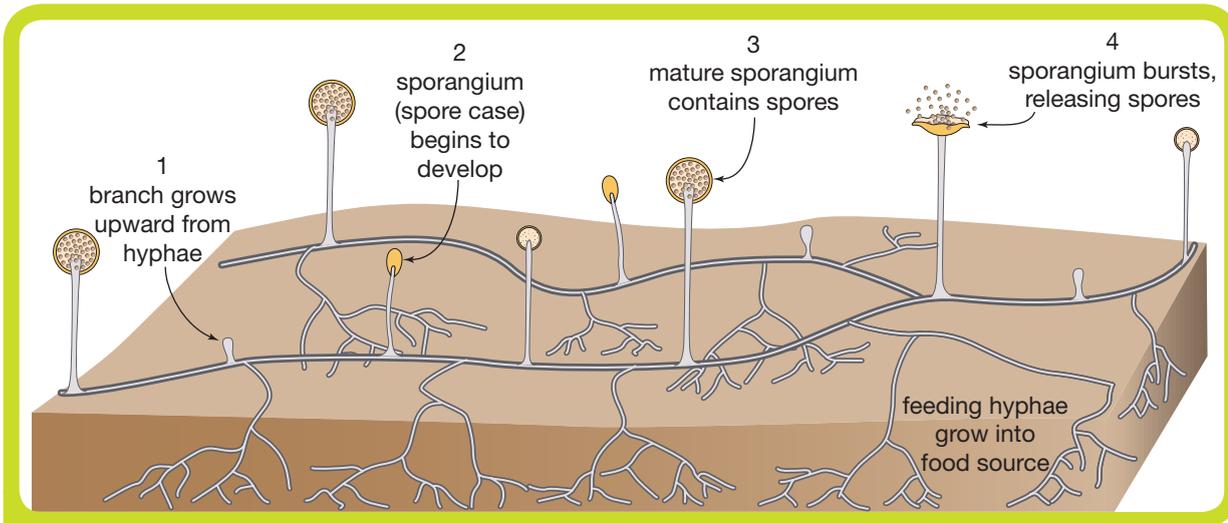


Fig 9.2.4 Reproduction and growth in fungi

Yeasts are another group of fungi. They reproduce by budding. The parent cell forms a ‘bud’ on its outer surface and a copy of everything in the cell is moved into it. A cell wall then forms between the bud and the parent cell, and the bud breaks away. The bud looks exactly the same as the parent cell. Figure 9.2.5 shows an example of yeast cells budding.

Activity 6

Budding yeast

Aim

To observe yeast cells reproducing by the process of budding

Equipment

Freshly made yeast and sugar solution, microscope slides, cover slips, probes, dropper, tissues, microscope

Method

- 1 Add a drop of yeast and sugar solution to the microscope slide.
- 2 Gently lower a cover slip onto it using the probe.
- 3 Draw out excess yeast solution using a tissue.
- 4 Focus the microscope slide under low power, then increase to high power.
- 5 Find an area to view and draw five different examples of yeast budding.

Questions

- 1 Which type of microorganism would you classify yeast as?
- 2 Explain why sugar was added to the yeast solution.
- 3 Use your results to explain how yeast reproduces.
- 4 Based upon observations in this experiment, evaluate budding as a means of reproduction.

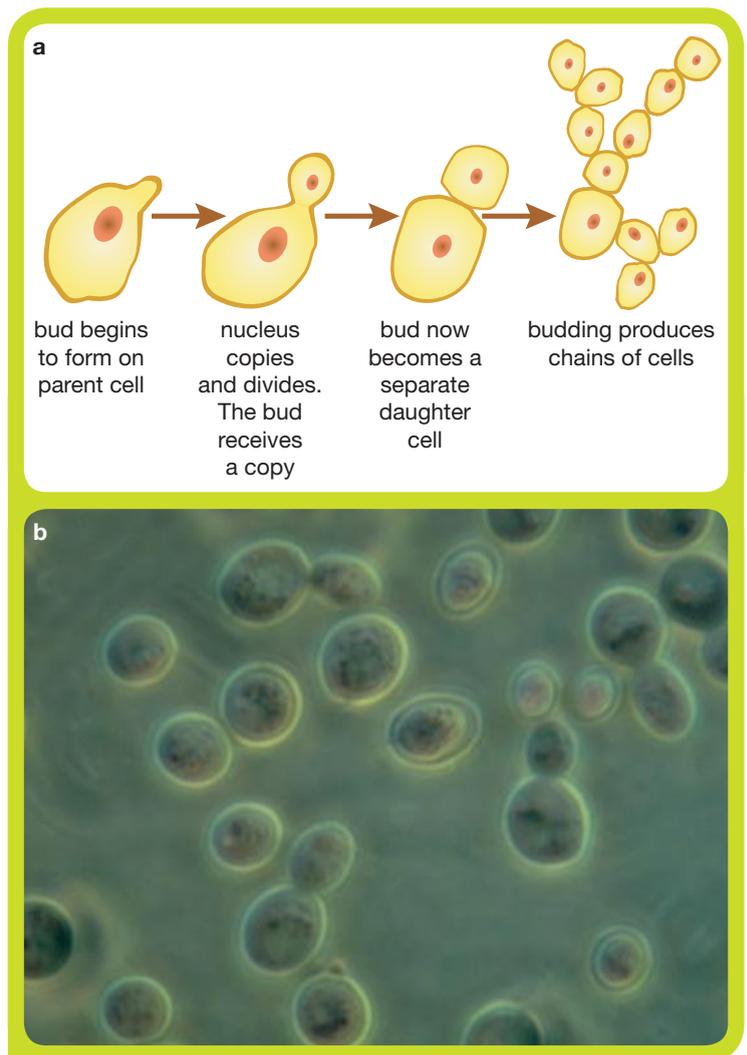
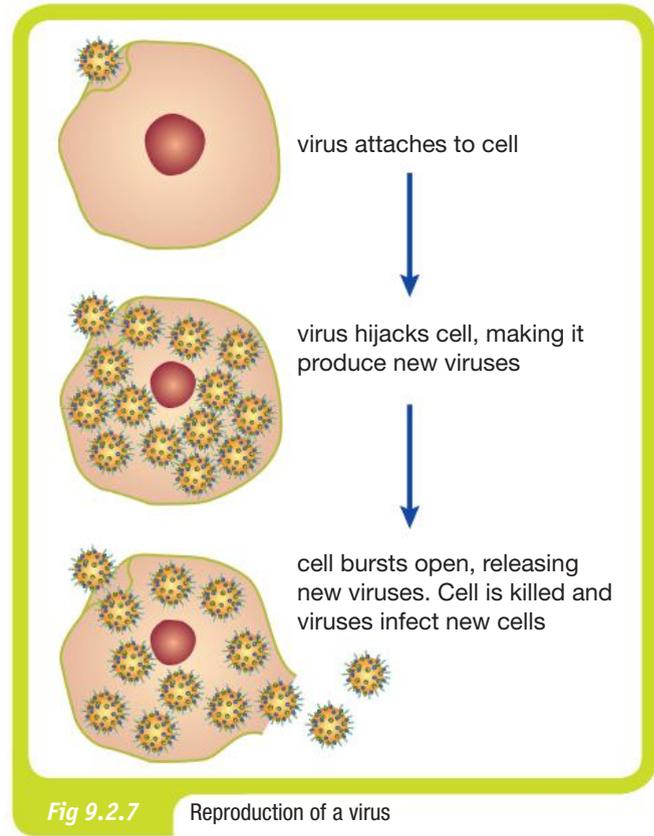
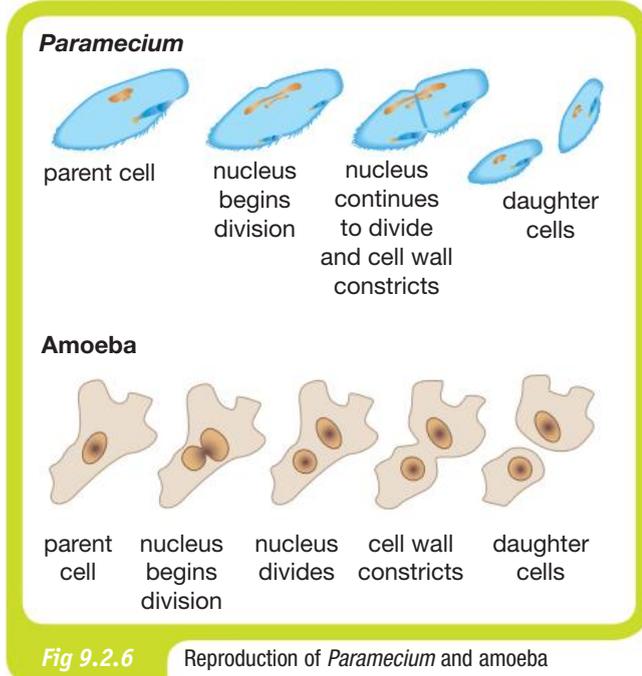


Fig 9.2.5

a Yeast cells reproduce by budding. **b** The yeast cells in this image can be seen in various stages of the budding process.

Reproduction of protists

Like bacteria, protists are able to reproduce by binary fission, as illustrated in Figure 9.2.6.



Viruses invade!

A virus can only reproduce inside a host cell. A host cell is any cell that the virus attacks and takes over. When a virus comes into contact with a host cell, it takes over the cell, forcing it to become a virus factory. When the host cell is full of new viruses it bursts open, releasing the viruses, which then go on to infect more cells. A virus can lay dormant—or asleep—for many years without a host cell.

Antibiotics (medicines such as amoxicillin) kill only bacteria. Consequently they do not work against viruses. Instead, your body has an immune system that builds antibodies to destroy the attacking virus. You have very few of these antibodies when you are young, and so you get sick with all sorts of viruses such as colds, chicken pox, measles and mumps.



Your body builds antibodies to fight every time a new virus enters. This takes time and you get sick. However, once you have these antibodies it is unlikely that you will get ill with that virus again. The antibodies are there and are ready to fight at the first sign of invasion. Vaccinations ‘infect’ you with something very similar to virus. This could be a modified virus or a harmless virus that is very similar in shape to one that is nasty. Your body is ‘bluffed’ into making antibodies that then protect you from the real disease.

You might be asking why you keep getting colds when the antibodies built from your first cold should be protecting you. All viruses can mutate, making slightly different versions of the same virus and the antibodies made for one version might not fight another version of same virus. Unfortunately, the cold virus mutates very quickly. This means that although you are probably safe from last year’s version of the cold, you could catch this year’s ‘new improved’ version.

9.2 [Questions]

Checkpoint

Bacterial reproduction

- 1 Define the following terms: parent cell, daughter cell, antibiotic.
- 2 Construct a diagram to describe the process of binary fission.
- 3 Describe reproduction in bacteria and identify two benefits binary fission gives them.
- 4 Outline the conditions needed for bacteria to grow.

A fungi way to reproduce

- 5 Draw a labelled diagram to demonstrate the structure of fungi.
- 6 Outline the role of the hyphae.
- 7 Outline two ways in which fungi can reproduce.
- 8 Describe the stages of budding in yeast.

Reproduction of protists

- 9 Copy and modify the following statements so that they are correct:
 - a Protists reproduce by a process known as budding.
 - b Water that contains giardia is safe to drink.
- 10 Draw a diagram to demonstrate how amoeba reproduce.

Viruses invade!

- 11 Define the term ‘host cell’.
- 12 State whether the following statements are true or false:
 - a The host cell is able to destroy a virus.
 - b Viruses can reproduce only within a host cell.
 - c A host cell makes copies of the virus before bursting open.
 - d Antibiotics can kill a virus.
- 13 Outline why:
 - a you probably won’t get chicken pox if you’ve already had it
 - b vaccination can protect you from getting ill from a virus.

Think

- 14 Microbes have survived and flourished over billions of years. Propose a reason for their success.
- 15 If microbes are able to reproduce so rapidly, propose reasons why they have not overrun the planet.
- 16 State whether the following statements are true or false.
 - a Viruses and bacteria reproduce in the same way.
 - b Yeast reproduces using binary fission.
 - c Bacteria grow best on moist rather than dry skin.
- 17 Compare viral and bacterial reproduction.
- 18 You see only a small part of the organism when you look at a mushroom. Explain why.

Analyse

- 19 The amount of bacteria in saliva samples before and after using various mouthwashes was determined by collecting saliva and growing colonies on agar plates. The plates were incubated for 48 hours at 37°C and the following results were recorded.

Mouthwash	Colonies counted before using mouthwash	Colonies counted after using mouthwash
1	25	10
2	11	14
3	9	6

- a State an aim for the experiment.
- b Identify which mouthwash was not effective in reducing bacteria.
- c Propose reasons why this mouthwash increased the number of bacteria in saliva.
- d Draw a conclusion from the data about the most effective mouthwash.

>>

Skills

- 20 a** If a single bacterium reproduced every 20 minutes, calculate how many there would be after two hours.
- b** Construct a line graph showing the number of bacteria formed each 20 minutes for two hours.
- c** Use the graph to explain why bacteria can make you sick within one day.
- d** Use the graph to predict the bacterial population after five hours.

[Creative writing]

Write a short story about a microbe and its reproduction. Compile the stories written by each class member and present information as a book with a collective title.

[Extension]

Investigate

- 1** Bacteria and protozoa can cause food poisoning in humans due to their fast rate of reproduction. Investigate a microbe that causes food poisoning and:
- a** describe the conditions that may cause bacteria to grow to levels that cause food poisoning
 - b** outline the main ways that food poisoning occurs and how microbes are transmitted between people and food
 - c** outline how to handle food in order to avoid food poisoning.

Action

- 2** Plan an excursion, or obtain information, from Honiara Water, or your village water supplier in order to identify the measures taken to stop microbes contaminating the water supply.

UNIT 9.3

Friend or foe?

Introduction Microbes are not all bad. Bacteria can provide us with food and drinks. They help garbage and compost to decompose, and they keep the soil fertile. They are even used to make some very important medicines. Scientists are trying to find ways of making viruses that can enter cells and help cure diseases such as cancer. It would be fair to say, however, that protists and viruses are more foe than friend, as they are responsible for a large number of diseases.

Good and bad bacteria

Compost bins are amazing: all sorts of vegetable food scraps are thrown in and they break down into compost for the garden. Bacteria helps to break down matter that was once living or was once part of a living organism. This decomposition occurs everywhere: in the garden, in the soil, in decaying animal remains and in the waste of animals. Decomposition is important for two reasons. First, it returns nutrients to the soil that can then be used by plants. Second, it rids the Earth of dead plants, animals and their waste. Imagine the Earth if nothing decomposed! Everything that has ever died would still be here! All their waste would be here too!



Fig 9.3.1 Bacteria and fungi help break down food and garden waste in compost.

Bacteria are used in the treatment of industrial waste and to break down human faeces in sewage. Scientists are trying to find bacteria that can break down oil, so that they could then be used to clean up oil spills.

Decomposition is not always a good thing. Bacteria will begin to decompose and ruin food if you leave it out of the fridge for too long. As they work, the bacteria produce toxins (or poisonous chemicals). If you eat the food, these toxins can make you very sick. This is known as food poisoning.



Fig 9.3.2 Keeping food in the refrigerator slows down the growth of bacteria and reduces the risk of food poisoning.

Some bacteria can destroy food while others are used to make it. Yogurt, yogurt drinks and cheese all need bacteria in their production. To make yogurt, bacteria are added that use the sugar in the milk as food, turning the milk sour. Yogurt is often sweetened to take away the sour taste of natural yogurt. The right bacteria must be chosen as there are bacteria that cause food such as milk to go sour, but taste terrible and may cause food poisoning.

In agriculture, bacteria assist with the supply of nitrogen in the soil. Nitrogen is used by plants for growth and so is very important. Nitrogen-fixing

bacteria take nitrogen from the air and put it in the soil in a form that plants can use. These bacteria often live in nodules on the roots of plants such as beans, peanuts and native wattle trees.



Fig 9.3.3 Bacteria are used to produce many foods.



Fig 9.3.4 Antibiotics are able to kill a large number of bacteria. Unnecessary use and incomplete use can lead to the breeding of drug-resistant bacteria.

Bacteria can be used to produce hormones, such as insulin for people with diabetes. They can also introduce resistance to disease in plants.

Since the discovery of antibiotics, medical science has found ways to cure many of the diseases caused by bacteria. A minor scratch was once quite deadly, since nothing could stop the infection from spreading. With antibiotics, few people now die from these types of bacterial infections. A disadvantage of antibiotics, however, is that bacteria can become resistant to them and therefore even more deadly.



Fig 9.3.5 You must be very careful about the type of mushrooms you eat.

Fungi to eat, fungi that kill

One of the most famous uses for a fungus was discovered by accident. In 1928, Alexander Fleming, a Scottish physician and bacteriologist, discovered that mould had contaminated some agar plates that he was using to grow bacteria. On closer inspection, Fleming noticed that the bacteria around the mould had stopped growing. The mould was a bread mould, *Penicillium notatum*, commonly called penicillin. Penicillin was the first antibiotic and is now commonly used to treat many bacterial infections. Some people are allergic to penicillin, however, and penicillin is not effective for all the different bacterial infections that exist. For these reasons, many different antibiotics have been developed.

Yeast is a useful fungus used in the production of bread, wine and beer.



Fig 9.3.6 Some breads and the yeast used to produce them

Yeasts release energy through a process called respiration in which glucose is used to produce carbon dioxide, water and energy. If the respiration requires oxygen it is called aerobic respiration and has the word equation:



This is what occurs in yeast in the making of bread. It is the bubbles of carbon dioxide produced that cause the bread to rise and give it a spongy look.

Anaerobic respiration occurs in the absence of oxygen. Under these conditions, yeast will feed on the glucose in fruit, vegetables or cereal grains, making alcohol as a product. Any type of fruit, vegetables or grains can be used, including cassava, although grapes (producing wine), potatoes (vodka), barley (beer) and wheat (whisky) are most commonly used. Yeast will even work on the glucose in cactus to make tequila. The process is more commonly known as fermentation. Its word equation is:



The carbon dioxide produced by the yeast causes the bubbles in beer and champagne. In wine this gas is allowed to escape before the wine is placed in a bottle.

Fungi are not always friendly. They are responsible for quite a range of fungal diseases. Some examples, shown in Figure 9.3.9, include thrush, tinea (sometimes called athlete's foot) and ringworm. Fungal diseases are usually easily treated with antifungal powders or creams.



Fig 9.3.7 The yeast on these grapes will give the wine flavour while converting sugar in the grapes to alcohol.



Fig 9.3.8 The bubbles in champagne are caused by the build-up of carbon dioxide gas from the respiration reaction of yeast and the glucose in grapes.

Viruses

If a human, animal or plant gets sick, it is usually because a virus has invaded it. Billions of dollars are spent each year on learning more about viruses and ways to control them. The flu (influenza) is one example of a common disease caused by a virus.

Some beneficial uses for viruses are now being investigated. Recently in a medical breakthrough, a virus was injected into a brain tumour in a human. The virus killed the cancerous cells, reducing the size of the tumour, and the person survived. Who knows in what other great ways viruses may be used in the future?

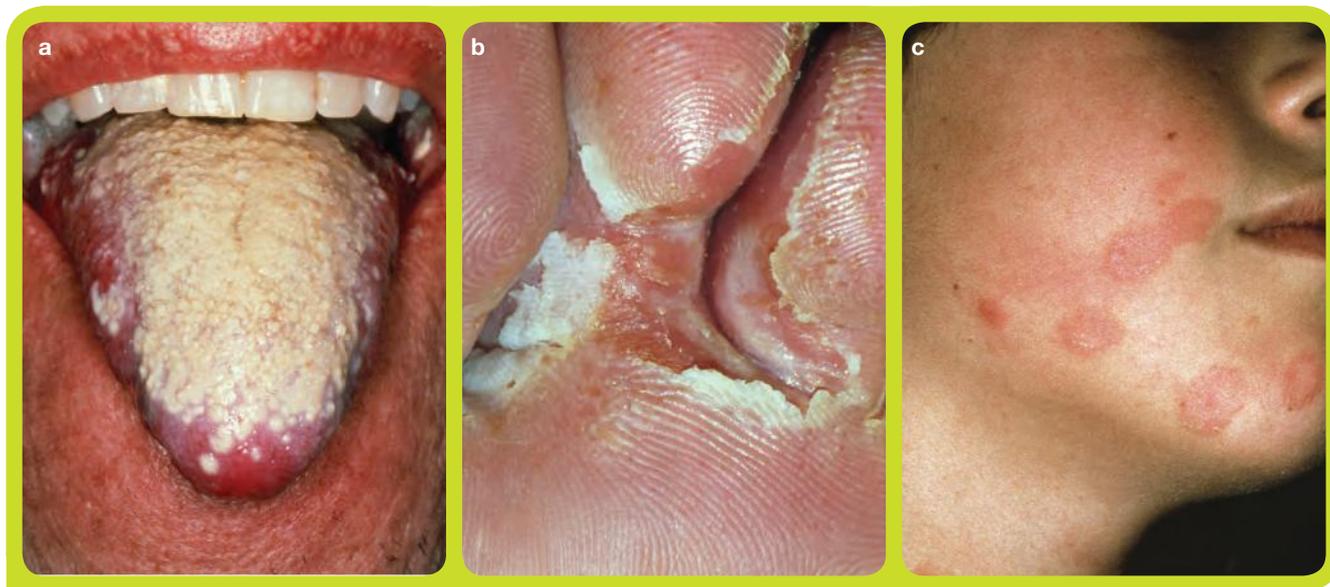


Fig 9.3.9 a Severe oral thrush. b Athlete's foot between the toes. c Ringworm

Activity 7

Bread making

Aim

To identify a suitable temperature for the action of yeast in bread making

Equipment

Yeast suspension, sugar, flour, a range of beakers and measuring cylinders, stopwatch, balance, graph paper

Method

- 1 Research the most effective temperature for yeast production.
- 2 Construct a hypothesis to test the aim.
- 3 Design a method, including such things as:
 - which temperatures should be tested
 - how to keep the experiment at the chosen temperatures
 - what equipment will be required (Hint: Think about how the measuring cylinder would be useful.)
 - which measurements would be helpful to enable the results to be graphed (Hint: Think about a way

of having a dependent variable and an independent variable.)

- what quantities of flour, sugar, and yeast suspension to use
- how to record and plot your results on a graph.

You may need to do some pretests to work out some of this information accurately.

Questions

- 1 Analyse the graph(s) and describe any patterns that seem evident.
- 2 Discuss your results and decide whether the hypothesis written has been proved or disproved.
- 3 Discuss any steps taken to make results reliable as well as any improvements in the experiment design to help reliability.
- 4 Describe how the variables were kept constant in the experiment.
- 5 Draw a conclusion for the experiment.

[Questions]

Checkpoint**Good and bad bacteria**

- State whether the following statements are true or false.
 - Bacteria are always harmful.
 - Decomposing bacteria help break down food waste to form compost.
 - Nitrogen-fixing bacteria help plants to grow by supplying nutrients to the soil.
- List two ways in which bacteria benefit human society.

Fungi to eat, fungi that kill

- List two types of useful fungi.
 - Outline how each fungus is used.
- Modify the following statements so that they are correct.
 - Penicillin is an antibiotic that is produced by a yeast.
 - Alcohol is produced by aerobic respiration of yeast.
 - Thrush, tinea and ringworm are caused by the same fungi.
- Construct a word equation for aerobic respiration.
 - Construct a word equation for anaerobic respiration.
 - Identify which of these equations is also called fermentation.

Viruses

- Outline how viruses might be used to actually benefit humans.

Think

- Compare the word equations for aerobic and anaerobic respiration, outlining at least two differences.
- Wine is produced by fermentation. Outline the requirements and products of this process.
- Explain how a microbe is useful in each of the following cases:
 - making bread
 - making yogurt
 - making wine
 - treating sewage
 - composting.
- Explain why bread appears soft inside.
- Propose how bacteria could be useful in cleaning up oil spills.
- From what you have learnt about the reproduction of viruses in the previous unit, predict how a virus injected into a tumour will kill the cancerous cells.
- Wine and champagne are both produced by fermentation. Explain why wine has no bubbles, but champagne does.

Analyse

- All cheeses are made with bacteria, yet they have many different styles and flavours. Explain how this is achieved.
- Outline some effects on society of disease-causing microbes.
 - Present two examples to support your answer.
- Evaluate whether overall microbes are friends or foes to society.

[Extension]

Investigate

- Choose one particular type of cheese that is made using a fungus.
 - Research how the cheese is made.
 - Construct a poster explaining the steps in making the cheese.
 - Outline the role played by the fungus in developing that type of cheese.
 - Explain how the temperature affects the product.
 - If the cheese is hard or soft, explain how this is accomplished.
- Research how yogurt is made and outline the steps involved.
 - The milk used to make yogurt is chemically changed. Explain the chemical change using equations, and clarify the role and type of bacteria needed to make yogurt.

- Investigate a disease caused by microbes, such as influenza, AIDS, hepatitis or polio. Your teacher will give you many other examples. Produce a report outlining the cause, symptoms and signs, cures and treatments.

Action

- Organise an excursion to a factory or institute that makes cheese or yogurt.
- Use antibiotic test rings and agar plates to design experiments testing the effectiveness of antibiotics.

[Creative writing]

Imagine that all of the world's decomposing microbes have disappeared. Write a story in order to describe what the world has become.

Chapter review

Summary questions

- Define the following terms: microorganism, budding, binary fission, fermentation, antibiotic, mould, flagella, fomite, decomposition.
- Modify the following statements so that they are correct.
 - Protists are many-celled animals found in water.
 - Light microscopes are used to study viruses.
 - Yeast reproduces by means of binary fission.
- Use an example and equation to clarify the term 'anaerobic respiration'.
- Construct a diagram to show fungal reproduction.
- Microbes are studied by growing cultures on agar in petri dishes. Outline three safety precautions required for such experiments.
- Outline one use for each type of microbe.
- Identify two types of microscopes that would be suitable for observing fungi.
- Copy and complete the following table to summarise how microbes reproduce.

Microbe type	Example	Method of reproduction
	<i>E. coli</i>	
Fungi		Budding
Protist	Amoeba	
	Influenza	

Thinking questions

- Identify two microbes that you may expect to find in pond water.
- Chicken meat sitting out of the refrigerator for a short time can be safe to eat, but after only a few hours on the bench it may no longer be able to be eaten.
 - Explain why this is the case.
 - Explain how a refrigerator helps keep food fresh.
- Food is more likely to 'go off' on a hot day than on a cold one. Explain why.
- State whether these statements about protists are true or false.
 - Amoeba have cilia for movement.
 - Drinking water containing protists can cause diarrhoea and vomiting.
- Use an example to justify how microbes can be both friend and foe.

- Spa baths that are rarely emptied (eg external spas and those in gyms) need to have their chlorine levels regularly checked. Account for this fact given that most bacteria multiply best at temperatures of about 37°C.
- Discuss the effectiveness of reproduction by binary fission.
- Use the concept of mutation to explain why people catch colds each year.
- Construct a diagram to explain how a virus reproduces.
- Draw the shapes of bacteria and identify each by name.
- Describe how yeast is used in making bread.
- Outline how bacteria are important in 'cleaning up' the environment.

Interpreting questions

- Construct a key to classify the following classes of microorganisms: bacteria, fungi, protists and viruses.
- Figure 9.4.1 shows a *Paramecium*. Use the diagram and scale to calculate the length of the *Paramecium* in nanometres.

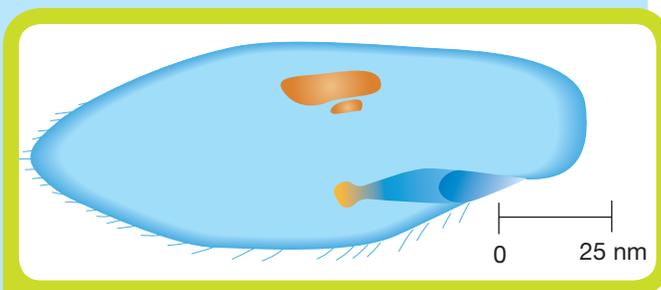


Fig 9.4.1

- Copy and complete the following table to summarise the benefits and problems to society of each type of microbe. Try to use some specific examples in your summary.

Microbe type	Benefits	Problems and cost to society
Bacteria	Making foods such as yogurt and cheese.	
Fungi		
Protist		
Virus		Cause many diseases and illnesses that kill many people every year. Many people miss work. This costs society a lot of money in medical research.

The periodic table

Specific learning outcomes

8.10.1.1, 8.10.2.1, 8.10.3.1, 8.10.4.1, 8.10.4.2, 8.10.5.1,
8.10.6.1, 8.10.7.1

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

- describe that the periodic table is a special table that lists the names (symbols) of all the elements found on Earth
- state that Dmitri Mendeleev first published the periodic table in 1869
- state that, in the periodic table:
 - i columns are 'group numbers'
 - ii rows are 'period numbers'
 - iii metals are generally on the left and non-metals are on the right
- state that the mass number is the number of protons plus the number of neutrons in an atom
- state that the atomic number is the number of protons or electrons in an atom
- draw the structure of the first twenty elements and write the electronic configuration of the atoms
- explain the formation of simple molecules or compounds (use very simple examples such as hydrogen, H_2 ; oxygen, O_2 ; carbon dioxide, CO_2 ; and water H_2O)
- express that all things both living and non-living are made up of atoms.

- 1 Identify some of the metals around you right now.
- 2 Draw what you think an atom looks like.
- 3 Roughly how many different types of atoms do you think there are? Would it be ten, a hundred, thousands or millions?
- 4 Why do scientists often use symbols instead of names for elements?
- 5 Why do some elements have apparently illogical symbols, such as Fe for iron and Na for sodium?
- 6 Do fish swim in H_2O or H_2O_2 and what's the difference anyway?
- 7 The picture on this page is of an alchemist. What were these scientists trying to do?



Challenges

UNIT 10.1

Atoms and elements

Introduction

All around us is matter: we breathe it, we drink it and we sit on it. But what is matter made from? This question has been asked many times throughout history. As early as 400 BC the Greek philosopher Democritus thought all matter was composed of atoms of the four elements. It was believed that atoms could not be broken down or made smaller. The word *atomos* is Greek for 'indivisible'.

Atoms

Last year you discovered that atoms were smaller-than-microscopic particles that make up all matter. Atoms are made up from even smaller particles called protons (often shown as p^+), neutrons (n) and electrons (e^-). Protons and neutrons are roughly 1800 times bigger than electrons and are located at the centre of the atom, in the nucleus. Electrons spin fast around the nucleus in a region of empty space.

Neutrons are neutral, having no electrical charge. Protons have a positive charge and electrons a negative charge. Opposite charges attract each other and this stops the electrons from spinning out from the atom.

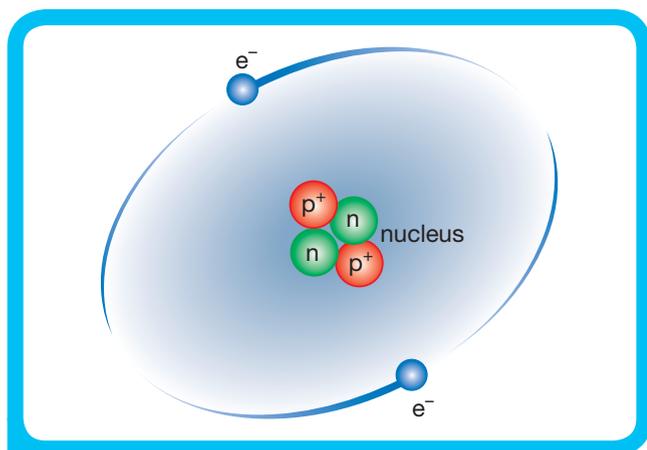


Fig 10.1.1 A simple model of a helium atom

Atomic and mass numbers

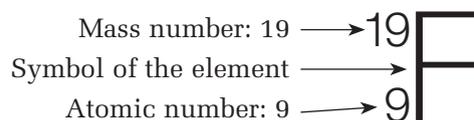
The number of protons in an atom is called its atomic number. Atoms are electrically neutral because they have the same number of electrons and protons. In a neutral atom:

$$\text{atomic number} = \text{number of protons} = \text{number of electrons}$$

The total number of particles in the nucleus (protons + neutrons together) is called the mass number. Neutrons do not add any charge to an atom, so there is no rule connecting them with protons or electrons.

$$\text{mass number} = \text{number of protons} + \text{number of neutrons}$$

These numbers can be shown as:



This indicates that the atom is fluorine and has:

- 9 protons and 9 electrons
- 10 neutrons ($19 - 9 = 10$)

Elements

Elements are the basic building blocks of all matter and each element is made up of only one type of atom: gold contains only gold atoms, and oxygen contains only oxygen atoms. If atoms belong to the same element then they have the same number of protons and the same atomic number. There are about 118 different types of basic atoms, so there can only be 118 different elements

Each element is given its own symbol. Those known in ancient times often have Latin or Greek names but the rest are more logical. The symbol of an element is usually the first letter of its name, as a capital letter. If the name of another element starts with the same letter, then two letters are used. The first letter is a capital and the second letter is in lower case.

ELEMENTS					
	Hydrogen.	1		Strontian	46
	Azote	5		Barytes	68
	Carbon	5		Iron	50
	Oxygen	7		Zinc	56
	Phosphorus	9		Copper	56
	Sulphur	13		Lead	90
	Magnesia	20		Silver	190
	Lime	24		Gold	190
	Soda	28		Platina	190
	Potash	42		Mercury	167

Fig 10.1.2 Dalton's table of elements and their symbols

A short history of the elements

Aristotle's theory that all matter was made from the four 'elements'—earth, air, fire and water—lasted for nearly 2200 years and pushed Democritus's idea of atoms into the background. In the twelfth century, alchemists began to learn a lot about the chemicals and elements that they worked with in their attempt to change base metals such as copper into gold. This new knowledge made the ancient Greek ideas of the four elements seem unsatisfactory.

Over the next 600 years, scientists continued to improve their understanding of the properties of matter. Using some of Democritus's original ideas, in 1808 the English scientist John Dalton proposed a new 'atomic theory'. This stated that:

- all matter was composed of tiny particles called atoms
- atoms could not be broken into smaller particles
- atoms of the same element are alike
- atoms join together in different ratios.

Dalton also produced a table showing symbols and atomic masses of the elements. A section of the table is shown in Figure 10.1.2.

We now know that Dalton was not 100 per cent correct. Later chemists discovered that it is possible to break down atoms into protons, neutrons and electrons.

Table of some elements and their symbols

Name	Symbol
Hydrogen	H
Helium	He
Boron	B
Beryllium	Be
Carbon	C
Calcium	Ca
Nitrogen	N
Neon	Ne
Iron (ferrous)	Fe

Molecules and lattices

Atoms do not normally exist by themselves but exist in molecules or lattices. A molecule is a group of atoms bonded or joined together. In a crystal lattice, atoms keep bonding together until something stops them. Molecules and lattices have a chemical formula that tells us what type of atoms they contain and the proportion of atoms in them.

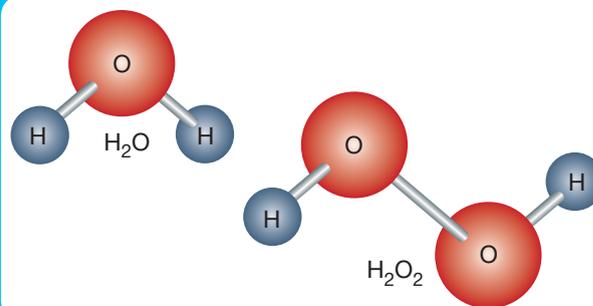


Fig 10.1.3 Molecules of water and the bleach hydrogen peroxide are both made from hydrogen and oxygen atoms. What a difference a single O atom makes!

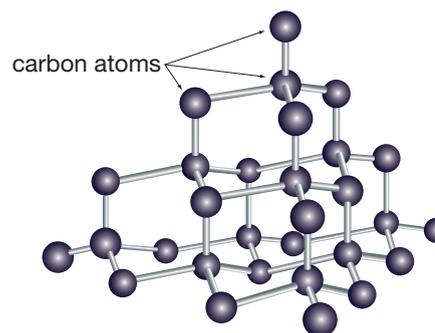


Fig 10.1.4 An example of a lattice—this one is diamond.

Activity 1

Making a compound

Aim

To prepare the compound carbon dioxide

Equipment

2 test tubes, test-tube rack, drinking straw, 2 1-hole rubber stoppers with glass tubing, limewater, limestone/coral, 2 M hydrochloric acid, safety glasses

Method

PART A

- 1 Place 5 mL of the limewater in a test tube. Place a fresh straw in the test tube and gently blow bubbles through the limewater. Record your observations.

PART B

- 2 Add a couple of pieces of limestone or coral to another test tube. Cover with 2 cm of hydrochloric acid.
- 3 Stopper immediately and pass the rubber tubing into a test tube filled with limewater.
- 4 Record what you see happening in both test tubes.

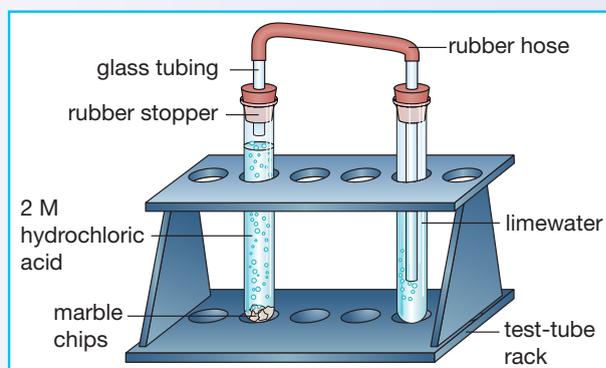


Fig 10.1.5 Apparatus set-up for preparation of CO₂

Questions

You might need to read ahead to find the information to answer some of these questions.

- 1 Identify the gas that humans breathe out.
- 2 Evaluate evidence to determine whether the gases made in Parts A and B are the same.
- 3 Is carbon dioxide an element or a compound? Explain.

Compounds

Compounds are formed when different elements combine chemically. Compounds can be either many identical molecules or a lattice: a drop of water contains millions of H₂O molecules and a grain of salt has millions of NaCl units.

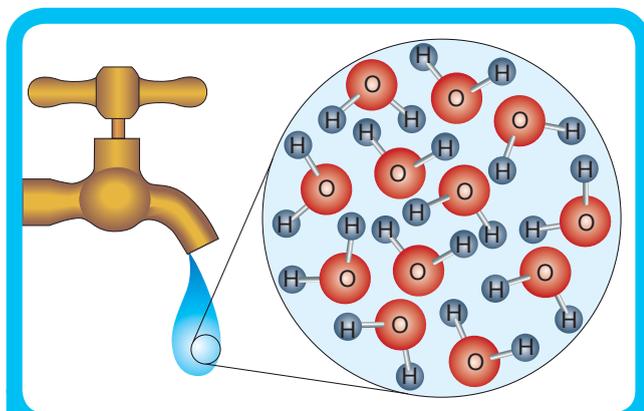


Fig 10.1.6

A compound is made up of many identical molecules or units.

Mixtures

A mixture can be separated by simple physical techniques such as filtration or evaporation since it is made of different elements or compounds simply thrown together. No formula can be written for a mixture. Examples of mixtures include salt water, a can of cola, soil, air and blood.

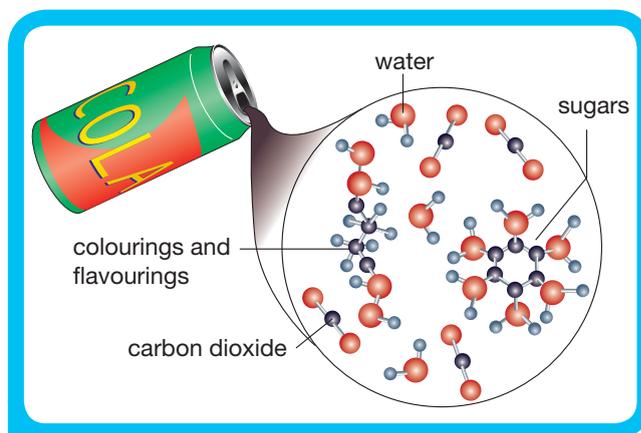


Fig 10.1.7

Soft drinks are mixtures of many compounds.

Checkpoint

Atoms

- Identify which of the three subatomic particles (p^+ , n , e^-):
 - is the smallest
 - is positive
 - is neutral
 - spins around the nucleus
 - are in the nucleus
 - is negative.
- Use Figure 10.1.1 to help you describe the structure of an atom, using the terms 'protons', 'neutrons' and 'electrons'.

Atomic and mass numbers

- Explain the relationship between the number of protons and electrons in an atom.
- Clarify the following expressions:
 - atomic number
 - mass number
 - nucleus.
- Identify the number of protons, neutrons and electrons that would be found in each of the following atoms:
 ${}_{26}^{56}\text{Fe}$, ${}_{26}^{59}\text{Ni}$, ${}_{29}^{64}\text{Cu}$, ${}_{79}^{197}\text{Au}$
- What information would you use to differentiate between atoms of different elements?

Elements

- Use an example to identify the smallest unit of an element.
- Dalton proposed his atomic theory in 1808. Outline the theory.
 - Explain which part of Dalton's atomic theory was later found to be incorrect.

Molecules and lattices

- Use examples to distinguish between atoms and molecules.
- Construct a diagram to represent:
 - an atom of carbon, C
 - a molecule of water, H_2O
 - a molecule of oxygen, O_2
 - the lattice of sodium chloride, NaCl.

Compounds

- Describe how compounds are formed.
- Identify three examples of compounds.
 - Describe where these compounds may commonly be found.

Mixtures

- Use an example to outline how a mixture can be identified.
- 'A chemical formula could never be written for a glass of cordial.' Analyse this statement.

Think

- Copy the following and change any incorrect statements so they become true.
 - The mass number is usually bigger than the atomic number of an atom.
 - The chemical symbol for iron is Fe.
 - Salt is the compound NaCl.
 - Most of the atom is empty space.
 - A molecule is the same as a lattice.
- Identify each of the following as an element, compound or mixture. Explain your choice for each:
 - lead, Pb
 - nitric acid, HNO_3
 - ammonia, NH_3
 - peanut butter
 - sea water.
- Copy the diagrams in Figure 10.1.8 into your workbook. Identify and label each diagram as an atom, a molecule, a compound, a lattice or a mixture.

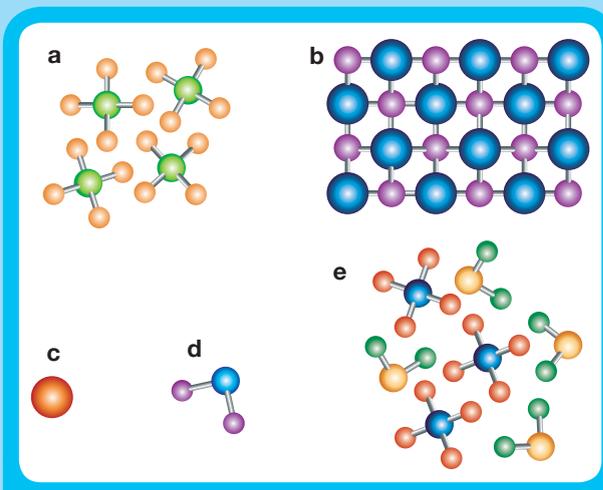


Fig 10.1.8

Analyse

- Distinguish between:
 - an element and a compound
 - the element iron and an atom of iron
 - the compound water and a molecule of water
 - a compound and a mixture
 - an atom and a molecule.
- State the elements, and how many there are of each, in a single molecule of:

a SO_2	b H_2S
c $\text{C}_{12}\text{H}_{22}\text{O}_{11}$	d H_2SO_4
e CH_3COOH (take care!).	

>>



Skills

- 20 Atoms can be compared by examining their atomic structure. Copy and complete the table opposite.
- 21 Construct models of various chemical compounds using toothpicks to represent the bonds between atoms, and various fruit pieces to represent different types of atoms. Build models of:
- the molecules H_2O , H_2O_2 and other molecules found in this unit
 - the lattices of diamond and sodium chloride
 - a mixture that could represent a soft drink.

Atom	Atomic number	Mass number	Number of protons	Number of neutrons	Number of electrons	Symbol for the atom
Carbon	6			6	6	$^{12}_6C$
Sulfur		32		16		
Sodium	11			12		
Oxygen			8	8		
Fluorine	9	19				
Iodine		127		74		

[Extension]

Investigate

Check the nutrition information on the labels of:

- a canned food
- a packet of Weet-Bix (see the information in Figure 10.1.9)
- a soft drink

List the ingredients under the headings: element, compound, mixture.

INGREDIENTS: WHOLE GRAIN WHEAT (97%), RAW SUGAR, SALT, MALT EXTRACT, VITAMINS (NIACIN, THIAMIN, RIBOFLAVIN, FOLATE), MINERAL (IRON). NO ARTIFICIAL FLAVOURINGS OR COLOURINGS.

TIP: When reading the ingredients list, the first item on the list makes up the largest amount of the product. Pure Australian wheat makes up 97% of Weet-Bix.

NUTRITION INFORMATION (average)			
	Per serve	Per 100g	Per serve with 1/2 cup whole milk
SERVING SIZE: 30g (2 biscuits)			
SERVINGS PER PACK: 33			
Energy (kJ)	444	1480	792
(Cal)	106	354	189
Protein (g)	3.6	12.0 (12%)	7.7
Fat - Total (g)	0.4	1.3 (1.3%)	5.2
- Saturated Fat (g)	0.1	0.3 (0.3%)	3.4
Cholesterol (mg)	0.0	0.0	16.3
Carbohydrate - Total (g)	20	67	26
- Sugars (g)	0.8	2.8 (2.8%)	6.7
Dietary Fibre (g)	3.3	11.0 (11%)	3.3
Sodium (mg)	84	280	135
Potassium (mg)	102	340	292
Thiamin (mg)	0.55 (50% RDI)*	1.83	0.55
Riboflavin (mg)	0.42 (25% RDI)*	1.4	0.72
Niacin (mg)	2.5 (25% RDI)*	8.3	2.5
Folate (μ g)**	100 (50% RDI)*	333	106
Iron (mg)	3.0 (25% RDI)*	10.0	3.0

* RDI – Recommended Dietary Intake
 ** = 1 serve provides 25% of the folate RDI for women of childbearing age

Fig 10.1.9

UNIT 10.2

Arranging the elements

Introduction

The story of the periodic table begins in 1829, with the German chemist Johann Dobereiner. He was the first to see a relationship between the properties of the fifty-five elements known at that time and their atomic masses. Dobereiner showed that groups of elements acted remarkably similarly to each other, as if they belonged to the

same 'family': their physical properties (colour, melting and boiling points, density, hardness) and chemical properties (the way they reacted with other chemicals) were alike. He noted that the properties of the element bromine seemed halfway between those of chlorine and iodine. Being able to group similar elements together was the beginning of the periodic table.

A short history of the periodic table

In 1864, the English chemist John Newlands arranged the sixty or so known elements in order of increasing atomic mass. When placed in columns of seven, similar elements tended to be in the same horizontal rows. Unfortunately, the rows of his table also contained some dissimilar elements, but at least it was a start.

Later, in 1869, Russian chemist Dmitri Ivanovich Mendeleev arranged the known elements in order of atomic mass, putting the known 'families' into vertical columns. To do this he needed to leave gaps in the table, predicting that these were elements not yet discovered. Using 'family likeness', Mendeleev predicted the chemical properties these unknown elements could have. When eventually these elements were discovered, their properties closely matched his predictions.

In 1868–69, German chemist Lothar Meyer constructed a similar table to that of Mendeleev by comparing the physical properties of elements with atomic mass. He did not leave gaps for undiscovered elements and went into print in 1870, one year after Mendeleev. Despite losing the race to be first, Meyer is acknowledged as a joint 'father' of the periodic table.

The present periodic table (see Figure 10.2.2) is very much like the later table designed by Meyer.

The final 'modern' periodic table was the result of work by a young English physicist,

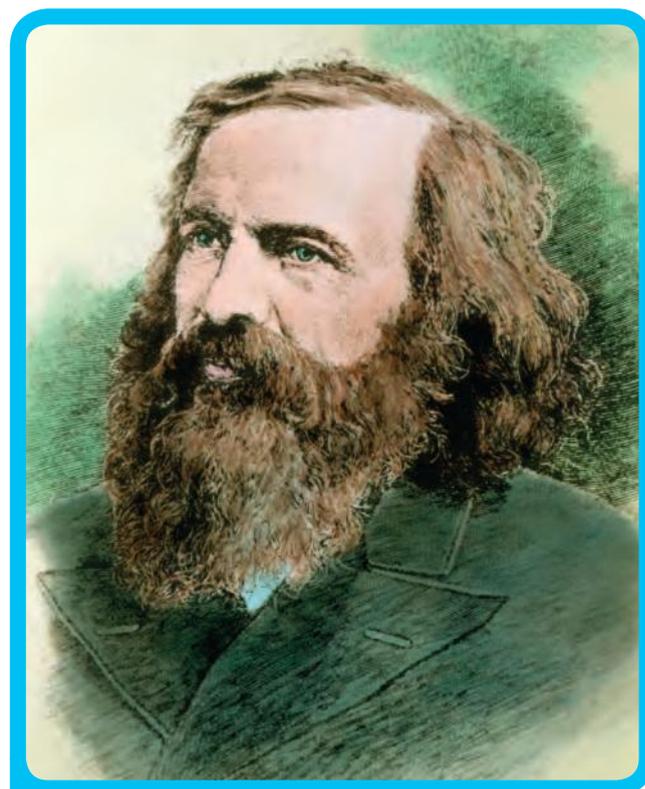


Fig 10.2.1 A portrait of Mendeleev

Henry Moseley, in 1913. He suggested that the physical and chemical properties were related to the atomic number, rather than mass. He refined the previous periodic tables to come up with a more accurate one with fewer errors and fewer missing elements.

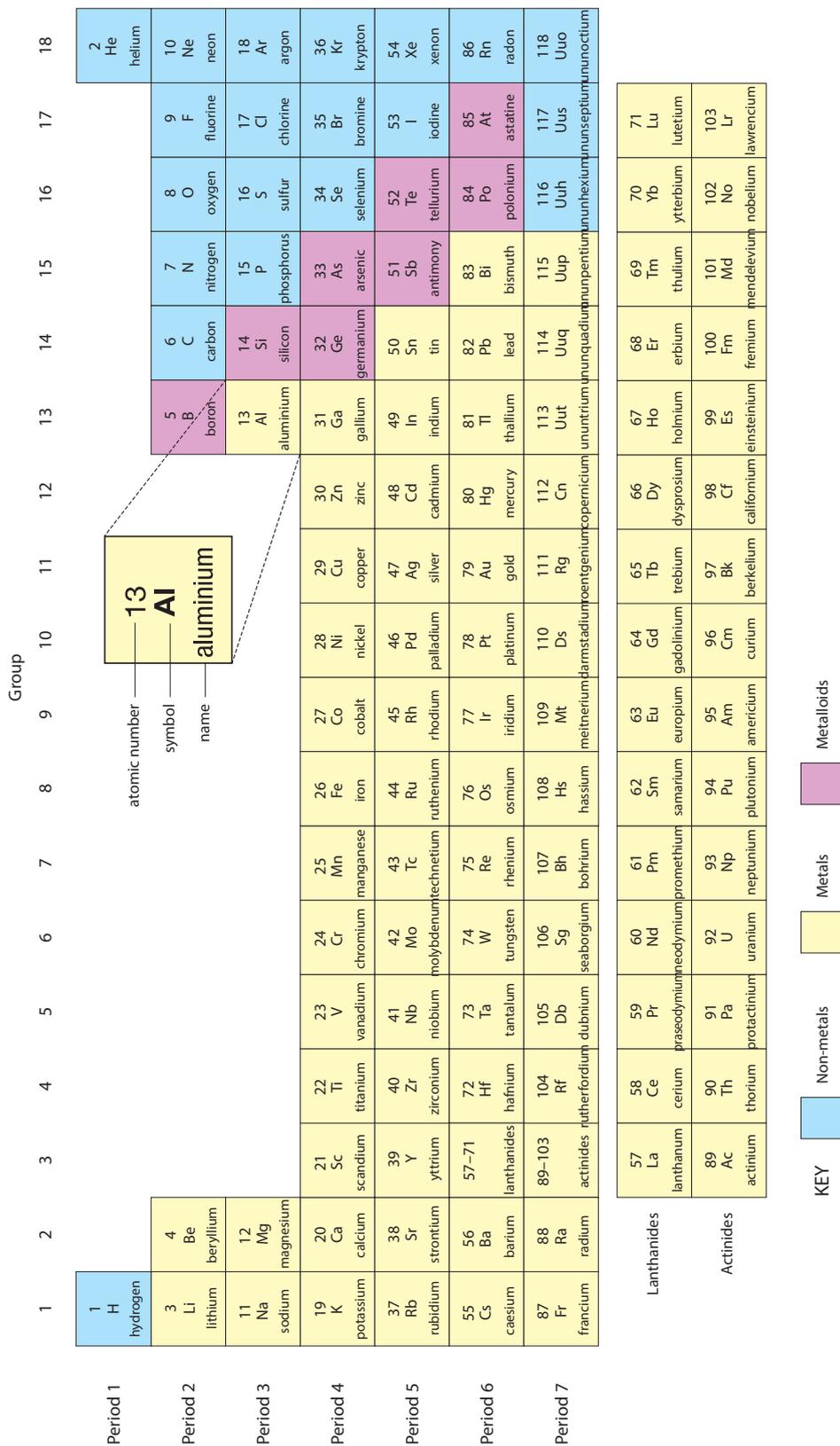


Fig 10.2.2 The periodic table

Features of the periodic table

About 80 per cent of the elements in the periodic table are metals. Another smaller set of elements is classified as non-metals. Separating the metals and non-metals is a set of elements that act a little like both—the semi-metals (sometimes called the metalloids).

The most reactive metals (for example Fr) are in the bottom left of the table and the most reactive non-metals are in the upper right (F).

Horizontal rows in this table are called periods and are numbered 1 to 7. Vertical columns are

called groups and are given the roman numerals I to VIII.

There are blocks of elements without normal group numbers: the transition elements, the lanthanides and the actinides.

There are at least fifteen synthetic (artificial) elements, made solely in the laboratory by nuclear reactions. All of these quickly break down into other stable elements. Some change so quickly that few experiments have been able to be performed on or with them.

Activity 2

Comparing elements

Aim

To examine the physical and chemical properties of common elements

Equipment

Samples of sulfur, aluminium, carbon, silicon, tin, zinc, lead, magnesium, calcium and iron; steel wool; 3 to 4 test tubes and rack; power pack about 2 V or 2×1.5 V dry cells; wires with alligator clips; light globe; safety glasses

Method

- 1 Construct a table in your workbook like the one below.
- 2 Describe the appearance of each sample.
- 3 'Shine' the sample with the steel wool. Record its appearance now.
- 4 Try to bend the sample. Does it bend or crumble?
- 5 Place some of the sample in water: does it float? Watch for any reaction.
- 6 Using the light globe, test whether the sample conducts electricity.

Questions

- 1 Identify the properties that are similar in each of the metals.
- 2 Identify the properties that are similar in each of the non-metals.

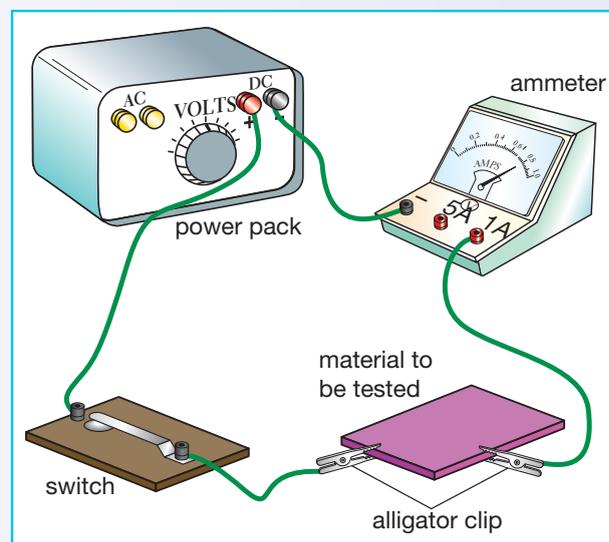


Fig 10.2.3 Does it conduct?

Element	Metal or non-metal	Appearance	Shiny or dull when polished	Floats or sinks	Action with water	Electrical conductivity



10.2 [Questions]

UNIT

Checkpoint

A short history of the periodic table

- Identify three scientists who worked on the periodic table.
 - Outline the contribution that each scientist made.
- Explain why Mendeleev left some gaps in his original table.

Features of the periodic table

- Copy the following statements and change any that are incorrect so they become true.
 - Horizontal rows in the periodic table are transition metals.
 - Vertical columns are called 'periods'.
 - The most reactive metallic atom is lithium, Li.
 - The most reactive non-metallic atom is fluorine, F.
 - The transition elements are all metals.

Use the periodic table to answer questions 4–10.

- Identify the following elements and classify them as either metal, non-metal or semi-metal: Cl, Na, Ar, Si, Cu, Ge
- List the names of the semi-metals.
- List the symbols of ten non-metals.
- List five common transition elements.
- Identify the groups in which most metals and non-metals are found.
- Identify five physical properties that can be used to describe elements.
- Identify three elements that:
 - are in Group VI
 - are in Period 3
 - would be in the same 'family' but not in Group VI
 - would show similar chemical properties but are not in a, b or c above

Think

- The symbols of some elements come from their Greek or Latin names. Use the periodic table to interpret which elements these names describe:
 - cuprum
 - aurum
 - wolfram
 - bromos
 - plumbum.
- The word 'ferrous' means 'containing iron'. Use the element symbols to suggest a reason why.
- Plumbing pipes were once made of lead. Work out where the words 'plumber' and 'plumbing' came from.

Analyse

- Use the periodic table to predict the mass number of:
 - a hydrogen atom with three neutrons
 - a chlorine atom with twenty neutrons
 - a nickel atom that has thirty neutrons.
- Construct a timeline to represent the historical development of the periodic table. Include dates, scientists' names and their main contributions.

[Extension]

Investigate

- The scientist Mendeleev had an element named after him. Investigate his life and the important work done by him. Write a short biography to summarise your information.

Create

- Research an element of your choice and gather the following details:
 - name of element, symbol, atomic number and whether it is a metal, non-metal or semi-metal
 - appearance; include state (solid, liquid or gas) at room temperature
 - at least two uses of the element
 - a brief history of its discovery.
 - Present your information as a poster.
- Do some further research on the properties and uses of some elements of your choice.
- Compare Mendeleev's original periodic table with the table we use today. What differences and similarities are there?

UNIT 10.3

Discovery of the elements

Introduction

By 1808, John Dalton had provided a solid scientific basis for an atomic theory of matter. In producing his theory, Dalton had used the ideas and studies of many who had died.

An idea proposed by Frenchman Pierre Gassendi in 1649 was important in making way for the idea of atoms to become accepted. The Church had originally adopted Aristotle's idea that matter was composed of the four elements: earth,

air, fire and water. However, it had opposed 'atomism' and considered atoms as 'godlessness' due to the original suggestion by Democritus that there was no end to the universe since it had not been created by any outside power. But unlike the early Greeks, Gassendi suggested that atoms existed and moved *dei gratia* (as a gift of God). This new view was important in allowing the atomic view to gain eventual acceptance by the Church.

The path to the elements

The alchemists based their ideas on Aristotle's four elements. Although they did not succeed in their aim to change base metals into gold, they did provide a lot of useful information about the composition and properties of many materials. The materials that were considered elements by early chemists such as Dalton were those that could not be separated into simpler parts.

The English scientist Robert Boyle (1627–91) supported an atomic view, and suggested in his 1661 book, *The Sceptical Chymist*, that 'the chemical elements must be actual, physical substances rather than the "principles" used by the alchemists'.

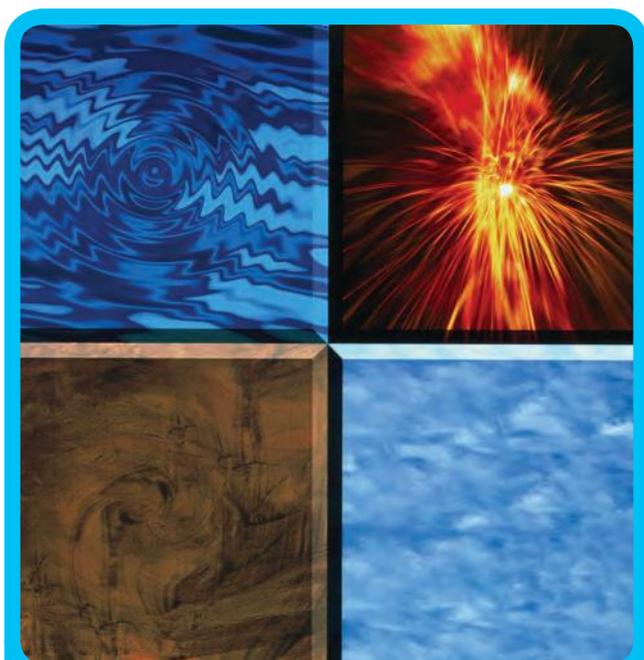


Fig 10.3.1 The four elements of matter as proposed by Aristotle: water, fire, earth and air

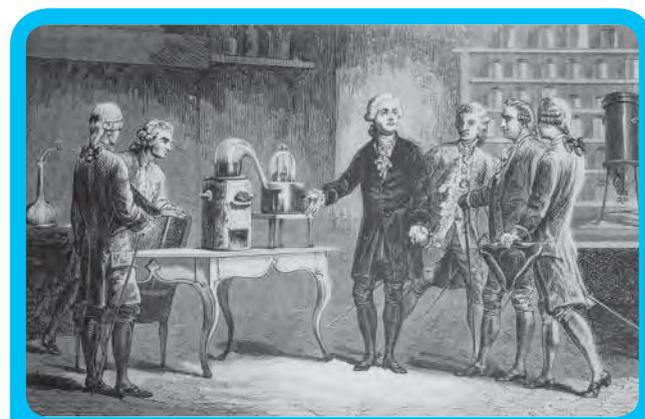


Fig 10.3.2 Lavoisier used sound scientific method to investigate elements. In this experiment done in 1776 he separated air and discovered the element oxygen.

The French chemist Antoine Lavoisier (1743–94), who clearly established chemistry as a modern science, also suggested that matter was made up of the atoms of two or more elements combined. The following text is an excerpt from his book, *Elements of Chemistry*, published in 1789. The text reveals his insight into atoms, and clearly demonstrates how he applied the scientific method to his work.

... if, by the term elements we mean to express those simple and indivisible atoms of which matter is composed, it is extremely probable that we know nothing at all about them; but if we apply the term elements, or principles of bodies, to express our idea of the last point which analysis is capable of reaching, we must admit as elements all the substances into which we are capable, by any means, to reduce bodies by decomposition.

A discovery provides a valuable tool

Towards the end of the eighteenth century, the list of known elements had begun to grow rapidly. The development of the electrochemical cell (battery) by Alessandro Volta in 1800 provided those exploring matter with the first continual source of electricity to use in experiments. It was not long before electricity had been used to break up water into the elements hydrogen and oxygen using electrolysis. In 1807, the English chemist Sir Humphry Davy used a large battery with conducting electrodes to explore soda and potash, which were believed to be elements. He found that as the solid blocks melted, drops of shiny metal began to form which burnt spontaneously. When he removed air to prevent combustion, Davy was able to produce two undiscovered, highly reactive metal elements, sodium and potassium. This proved that soda and potash were in fact compounds.

Quantitative studies bring increased understanding

The use of electricity significantly improved the understanding of matter and elements over the next few years. New quantitative ways of measuring elements were developed, and as scientists discovered new elements the properties of these were studied carefully. Many scientists carrying out quantitative physical and chemical investigations identified patterns from this research. Ultimately this new information led to Mendeleev developing the periodic table. The search for the missing elements predicted by Mendeleev as gaps in his periodic table eventually led to all but a few of the elements with an atomic number less than 92 being found.



Fig 10.3.3 Sodium metal is highly reactive and burns in contact with air.

The order of discovery of the elements

Discovery period	Elements in order of discovery	Total number known
Ancients	C, S, Au, Cu, Ag, Fe, Pb, Sn, Hg	9
Alchemists	Sb, As, Zn, Bi, P	14
1735–1745	Co, Pt	16
1745–1755	Ni	17
1755–1765	None discovered	17
1765–1775	H, N, O, Cl, Mn, F	23
1775–1785	Mo, Te, W	26
1785–1795	U, Zr, Sr, Ti, Y	31
1795–1805	Cr, Be, V, Nb, Ta, Ce, Pb, Rh, Os, Ir	41
1805–1815	K, Na, Ba, Ca, Mg, B, I	48
1815–1825	Li, Cd, Se, Si	52
1825–1835	Al, Br, Th	55
1835–1845	La, Tb, Er, Ru	59
1845–1855	None discovered	59
1855–1865	Cs, Rb, Tl, In	63
1865–1875	None discovered	63
1875–1885	Ga, Yb, Sm, Sc, Ho, Tm	69
1885–1895	Pr, Nd, Gd, Dy, Ge, Ar	75
1895–1905	He, Eu, Kr, Ne, Xe, Po, Ra, Ac, Rn	84
1905–1915	Lu	85
1915–1925	Hf, Pa	87
1925–1935	Re	88
1935–1945	Tc, Fr, At, Np, Pu, Cm	94
1945–1955	Am, Pm, Bk, Cf, Es, Fm	100
1955–1965	Md, No, Lr	103
1965–1999	Db, Rf, Sg, Bh, Hs, Mt, Uun, Uuu, Uub	112

The final steps: artificial elements

As a greater understanding of the structure of atoms developed, particularly knowledge about the nucleus and nuclear forces, it became obvious that the missing elements would not exist naturally. In order to complete the picture, humans have used nuclear reactions to artificially create (synthesise) the missing

elements, including promethium (61) and technetium (43). The use of nuclear reactors, and the explosion of nuclear weapons, have added to the known elements. A number of new artificial (synthetic) elements have been created that have an atomic number greater than atomic number 92, uranium.

10.3

[Questions]

UNIT

- 1 Explain some of the reasons why the list of elements was so small in 1750 (fewer than twenty known elements).
- 2 Research and outline some of the sources of electricity that were available before the invention of the electrochemical cell by Alessandro Volta.
- 3 The real breakthrough with organising the elements into the periodic table came with the development of quantitative methods for measuring properties.
 - a Explain the term 'quantitative'.
 - b John Dalton developed a way to measure the relative atomic mass of the different elements. Research and describe the meaning of the term 'relative atomic mass', using examples.
- 4 Examine the table showing the discovery of elements over time.
 - a In small groups discuss reasons why some elements were easy to find and obtain, while others proved to be very difficult.
 - b Construct two lists:
 - things that make elements easier to find and purify
 - things that make elements difficult to find and purify.
 - c The element potassium is difficult to identify and collect, while the element carbon is easy. Propose possible reasons for this difference.
- 5 Choose one of the scientists mentioned in this chapter and research their background. Find out:
 - a when they lived and died (or are they still alive?)
 - b what contribution they made to the knowledge of the periodic table, elements and science
 - c whether they worked with other scientists, and if so, with whom.

Present your research to the class as a short presentation (2 to 3 minutes long).

UNIT 10.4

The role of electrons

Introduction

Atoms in the periodic table are arranged according to their atomic numbers. Some physical properties (such as density) depend on an atom's atomic number and mass number. In chemical reactions, however, the electrons are far more important. The British physicist J.J. Thomson discovered electrons in 1897, and this led to our current understanding of chemical reactions and

properties. In fact, electrons determine all the chemical reactions that an atom takes part in and the numbers of each atom in any new compound formed.

Chemical reactions happen when atoms bump into each other. The protons and neutrons are relatively unaffected by the bump, being at the centre of the atom in the nucleus. The outermost electrons, however, are greatly affected and are easily 'grabbed' or shared by other atoms.

Electron shells

Electrons do not orbit just anywhere around the atom, but in shells or energy levels, which are numbered 1, 2, 3 and 4.

It is easy to picture these shells if we imagine a bean seed as the nucleus of our atom. The seed sits in the middle of a table tennis ball (first shell). All this sits inside a tennis ball (second shell), which sits inside a basketball (third shell), which sits inside a beach ball (fourth shell). Imagine electrons as ants on the outside of each ball. Each ant stays as far away as possible from the other ants (electrons repel each other because of their negative charges). Only two ants fit on the first ball (otherwise they would be too close) but more ant-electrons can fit onto the next three balls because those balls are bigger.

The number of electrons that can actually fit in each shell is:

First shell	Second shell	Third shell	Fourth shell
Maximum of 2 e ⁻	Maximum of 8 e ⁻	Maximum of 18 e ⁻ but happy if it holds only 8	Maximum of 32 e ⁻ but happy if it holds only 8

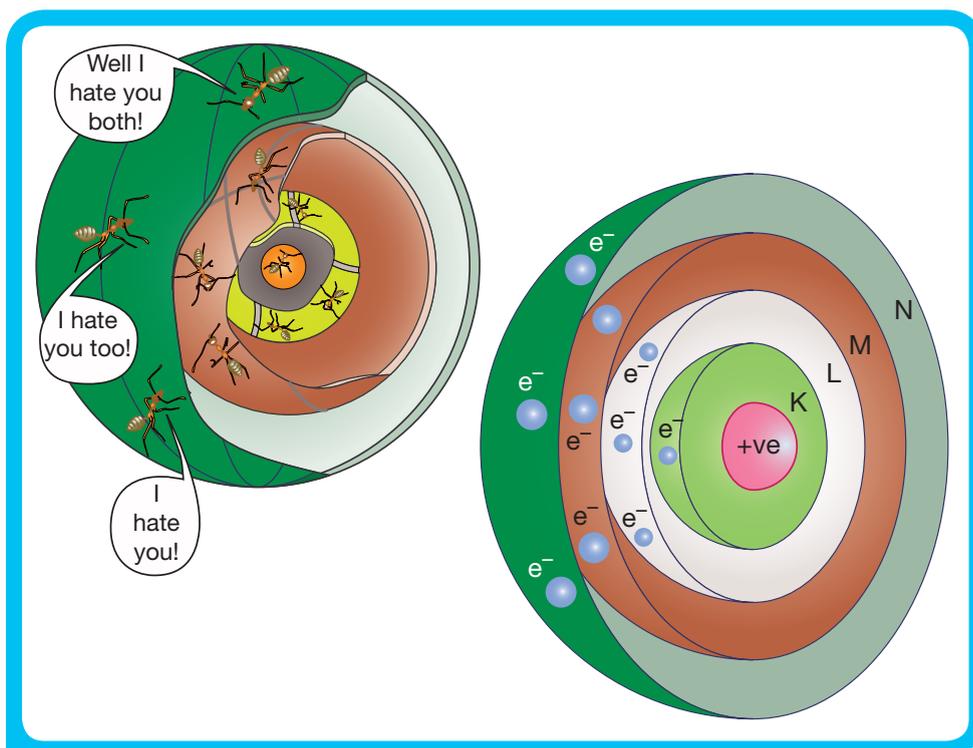


Fig 10.4.1 The structure of an atom showing energy levels, and a convenient way of imagining it!

Electronic configuration

The arrangement of electrons in the shells is called the atom's electronic configuration.

Silicon (Si) has fourteen electrons. Two electrons go into the first shell, eight into the second and the remaining four go into the outer shell: its electronic configuration is written as 2,8,4.

The electronic configurations of the first twenty elements are shown in the following table.

	Group I	Group II	Group III	Group IV	Group V	Group VI	Group VII	Group VIII
Period 1	H 1							He 2
Period 2	Li 2,1	Be 2,2	B 2,3	C 2,4	N 2,5	O 2,6	F 2,7	Ne 2,8
Period 3	Na 2,8,1	Mg 2,8,2	Al 2,8,3	Si 2,8,4	P 2,8,5	S 2,8,6	Cl 2,8,7	Ar 2,8,8
Period 4	K 2,8,8,1	Ca 2,8,8,2						

Periods, groups and electrons

Notice that:

- the number of shells used by an atom is the same as the period number
- the group number is the same as the number of outer shell electrons (helium, He, is an exception).

For example, F has the configuration 2,7. It has two shells, so it is placed in Period 2. It has seven electrons in its outer shell and so is placed in Group VII.

If two atoms are in the same group, they have the same number of outer shell electrons and will have similar properties. As we move down a group, more shells are used. The atoms get bigger and slight differences in properties can be expected.

Atoms that react and atoms that do not

Group VIII (sometimes called Group 0) contains elements that are stable and rarely react. Group VIII elements are called the noble gases. Helium (He) was the first to be discovered—in 1894 by the British scientists Lord Rayleigh and Sir William Ramsay. Ramsay later discovered all the other

noble gases and added them to Group VIII. The noble gases are stable because He and Ne atoms have their outer shells filled and Ar, Kr, Xe and Rn have eight electrons in their outer shell.

All other atoms react so that they can become as stable as the noble gases: they also want a filled outer shell, or eight electrons in it. To do this, atoms gain electrons, lose electrons or sometimes even share electrons. Knowing this allows us to start to predict what atoms will do in a chemical reaction.

Group VIII
He
Ne
Ar
Kr
Xe
Rn

Fig 10.4.2 The noble gases do not want to react.

Ions

If the number of electrons in an atom changes, it becomes electrically charged and we call it an ion (a Greek word for 'the ones that move').

- If an atom loses electrons, it becomes a positive ion.
- If an atom gains electrons, it becomes a negative ion.

To see an example of how ions form, let's look at how common table salt, sodium chloride, is formed.

If a sodium atom meets a chlorine atom, the sodium loses its outer shell electron to form the sodium ion, Na^+ . Chlorine takes the electron from sodium to become the ion Cl^- . It now has a new name: chloride. Both ions are stable and happily exist as Na^+Cl^- , or sodium chloride (common salt).

	Sodium		Chlorine		
	Before	After	Before	After	After
p^+	11	11	p^+	17	17
e^-	11	10	e^-	17	18
Charge	Neutral	+1	Charge	Neutral	-1

The attraction between the positive and negative ions holds the salt crystal together as shown in Figure 10.4.3. Ionic charges for several common elements are shown in the table on page 217.

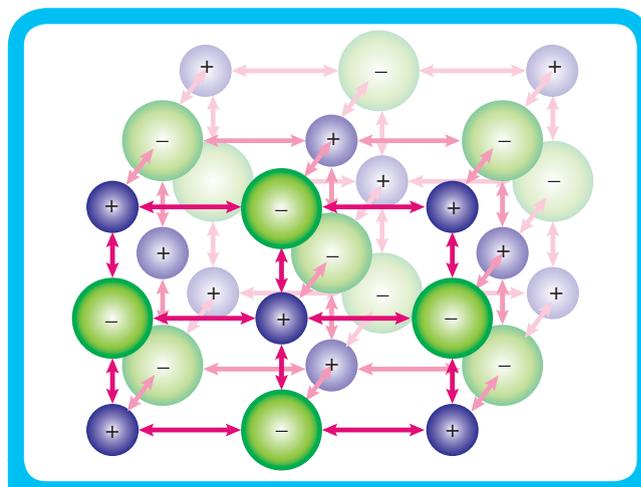


Fig 10.4.3 The sodium chloride lattice: positive and negative ions attract.

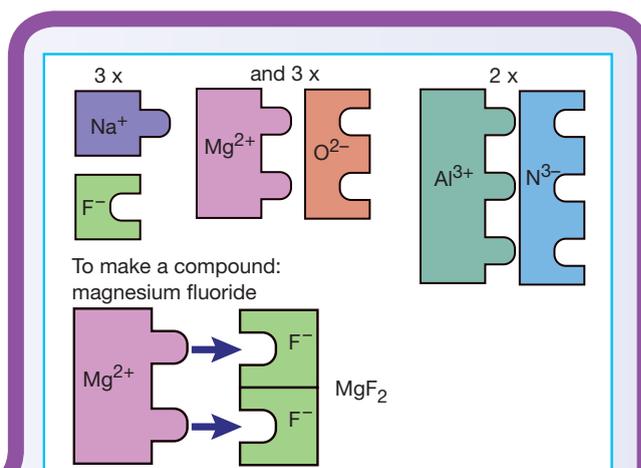


Fig 10.4.4 You need these jigsaw pieces.

Activity 3

Ions get together!

Aim

To construct models of ionic compounds using an ion jigsaw

Equipment

Photocopy of jigsaw pieces (Figure 10.4.4)

Method

- 1 Carefully cut around the jigsaw pieces on the sheet provided by your teacher.
- 2 Copy the following table into your workbook with space for nine rows.
- 3 Use the jigsaw pieces to 'create' the following compounds: sodium fluoride, sodium oxide, sodium nitride, magnesium fluoride, magnesium

oxide, magnesium nitride, aluminium fluoride, aluminium oxide, aluminium nitride

- 4 Put all the relevant information about each compound in the table.

Questions

- 1 Identify whether the overall charge of each compound was positive, negative or neutral.
- 2 Propose a rule that allows you to predict the formula of a compound.

Compound name	Positive ion used	Negative ion used	Compound formula	Total positive charge	Total negative charge	Overall charge of compound

Element	Atomic number	Number of electrons	Electronic configuration	The atom could lose	Or it could gain	Most likely scenario	Most likely ion formed
H	1	1	1	1e ⁻	1e ⁻	Uncertain	H ⁺ or H ⁻
He	2	2	2	Unreactive		No ion formed	
Li	3	3	2,1	1e ⁻	7e ⁻	Lose 1e ⁻	Li ⁺
Be	4	4	2,2	2e ⁻	6e ⁻	Lose 2e ⁻	Be ²⁺
B	5	5	2,3	3e ⁻	5e ⁻	Lose 3e ⁻	B ³⁺
C	6	6	2,4	4e ⁻	4e ⁻	Uncertain	
N	7	7	2,5	5e ⁻	3e ⁻	Gain 3e ⁻	N ³⁻
O	8	8	2,6	6e ⁻	2e ⁻	Gain 2e ⁻	O ²⁻
F	9	9	2,7	7e ⁻	1e ⁻	Gain 1e ⁻	F ⁻
Ne	10	10	2,8	Unreactive		No ion formed	

10.4 [Questions]

Checkpoint

Electron shells

- 1 Define the term 'energy levels'.
- 2 Identify the number of electrons each shell normally holds.

Electronic configuration

- 3 Clarify what the electronic configuration of an atom shows.
- 4 Describe the electronic configuration of magnesium.

Periods, groups and electrons

- 5 Describe what the following have in common:
 - a atoms in the same group
 - b atoms in the same period.

Atoms that react and atoms that do not

- 6 Identify which group contains elements that rarely react.
- 7 Distinguish between atoms that react and atoms that do not react.

Ions

- 8 Compare a chlorine atom with a chloride ion.
- 9 Describe what happens when a sodium ion forms.
- 10 Explain the difference between the formation of a positive ion and a negative ion. Use a diagram to clarify your answer.
- 11 Identify three positive and three negative ions by name and symbol.

Think

- 12 Explain why noble gases do not form ions.
- 13 Sodium chloride has charges but no overall charge. Explain.
- 14 Identify the period and group to which these atoms belong:
 - a an atom with configuration 2,4
 - b an atom with configuration 2,8,6
 - c an atom with 7 electrons
 - d an atom with 15 electrons

- e Ca
- f Ne.

- 15 Write the electronic configuration of these atoms.

- a an atom in Period 2, Group VI
- b an atom in Period 3, Group VIII
- c an atom in Period 1, Group VIII (be careful)
- d an atom of Mg
- e an atom of S

- 16 'We don't worry about the number of neutrons when calculating the charge of an ion.' Justify this statement.

Analyse

- 17 a Copy the following table into your workbook with space for eight more rows:

Atomic number	Element (name and symbol)	Number of protons	Number of electrons
7	Nitrogen (N)	7	7

- Below is information about eight different atoms. Find their atomic number, name and symbol, number of protons and number of electrons. Place all this information in the table.
 - i an atom with 8 protons
 - ii an atom with 18 protons
 - iii an atom with an atomic number of 3
 - iv an atom with an atomic number of 19
 - v an atom in Period 2, Group VII
 - vi an atom in Period 3, Group II
 - vii an atom of phosphorus
 - viii an atom of aluminium
- c Write the electronic configuration for each of the above atoms and then predict their likely ionic charges.
- d Construct diagrams to show the structure of four of the above atoms.

Skills

18 Copy the following table into your workbook and complete it.

Number of protons	Number of neutrons	Number of electrons	Overall charge	Is it an atom or an ion?	Symbol
8	6	8			
10	10	10			
11	10	10			
17	16	18			
15	15	18			
19	18		+1		K ⁺
20	19		+2		
8	7	10	-2		

[Extension]**Create**

Construct a model of an atom. You could use different-coloured plasticine to represent protons, neutrons and electrons. Wire could be used to represent each electron shell. Shells increase in diameter as you move from the first shell outwards. Use string to assemble the atom so that each shell is free to move independently of the other shells. Have the nucleus hanging in the centre.

Chapter review**[Summary questions]**

- Construct a simple outline of the periodic table, then use different colours to indicate the location of:
 - the transition metals
 - the semi-metals
 - the non-metals
 - the noble gases.
- Describe the position of electrons in an atom and how many electrons each shell can hold.
- Define what the period number and the group number represent.
- Name some ways in which metals are different from non-metals.
- Distinguish between a chlorine atom and a chloride ion.
- Identify the most likely charge of ions formed from an atom of:
 - five electrons
 - 17 electrons
 - oxygen
 - neon
 - Group II
 - Group V
- True or false?
 - The mass number of an atom is the number of protons it has.
 - Mercury is a solid at room temperature.
 - There are millions of different types of atoms.
 - Group V atoms all have five electrons in their outer shell.
 - Period 4 atoms all have four shells in use.
 - An atom with an electronic configuration of 2,8,5 would be in Period 5, Group III.
 - Carbon dioxide is an element.
 - Air is a compound.
 - The element carbon is found in all living things.
 - In an atom the number of electrons equals the number of protons.
 - Ions are always charged.
 - Ions are formed when atoms lose or gain protons.
 - If an atom loses electrons it becomes a negative ion.
 - An atom that has gained three electrons would now be an ion of charge -3.

[Thinking questions]

- Explain why elements of the same 'family' are always found in the same group.
- Explain which has the higher electronegativity: metals or non-metals.

10 Copy and complete the table.

Atom	Atomic number	Mass number	Number of protons	Number of neutrons	Number of electrons	Atomic symbol
Sulfur		32		16		
Hydrogen	1			0		
Beryllium		9			4	
Iodine		127		74		
Nickel	28	59				$^{59}_{28}\text{Ni}$

- 11 Hydrogen and helium can be placed in a number of places in the periodic table. Explain.
- 12 Describe what happens to the size and weight of elements as we move down any group.
- 13 Look back at the information about the main scientists and their contributions to the understanding and development of the structure of the atom and the periodic table. Construct a table to summarise this information.

[Interpreting questions]

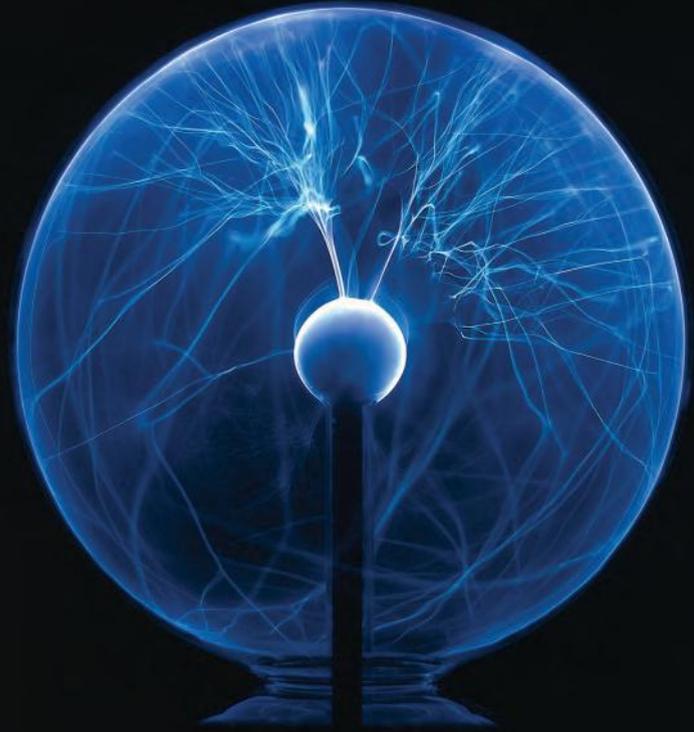
- 14 Determine how many p^+ , n and e^- these atoms have.
- a $^{35}_{17}\text{Cl}$
- b ^3_1H
- c $^{197}_{79}\text{Au}$
- 16 Explain what happens if a potassium atom meets a fluorine atom in a chemical reaction.
- 17 The outer electrons control what the atom does in a chemical reaction. Analyse reasons why this is the case.
- 18 Carbon also forms the molecule CCl_4 . Predict the compounds that would form from chlorine and the other Group IV elements.

Electricity

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

- 1 state that static electrical charge is produced by rubbing different materials together
- 2 explain the flow of electrons in a simple electric circuit
- 3 illustrate the flow of electrons using a simple circuit
- 4 express safety measures in handling household appliances
- 5 determine the average cost of using electricity for a month in several households in Honiara and other provincial centres.

- 1 What is electricity?
- 2 Why do you sometimes get 'zapped' when you rub your shoes on carpet?
- 3 What causes lightning?
- 4 What is inside a battery?
- 5 What is AC and DC and what is the difference anyway?
- 6 'It takes a lot of electricity to electrocute you.' True or false?
- 7 What devices in the home help to protect us against electrocution?



Static electricity

Introduction

Have you ever been 'shocked' after touching someone who has just slid down a plastic slide, or noticed a crackling sensation after you have removed your jumper over your head? These phenomena are caused by electricity—or more specifically, static electricity. So what exactly is electricity?

Are you positive (or negative or neutral)?

Most objects are neutral—that is, they have no overall electric charge. Objects can become charged, however, if they rub against other objects or materials. To understand how this happens, you need to look at what is happening to the atoms.

You will recall from Chapter 10 that everything is made of atoms. Atoms contain positively charged protons, negatively charged electrons and neutral neutrons. Atoms always contain an equal number of protons and electrons, and are said to be neutral. Electrons are found in the outer parts of atoms and may be moved by rubbing different materials together. This means that they might move from one surface to another if two are rubbed together. This causes one of the objects to have more electrons than protons, and the other to have fewer electrons than protons. When this occurs, the objects are said to be charged. It is important to remember that it is only the electrons that can move.

Activity 1

Positives and negatives

Aim

To investigate static electricity

Equipment

2 perspex (acetate) and 2 polythene rods or strips, 2 dry woollen cloths, watch-glass, Blu-Tack or plasticine

Method

- 1 Charge one perspex rod by rubbing it with a dry cloth and place it on a watch-glass as shown. Quickly charge the other perspex rod and bring it near the one on the watch-glass. Note the direction of any movement.

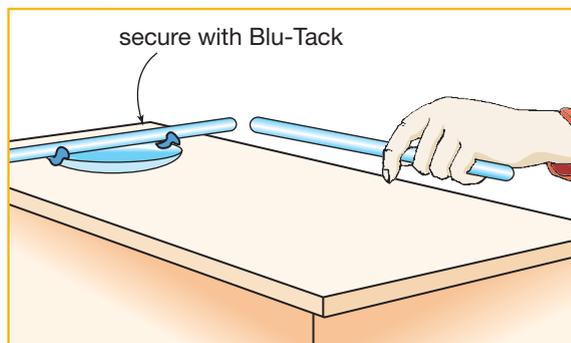


Fig 11.1.1 Apparatus set-up for investigating static electricity

- 2 Repeat step 1 for the polythene rods but use the other cloth.
- 3 Now study the effect of a charged perspex rod on a charged polythene rod, using the same cloths that were rubbed on each previously.

Questions

- 1 Explain which combinations produced attraction, and which produced repulsion.
- 2 The charge produced on the perspex rod was positive. Use this information to predict the charge produced on:
 - a the polythene rod
 - b the cloth when rubbed on perspex
 - c the cloth when rubbed on polythene.
- 3 Account for the use of a new cloth with the polythene rod in step 2.

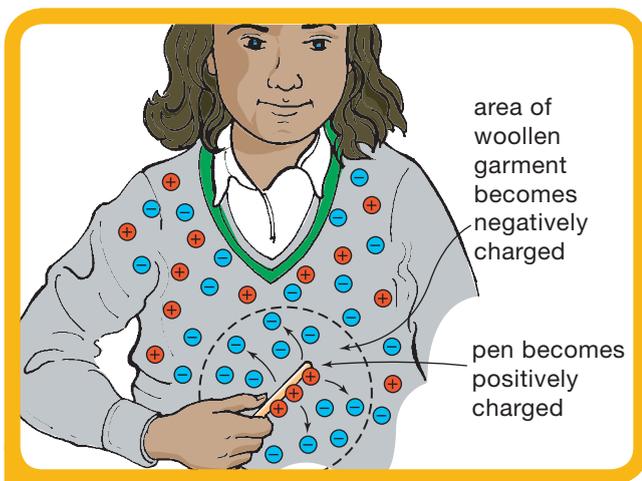


Fig 11.1.2 Negative charges (electrons) may be rubbed off a plastic pen and onto a woollen garment, leaving the pen positively charged.

An object that contains fewer electrons than protons is said to be positively charged. This object would have lost electrons to another material.

An object that contains more electrons than protons is said to be negatively charged. This object would have gained electrons from the other material.

We use the term charge to refer to either a single proton or electron, or a group of protons or electrons. In the diagrams that follow, a + or - symbol represents many millions of individual protons or electrons respectively.

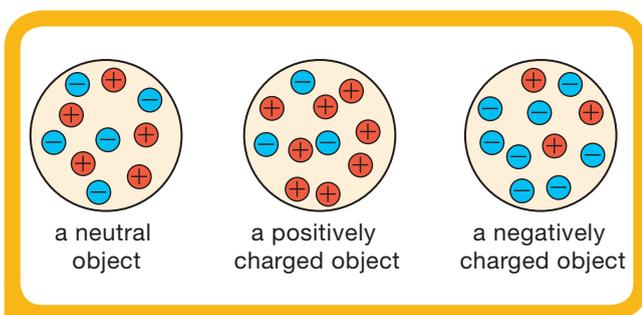


Fig 11.1.3 A neutral, a positively charged and a negatively charged object

Scientists have found that a:

- positively charged object and a negatively charged object will attract each other

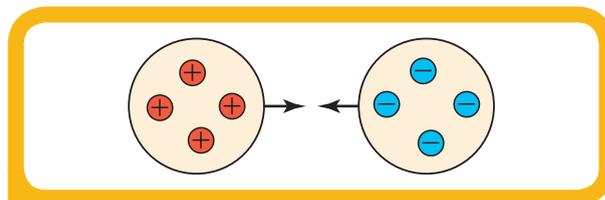


Fig 11.1.4 Opposite charges attract.

- positively charged object will repel other positively charged objects

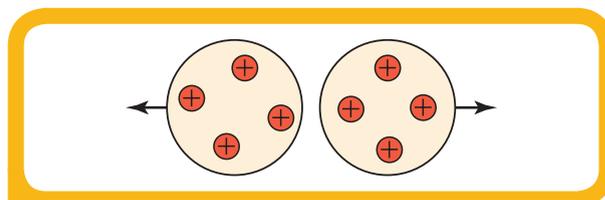


Fig 11.1.5 Like charges repel.

- negatively charged object will repel other negatively charged objects.

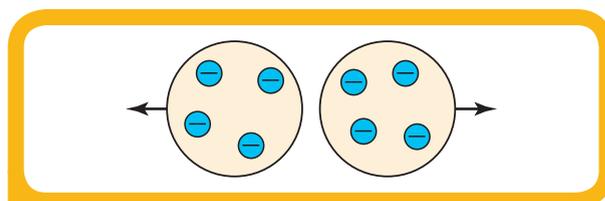


Fig 11.1.6 Like charges repel.

The attraction and repulsion forces referred to above are called electrostatic forces.

The attraction between opposite charges keeps the negative electrons orbiting the positive nucleus in atoms.

You are now in a position to answer the question 'What is electricity?' It is really just a collection of charges. Static electricity is a collection of charges that remain stationary for some time, though eventually so-called static electricity will move as it dissipates or leaks into the air.

Activity 2

Static magic

Aim

To electrostatically charge a balloon and a pen

Equipment

Balloon, plastic pen, woollen scarf or other garment

Method

- 1 Inflate a balloon and rub it on the woollen garment for a minute or so.
- 2 Hold the balloon on a smooth wall and let go.
- 3 Rub a pen on the woollen garment.
- 4 Hold the pen near (but not in) a thin stream of running water.

Questions

- 1 Explain in words what happened in each case.
- 2 Construct diagrams to support your explanations in Question 1.

Extension

A balloon becomes negatively charged when it is rubbed on a woollen garment. Devise a way of finding whether the charge produced on a rubbed pen is positive or negative.

No charge, but still attracted?

If you rub a plastic pen on a woollen jumper you will probably find it can attract small pieces of paper. The pen is charged (and so is the jumper you rubbed it on). The paper, however, has no charge and therefore should not be attracted to the pen. So, what's happening? The words 'no charge' can be misleading—what is really meant is that there are equal numbers of positive and negative charges, or that there is no overall charge.

When a negatively charged pen approaches neutral paper, negative charges in the paper are repelled and move as far away as they can. This means they move to the bottom side of the paper. The positive charges cannot move as they are tightly held in the nucleus of the atoms and so are left at the top of the paper. These positive charges in the paper are attracted to the negative pen and so the paper sticks.

After the pen and paper have been in contact for a short time, the charges spread out over both, leaving both with the same (negative) charge. They now repel each other and the paper falls off.

Charges such as those on either side of the paper are called induced charges, as, in this case, they were created or 'induced' by the charges on the pen.

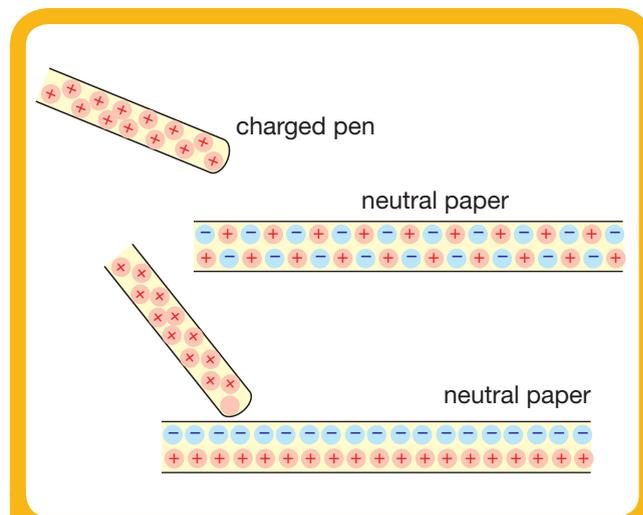


Fig 11.1.7

A neutral object can be attracted to a charged object because of induced charges.

Activity 3

Making an electroscope

Aim

To make an electroscope and test for the presence of an electrostatic charge

Equipment

Glass jar, aluminium foil, thick wire, card, tape, various rods (eg glass, polythene, ebonite) and cloths (eg wool, cotton, synthetic)

Method

- 1 Using Figure 11.1.8 as a guide, design and construct a device called an electroscope to detect an electric field.
- 2 Use the electroscope to compare the electric fields produced by various combinations of rods and cloths.
- 3 Record your results in a table.

Questions

- 1 Explain how the electroscope works. Use a diagram to support your answer.
- 2 Identify which rod and cloth produced the largest electric field.
- 3 Propose a use for an electroscope in an everyday situation.

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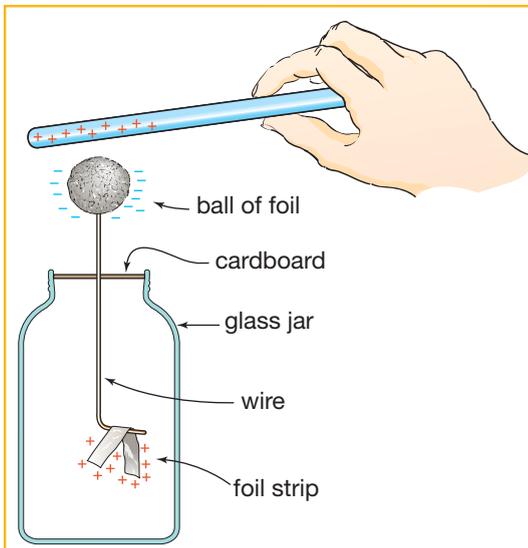


Fig 11.1.8 Electroscope set-up to test for electrostatic charge

The Van de Graaff generator

A device known as a Van de Graaff generator produces a large build-up of charge on its metal dome. This can be used to demonstrate static electricity effects, some of which are really hair-raising.

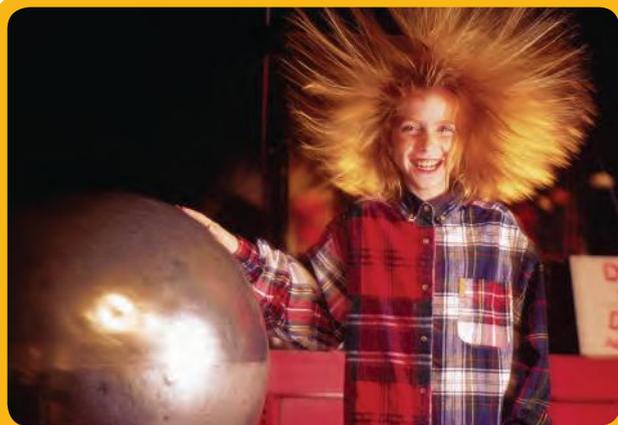


Fig 11.1.9 A Van de Graaff generator uses a belt to transfer negative charges to its metal dome.

Good and bad static electricity

Carpet static

Static electricity often charges you after you have walked on a carpet. When you walk you rub your shoes against the carpet sometimes, causing a

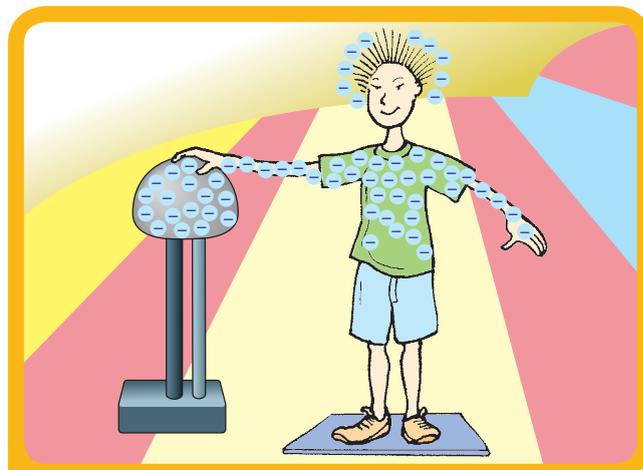


Fig 11.1.10 Negative charges accumulated on the head and hair repel each other and so spread out.

build-up of charge on your body. Rubber soles may prevent charge leaving via your feet, so that when you touch another object, all that excess charge may jump into the object. This causes a spark and gives you a small electric shock.

Charge tends to concentrate on sharp corners and spreads out more over flatter surfaces, so one way of avoiding a shock when touching an object that has built up charge is to first touch it with an open palm instead of a finger. This spreads the movement of charge and avoids a spark.

Aircraft refuelling

During refuelling, an aircraft needs to be protected from the effects of static electricity. Friction between the air and the body of the aircraft creates a large charge on the outside of the aircraft and a charge jumping from the aircraft to the fuel hose during refuelling would cause a disastrous explosion. To prevent this, a wire is first connected between the aircraft and the ground, allowing any excess charge to safely leave the aircraft.

Photocopiers

Photocopiers use static electricity to produce images. A cylindrical drum is positively charged, and an image of the original page is projected onto it. Light areas of the image destroy the charge, while black regions leave the charge intact. A fine, negatively charged powder (called toner) drops onto the drum and sticks to the positive areas. The drum then rolls its powder image onto paper, which is then heated to melt the toner permanently

onto it. Some people use the term ‘photostat’ to refer to a photocopy made in this way. Can you suggest how the word ‘photostat’ came to be used?

Thunder and lightning

Movement of water droplets and air molecules can cause charges to build up within storm clouds. If the build-up is large enough, charges may flow suddenly from one part of a cloud to another, or to a separate cloud, or even to the ground. The sudden movement of charges causes the surrounding air to become super-heated and expand rapidly. The temperatures can be as high as 30 000°C. This expansion causes shock waves to travel through the air, which we hear as thunder.

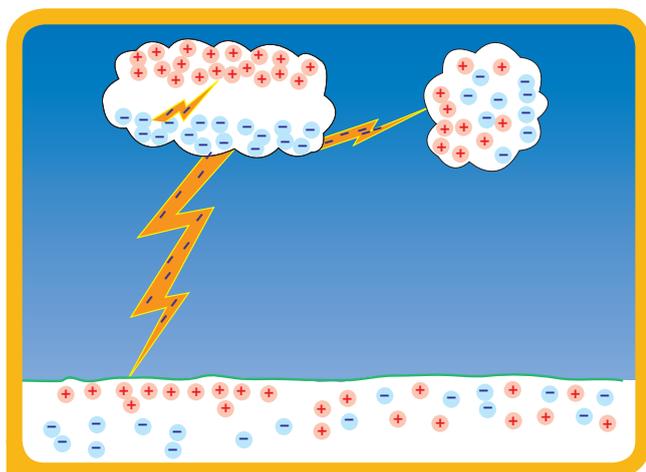


Fig 11.1.11 When electrostatic attraction is strong enough, large amounts of negative charges may move in the form of lightning.

Fields

Scientists use the term ‘gravitational field’ to describe the invisible force-field that causes objects on Earth to fall downwards towards the centre of the Earth.

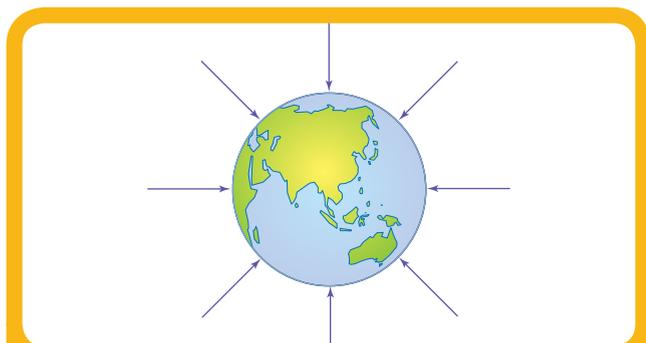


Fig 11.1.12 Earth’s gravitational field exerts a force on all objects, towards its centre.

All objects have a gravitational field, but it is only noticeable when the object is very large, for example a planet or a star.

The direction of a gravitational field of a planet is the direction in which an object would move if dropped. The gravitational field is stronger for heavier planets, and decreases as you get further away from the planet. Just as a planet has a gravitational field, a charge is surrounded by an electric field.

The direction of an electric field is the direction in which a small positive charge would move if it was free to do so. This means the electric field comes out from a positive charge and in towards a negative charge. Larger charges have stronger electric fields. Once again, the further away you go, the weaker the field becomes.

Combinations of charges can produce very complex fields, as shown in Figure 11.1.13.

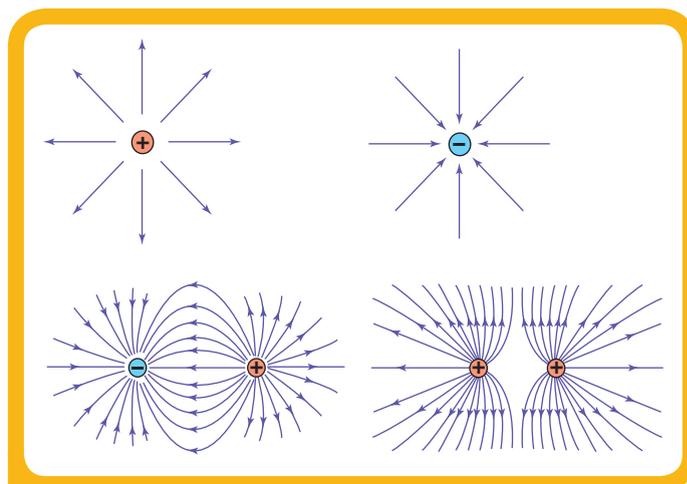


Fig 11.1.13 Electric field lines—positive and negative charges

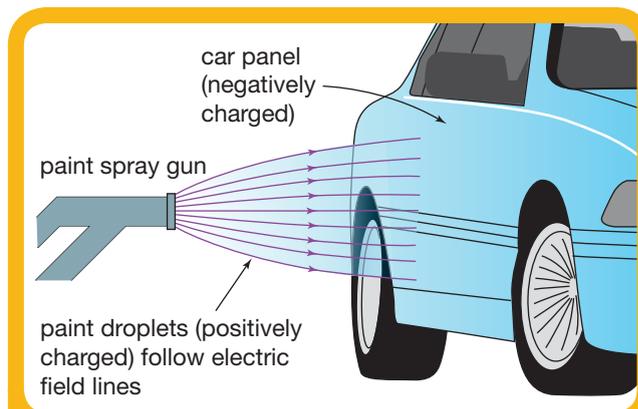


Fig 11.1.14 Electrostatic charging of paint and metal panel helps ensure an even coat.



11.1

[Questions]

UNIT

Checkpoint

Are you positive (or negative or neutral)?

- State the charge and sign for:
 - an electron
 - a proton.
- Outline what can you say about the number of protons and electrons on:
 - a neutral object
 - a positively charged object
 - a negatively charged object.
- Clarify the term 'electrostatic forces'.

No charge, but still attracted?

- Define what is meant by an 'induced charge'.
- Construct a diagram to show how a neutral object and charged object can attract each other.
- Clarify the term 'static' in static electricity.
- Describe how charge is built up in a Van de Graaff generator.

Good and bad static electricity

- Identify two uses for static electricity.
- Identify two situations in which static electricity is a nuisance.

Fields

- Define the term 'field'.
- Explain what is meant by the direction of an electric field.

Think

- Using the terms 'attract', 'repel' and 'no force', choose a term that describes each charge in the table below.

	Positive charge	Negative charge	Neutral charge
Positive charge			
Negative charge			
Neutral charge			

- In some industries, paint is positively charged before being sprayed onto negatively charged panels.
 - Explain why this method would get the paint to spread out nicely.
 - Explain why the paint is given an opposite charge to the metal panel.

- List two examples of how electric charge may be produced.
- Cleaning and polishing a mirror might actually make it more dusty. Explain how.
- Explain why a Van de Graaff generator makes a person's hair stand on end, and why it is even more dramatic if the person stands on a rubber mat.
- A spark is more likely to jump to your finger than your forehead when you approach a charged Van de Graaff generator. Explain why.
- If you tear a polythene shopping bag and try to put the pieces in the bin, they may stick to your fingers. Explain why.
- Explain why static electricity demonstrations work better on warm, dry days.
- Examine the following statements and change any that are incorrect.
 - A positively charged object contains only positive charges.
 - A neutral object contains no charges.
 - Induction is the 'coaxing' of charges in a neutral object to move to different positions within the object.
 - An object may become charged only by rubbing electrons off it.
 - Lightning is caused when a build-up of charge within a cloud jumps from the cloud to earth.
- Compare an electric field with a gravitational field.

Analyse

- Use + and - signs in Figure 11.1.15 to demonstrate the position of various concentrations of charge.

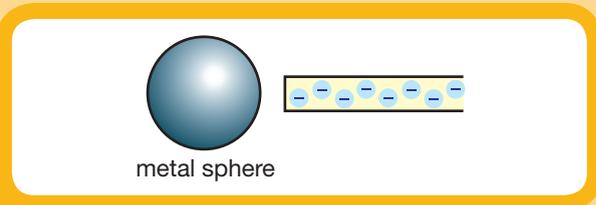


Fig 11.1.15



23 Figure 11.1.16 shows one type of Van de Graaff generator. Account for the charge transfer to the dome.

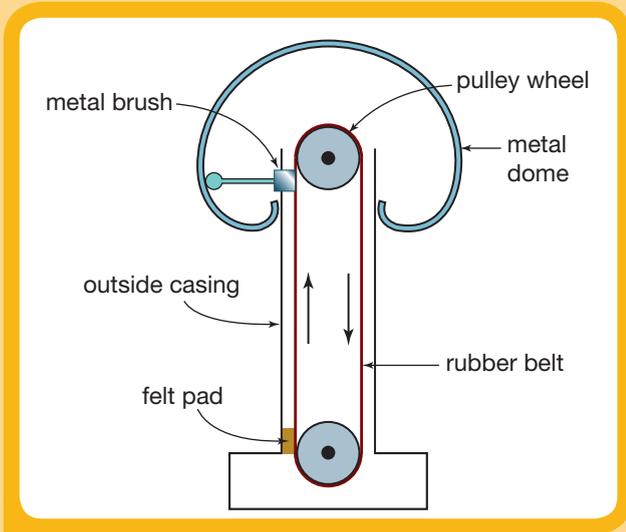


Fig 11.1.16

Skills

- 24 If a balloon is rubbed with wool, it will often stick to a wall. Demonstrate how this happens using a diagram.
- 25 Construct diagrams to show the electric field near the charges in Figure 11.1.17.

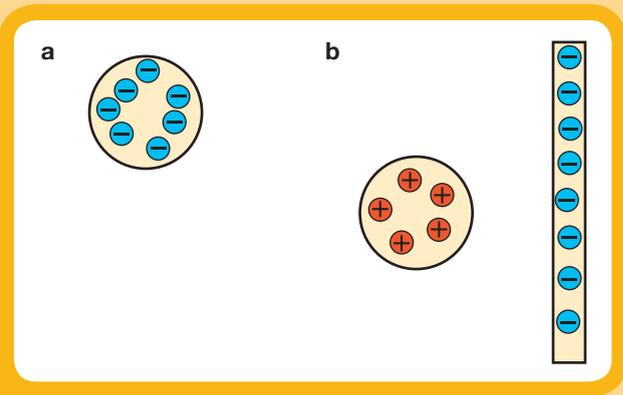


Fig 11.1.17

Introduction

Most of the appliances we use rely on electricity to function. Televisions, computers, DVD players, toasters and calculators all have one thing in common—they need electricity moving through them to work.

A simple circuit

Moving electricity is actually moving charges. The path along which these charges flow is called a circuit, and electricity will flow only if there is a complete circuit for it to go around.

The four basic parts of a simple circuit are:

- an energy source, such as a battery
- a conductor (wires) for the electricity to flow through
- something to use up the electrical energy, such as a globe or motor
- a switch to turn the current on and off.

Figure 11.2.2 shows a simple circuit used to operate a light globe. To save time describing circuits, symbols are used to form a circuit diagram. A circuit diagram shows the parts or components of a circuit, what each is connected to and the order in which they are connected.

Activity 4

A lemon cell

Aim

To construct a cell using a lemon

Equipment

A galvanometer or microammeter (for detecting small currents), copper and zinc plates (or a galvanised nail and uninsulated copper wire), a lemon, 2 connecting wires

Method

- 1 Squeeze the lemon without breaking the skin to 'juice it up' inside.
- 2 Insert the plates (or substitute items) into the lemon.
- 3 Connect the plates to the current-measuring meter, ensuring the copper is connected to the positive terminal of the meter.
- 4 Predict and then investigate the effect of:
 - a pushing the copper and zinc plates further into the lemon
 - b increasing the distance between the copper and zinc plates
 - c squeezing the lemon.

Extension

- 5 Combine with another group and attempt to use two lemons to produce a larger current reading.

Questions

You might need to read ahead to find the information to answer some of these questions.

- 1 Some chemical cells require acid. Explain where the acid comes from in this experiment and what sort of acid is involved.

- 2 Discuss the validity of your predictions in step 4 above.
- 3 Explain why the current increased or decreased in each case.
- 4 In step 5, lemons were linked together to produce a larger current. Was this a cell or a battery? Justify your answer.

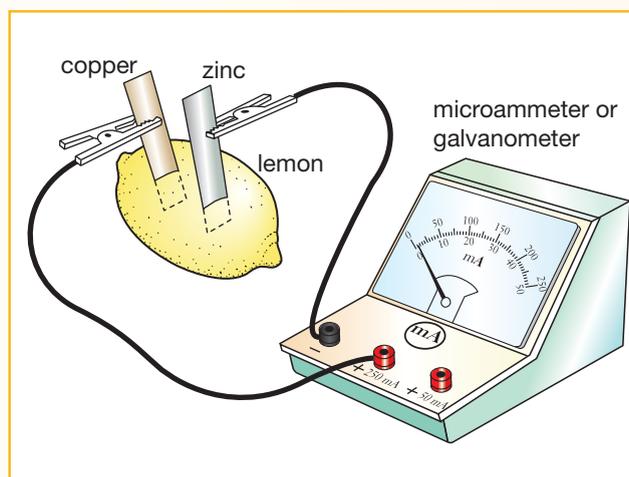


Fig 11.2.1 Cell constructed using a lemon

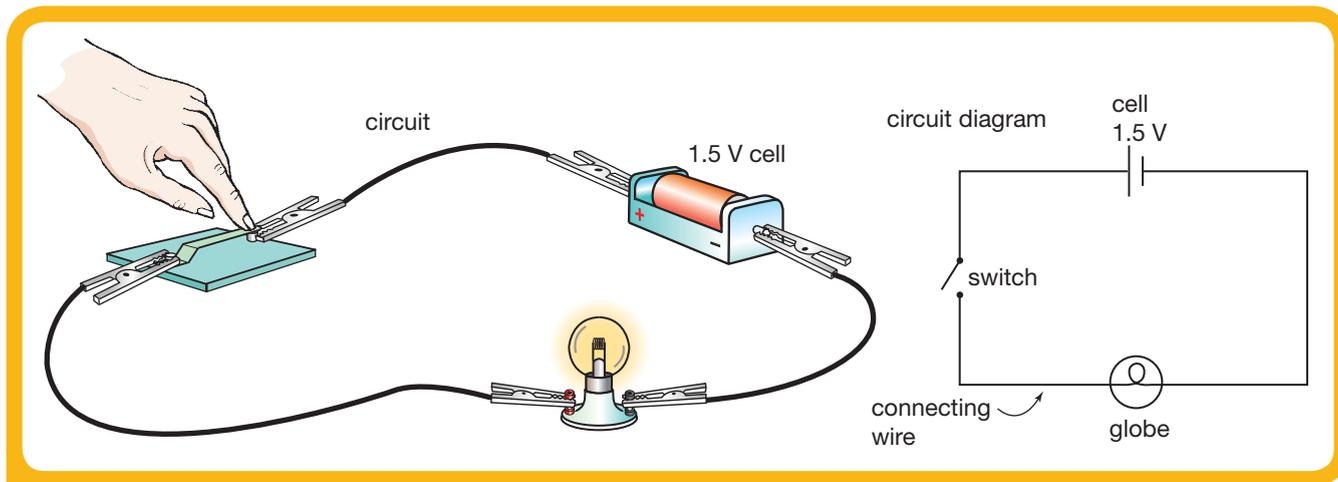


Fig 11.2.2 A simple circuit and its equivalent circuit diagram

The simple circuit shown contains flowing electric current, a voltage source, a switch, conductors and a resistance.

Current

The term electric current is used to describe moving electric charges. In circuits such as that shown in Figure 11.2.2, these charges are electrons.

A large current involves more electrons passing through a circuit each second than a small current does. Current is measured in a unit called an ampere (A or ‘amp’ for short). A milliamp (mA) is equal to one-thousandth of an ampere and is used to measure extremely small currents. Most parts of circuits are made from metals. If you could magnify a metal enough, you would see a network of fixed positive atomic nuclei surrounded by a ‘sea’ of loose negative electrons. It is these electrons that flow in most circuits.

Because early scientists wrongly thought that electricity flowed from the positive terminal of a voltage source to its negative terminal, we are stuck with the convention of labelling current direction as the way imaginary positive charges flow. Scientists refer to it as conventional current. The electrons actually move in the opposite direction to conventional current.

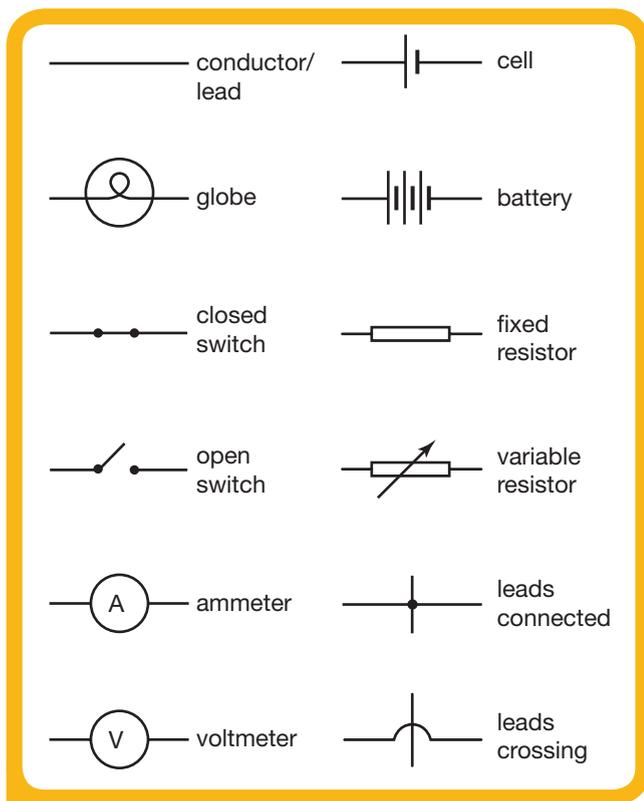


Fig 11.2.3 Common symbols used to draw circuits

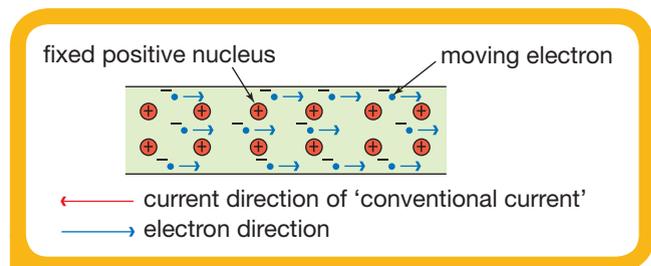


Fig 11.2.4 A current made up of moving electrons

The flow of electric current is similar to the flow of water, but differs in one important aspect: water will flow out of a cut pipe, but electric current will not usually flow out of the end of a cut wire.

To measure the flow of current, an instrument called an ammeter is placed in the path of the current to be measured. This involves ‘breaking’ the circuit and inserting the ammeter.

Voltage

Voltage is a measure of the amount of energy available to push charges around a circuit, and the unit of measurement is the volt (V). Voltage is supplied by electric cells and household power points. Voltage is like the pressure from the pump that pushes the water through the pipes.

To measure the voltage, or energy transferred between two points of a circuit, terminals from a voltmeter are connected in parallel across the section. You can think of an ammeter as counting every charge that passes through it, and a voltmeter as sampling how much energy is used between two points in the circuit.

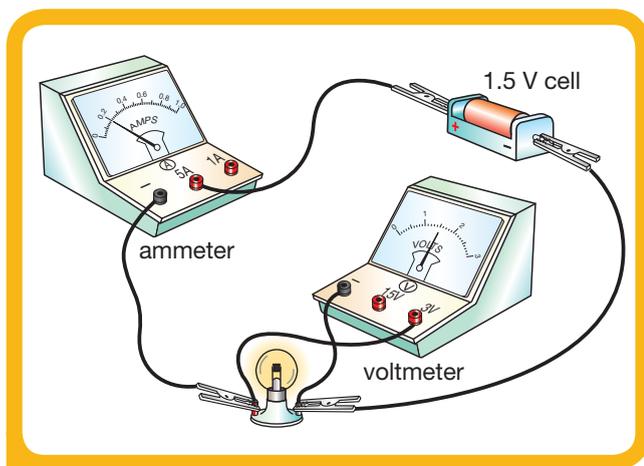


Fig 11.2.5 How to connect an ammeter and a voltmeter

Cells and batteries

Electricity typically comes from a power point in the home, or from cells or batteries.

Power points should be treated with extreme care—the 240 volts they supply can be deadly, so always ensure the switch is off before connecting or disconnecting appliances.

A cell is a single unit and a battery a group of cells, but people tend to use both words to describe a single unit. A typical small cell, such as an AA battery, provides 1.5 volts, while a car battery supplies 12 volts. Think of a cell as a charge pump or an electrical energy supplier.

A diagram of a wet cell is shown in Figure 11.2.6. A wet cell consists of two different metal plates placed in an acid. The zinc plate begins to dissolve in the acid in a chemical reaction, which releases electrons. If a circuit is made that joins the two plates, the electrons flow to the copper plate, lighting the globe as they travel through it. The lemon cell that you made in Activity 4 is an example of a wet cell.

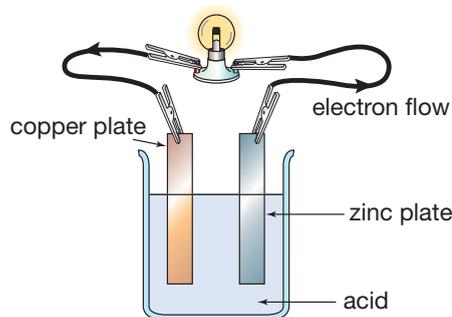


Fig 11.2.6 A wet cell

Activity 5

Conductors and insulators

Aim

To test various materials and classify them as conductors or insulators

Equipment

A 1.5 V cell, a 2.5 V mounted globe, 3 connecting wires, various materials such as a nail, coin, plastic, glass, wood, cloth, metal pieces, paper, rubber, steel wool

Method

Assemble the circuit shown in Figure 11.2.7, and test whether each material conducts well or not.

Questions

You might need to read ahead to find the information to answer some of these questions.

- 1 Classify the materials used as conductors or insulators.
- 2 If the light globe does not light up, explain whether this means the material is definitely an insulator.
- 3 Rubber is normally classified as an insulator, but will conduct electricity if an extreme voltage is connected across it. Justify the use of the term ‘insulator’ for rubber.

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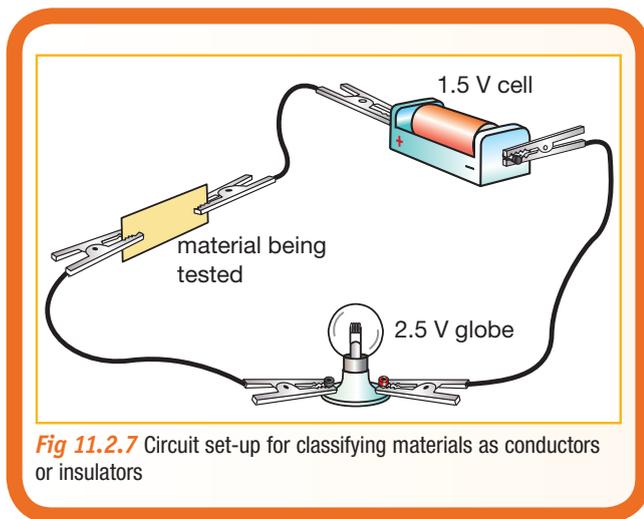


Fig 11.2.7 Circuit set-up for classifying materials as conductors or insulators

A car battery is a collection of wet cells. The wet substance is sulfuric acid and the plates or electrodes are made of lead and lead oxide. When a car is running, chemical reactions in the battery are reversed, and help recharge the battery. Eventually, build-up of chemicals on the electrodes prevents recharging and the battery ‘dies’.

A dry cell is not completely dry, but contains a chemical paste instead of a liquid. As in a wet cell, a chemical reaction generates charge that will flow when the cell is connected to a circuit. There are several types of dry cell.

Zinc-carbon cells are cheap; alkaline-manganese cells are longer lasting but more expensive; lithium cells are compact, light and long-lasting. A nickel-cadmium (nicad for short) cell may be recharged using current from a power point to reverse the chemical reactions within the cell.

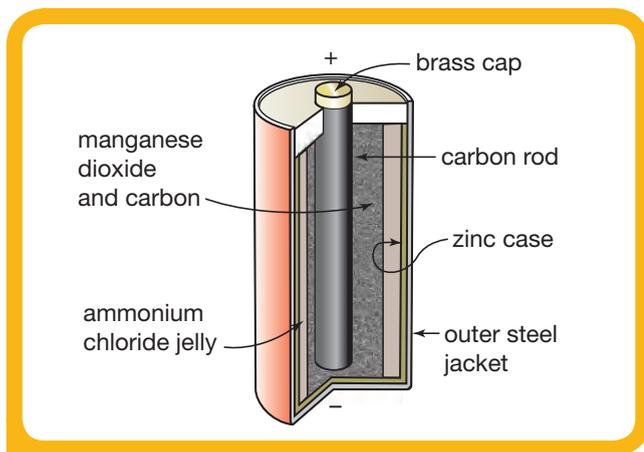


Fig 11.2.8 The internal structure of a typical dry cell.

Often several cells are connected as shown in Figure 11.2.9 to provide greater electrical energy or voltage.

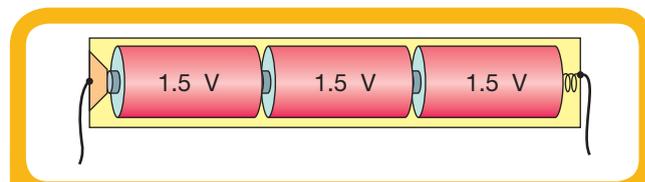


Fig 11.2.9 Cells joined together to provide a higher voltage (4.5 V)

A photovoltaic cell or solar cell is made of two layers of a substance called a semiconductor. When sunlight strikes the top layer, electrons are given energy to move from one layer to the other, creating an electric current. Several cells are used to make a solar panel.

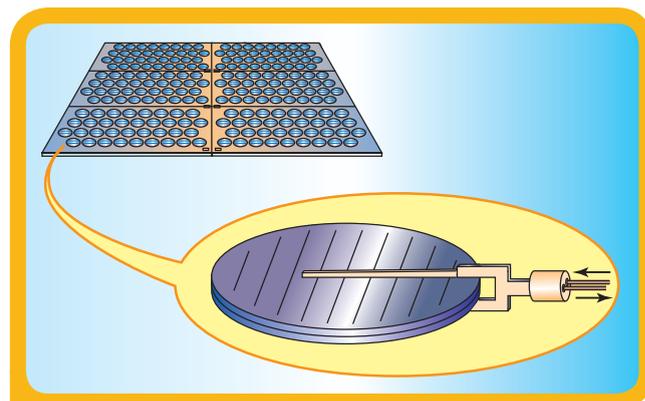


Fig 11.2.10 Sunlight falling on a photovoltaic cell forces electrons from one layer to the other, causing an electric current.

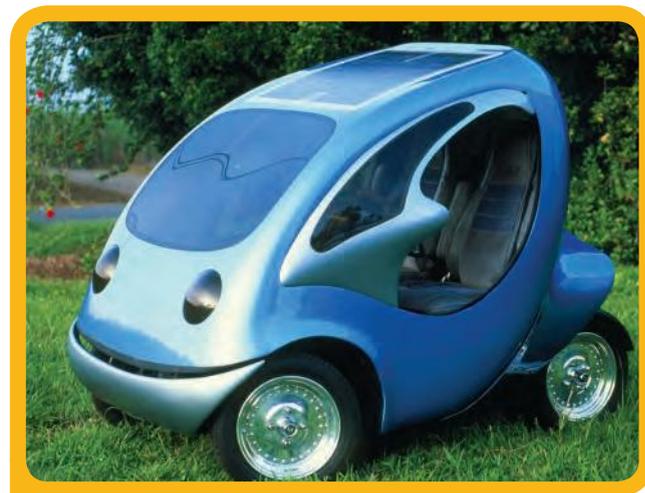


Fig 11.2.11 A solar-powered vehicle



Conductors and insulators

A conductor is a substance that allows current to flow through it easily. Metals are good conductors of electricity. Copper wire is a low-cost and widely available conductor commonly used in electric circuits around the house, in factories and in cars. Aluminium is more expensive but is used where copper would be too heavy, for example for high-voltage transmission lines that need to be strung between distant pylons.

Materials that do not normally allow current to pass through them are called insulators. Plastic and rubber are two very effective insulators.

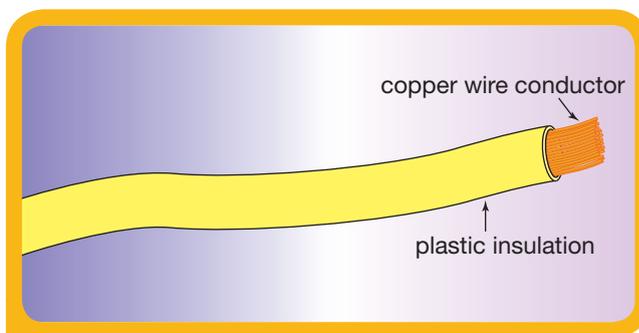


Fig 11.2.12 Electrical cable consists of both insulating and conducting materials.

Activity 6

A mini water heater

Aim

To construct a mini water heater and observe the heating effect while varying the voltage

Equipment

Nichrome wire (20 cm), power pack capable of supplying 12 V, 250 mL beaker, thermometer, stopwatch or clock, connecting wires

Method

- 1 Copy the table below into your workbook.
- 2 Connect the apparatus as shown in Figure 11.2.13. Don't connect the power pack.
- 3 Take the temperature before any heating takes place.
- 4 Set the voltage knob on 6 V. As you turn the power pack on, start the timer.
- 5 Record the temperature of the water every minute for 10 minutes.
- 6 Predict what would happen if you were to increase the voltage to 12 V. Write down your prediction.
- 7 Repeat the above steps but increase the voltage to 12 V to test your prediction.

Time (min)	0	1	2	3	4	5	6	7	8	9	10
Temperature (°C)											

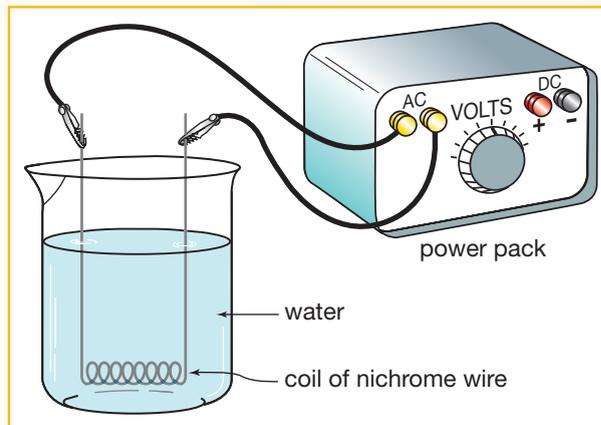


Fig 11.2.13 Apparatus set-up for observing heating while varying voltage

Questions

- 1 Explain where most of the energy supplied by the power pack is being transferred to.
- 2 Construct a line graph showing the temperature variation over the 10 minutes.
- 3 Predict what would have happened to the temperature if the water was heated for another 10 minutes.
- 4 Would the temperature keep rising if the water was heated for a much longer time? Justify your answer.

More on circuits

For current to flow, there must be a complete circuit made of conducting material, and a voltage source such as a battery.

The pump

The voltage source acts as a pump that creates an electric field that pushes charges around the circuit, just as a water pump creates pressure that pushes water through pipes.

The resistance

Electrons have much more difficulty getting through the thin tungsten filament of a light globe than they do getting through the much thicker and highly conductive copper wire. The electrons give up a lot of energy trying to get through the filament. This energy is turned into heat and light.

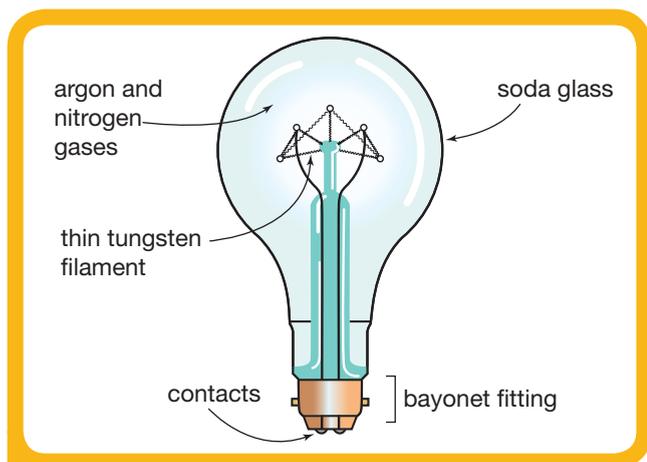


Fig 11.2.14 A typical light globe

A globe is an example of resistance—something that restricts the flow of charge and ‘robs’ moving charges of energy. Resistance converts electrical energy into heat and light energy.

Devices such as electric kettles, toasters, irons and electric hotplates are all simple electric circuits that contain a resistance wire made from the metal nichrome. Nichrome has much greater resistance than the copper wire used in the rest of the circuit, and so it heats up when a current passes through it. Nichrome is ideal as it does not react with oxygen or become brittle when heated until red-hot.

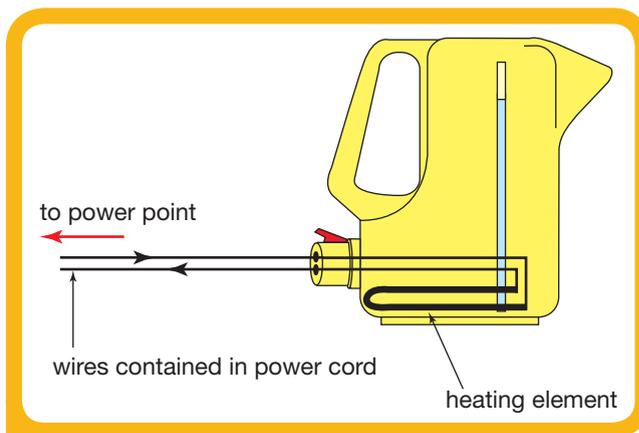


Fig 11.2.15 The heating element in an electric jug is part of a simple circuit.

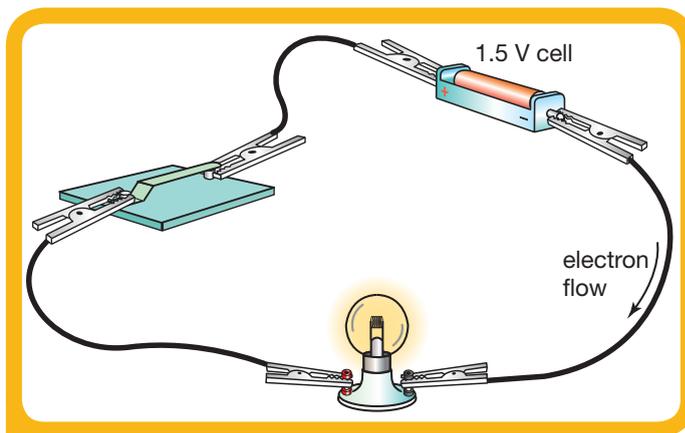


Fig 11.2.16 A simple circuit with a switch in the ON position

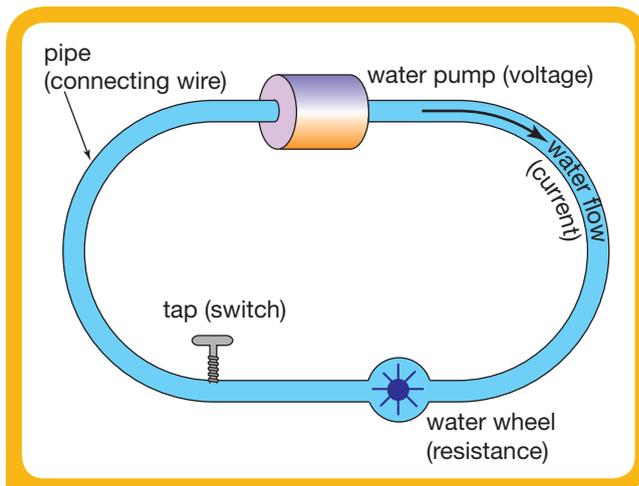


Fig 11.2.17 The electric circuit in Figure 11.2.16 may be compared to a water pump arrangement.



11.2 [Questions]

UNIT

Checkpoint

A simple circuit

- 1 Recall the components needed to get an electric current flowing.
- 2 List ten devices that use electricity in the home.

Current and voltage

- 3 Define the following terms:
 - a current
 - b voltage.
- 4 Recall the device used to measure:
 - a current
 - b voltage.

Cells and batteries

- 5 List five objects that use dry cells.
- 6 Describe what produces the charges that provide current in a cell.
- 7 State which type of cell would be best suited to a heart pacemaker.
- 8 Outline why car batteries are so heavy.
- 9 Outline why a car battery 'goes flat' if the car is not used often.

Conductors and insulators

- 10 Define the terms 'conductor' and 'insulator' using examples.

More on circuits

- 11 In a light globe, oxygen is replaced by other gases, rather than simply removed. Outline why.
- 12 Identify which part of a circuit causes electrons to lose most of their energy.

Think

- 13 Outline why copper is used in circuits to connect components and tungsten is not.
- 14 Copy and complete the following table to demonstrate similarities between electricity and water.

Current electricity	Water
Charge	Water particles
Current	
Connecting wire	Pump
Globe	
	Tap

- 15 Explain why electricians use screwdrivers with plastic or rubber handles.
- 16 Distinguish between a cell and a battery.
- 17 Propose a voltage for each of the following:
 - a torch cell
 - b household power point
 - c car battery.

Skills

- 18 Construct a table of examples of good conductors and good insulators.
- 19 Construct a diagram of a dry cell.
- 20 Construct a circuit symbol for:
 - a a cell
 - b a globe
 - c a switch.

Analyse

- 21 Evaluate which of the circuits in Figure 11.2.18 are equivalent.

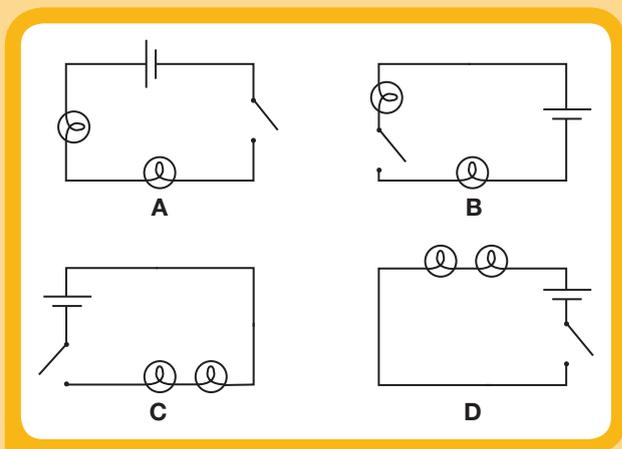


Fig 11.2.18

[Extension]

Action

- 1 Design an alarm that activates when someone stands on a mat near your bedroom doorway.
- 2 Design a test to compare the lasting power of different brands of batteries.
- 3 Investigate electroplating and how it works. Design and conduct an experiment to electroplate a key.
- 4 Compare cells made using various fruits (see Activity 4 on page 228).
- 5 Construct one of the games in Figures 11.2.19 and 11.2.20. Once you get the game working, try adding a buzzer to the circuit, connected in parallel (see Unit 11.3).

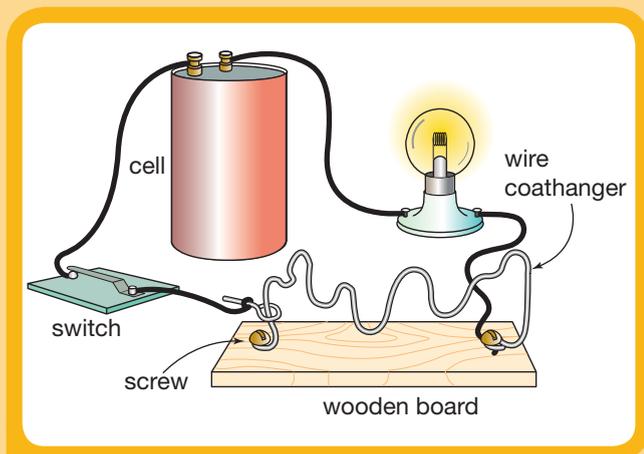


Fig 11.2.19

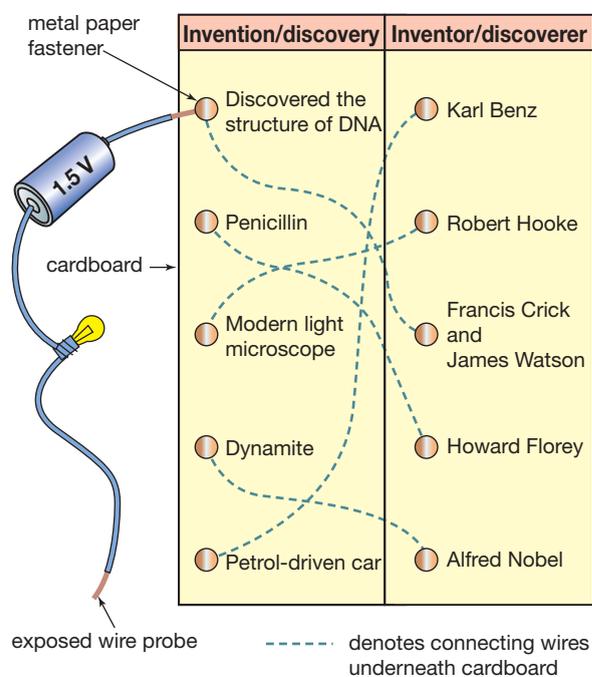


Fig 11.2.20

Introduction

Circuits are connected in different ways depending on how we want lights or other appliances to operate. Imagine if we had to turn on the dishwasher, washing machine and all the other appliances around the house just to get the TV working! Or if we switched the bedroom light on and all the other lights in the house got

dimmer. Some circuits will do exactly this: we need to pick the right type of circuit to do what we want it to do.

Circuits

Series circuits

If two globes are arranged one after the other, in a line with the battery, then the globes are said to be in series. This is shown in Figure 11.3.4.

The voltage supplied is shared between globes in series, but the current that passes through each is the same. Each globe glows more dimly than in a circuit containing just one globe.

If either globe in the series circuit is removed or 'blows', the circuit is broken, and neither globe will light up.

Activity 7

Series and parallel circuits

Aim

To construct a series and parallel circuit

Equipment

Two 2.5 V globes, 4 connecting wires (eg with alligator clip ends), 2 connection posts (eg nails in wooden blocks), 1.5 V dry cell

Method

- 1 Connect and observe the brightness of a single globe in the circuit shown in Figure 11.3.1.
- 2 Modify the circuit by inserting an extra globe in series as shown in Figure 11.3.2 and note the brightness of each globe. What is the effect of removing a globe? Does it depend on which globe you remove?
- 3 Assemble the parallel circuit in Figure 11.3.3 and again compare the brightness of the globes. Again, what is the effect of removing a globe? Does it depend on which globe you remove?

Questions

You might need to read ahead to find the information to answer some of these questions.

- 1 Contrast the brightness of globes in series with that of a single globe.
- 2 Contrast the brightness of globes in parallel with that of a single globe.
- 3 Predict the effect of removing a globe when they are:

a in series	b in parallel.
-------------	----------------
- 4 Predict the circuit in which the cell will go flat most quickly.

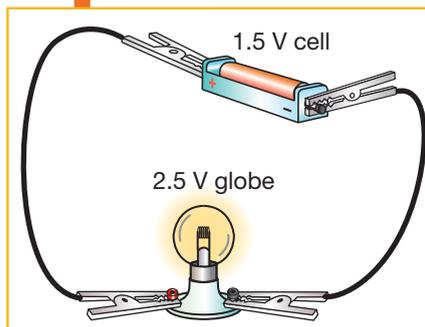


Fig 11.3.1 A simple circuit

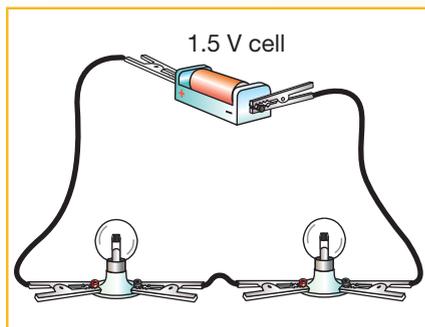


Fig 11.3.2 A series circuit

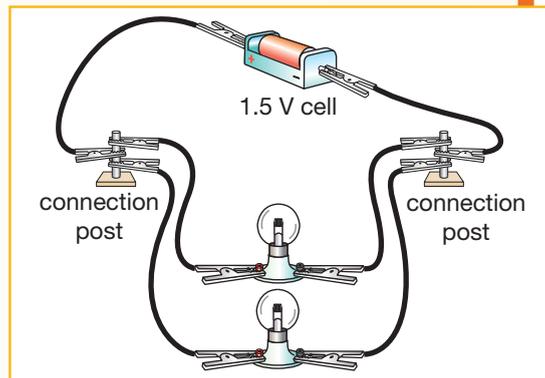


Fig 11.3.3 A parallel circuit

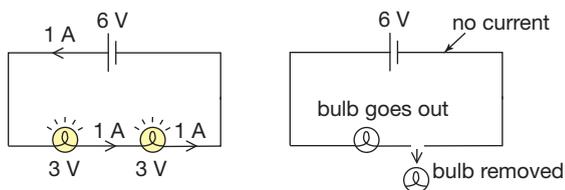


Fig 11.3.4 A series circuit

Parallel circuits

The circuit in Figure 11.3.5 shows two globes in parallel—that is, in separate branches between the same points.

The voltage is the same for each globe in parallel, but the current from the cell is shared between each branch. Each globe glows with equal brightness.

If either globe in this circuit is removed or ‘blows’, the other globe will stay alight, as there is still a circuit through which current could flow.

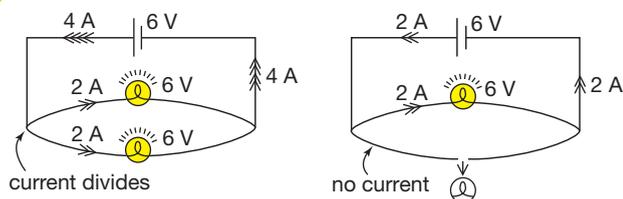


Fig 11.3.5 A parallel circuit

More complex circuits

A circuit may be a combination of both series and parallel sections, and contain switches to control current flow, like the one in Figure 11.3.6.

As a general rule, current divides so that most current goes the easy way. If switch 1 (S1) is opened, no current flows anywhere. If switch 2 (S2) is opened, current flows only through the branch containing the single globe.

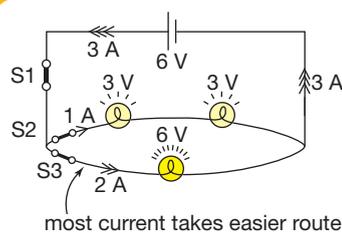


Fig 11.3.6 This circuit has two globes in series in one branch of a parallel circuit.

Activity 8

Connecting ammeters and voltmeters

Aim

To measure the voltage and current in series and parallel circuits

Equipment

Two 2.5 V globes, 6 connecting wires (eg with alligator clip ends), 1.5 V dry cell, ammeter, voltmeter

Method

- 1 Assemble the circuit in Figure 11.3.7 and record the current and voltage measurements.
- 2 Copy each of the circuit diagrams in Figure 11.3.8 into your workbook.
- 3 Use an ammeter to record the current where indicated by ammeter symbols. Note: The red or positive ammeter terminal connects to the ‘side’ of the circuit closest to the positive of the cell or battery. Record your current readings on your diagrams.
- 4 Use a voltmeter to measure the voltage where indicated by voltmeter symbols in Figure 11.3.9. Note: The red or positive voltmeter terminal connects to the ‘side’ of the circuit closest to the positive of the cell or battery.

Questions

- 1 Describe the current at various points around the:
 - a series circuit
 - b parallel circuit.
- 2 Describe the voltages around the:
 - a series circuit
 - b parallel circuit.

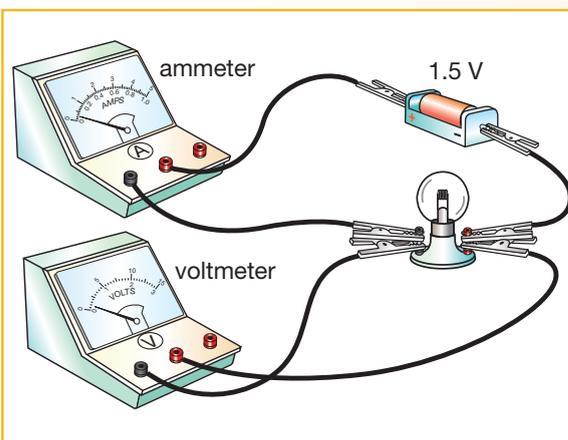


Fig 11.3.7 Circuit set-up for measuring voltage and current

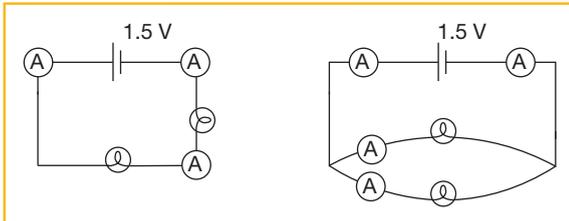


Fig 11.3.8 Left: a series circuit; right: a parallel circuit

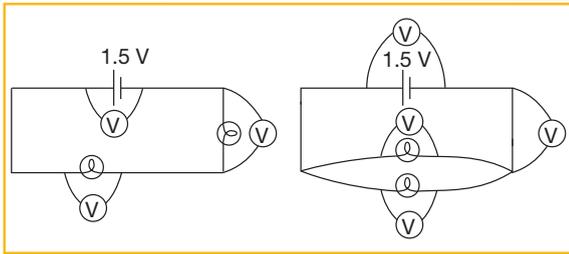


Fig 11.3.9 Left: a series circuit; right: a parallel circuit

Christmas-tree lights

Christmas-tree lights come in two types—series and parallel. A series arrangement of twenty lights would share the 240 V from the power point, giving each globe 12 V. Globes come in different sizes (often 6 and 12 V). For this circuit, 12 V globes should be used.

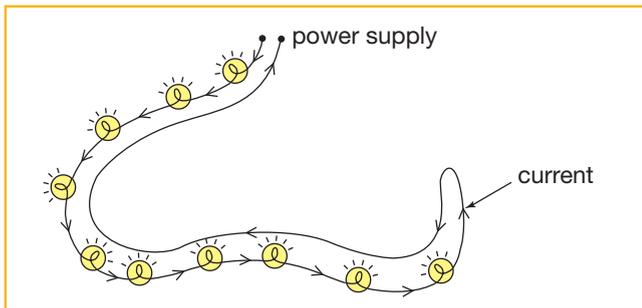


Fig 11.3.10 Christmas lights in series—if one globe blows, they all go out.

One disadvantage of the Christmas lights in series is that if one globe ‘blows’, they all go out. This makes it very difficult to find the failed globe.

Other types of Christmas-tree lights may be powered by a low-voltage source. A transformer changes the 240 V from the power point to 12 V. The globes are then connected in parallel, with every globe operating at 12 V. The advantage is that if one globe blows all the others continue to operate.

power supply

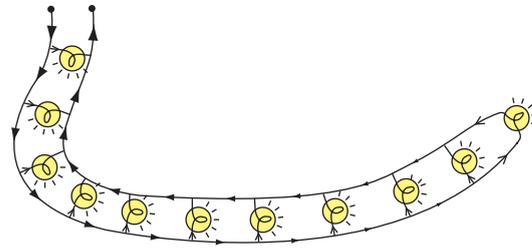


Fig 11.3.11 Christmas lights in parallel—if one globe blows, the others keep working.

Household circuits

The mains electricity wiring in your house is just one big parallel circuit. Can you imagine what would happen if it was a series circuit? Power points within the home allow extra parallel branches to be connected. Each branch gets the same 240 V.

The diagram in Figure 11.3.12 shows a simplified version of household wiring.

Unlike a battery, in which current flows one way (known as direct current, or DC), power stations supply a house with current that is pulled forwards and backwards many times every second. This is known as alternating current, or AC. Electricity is supplied as AC because it is easier to generate and transmit than DC.

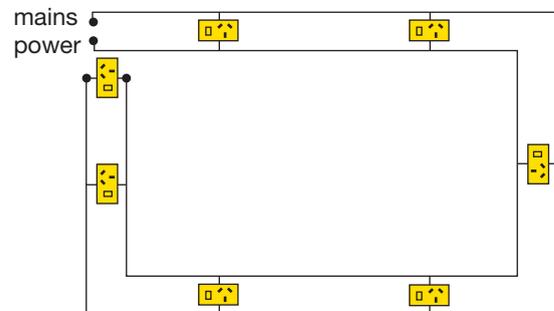


Fig 11.3.12 One of the many large parallel circuits in a house

Electrical safety

Electric shock or even electrocution (death by electricity) may occur if current finds a path through your body (usually to the earth). A tiny current can cause death by damaging tissues and interfering with electrical signals driving the heart. For this reason, electricians wear rubber-soled shoes and use tools with insulated handles.

Never handle a plug without turning off the power point, and never interfere with circuits connected to mains power. If you do come across someone who has had an electric shock, first turn off the power, using the main switch at the fuse box if necessary.

If this is not possible, do not touch the person directly, or you will be given a shock too. Sometimes, insulators such as a plastic rope or garden hose can be used to move the person away from the source of electricity. Then assistance and appropriate first aid can be given.

A device called a safety switch or residual current detector (RCD) may be connected to the household power supply to reduce the risk of electric shock. An RCD compares the current entering a home with that leaving via the correct circuit. If there is a difference caused by some current 'leaking out' (eg through a person's body), it switches off the main power switch within a few thousandths of a second. Serious electric shock is prevented.

11.3

[Questions]

UNIT

Checkpoint

Circuits

- 1 Explain how series and parallel circuits are connected.
- 2 Copy the following paragraph into your workbook, supplying the missing words.

In a series circuit, the _____ is shared between the components, but the _____ is the same. In a parallel circuit, the _____ is shared between the branches, but the _____ is the same for each branch.

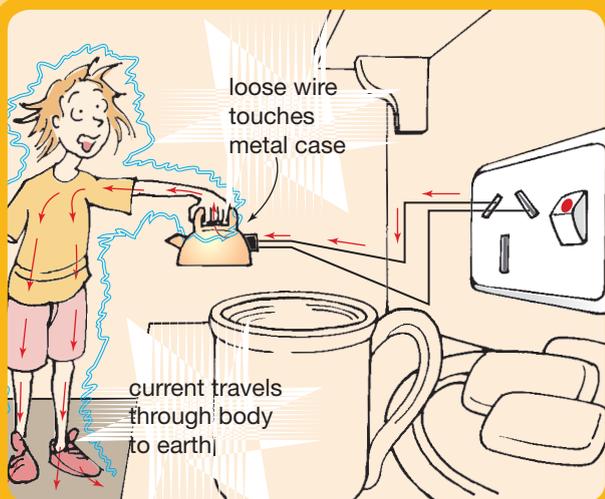


Fig 11.3.13

Christmas tree lights

- 3 One globe 'blows' in a set of Christmas tree lights. Predict its effect if the lights are wired in:
 - a parallel
 - b series.

Household circuits

- 4 State whether the following statements are true or false.
 - a Household wiring is like a big parallel circuit with many branches.
 - b Current supplied to households goes in one direction only.
 - c A large current is required to cause damage to your body.

Electrical safety

- 5 Use Figure 11.3.13 to outline how you can reduce the risk of electric shock.

Analyse

- 6 In Figure 11.3.14, identical globes and cells are used. Identify the circuit or circuits in which the globes glow:
 - a brightest
 - b most dimly.

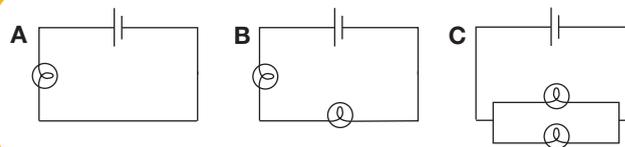


Fig 11.3.14

- 7 Examine the circuit in Figure 11.3.15 and state which other globes will go out if:
- globe A blows
 - globe B blows
 - globe C blows
 - globe D blows
 - globe E blows.

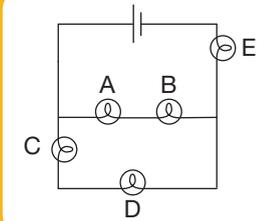


Fig 11.3.15

- 8 Copy the circuit in Figure 11.3.15 and modify it to show:
- a switch that turns all globes on and off
 - an ammeter that measures the current through globe A
 - a voltmeter that measures the current through globe E.
- 9 The circuit diagram for a light at the bottom of a stairway is shown in Figure 11.3.16.

- 11 State which fraction of the cell voltage is used by globe G in Figure 11.3.17.
- 12 Predict what the effect would be if a connecting wire was placed between points A and B (causing what is called a 'short circuit') in Figures 11.3.18 and 11.3.19.

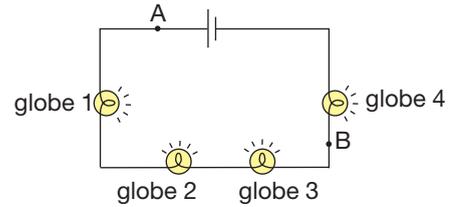


Fig 11.3.18

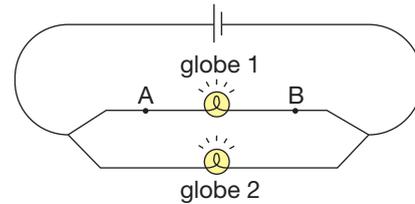


Fig 11.3.19

- 13 The diagrams in Figure 11.3.20 represent three safety switches. The numbers represent currents. Select the diagram in which the safety switch would shut off the main power.

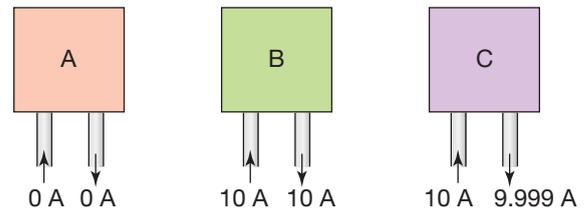


Fig 11.3.20

- 10 Identify the correct answer from the list below. The current that flows through point A in Figure 11.3.17 is:
- the same as the current that flows through point B
 - half the size of the current through point B
 - twice the size of the current through point B
 - three times the size of the current through point B.

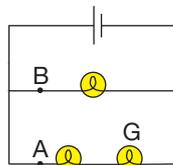


Fig 11.3.17

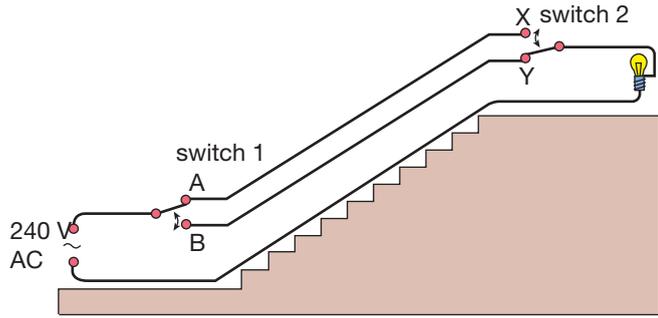


Fig 11.3.16

Copy and complete the following table in your workbook in order to summarise the operation of the circuit.

Switch 1 at position	Switch 2 at position	Light
A	X	ON
B	X	
A	Y	
B	Y	

Skills

- 14 Use circuit symbols to construct a circuit with a cell and:
- three globes in series
 - four globes in parallel
 - two globes in series with three globes in parallel.
- 15 Construct a diagram showing the circuit in Question 14c and insert a single switch that controls the current in:
- the entire circuit
 - one of the globes in parallel.
- 16 Greg notices that if one globe on his Christmas tree blows, four of its neighbours go out, but the other forty-five stay lit. Construct a likely circuit diagram for Greg's Christmas tree lights.

[Project]**A model household circuit**

Construct a model of a household electricity circuit using a low voltage supplied by a cell or battery. Include a main switch, lighting and a power point.

[Creative writing]**Globe trotting**

Imagine you are an electron travelling with several friends around a circuit containing two light globes in series followed by two globes in parallel as shown in Figure 11.3.21. Write an account of what you experience as you and your friends complete a circuit. Consider things such as:

- How do you get your energy?
- How do you lose energy?
- Was your movement restricted at any stage?
- What happens to your friends? Where were they as you were travelling?

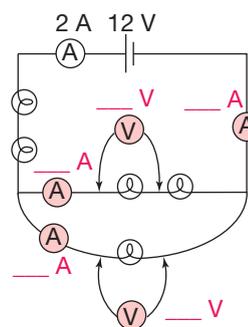


Fig 11.3.21

UNIT 11.4

Electrical energy calculations

Introduction

In a circuit, appliances such as heaters, televisions and light bulbs take energy from the supply and transform it (change it into other forms). For example, appliances with heating elements change it into thermal energy (heat).

Calculating energy

Energy and power are linked (see box). If the power of an appliance is known, the energy transformed in any given time can be calculated by rearranging the equation like this:

$$\text{energy transformed} = \text{power} \times \text{time}$$

(J) (W) (s)

For example, if a 1000 W heating element is switched on for 5 seconds (s):

$$\text{energy transformed} = 1000 \text{ W} \times 5 \text{ s} = 5000 \text{ J}$$

So the heating element gives off 5000 J of thermal energy.

Electrical energy equation

As power = PD × current, the above equation can also be written like this:

$$\text{energy transformed} = \text{PD} \times \text{current} \times \text{time}$$

(J) (V) (A) (s)

In symbols:

$$E = \frac{V}{t}$$

For example: a 12 V water heater takes a current of 2 A. If it is switched on for 60 seconds, how much thermal energy does it produce?

$$\begin{aligned} \text{energy transformed} &= \text{PD} \times \text{current} \times \text{time} \\ &= 12 \text{ V} \times 2 \text{ A} \times 60 \text{ s} \\ &= 1440 \text{ J} \end{aligned}$$

In this case, all the energy is transformed into thermal energy, so the heater produces 1440 J of thermal energy.

Energy and power essentials

- Energy is measured in joules (J).
- Power = $\frac{\text{energy transformed}}{\text{time taken}}$
- Power is measured in watts (W). For example, if a heating element is transforming energy at the rate of 1000 joules per second, it has a power of 1000 watts.
- For circuits, the following equation is more useful for calculating power:
power = PD × current
In the above equation:
 - PD (potential difference, or voltage) is measured in volts (V)
 - current is measured in amperes (A).

Measuring energy in kilowatt-hours

Electricity supply companies use the kilowatt-hour rather than the joule as their unit of energy measurement.

One kilowatt-hour (kWh) is the energy supplied when an appliance whose power is 1 kW is used for 1 hour.

1 kW is 1000 W, and 1 hour is 3600 s. So, if a 1 kW appliance is used for 1 hour: energy supplied = power × time = 1000 W × 3600 s = 3 600 000 J
Therefore: 1 kWh = 3 600 000 J.

Energy in kilowatt hours is calculated like this:

$$\text{energy supplied} = \text{power} \times \text{time}$$

(kWh) (kW) (hours)

For example: If a 2 kW heater is used for 3 hours, the energy supplied is 6 kWh.



Fig 11.4.1 Batteries are a very convenient, portable source of electricity, but their energy can cost over 200 times more per kilowatt-hour than energy from the mains.

The diagrams at the bottom of the page show the meter readings at the beginning and end of a quarter (three-month period). In this case:

$$\begin{aligned} \text{energy supplied} &= 42\,935 \text{ kWh} - 41\,710 \text{ kWh} \\ &= 1225 \text{ kWh} = 1225 \text{ units} \end{aligned}$$

If the electricity supply company charges \$3.93 per unit:

$$\begin{aligned} \text{cost of energy supplied} &= 1225 \times \$3.93 \\ &= 481\,425 \text{ cents} \\ &= \$4814.25 \end{aligned}$$

The cost of running individual appliances can be calculated as follows:

Example 1: If energy is \$3.93 per unit, what is the cost of running a 2 kW heater for 3 hours?

$$\begin{aligned} \text{energy supplied} &= \text{power} \times \text{time} \\ &= 2 \text{ kW} \times 3 \text{ h} = 6 \text{ kWh} \\ &= 6 \text{ units} \end{aligned}$$

As the cost per unit is \$3.93:

$$\text{total cost} = 6 \times \$3.93 = \$23.58$$

Example 2: If energy costs \$3.93 per unit, what is the cost of running a 100 W lamp for 30 minutes?

To calculate the number of kWh, the power must be in kilowatts and the time in hours. In this case: 100 W is 0.1 kW, and 30 minutes is 0.5 h. So:

$$\begin{aligned} \text{energy supplied} &= \text{power} \times \text{time} \\ &= 0.1 \text{ kW} \times 0.5 \text{ h} \\ &= 0.05 \text{ kWh} \\ &= 0.05 \text{ units} \end{aligned}$$

As the cost per unit is \$3.93:

$$\text{total cost} = 0.05 \times \$3.93 = 20 \text{ cents}$$

Calculating the cost of electricity

Present meter reading (kWh)	Previous meter reading (kWh)	
42935	41710	
Units used	Cost per unit (\$)	\$
1225	\$3.93	\$4814.25

Fig 11.4.2 Part of an electricity bill, based on the meter readings in the text opposite. On most bills, the cost is shown before tax is added, and there is usually an additional standing charge to pay.

The electricity meter in a house is an energy meter. The more energy you take the more you have to pay. The reading on the meter gives the total energy supplied in units. The unit is another name for the kilowatt-hour.

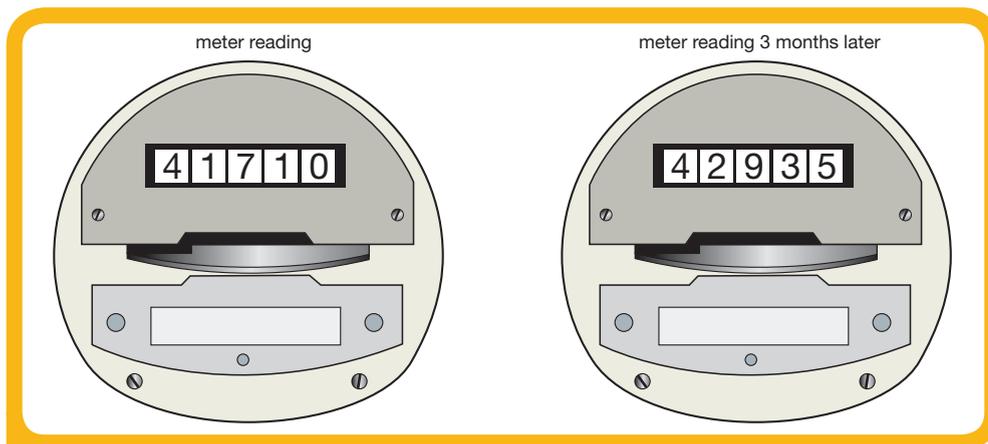


Fig 11.4.3 Reading a meter



11.4 [Questions]

UNIT

Checkpoint

- Calculate the energy supplied to a 60 W bulb
 - in 1 second
 - in 1 minute.
- A bulb takes a current of 3 A from a 12 V battery.
 - What is the power of the bulb?
 - How much energy is supplied in 10 minutes?
- A 2 kW heater is switched on for 4 hours. Calculate the thermal energy given off by the heater.
 - in kWh
 - in joules.
- If energy costs \$3.93 per unit, calculate the cost of using:
 - a 3 kW electric fire for 5 hours
 - five 60 W bulbs for 12 hours
 - a 1200 W hair dryer for 15 minutes.
- A person decides to replace six 60 W filament bulbs with six 15 W low-energy bulbs. If energy costs \$3.93 per unit and the bulbs are used, on average, for 4 hours per day, what will the annual saving be?

Chapter review

[Summary questions]

- State whether the following statements are true or false.
 - Like charges attract each other.
 - A charged object may attract a neutral one.
 - An electron is a small negative charge.
 - Charge tends to concentrate on sharp corners.
 - Lightning can occur only when charge flows from a cloud to the ground.
- Copy each of the following statements and apply the correct word from the brackets.
 - Current is the flow of (electric/magnetic) charges.
 - Current is measured in (volts/amperes).
 - (A conductor/an insulator) does not allow charge to flow through it.
 - Most (plastics/metals) are good conductors.
 - (Voltage/current) is a measure of the energy available to push charges around a circuit.
 - A (wet/dry) cell contains a chemical paste and electrodes to produce free electrons.
 - It is usually (positive/negative) charges that flow in a circuit.
- State whether the following statements are true or false.
 - A circuit contains a single globe glowing normally. It is possible to add ten more globes to the circuit so that each glows just as brightly as the single globe did.
 - Voltage is shared in a series circuit.
 - Current always divides equally when it reaches several parallel branches in a circuit.
 - Current is measured with an ammeter.

- The least energy is used in the resistance sections in a circuit.
 - A set of Christmas tree lights is connected in series. If one globe blows, all will go out.
- Contrast a cell with a battery.
 - Outline how a safety switch works.
 - Use Figure 11.2.15 to describe how the element in an electric jug heats the water.
 - Outline the purpose of a fuse in an electric circuit.

[Thinking questions]

- Explain how wearing rubber-soled shoes helps to protect electricians.
- Identify which two surfaces rub together to produce charge in each of the following situations:
 - You brush your hair and generate a spark.
 - A car moves along a road and becomes charged.
 - You rip off the thin plastic that seals the lid of a container, only to find that it sticks to your fingers.
 - The hair on your arm is attracted to the surface of a plastic chair.
- Explain why on some cars there is a rubber strip containing metal dangling from the rear of the car and touching the road surface.
- Contrast a household power supply with a battery or cell.
- Contrast static electricity with current.



[Thinking questions]

- 13 Draw a diagram of a basic light globe, labelling the main parts.
- 14 Examine Figure 11.5.1 and identify which diagram best illustrates:
- a neutral object
 - a positively charged object
 - a negatively charged object.

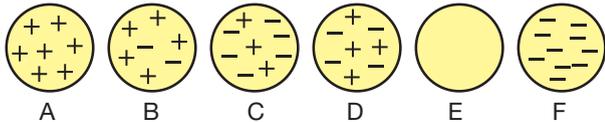


Fig 11.5.1

- 15 Draw diagrams to demonstrate the appropriate symbols for the following circuit components:
- open switch
 - globe
 - cell
 - conducting wire.
- 16 Use appropriate symbols to draw a simple circuit that could turn a globe on and off.
- 17 Use Figure 11.5.2 to construct a circuit diagram.

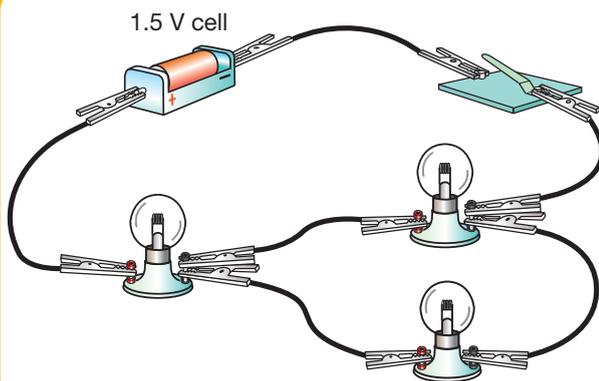


Fig 11.5.2

- 18 Copy Figure 11.5.3 and identify devices used to measure the energy used by globe G and the current that passes through it.

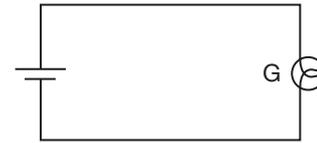


Fig 11.5.3

- 19 In Figure 11.5.4 a positive charge is being pulled in the direction shown by another charge. Identify which arrow gives the direction of the electric field acting on the charge.

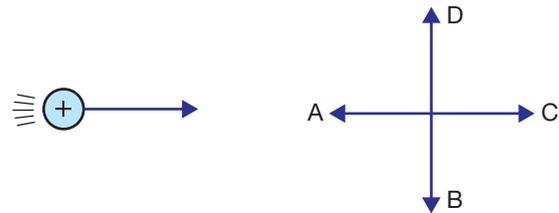


Fig 11.5.4



Solomon Islands Science

Year **8**

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