



Solomon Islands Science

Year **9**

Learner's Book



Solomon Islands
Science
Year **9**

Learner's Book

Solomon Islands Curriculum Development Division

This book was written, compiled and adapted by the following members of the Curriculum Development Division (CDD) in the Science Subject Working Group.

Curriculum Development Division:

- Edwin P. Ha'ahoroa, Acting Director
- Ian Waena, Principal Curriculum Development Officer

Subject Writing Group:

- Andrew Misitom, School of Education, SINU
- Cephas Teiraru, Bishop Epale Community High School
- Daniel Manata, Mbokona Community High School
- Elison Giano, School of Education, SINU
- Elwin Boi, Panatina Community High School
- John Fasi, School of Education, SINU
- John Gomi, Honiara Senior High School
- John Kwakwala, Naha Community High School
- Lionel Kakai, King George Sixth National Secondary School
- Simon Tepuke, Koloale Community High School
- Steven Anisitolo, Betikama Adventist College

Quality Assurance Group:

- Steven Anisitolo, Betikama Adventist College
- Elijah Wahere, St Joseph's Tenaru National Secondary School

Funding Support

The development and publication of this series was funded by the Solomon Islands Government, with assistance from the New Zealand Agency for International Development.



Pearson Australia

(a division of Pearson Australia Group Pty Ltd)
707 Collins St, Melbourne, Victoria 3008
PO Box 23360, Melbourne, Victoria 8012
www.pearson.com.au

Publisher: Rachel Davis

Project Manager: Anna O'Bryan

Editor: Writers Reign

Designer: Paul Ryan

Copyright & Pictures Editors: Julia Weaver and Robyn Formosa-Doyle

Front Cover Image: Getty Images: Rodger Klein/VWPICS, Cover

Illustrator: Bruce Rankin

Printed in Malaysia

Copyright © Pearson Australia (a division of Pearson Australia Group Pty Ltd) and the Solomon Islands Curriculum Development Centre

This book has been adapted from *Science Focus 1 Student Book (1st edn)*, *Science Focus 2 Student Book (1st edn)*, *Science Focus 3 Student Book (1st edn)* and *Science Focus 4 Student Book (1st edn)* by Kerry Whalley, Carol Neville, Peter Roberson, Greg Rickard et al, and originally published by Pearson Australia in 2005.

First published 2016 by Pearson Australia

2018 2017 2016

10 9 8 7 6 5 4 3 2 1

Solomon Islands Science Year 9 Learner's Book
978 1 4425 1359 4

Pearson Australia Group Pty Ltd ABN 40 004 245 943

Acknowledgements:

We thank the following for their contributions to our text book. The following abbreviations are used in this list: t = top, b = bottom, c = centre, l = left, r = right.

123RF: Dave Montreuil, p. 96tr; Vitezslav Halamka, p. 96c; VĀ;clav Mach, p. 138; Anuncha Ruenin, p. 160l.

AKG Images: p. 72.

Alamy Ltd: Phototake Inc, p. 21; Atmotu Images, p. 90.

Ausccape International Photo Library: Attila Bicskos Kaszo, p. 101l.

CSIRO Images: Atmospheric Research/CSIRO Science Image, p. 103l.

Corbis Australia Pty Ltd: Andy Richter, p. 24r; Joel W. Rogers, p. 45; Howard Sochurek, p. 69.

DK Images: Susanna Price, p. 67r; Andrew McKinney, p. 137; Tim Ridley, p. 163.

Fotolia: rob3000, p. 82l.

Gareth Boden: p. 18.

Getty Images: Willie Maldonado, p. 25l; Sean Garnsworth, p. 60br; Peter Solness, p. 101r; Tortsten Blackwood, p. 143; Phillip Game, p. 156.

Imagemore Co Ltd: p. 76.

Imagestate John Foxx Collection: p. 1.

Lennart Nilsson / Albert Bonniers Forlag: p. 63 both.

Ministry of Environment, Conservation and Meteorology: Climate Change Division, pp 117-120

NASA Visible Earth: p. 108.

NZ Aid Programme: New Zealand Ministry of Foreign Affairs and Trade, p. 98.

Pearson Australia: Rachel Davis, pp 96lc, 96br, 118 all, 144; Trisha Confoy, p. 39, 134 both.

Photo disc: pp. 2, 19tr, 120, 20c, 40, 131 all, 136, 151 both, 152 all.

Science Photo Library: Ria Novosti, p. 11; Mehau Kulyk, pp. 15, 56;

Steve Gschmeissner, pp. 28, 75; Eye of Science, p. 19tl; Volker

Steger, p. 20r; Andrew Lambert photography, pp. 36, 37; Prof

P. Motta, p. 60tr; Dr M.A. Ansary, p. 83t; Science Photo Library,

p. 83b; Coneyl Jay, p. 84; W.F.Meggers Collection/American

Institute of Physics, p. 111; Hank Morgan, p. 113; James King-

Homes, p. 114; David Taylor, p. 127; EFDA-JET, p. 150; Ocean

power delivery/look at Sciences, p. 152br; Rvi medical physics

Newcastle/Simon Fraser, p. 159l; Dr Arthur Tucker, p. 160rt; Sheila Terry, p. 164.

Shutterstock: Marek Piotrowski, p. 153; Sementer, p. 159r;

Ducu59us, p. 66; Nickolay Khoroshkov, p. 119; Aleksnadra H.

Kossowska, p. 122; Svetlovskiy, p. 141; Mirounga p. 165rt.

Solomon Islands Curriculum Development Division: pp. 32, 35, 47, 51; 96tl, 96bl, 104, 160rb, b165.

The Picture Source: Terry Oakley, p. 52; John Ross UTAS, p. 85.

Worradirek, p. 7.

Every effort has been made to trace and acknowledge copyright. However, should any infringement have occurred, the publishers tender their apologies and invite copyright owners to contact them.

Contents

Introduction	iv	5 Human effects on ecosystems	90
1 Magnets and electromagnets	1	5.1 Human effects on ecosystems	91
1.1 Magnetic forces	2	6 Environmental issues: Global and local	98
1.2 Electromagnetism	6	6.1 Global warming	99
Chapter review	13	6.2 The ozone layer	106
2 Sense and control	15	6.3 Nuclear radiation	110
2.1 Sight	16	6.4 Climate change and Solomon Islands	117
2.2 Hearing	23	Chapter review	121
2.3 Smell, taste and touch	27	7 More chemical reactions	122
2.4 Responding	30	7.1 Writing chemical equations	123
Chapter review	33	7.2 Naming compounds	130
3 Materials	35	Chapter review	135
3.1 Metals, non-metals and semi-metals	36	8 Mining and energy sources in Solomon Islands	136
3.2 Corrosion of metals	39	8.1 Minerals and mining	137
3.3 Reactions of metals with dilute acids	42	8.2 Energy sources: Fossil fuels	146
3.4 Pure metals and alloys	44	8.3 Nuclear and other energy sources	149
3.5 Plastics and fibres	47	Chapter review	154
Chapter review	55	9 Communication technology	155
4 Human body systems	56	9.1 Waves in communication	156
4.1 Skeleton and muscles	57	9.2 The communications network	163
4.2 Human reproductive systems	62	Chapter review	168
4.3 From gamete to birth	66		
4.4 Reproductive problems	71		
4.5 Nervous control	74		
4.6 Chemical control	80		
Chapter review	87		

Introduction

The exciting new ***Solomon Islands Science Year 9 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 9 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

Magnets and electro-magnets

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

- explain that the two ends of magnets are called the north (N) and south (S) poles
- demonstrate using a magnet that: (i) like poles repel (N–N, S–S) and (ii) unlike poles attract (N–S, S–N)
- demonstrate using iron nails that a magnetic force is a non-contact force
- demonstrate the path that a magnetic field takes around a magnet by using iron filings and paper
- demonstrate by using a compass the direction of field lines
- explain that the needle of the compass always points towards the Earth's geographical north pole (south magnetic pole)
- use a simple circuit with a compass to show that a magnetic field is generated when an electric current passes through
- list appliances that use electromagnets: radio, video, speakers.

- 1 List some of the things you use every day that have magnets in them.
- 2 What type of force is produced by a magnet?
- 3 The needle of a compass always points north. Explain why.
- 4 What do you know about electromagnets?
- 5 What do you think makes a loudspeaker function the way it does?

Specific learning outcomes

9.1.1.1, 9.1.1.2, 9.1.3.1, 9.1.4.1, 9.1.4.2, 9.1.5.1, 9.1.6.1, 9.1.7.1

Challenges



UNIT 1.1

Magnetic forces

Introduction

Magnets exert an invisible force that is strong enough to push or pull without even touching. This force is called a magnetic force. It is a non-contact force that has many uses. You would have felt the pull of a cupboard door just before it closes, or the pull of the rubber magnets that are on the fridge door. These magnetic forces attract only over a short distance between the magnet and the metal.

Introducing magnets

Magnets can:

- attract metals containing the elements iron, nickel or cobalt. Steel is a common metal that contains a high percentage of iron. Magnets therefore also attract steel.
- pull the ends of other magnets towards them (attract), or push the ends of those same magnets away (repel)
- point to the north and south poles of the Earth
- make some other objects magnetic.

Activity 1

Attracting and repelling

Aim

To investigate the two poles of a bar magnet

Equipment

Watch-glass, 2 bar magnets

Method

- 1 Balance a magnet on the back of a watch-glass.
- 2 Hold another magnet near the poles as shown, and record your results in the table below.

	North pole	South pole
North pole		
South pole		

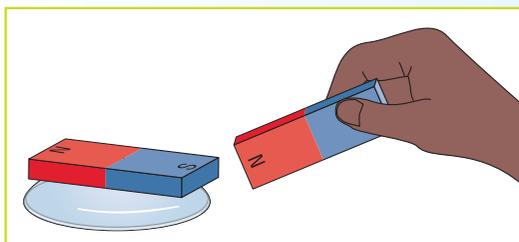


Fig 1.1.1 Magnets attract and repel.

Questions

- 1 Propose a rule for the attraction and repulsion of magnetic poles.
- 2 Explain the term 'poles'.



Fig 1.1.2 Iron filings in the magnetic field of a bar magnet

Attraction and repulsion

The magnetic force fields are particularly strong at the ends of a magnet. The ends are called poles: the north pole and the south pole. Poles that are the same (called 'like' poles) push away or repel each other. Poles that are different ('unlike') pull together or attract each other.

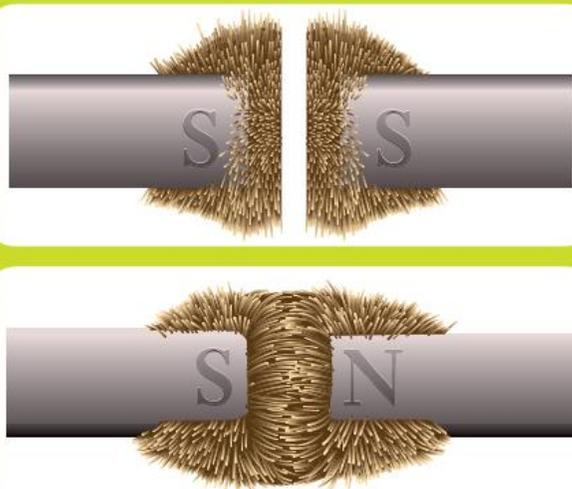


Fig 1.1.3 Magnetic like poles repel (top), magnetic unlike poles attract (bottom).

Making and destroying magnets

The first magnets were simply lumps of rock that were naturally magnetic. These rocks contained a lot of iron and were called magnetite or lodestones.

All magnets, iron and steel contain mini-magnetic particles called domains. In iron, these domains are pointing in different directions, so their forces cancel each other out. Overall, iron is not magnetic, but if a magnet is close to a piece of iron it can push the domains in the iron to align in one direction. This will make the piece of iron magnetic. This process is shown in Figure 1.1.4.

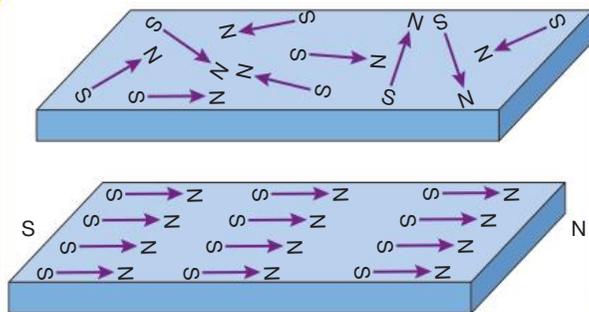


Fig 1.1.4 Iron becomes magnetic if its domains align.

This can be done by:

- stroking the piece of iron or steel repeatedly, in the same direction, with another magnet
- lining up a piece of iron with the north and south poles of the Earth and gently tapping it

- leaving the iron in the core of an electromagnet. If magnets are dropped, hit or heated, the domains can be knocked out of alignment and the magnetism is lost. Permanent magnets are made from harder steel or cast iron, in which the domains are more resistant to being knocked.

Activity 2

Getting magnetic

Aim

To make an object magnetic

Equipment

A permanent magnet; a large nail; small pins or paperclips; polystyrene, cork or other floating material; bucket or ice-cream container

Method

- 1 Repeatedly stroke the large nail with the same end of the magnet, lifting it high at the end of each stroke. Count the number of strokes you make.
- 2 Keep stroking until the nail is able to attract some pins or paperclips.
- 3 Rest the nail on a piece of floating material such as polystyrene.
- 4 Carefully rest the float on water in a bucket or ice-cream container.
- 5 Compare the direction in which the nail points with that of a 'standard' compass.

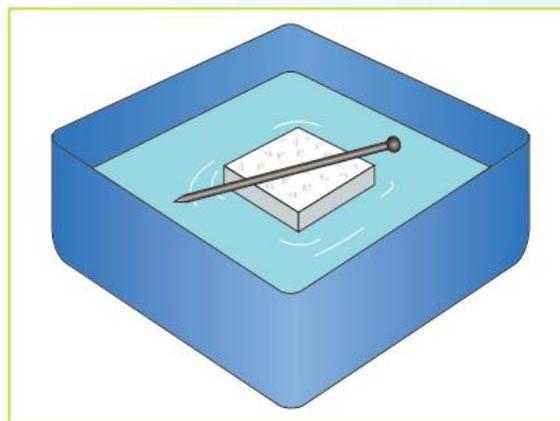


Fig 1.1.5 A compass is simply a magnet.

Questions

- 1 State the number of strokes you made to magnetise the nail.
- 2 Describe whether the nail successfully acted as a compass.
- 3 Describe how you could check.

Magnetic fields

Non-contact forces must have a method of moving other objects without touching them. This happens because there is a force field around the magnet.

This magnetic field is the area around a magnet where a magnetic force is felt. Magnetic field lines show the direction an iron filing or a compass needle would point in the field. Scientists show the direction of the field with arrows that point away from the north pole and to the south pole.

These lines never cross and come straight out of any surface. Lines that are close together show strong fields. Weak fields have their lines widely spaced.

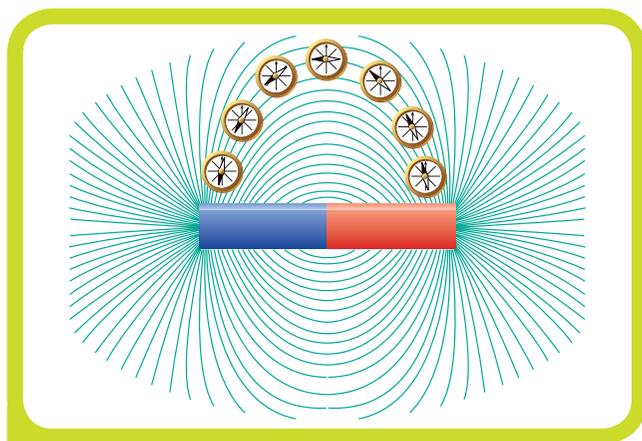


Fig 1.1.6 Bar magnet showing the force field with small compasses

Magnetic fields are strongest at the magnet's poles and get weaker as we move further away from them.

Magnetic Earth

Compasses are actually small magnets that are allowed to move. The compass needle aligns itself with the Earth's magnetic field lines and can be used to find north or south.

This suggests that the interior of the Earth is actually a magnet, with its own magnetic field flowing from the south pole to the north pole.

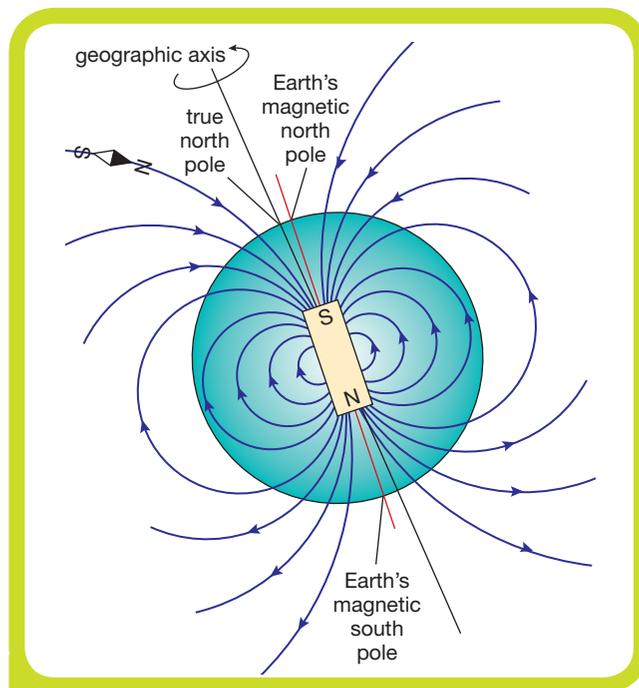


Fig 1.1.7 Bar magnets and the Earth have similar magnetic fields. The symbol at the top left shows the way a compass reacts in the Earth's magnetic field.

Activity 3

Magnetic fields

Aim

To observe magnetic fields

Equipment

A wooden board or bench mat, 1 sheet of waxed lunch-wrap, bar and horseshoe magnets, fine iron filings (preferably in a shaker), access to a 200–300 W spotlight to be used as a heat source (CAUTION: The spotlight will be extremely hot.)

Method

- 1 Place a magnet on the board or bench mat and lay a sheet of waxed lunch-wrap over the magnet.
- 2 Sprinkle a small amount of iron filings onto the sheet, gently tapping the sheet to spread them out around the magnet.

- 3 Shine the spotlight onto the sheet to melt the filings into the wax.
- 4 You now have a permanent record of the magnetic field of the magnet—paste it into your workbook.
- 5 An alternative is to use hair spray to fix the iron filings to the paper. (CAUTION: Check whether any students are allergic to perfumed hair sprays.)

Questions

- 1 Identify where the magnetic field was the strongest.
- 2 Identify and describe any positions on the magnet where no (or very few) filings were attracted.
- 3 Describe what you noticed about the strength of the field further away from the magnet.



[Questions]

Checkpoint**Introducing magnets**

- 1 Suggest how magnets were given their name.
- 2 Identify whether magnetic forces are contact or non-contact forces. Explain your answer.
- 3 List the three metals that can be attracted to magnets.

Attraction and repulsion

- 4 Identify the two poles found on magnets.
- 5 List the rules for attraction and repulsion of magnetic poles.

Making and destroying magnets

- 6 Explain the term 'domain'.
- 7 Describe how iron can be made magnetic.
- 8 Use a drawing to explain what the word 'align' means.

Magnetic fields

- 9 Draw magnetic fields for a bar magnet and a horseshoe magnet.
- 10 Identify where the magnetic field on a magnet is strongest and where it is weakest.

Magnetic Earth

- 11 Explain how a compass works.
- 12 Predict what the Earth's core is made up of, given that the Earth has a magnetic field.

Think

- 13 Copy the following and modify any incorrect statements so they become true.
 - a The north pole of a magnet will attract other north poles.
 - b Compasses are actually small magnets.
 - c The area around a magnet is called its poles.
 - d The ends of a magnet are called its magnetic field.
 - e Domains must be aligned for a piece of iron to be a magnet.
 - f The Earth does not have any magnetic field.
- 14 Magnets need to be stored carefully. Propose a set of recommendations for how they should be stored.
- 15 Steel ships often accidentally become magnetised while they are being built. Propose reasons for how this happens.
- 16 Draw the magnetic field of the Earth, indicating where the field is strongest.

[Extension]

Investigate

- 1 Investigate what the word 'ferromagnetic' might mean. (Hint: Use the periodic table on page 169 to find the chemical symbol for iron.)
- 2 Most permanent magnets are made from an alloy called 'alnico'.
 - a Use a periodic table (see page 169) to identify the meanings of the chemical symbols Al, Ni and Co.
 - b State the three elements that the alloy alnico contains.
 - c Propose a reason why each one might be included.
- 3 The north pole is not exactly where a compass points. Research and explain the difference between the true (geographic) and magnetic north poles.
- 4 Investigate how magnetism is used to record sound and images in cassette tapes, computer disks and videotapes. Draw a series of diagrams to show how these devices record information.

UNIT 1.2

Electromagnetism

Introduction

You use electricity every day in many different ways. Although magnets are less common, you will also have used them. They are the basis of all compasses and are used to hold notes on our fridges and to keep cupboard doors shut. There is an important connection between electricity and magnets: electricity can make magnetic fields and magnetic fields can make electricity! This connection is responsible for most of the appliances you use—everything from speakers to televisions, and alarm bells to electric motors.

Activity 4

Oersted's experiment and the electromagnet

Aim

To investigate the magnetic field around a current-carrying wire

Equipment

Power supply, switch, insulated copper wire (1 m), tape, small compass, cardboard tube, large iron nail

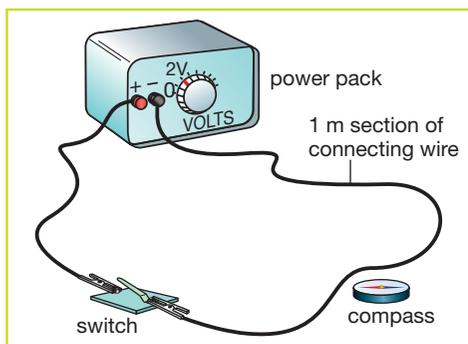


Fig 1.2.1

Method

- 1 Assemble the apparatus as shown in Figure 1.2.1. Ensure the power supply is set to 2 volts.
- 2 Hold the switch down and note any effect on the compass needle.

- 3 Investigate the effect of moving the compass further away from the wire.
- 4 What happens if the voltage is turned down (and the current reduces)?
- 5 Now wind the wire around the cardboard tube as shown in Figure 1.2.2. Use tape to secure the coils to the tube.
- 6 Compare the strength of the magnetic field inside the tube with that produced in step 2.
- 7 Now wind the wire around the nail instead of the cardboard tube. Use tape to secure the coils if required.
- 8 Hold the pointy end near the compass while holding the switch down.
- 9 Hold the head of the nail (the non-pointy end) near the compass while holding the switch down.

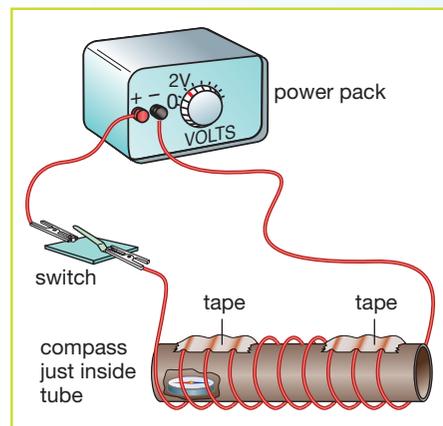


Fig 1.2.2

Questions

- 1 Explain what happens to the strength of a magnetic field as you move further from a wire.
- 2 Explain whether a larger current produces a stronger or weaker magnetic field.
- 3 Would several coils cancel each other's magnetic fields or reinforce them? Justify your answer.
- 4 Explain whether an electromagnet is stronger or weaker with an iron core.
- 5 Describe how the magnetic fields differ at each end of the nail.

An electric current causes a magnetic field

In 1820, Danish physics professor Hans Oersted was carrying out experiments with electric circuits when he noticed that the needle of a compass on his desk moved whenever an electric current flowed nearby. Oersted was able to move a compass needle without touching it, as if by magic.

The compass was doing what compasses do—it was reacting to a magnetic field. In this case, the magnetic field was produced by the electric current. Oersted had discovered that electricity could cause magnetism. Later in this unit you will see that the reverse is also true—that magnetism can cause electricity. This connection is known as electromagnetism.

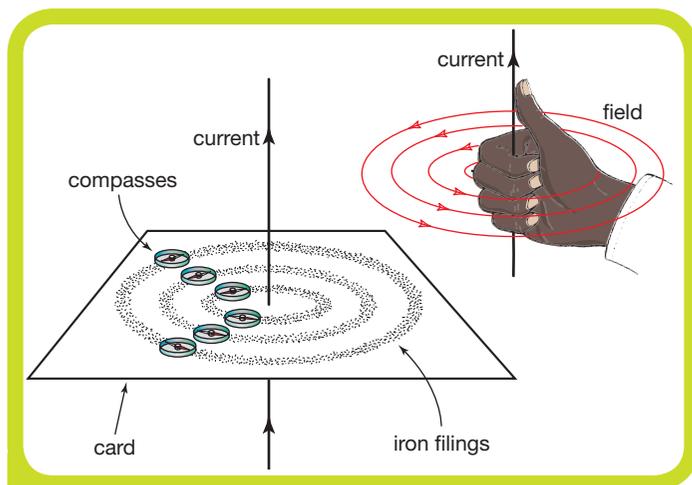


Fig 1.2.3 The magnetic field around a straight, current-carrying wire. The 'right-hand grip rule' can be used to determine the direction of the field, which is the way a small compass needle would point.

The magnetic field produced around a straight wire carrying current is circular, as shown in Figure 1.2.3. If straight wire is looped, several circular magnetic fields combine to produce a stronger field through the centre of the loops, as shown in Figure 1.2.4 (a). If straight wire is coiled so that several loops are placed together, the magnetic field is much stronger again. A coil with several loops is called a solenoid, shown in Figure 1.2.4 (b). An electromagnet is a solenoid with an iron core that further concentrates the field down its centre, as shown in 1.2.4 (c).

Unlike permanent magnets, electromagnets can easily be switched on and off.

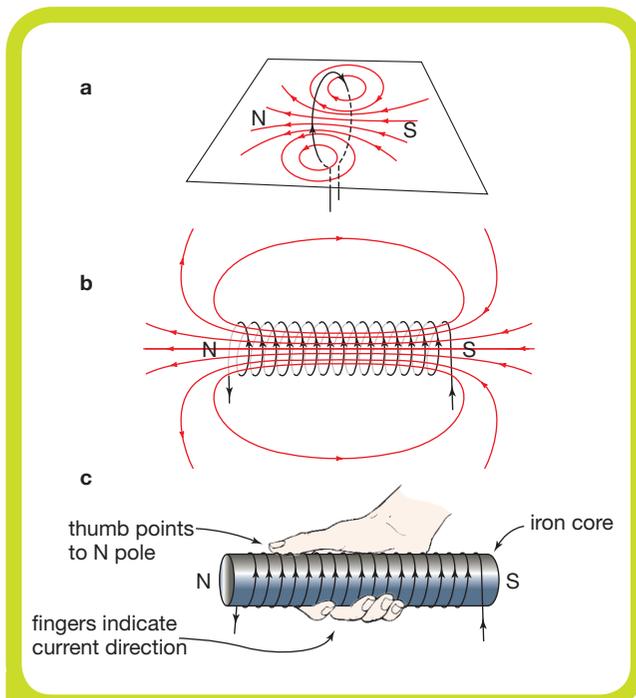


Fig 1.2.4 The magnetic fields from several loops are combined and concentrated in an electromagnet.

Uses for electromagnets

There are many applications for electromagnets that are essential to our everyday life. Many are not easily noticed and range from large industrial electromagnets to the tiny speakers in your mobile phone.

Industrial electromagnet

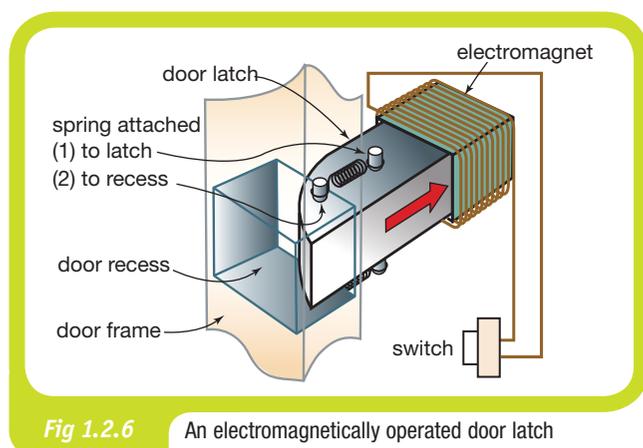
Industrial electromagnets are used extensively in metal scrap yards and allow the movement of large amounts of steel.



Fig 1.2.5 The ability to switch magnetism on and off is extremely useful in industry.

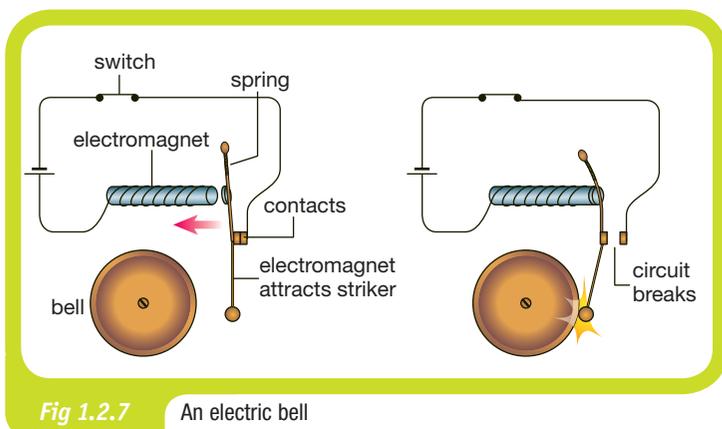
Door latch

Door latches are usually found in high-security areas. To open a door a button is pressed, resulting in a current flowing to a coil. The resulting magnetic field attracts the latch out of the door recess, opening the door.



Electric bell

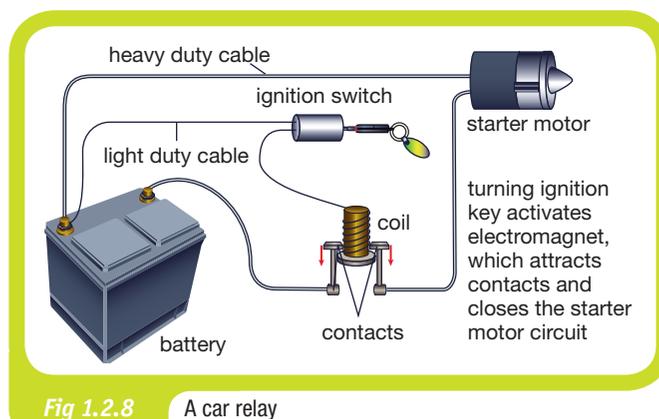
Some schools use an electric school bell. How does it work?



When the switch is pressed, the electromagnet effect begins and attracts the striker, causing it to sound the bell and simultaneously break the circuit by moving the contacts apart. With the contacts apart, current no longer flows and the electromagnet is turned off. This allows the striker to return to its 'rest' position, where the contacts touch once more, causing current to flow again, and the cycle repeats, resulting in the familiar bell-ringing sound.

Relay

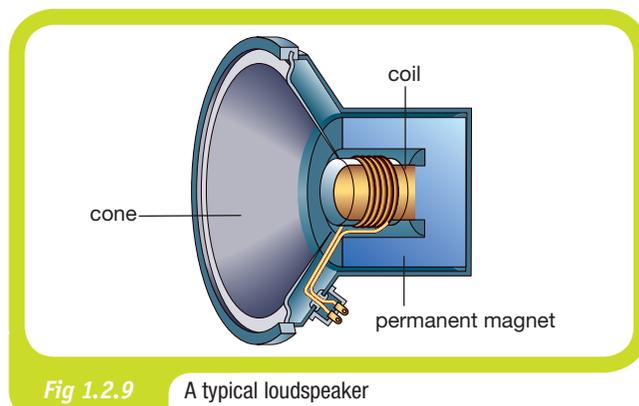
Electromagnetic relays are found in cars and industrial machinery. The starter motor in a car allows a small current within a thin wire to control a much larger current within a larger cable, thereby reducing the cost of connecting wires and increasing safety.



Speakers

Loudspeakers are an essential part of a teenager's life, being part of nearly everything that makes noise. Mobile phones, answering machines, stereos, televisions and surround-sound systems all have speakers of some sort.

A speaker receives varying electrical current that flows through a coil, causing it to become an electromagnet. The speaker also contains a permanent magnet, which interacts with the electromagnet. The two magnets attract when the current fed into the speaker flows one way, and repel when the current flows the other way, producing vibrations in the cone. These vibrate molecules in the air to create sound waves.



Television

Electromagnets control which pixels (coloured spots or rectangles) are illuminated on a television screen. Although the actual electron beams are not coloured, they are shown coloured in Figure 1.2.10 to show that there is one beam for each colour pixel in a section of screen.

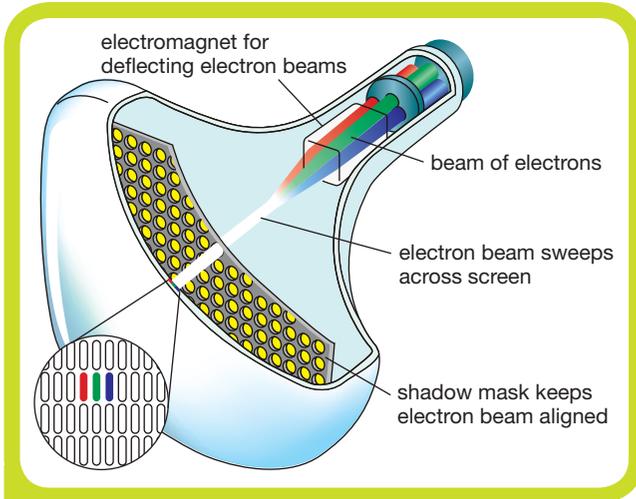


Fig 1.2.10 How a television works

Trains

Japan's experimental maglev (short for 'magnetic levitation') train uses superconducting electromagnets to lift it 10 centimetres above the track, position it correctly and propel it at speeds of over 500 kilometres per hour. Such high speeds are possible because of the train's streamlined shape, and the lack of friction between the train and track.

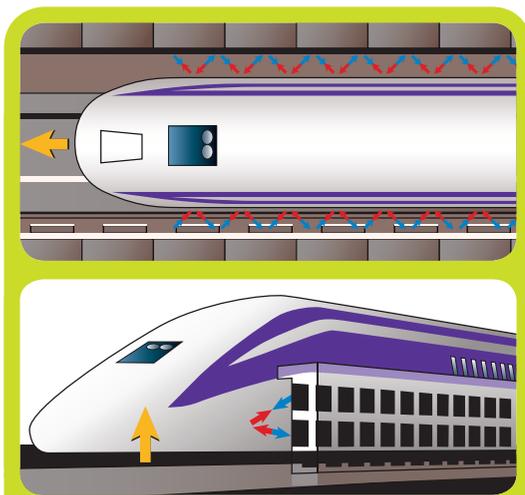


Fig 1.2.11 The maglev train 'floats' due to the repulsion between electromagnets, providing a frictionless track.

Activity 5

A simple generator

Aim

To investigate the correlation between magnetism and current electricity

Equipment

Solenoid, bar magnet, connecting wires, galvanometer or microammeter

Method

- 1 Connect the circuit as shown in Figure 1.2.12.
Note: A galvanometer is like a very sensitive ammeter, and detects small currents. In each step below, observe the reading on the galvanometer as you carry out the step.
- 2 Move the north end of the magnet into the solenoid.
- 3 Leave the magnet resting in the end of the solenoid for several seconds.
- 4 Withdraw the magnet from the solenoid.

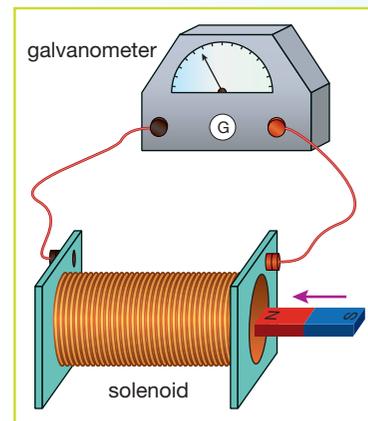


Fig 1.2.12

- 5 Repeat steps 2 to 4, but move the magnet more quickly.
- 6 Repeat steps 2 to 5, but move the south end of the magnet into the solenoid.

Questions

- 1 Explain why a globe was not used to detect current.
- 2 Explain whether a magnet in a solenoid always produces a current.
- 3 Describe the effect of varying the speed of the magnet.
- 4 Contrast the effect of the magnet when it is withdrawn with its effect when it enters the solenoid.
- 5 Describe whether changing the pole (north or south) that approaches the solenoid has an effect.
- 6 Predict the effect a stronger magnet would have.

A magnetic field causes an electric current

In 1831, English scientist Michael Faraday demonstrated that if a magnet is moved into a coil of wire, a current was produced in the coil. If the magnet stopped moving, so did the current. If the magnet was removed, a current was produced but in the opposite direction. By continually moving the magnet in and out of the coil, he produced a continuous but alternating current (AC). Faraday had found that by changing the magnetic field inside a coil, he could generate an electric current. He had produced a simple generator.

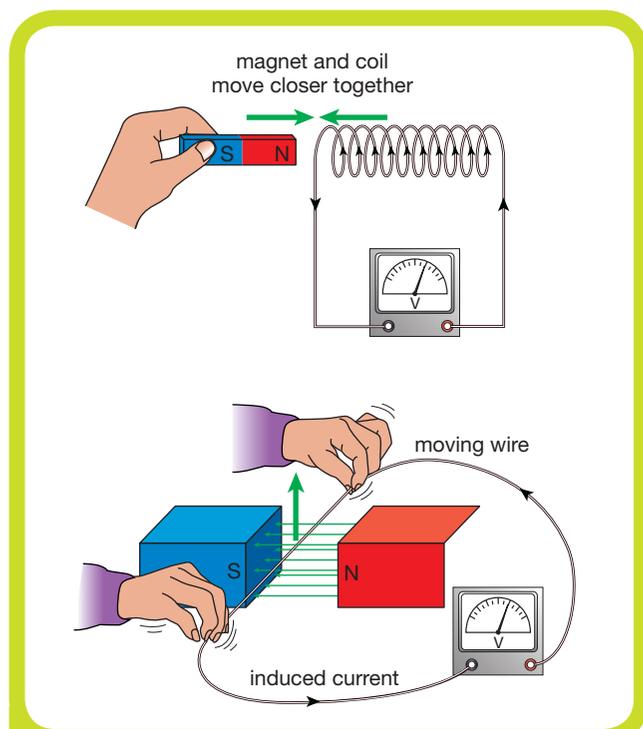


Fig 1.2.13 A current is produced if the coil of wire moves relative to the magnetic field.

Applications of generators

Apart from battery-powered devices, most of the electricity we use is AC and comes from electrical generators. These can be small (as on a bike) or huge, feeding the power grid of a city.

Bikes often have a small AC electric generator called a dynamo attached to their wheel rim. A rotating magnet inside the dynamo produces alternating current similar to that produced by

moving a magnet in and out of the coil in Faraday's experiment. More than a dynamo is needed to power a city, however. To generate sufficient electrical power, massive turbines are spun by water or steam. The principle is the same though: the turbines are attached to magnets that then spin in a coil to produce AC electricity.

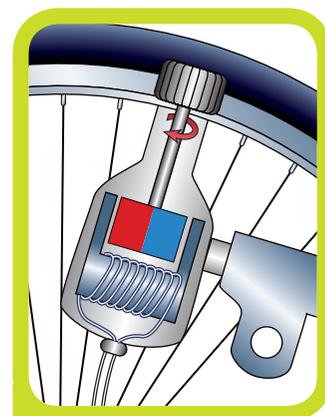


Fig 1.2.14 A bicycle dynamo

Activity 6

A simple electric motor

Aim

To construct a simple electric motor

Equipment

1.5 volt battery ('D' size), Blu-Tack, 2 rubber bands, 2 paperclips, 1.5 metres of enamelled copper wire, a small but strong disc magnet or a bar magnet, emery paper, pliers (optional)

Method

- 1 Wind the enamelled copper wire around the battery to make a solenoid.
- 2 Remove the wire from the battery and straighten 5 cm or so at each end.
- 3 Wind a centimetre or two of the ends around the loops of wire to keep them together.
- 4 Using emery paper, scrape the underside of each straight end to expose the copper (see magnified view of straight ends in Figure 1.2.15).
- 5 Use fingers or pliers to shape the two paperclips as shown.
- 6 Use the rubber bands to attach the paperclips to the battery.
- 7 Place the magnet so it sticks to the top of the battery (see Figure 1.2.15). Alternatively, hold a bar magnet near the coil.
- 8 Stabilise the battery using Blu-Tack.
- 9 Add the loops to complete the motor and check that measurements and positioning match the figure.
- 10 Give the loops a nudge (you may need to try spinning the coil both ways) to start the motor. You may need to experiment with the position of the magnet.

Microphone

A moving coil-type microphone contains a diaphragm that vibrates a coil in response to sound waves, generating a current that varies with the strength and frequency of the vibrations. This current can be fed into an amplifier and converted into a louder sound by attaching speakers.

Transformers

Sometimes the voltage provided is either too much or too small for the intended use. For example, laptop computers only need 16 V and mobile phones need only 5.7 V to recharge. The 240 V available from the power point would damage both if used directly. For efficiency reasons, the best voltage for long-distance transmission of electricity is 33 000 V, whereas the electricity is generated at a much lower voltage. In all these cases a transformer is needed. Transformers use solenoids and the magnetic fields they produce to either increase (step up) voltage or reduce (step down) voltage to the value required.

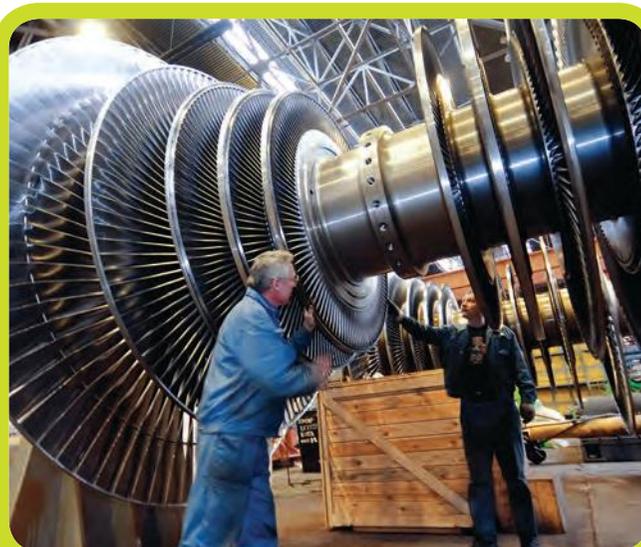


Fig 1.2.16 Compare the size of the person in this photo with the steam-driven turbine used to generate electricity.

Questions

- 1 Explain why several loops are better than a single one.
- 2 Predict what would happen if the entire wire (loops included) was not insulated.
- 3 Explain how scraping half the coating from the straight ends of the wire helps. Predict what might happen if you didn't do this.
- 4 Identify possible improvements to your model motor.
- 5 Take apart a small electric motor (eg from a broken toy) and compare the parts with your model.

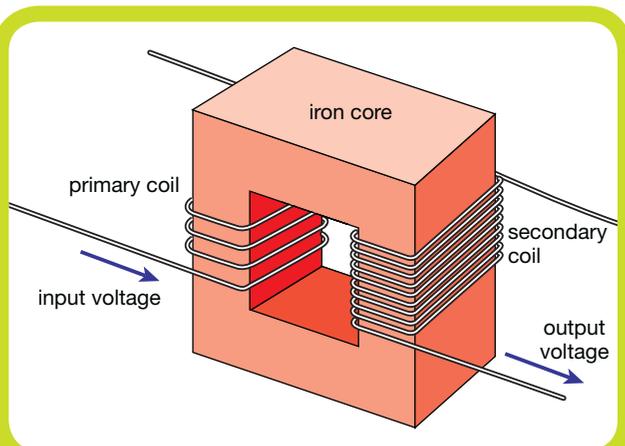


Fig 1.2.17 Transformers use electromagnetism to step up or step down voltages. This is a step-up transformer.

Power transmission

Power stations use energy from diesel (fossil fuel), burning coal, flowing water (hydro power) or other sources to spin turbines in large generators, and transmit power through an extensive network of overhead and underground power lines.

Because high-voltage transmission is more efficient, a transformer is needed close to the power station. These high voltages would be far too dangerous, however, if fed directly into your home, and so a series of transformers is used to reduce the voltage to the final (but still deadly) 240 V we use. The adaptors used for laptops, mobile phones and other appliances are transformers. They reduce 240 V from power points to required values.

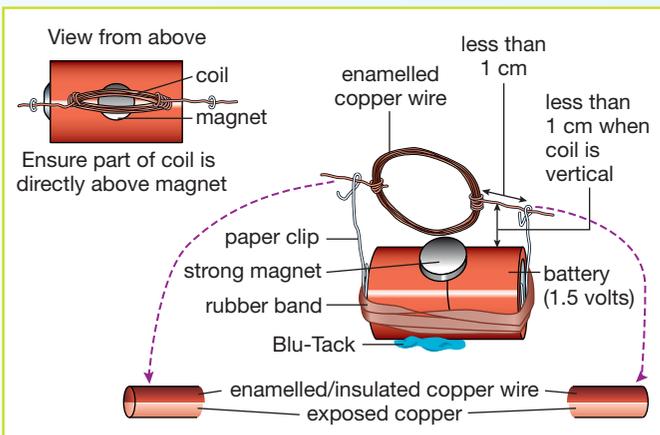


Fig 1.2.15

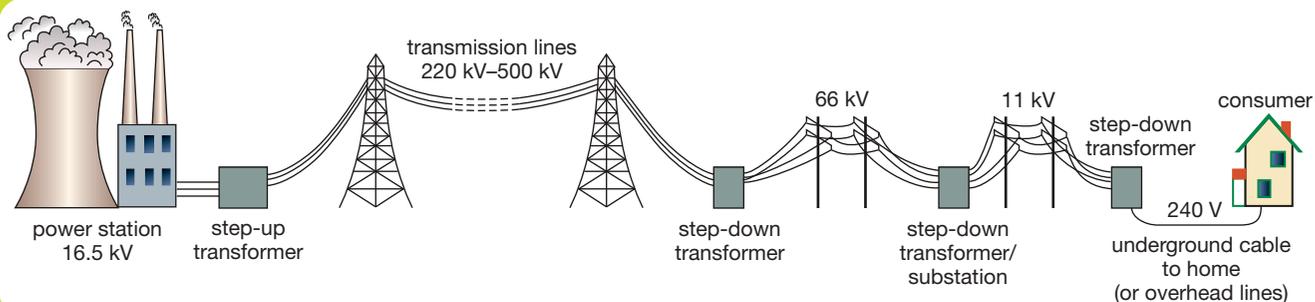


Fig 1.2.18 How electricity reaches our homes from the power station

1.2 [Questions]

Checkpoint

An electric current causes a magnetic field

- In which year did Oersted discover that a current produced a magnetic field?
- Construct a diagram showing the shape of the magnetic field around a straight wire.
- Outline the difference between a solenoid and an electromagnet.
- State the key advantage of an electromagnet over a conventional magnet.

Uses for electromagnets

- List three devices that use electromagnets.
- State the job done by the electromagnet in each case.

A magnetic field causes an electric current

- Use Figure 1.2.13 to outline the result of:
 - placing the magnet in the coil of wire
 - removing the magnet from the coil of wire
 - continually moving the magnet in and out of the coil of wire.
- List two devices that contain a simple generator.

Transformers

- State what a transformer is used for.
- List the two main types of transformer.
- Count the number of primary and secondary coils in Figure 1.2.17 and propose a way of deciding whether the transformer is step-up or step-down.
- Use Figure 1.2.18 to state the main stages in electricity transmission.

Think

- State what type of transformer would be needed:
 - for a laptop computer
 - for long-distance transmission
 - at a substation on the outskirts of a town
 - to recharge a mobile phone.
- Use an example to explain how an electromagnetic device operates.
- From the following, identify those situations in which an electric current is generated.
 - A magnet enters a wire coil.
 - A magnet sits still inside a wire coil.
 - A magnet is removed from a wire coil.
 - A wire coil moves towards a magnet.
 - A wire coil moves away from a magnet.
 - A current is turned on in a wire coil facing another wire coil.
- Compare the voltages of transmission lines with the voltage used at home.
- Explain why power companies bother increasing the voltage of power lines if it is only going to be reduced again before reaching homes.
- Propose a reason why high-voltage power lines are always kept well above the ground by tall pylons.

Skills

- Design and sketch a circuit that uses electromagnets to release a trapdoor when a person steps on a certain section of floor.

[Extension]

Investigate

- 1 Research how electromagnetism is used to record and erase magnetic audio or video tapes. Use a diagram to explain your information.
 - 2 Research some of the discoveries made by Joseph Henry (1797–1878) in the area of electromagnetism and give a one-minute oral presentation on one discovery.
 - 3 Use an example to explain how 'Fleming's left-hand rule' gives the direction of the force on a current in a magnetic field.
- 4 a Research whether it is dangerous to live near high-voltage power lines.
 - b Write a letter to the government outlining the potential dangers of electromagnetic radiation. Be sure to support your ideas with evidence.
 - c In your letter, recommend what should be done to reduce the risk of electromagnetic radiation to the community.
 - d Conduct a class debate on this issue.

Chapter review

[Summary questions]

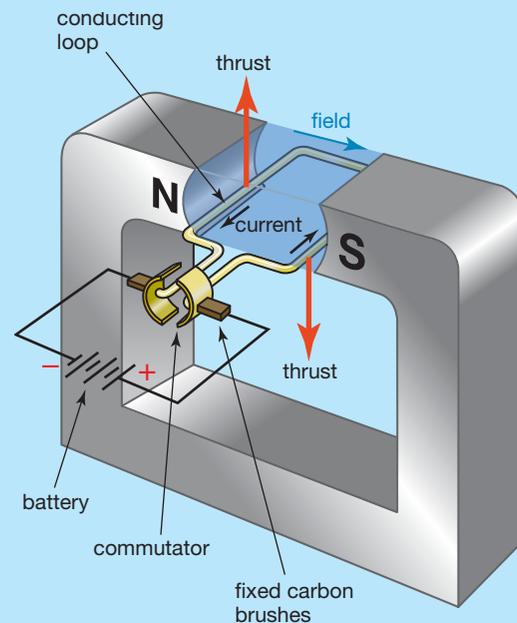
- 1 What was Hans Oersted's conclusion about electric current and magnetic field?
- 2 List some applications of electromagnets.
- 3 What was Faraday's conclusion about magnets and electric current?

[Thinking questions]

- 4 Describe three ways in which a magnet can be made.
- 5 Explain how magnets can lose their magnetism.
- 6 Draw the magnetic field that exists around a bar magnet.
- 7 Explain what a compass is and how it can be made.
- 8 Which way would a compass point if you were at the Earth's north magnetic pole?
- 9 Why do electric motors contain so many windings of copper wire?
- 10 Compare the voltages of transmission lines with those used in your homes.

[Interpreting questions]

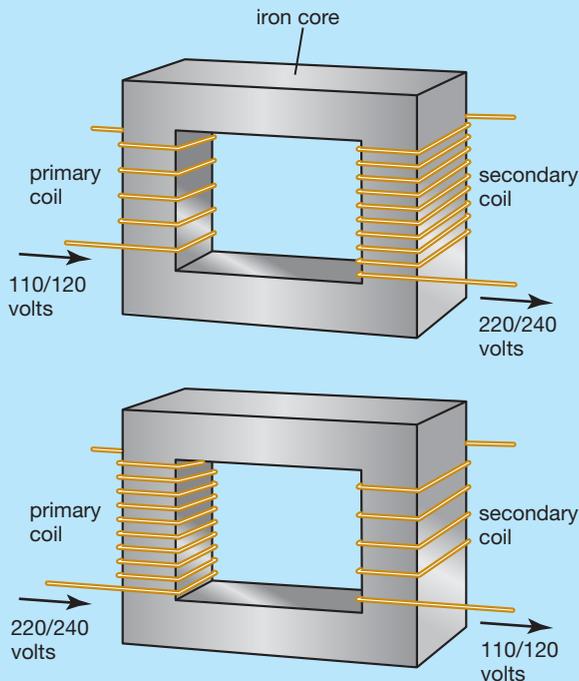
- 11 Below is a diagram of a DC motor. There is a current flowing through the loop as shown below.



- a Will the coil rotate in a clockwise or an anticlockwise direction?
- b What is the purpose of the commutator?

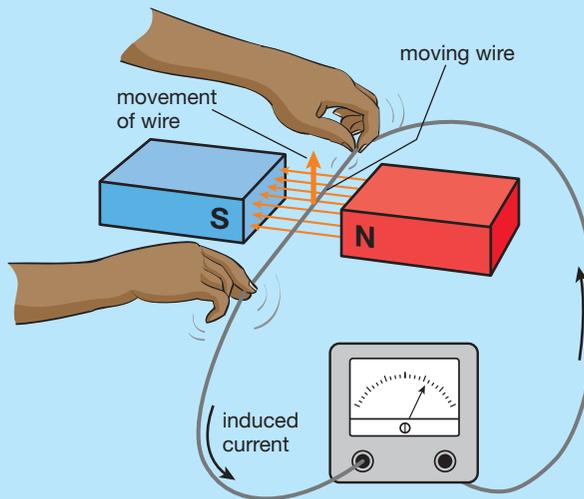
>>

12 The diagram below shows a transformer. Transformers use electromagnetism to step up and step down voltages. Study the diagrams carefully and answer the following questions.

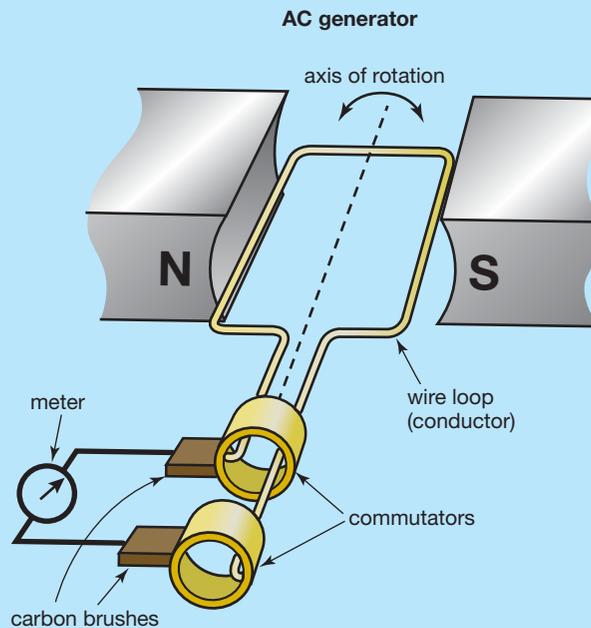


- What will happen if there is no primary coil in the transformer?
- What is the function of the secondary coil in the transformer?

13 A current is produced if the coil of wire moves relative to the magnetic field as shown in the diagram below.



- Where is the induced current produced?
 - What is the direction of the magnetic field when the moving wire moves up and down between the two magnets?
- 14** The diagram below shows a simple AC generator. Study the diagram and answer the following questions.



- Give one reason why it is important for a generator to have two magnetic poles.
- Name one similarity between an AC generator and an electric motor.

CHAPTER

2

Sense and control

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

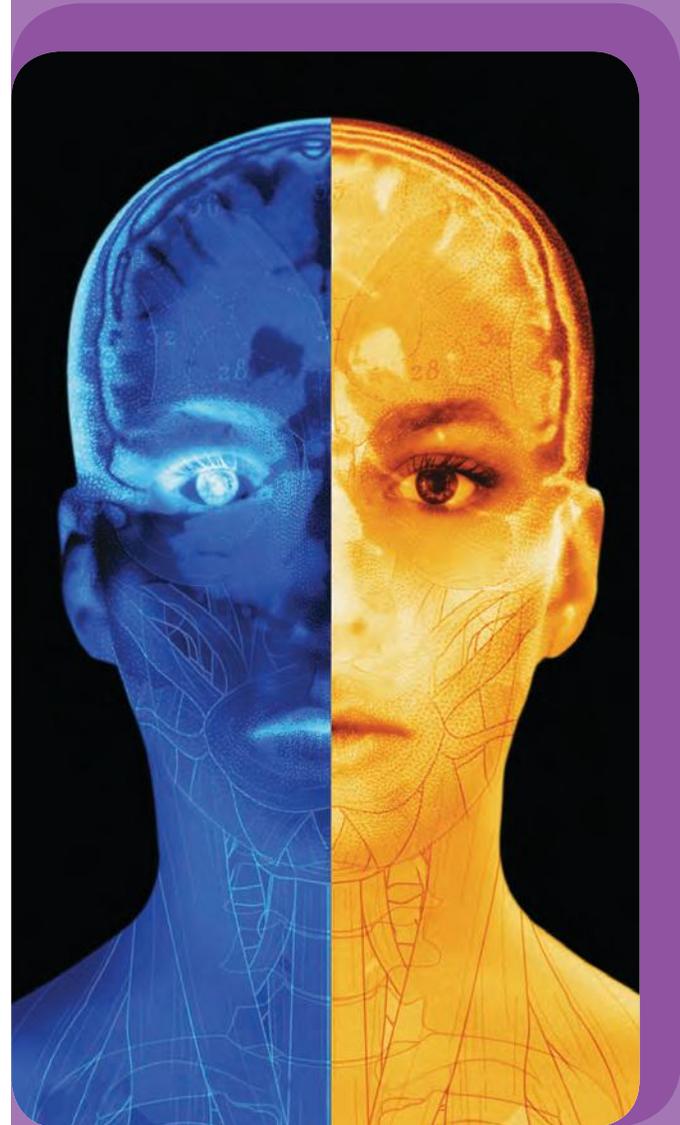
- 1 identify the five human senses
- 2 identify the parts of the body that are responsible for our senses
- 3 describe the main functions of the internal parts of the human eye, nose, ear and tongue
- 4 demonstrate the part of the tongue responsible for sour, bitter and sweet tastes
- 5 explain the problems associated with body parts
- 6 explain the use of different lenses to resolve short-sightedness and long-sightedness
- 7 explain ways to solve hearing problems
- 8 perform a simple stimulus–response exercise.

- 1 List your five senses.
- 2 What is the biggest organ of the human body?
- 3 What is the advantage of having two eyes and two ears?
- 4 What is your body doing right now without any thought from you?
- 5 Why is it dangerous to dive into water of unknown depth?

Specific learning outcomes

9.2.1.1, 9.2.2.1, 9.2.3.1, 9.2.4.1, 9.2.5.1, 9.2.6.1,
9.2.6.2, 9.2.7.1

Challenges



UNIT 2.1

Sight

Introduction

Your eyes provide what many would regard as the most important of all your senses—sight. Take a look around you now. If your eyes are working normally, they just give out automatically focused colour images of several objects located different distances away to your brain with very little effort! But how do eyes work?

Activity 1

Eye tests

Aim

To construct a mini eye chart and to find your eye's blind spot

Equipment

Pen and paper or card

Method

Part A: Your yellow spot

- 1 Use a centimetre grid to draw a larger version of the mini eye chart shown in Figure 2.1.1.

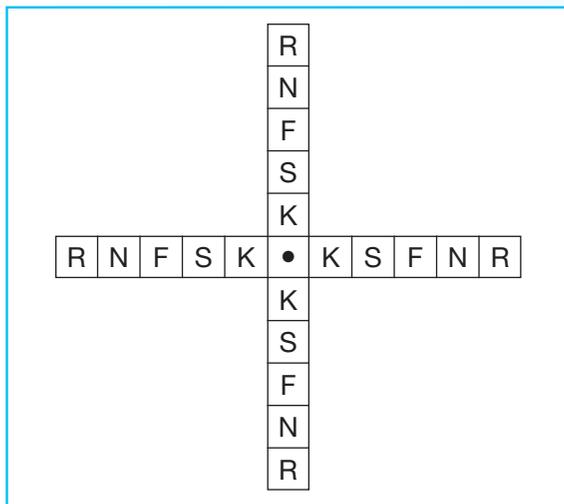


Fig 2.1.1 Mini eye chart

- 2 Hold the chart about 20 cm from your right eye while shutting your left eye.

- 3 Stare at the dot in the middle of the chart.
- 4 Note which letters you can make out clearly (do not memorise them).
- 5 Repeat, this time looking with your left eye while shutting your right.

Part B: Your blind spot

- 1 Hold the textbook at arm's length and look directly at Figure 2.1.2.
- 2 Shut your left eye, and stare at the cross with your right eye.



Fig 2.1.2

- 3 Gradually bring the textbook closer and note when the dot disappears. This happens when light from the dot falls on your right eye's blind spot.
- 4 Repeat with your left eye open and right eye closed.

Part C: Distance perception

- 1 Have a partner hold a pen upright at arm's length as shown.
- 2 With one eye shut, try to vertically line up another pen to touch your partner's pen. This may take several attempts.



Fig 2.1.3

- 3 Repeat steps 1 and 2 with the other eye shut.
- 4 Try again with both eyes open.

Questions

- 1 a State the number of letters you could see in part A.
b Calculate a class average.
- 2 a At what distance from your eye did the cross disappear (when its light fell on your blind spot)?
b Compare this with others in your class.
- 3 Evaluate your ability to judge distance with one eye only, compared to two eyes.

Parts of the eye

The eye contains several parts that may remind you of the parts of a camera. When you think about it, both the eye and the camera perform similar tasks—

focusing on and capturing images. You may recall from earlier studies of light that images produced by convex lenses are upside down.

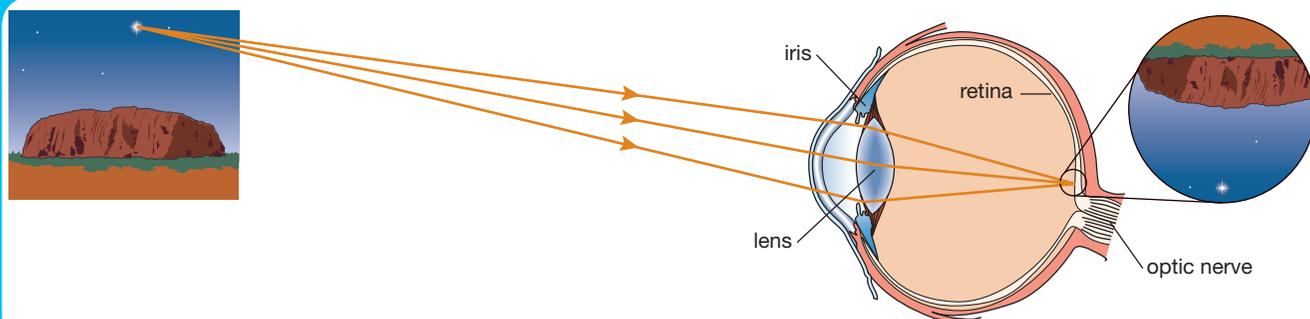


Fig 2.1.4 The eye focuses images in the retina. Although the image is upside down, the brain processes it so that we perceive it the correct way up.

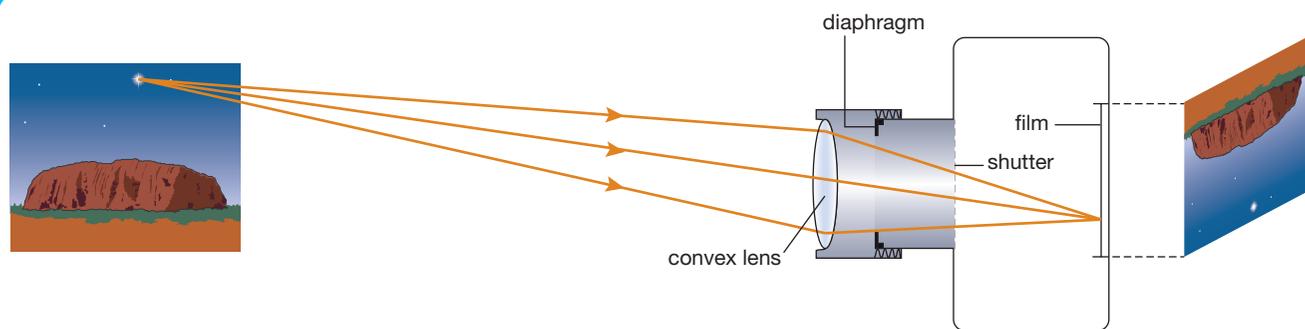


Fig 2.1.5 The similarities in the operation of a camera and the eye are obvious.

Eye protection

There are a number of features that help protect our eyes. Our eyebrows and eyelashes help keep dust out, and tear ducts produce tears to flush out any foreign particles. Our eyes are set back in depressions in our skulls called orbits to give them some protection from being knocked.

Warning! Always use protective eyewear in science classes when handling or heating chemicals that could spit or spill from their containers. If a foreign substance does get into your eye, flush it immediately with water while trying to keep your eye open to allow water to contact the affected area. An eyewash bottle should be available for this purpose.

Why two eyes?

Two eyes allow us to judge distances more accurately. Each eye sees a slightly different view. The brain combines the two images to create a three-dimensional view that gives us more information about how far away an object is. This is called binocular vision.

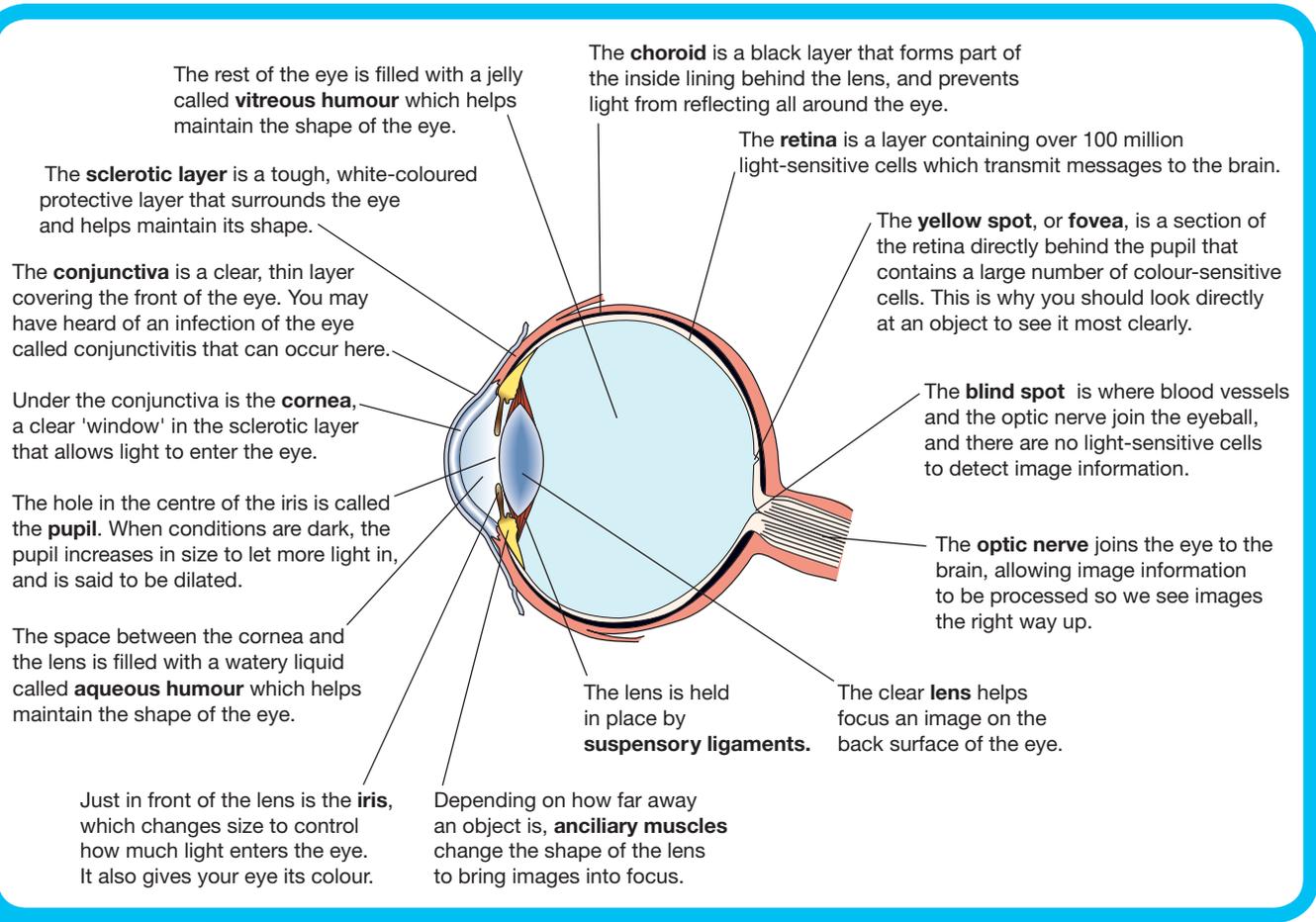


Fig 2.1.6 The human eye

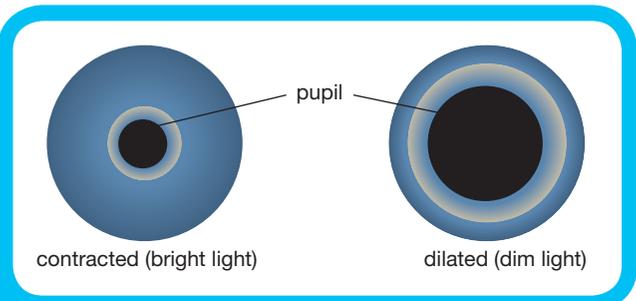


Fig 2.1.7 The pupil adjusts according to the amount of available light.



Fig 2.1.8 An eyewash bottle can be used to rinse foreign matter from the eye—make sure you know where one is in your classroom.

Colour vision

The retina contains special cells called rods and cones. Rods are more sensitive than cones, but respond only to light and dark, helping us to detect shapes. Cones need more light to be activated and come in three types, which detect the colours red, blue and green.

If red light falls on the retina, 'red' cones are activated. With purple light, both red and blue cones are activated. Both rods and cones send messages to the brain to help us see.



Fig 2.1.9 A scanning electron microscope photograph of rods and cones

Some people lack one or more types of cone cells and cannot easily tell the difference between some colours, most notably red and green. This condition is known as colour blindness and affects about 1 in 15 males and 1 in 1000 females.

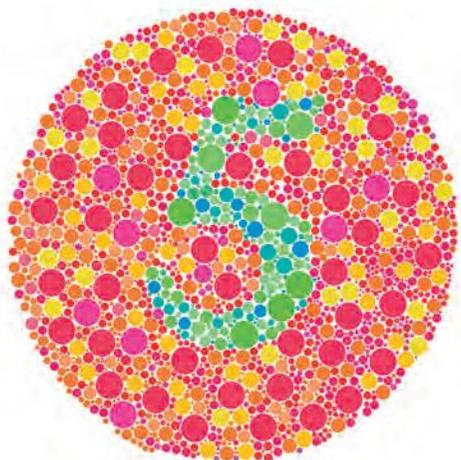


Fig 2.1.10 A colour blindness test. What do you see?



Fig 2.1.11 A rabbit can see both sides at once.

Animal eyes

The eyes of various animals are specialised to increase their chances of survival by detecting predators or food more easily. A rabbit's eyes are positioned on the sides of its head so that it can see most of its surroundings without moving its head and attracting attention. The eagle has excellent eyesight and can detect a rabbit from 3 kilometres away!

Like most predators, owls have both eyes at the front to allow better judgement of distance when swooping on prey.

Insects may have multiple lenses to provide an all-round view. Spiders have four, six or eight eyes, and scorpions have between six and twelve.

A chicken's eyes are on the opposite side of its head. Therefore to judge distance it needs to see an object with both eyes. The only way it can do this is to quickly move its head to view the object with one eye, then the other. That is the reason why chickens wobble their heads so frequently.

Do animals see in colour?

Yes, many animals see in colour, but not the same as we do—it depends on the number and type of cones they have. Some animals, like bees, see colours that we can't, as they have extra types of cones in their eyes. Birds that are active in daytime are able to see colours, but those that are active at night cannot. Cats, dogs and rabbits are thought to have very poor colour vision, and probably see virtually in black and white.



Fig 2.1.12 The forward-facing eyes of the owl give it good binocular vision, allowing it to judge distance as it swoops on prey.



Fig 2.1.13 A chicken must continually move its head to obtain a complete view of its surroundings.



Fig 2.1.14 An insect's compound eye contains thousands of lenses.

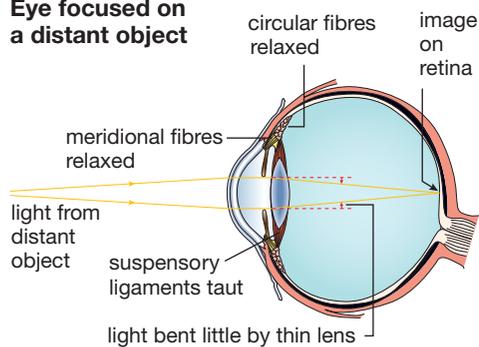
Cats' eyes are unusual for a couple of reasons. They have a slit-shaped pupil that opens and closes much faster than a round one, allowing their eyes to adjust to changes in light intensity more quickly. Have you ever noticed how cats' eyes shine at night? This is because a mirrored lining at the very back of the eye (called a tapetum) reflects light through the rods and cones a second time, giving the cat more chance of seeing objects, even in very dim conditions.

Sheep and horses have good colour vision. Insects can see colours, but not red. Some insects can see ultraviolet light, which is normally invisible to humans.

Eye defects

The job of the lens is to bend light so that an image is formed on the retina. It does this by using the ciliary muscles to change its shape. When these muscles relax, they pull on the suspensory ligaments and stretch the lens, making it thinner so it bends light less. When the ciliary muscles contract, they pull less and allow the lens to fatten up. Fatter lenses bend light more, which is what's required when looking at close objects. The ability of our eyes to change lens shape and focus at different distances is called accommodation.

Eye focused on a distant object



Eye focused on a near object

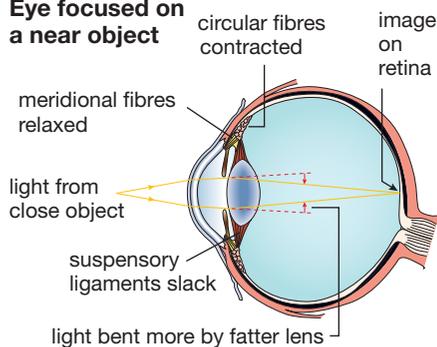


Fig 2.1.15 How the eye focuses on close and distant objects

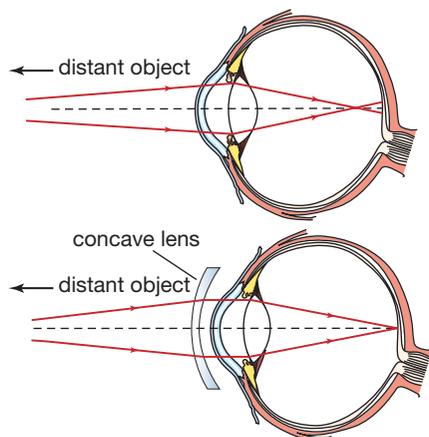


Fig 2.1.16 Correcting short-sightedness

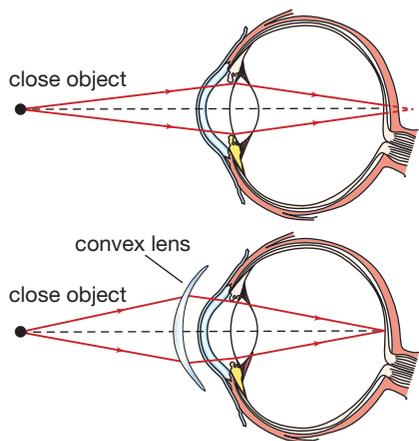


Fig 2.1.17 Correcting long-sightedness

In some people, the lens becomes less elastic and is unable to become thin enough or fat enough to focus images at exactly the right position in the eye.

Short-sighted people can focus on objects a short distance away, but not on distant objects. This condition is known as myopia. Myopia can be corrected by wearing concave lenses that move the focus point of the image back onto the retina, as shown in Figure 2.1.16.

Long-sighted people can see long distances away, but cannot focus on close-up objects. Another name for long-sightedness is hyperopia. Hyperopia can be corrected by wearing convex lenses, which bend light more so the focus point of the image is brought forward onto the retina, as shown in Figure 2.1.17.

Presbyopia is a condition in which a person loses the ability to focus at short distances (eg when reading), due to ageing. People with presbyopia often use reading glasses.

Some people have trouble focusing at both short and long distances, and may use bifocal lenses (invented in 1992 by Stephen Newman), which have two types of lens in one (eg convex at the bottom for reading, and concave at the top for distance vision).

As well as spectacles, contact lenses can be used to correct vision. Soft plastic lenses are available, which are more comfortable than hard glass lenses, but are not suitable for everyone. Wearers of contact lenses must ensure that their eyes still receive enough oxygen. Modern plastic contact lenses are gas permeable, allowing some oxygen to pass through to the cornea. The eye may react to a lack of oxygen by growing additional blood vessels to supply more oxygen via the bloodstream, but the extra vessels can cause irritation and other problems.

Laser surgery

A recent development in eyesight correction is laser surgery. Two main methods are PRK (photoreactive keratotomy) and Lasik (laser in situ keratomileusis).

PRK involves removing a layer of cells from the surface of the cornea and remodelling the shape of the cornea using a laser. With Lasik treatment, a thin flap of the cornea is lifted up, but not removed, and a laser is used to reshape the cornea before the flap is replaced over the laser-treated area. Patients undergoing Lasik feel less discomfort and healing time is reduced, while with PRK there is more cornea to work with.

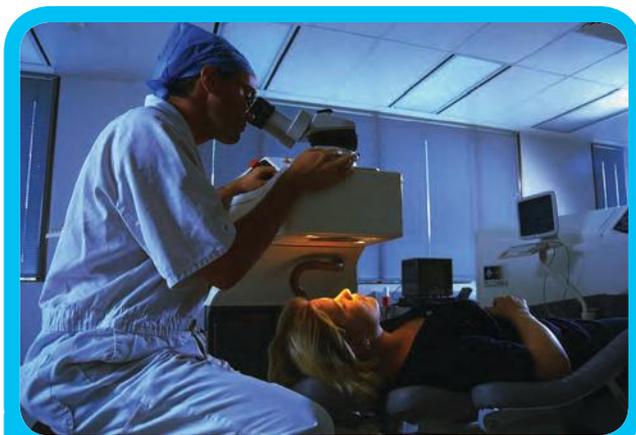


Fig 2.1.18 The Lasik procedure being used to correct myopia

2.1 [Questions]

Checkpoint

Parts of the eye

- 1 Compare the eye and the camera, listing similarities and differences.
- 2 Copy and complete the following table to summarise each part of the eye described in this section. The first entry has been done for you.

Part	Description/function
Conjunctiva	Thin, clear layer covering front of eye

- 3 Describe ways in which the eye is naturally protected.

Colour vision

- 4 Identify the light receptor in the retina that detects:
 - a light or dark
 - b colour
- 5 Explain what causes colour blindness.

Animal eyes

- 6 List two facts about animals' eyes.
- 7 Define 'tapetum'.

Eye defects

- 8 State the common names for myopia and hyperopia.
- 9 Define 'presbyopia'.
- 10 Illustrate what happens to the light path in the eye of a short-sighted person.
- 11 Describe how defective vision can be corrected. Illustrate your answer.

Think

- 12 Identify where most of the bending of light occurs in the eye.
- 13 Propose a reason why the choroid is black and explain what might happen without it.
- 14 There are no light-sensitive cells in the blind spot. Explain why.
- 15 When you walk indoors after being outside in bright sunlight, it is very difficult to see well for a short while. Explain why.
- 16 Explain why we squint when suddenly exposed to bright light.
- 17 If we had only one eye, state what we would not be able to do as well.

- 18 Explain why it is important for insects and animals active during daytime to see colours.
- 19 How good do you think an owl's colour vision is? Explain your answer.
- 20 Identify the parts of the eye involved in focusing.
- 21 Distinguish between Lasik and PRK surgery.
- 22 What do you think is the purpose of blinking?

Analyse

- 23 Robert can drive safely without glasses, but has trouble reading the street directory without them.
 - a Identify the condition Robert may have.
 - b Explain why you have selected this condition.
- 24 If an insect's eye provides almost all-round vision, images of the Sun must be frequently produced. Propose why the Sun does not appear to damage insects' eyes.
- 25 Explain why we virtually only see black and white and very little colour when outside at night.
- 26 Can you tell for sure whether you see the same colours as other people? Discuss.
- 27 Justify the need for humans to have two eyes.

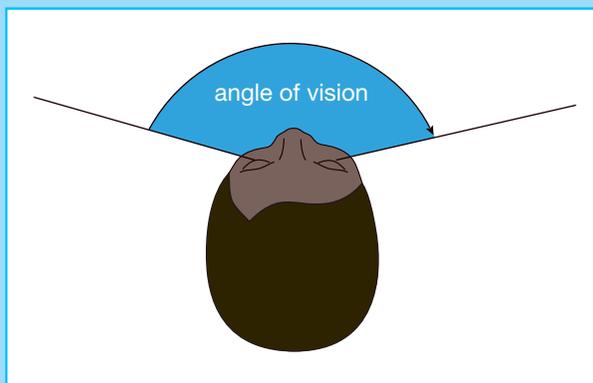


Fig 2.1.19

- 28 The approximate angle of vision for a person is shown above. Draw diagrams to demonstrate the approximate angle of vision for:
 - a an owl
 - b a rabbit

UNIT 2.2

Hearing

Introduction

When you cross a road, your ears can warn you of approaching traffic before you see it. In sport, sound helps players decide who to pass a ball to when their eyes are directed elsewhere on the field. Your ears work by detecting sound waves. They also sense the position of our head, helping you to keep balance. The ears are thus really two sense organs in one.

Sound

Sound travels through air at about 340 metres 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, which are sent via nerves to the brain for interpretation. The loudness of sound is measured in decibels (dB).

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. It is delicate and can easily be broken. Sharp, loud noises such as explosives can rip it, as can things inserted in the auditory canal. Vibrations are passed to a set of three tiny bones: the hammer, anvil

Activity 2

Hearing tests

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.

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 30 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, which are then interpreted as sounds.

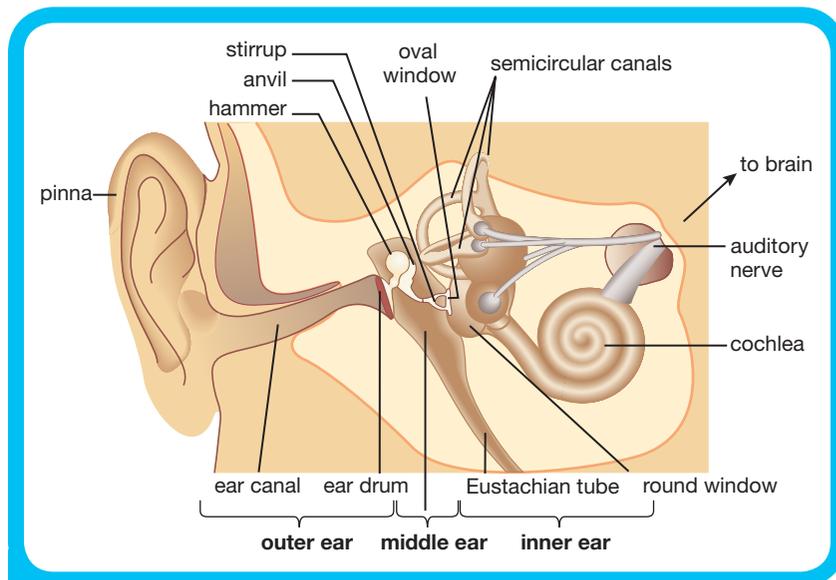


Fig 2.2.1

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.

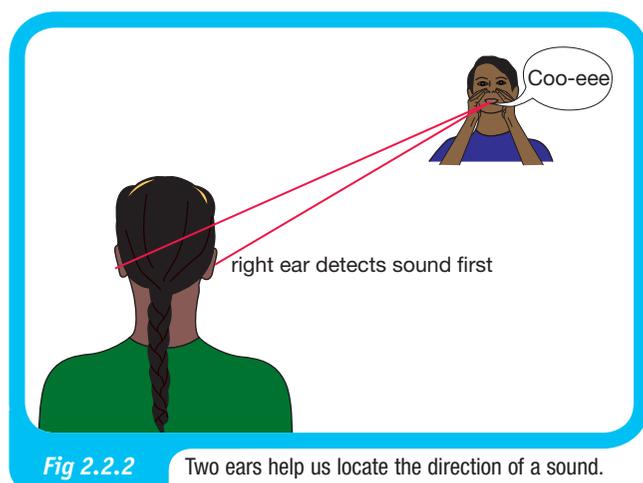


Fig 2.2.2 Two ears help us locate the direction of a sound.

Ear problems

Prolonged exposure to loud sounds can flatten the hairs of the cochlea. When you listen to very loud music, the hairs of your cochlea are 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 listening to loud music will destroy more hairs, leading to more permanent deafness.

A blow to the head or a very loud sound (eg an explosion) can 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 at all 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.

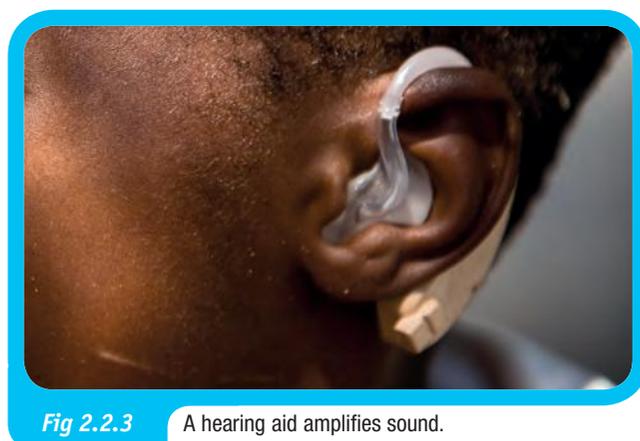


Fig 2.2.3 A hearing aid amplifies sound.

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 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.

Popping ears

Sometimes when you climb to a higher altitude, you experience an uncomfortable 'blocked ear' sensation. This is caused by a pressure difference between the outer and middle ear. When climbing (eg in an aircraft), the outer ear responds quickly to the falling pressure, but the middle ear lags behind and is at a higher pressure. The resulting pressure difference causes the blocked feeling.

Eventually the Eustachian tube opens and allows air to rush out of the middle ear so pressure on both sides of the eardrum is again equal. Some people experience a 'popping' sensation when this happens. When descending, air rushes into the middle ear to increase pressure to the same as that in the outer ear.

If the Eustachian tube gets blocked due to an infection such as a cold, pressure differences will once again give that 'blocked ear' sensation.

Ear protection

If you are to 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



Fig 2.2.5 Ears should be protected when exposed to loud sounds.

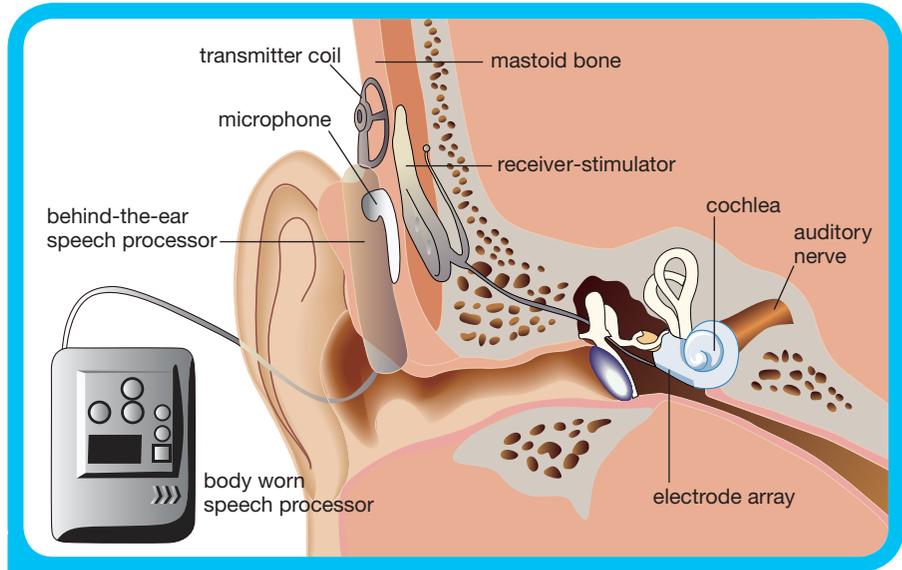


Fig 2.2.4 A bionic ear has several components.

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.

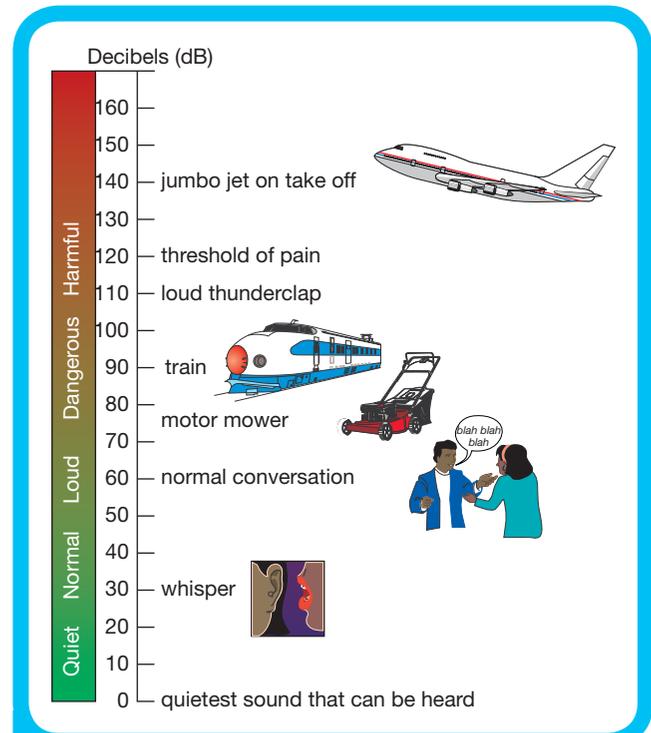


Fig 2.2.6 Use this chart to work out which sounds will harm your hearing.



2.2 [Questions]

UNIT

Checkpoint

Sound

- 1 What causes the eardrum to vibrate?
- 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.

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 that the auditory nerves attach to.
- 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.

Ear problems

- 9 Describe two ways in which damage can be done to your hearing.
- 10 Describe how ear wax may be:
 - a useful
 - b a hindrance.

Ear protection

- 11 Identify three common situations in which some form of ear protection is advisable.
- 12 Use Figure 2.2.6 to identify some sounds that can be:
 - a dangerous
 - b harmful
 - c quiet.
- 13 State the sound level in decibels at which sound becomes hazardous to your hearing.

Think

- 14 Sounds from directly in front arrive at both ears at the same time and so do sounds from directly behind. Propose how we know which direction it is coming from.
- 15 Identify an example of a task that involves mainly hearing.
- 16 Propose a reason why airlines sometimes offer lollies to travellers during take-off and landing.
- 17 Propose a reason why animals like rabbits, deer and zebras have large ears.
- 18 Evaluate whether two ears are more valuable than one for survival.
- 19 Explain why an ear infection may upset your sense of balance.
- 20 In young children, the Eustachian tube is almost horizontal. In the adult ear shown in Figure 2.2.1, this tube is nearly vertical. Use these facts to explain why young children are more prone to middle-ear infections.
- 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. Propose a reason for this.
- 22 For each of the following sounds found out the approximate decibel level, and whether the sound will damage the ear. Use Figure 2.2.6 to help you decide.
 - a Outboard motor (OBM)—15 horsepower
 - b Large truck passing by
 - c Helicopter up close
 - d Person shouting at 1 metre away
 - e Normal level of music through headphones
 - f Normal classroom chatter.

UNIT 2.3

Smell, taste and touch

Introduction

It is said that we have five senses. Sight and hearing are provided by the eye and the ear. Three other important sense organs are the nose, tongue and skin, responsible for the senses of smell, taste and touch respectively. Imagine life without these sensations!

Activity 3

Smell fatigue

Aim

To investigate the phenomenon of smell fatigue

Equipment

A safe, strong-smelling substance (eg aftershave, soap or perfume), a watch, a small container (eg a film canister and lid)

Note: Check with the class for students who may be allergic to any of the substances to be used in the experiment.

Method

- 1 Obtain a sample of a safe, strong-smelling substance in a container that can be sealed.
- 2 Carefully take a small whiff of the substance. Do not breathe in too deeply. Avoid taking your breath away.
- 3 Reseal the container and wait 30 seconds before taking a similar whiff. Rate the strength of the smell from 0 (no smell) to 5 (the strength of your first smell).
- 4 Continue to take a whiff every 30 seconds, giving the strength of the smell a rating each time until you have about six ratings.

Questions

- 1 Describe what happens to the strength of what you smell after several whiffs.
- 2 Construct a graph to display your ratings.

Smell

You detect a smell because a few tiny chemical particles enter your nose and dissolve in its moist lining. Considering some of the nasty smells we detect each day, this may not be a pleasant thought! The dissolved substance triggers nearby nerve cells in the upper part of the nasal cavity, called olfactory cells. Impulses in the olfactory nerve send messages to the brain so we can smell the substance.

The typical human nose can detect about 2000 smells, and may be trained to detect up to 10 000.

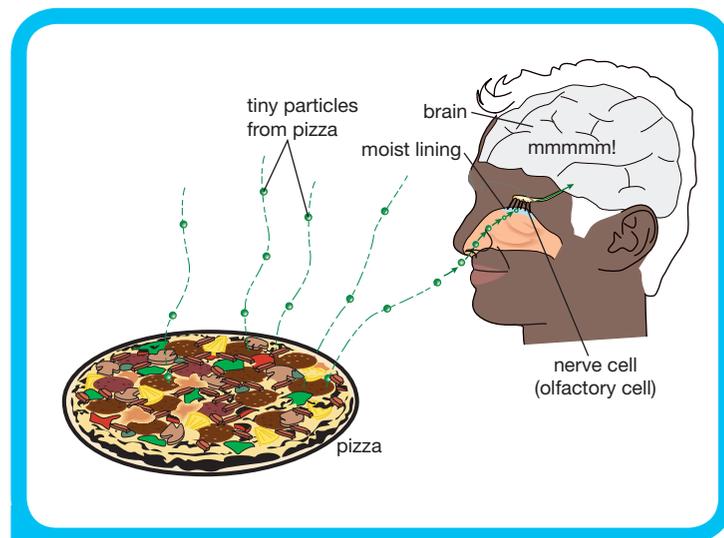


Fig 2.3.1 How we detect smells

Ahh-choo!

Sneezing is a reflex action that removes irritating dust or other foreign particles from the nasal passages. A sneeze can travel at 160 kilometres per hour right across a room, so duck next time one comes your way! You also close your eyes when you sneeze—some say to stop your eyes from popping out!

Taste

The surface of the tongue is covered with thousands of bumps, called papillae. More than 10 000 taste buds are embedded between the papillae. Humans can detect five primary taste sensations: sweet, sour, salty, bitter and umami. Umami is distinctly different from the other basic tastes and is believed to activate a separate set of taste receptors. It is the savoury taste of glutamate found in processed meats, cheeses and monosodium glutamate (MSG).



Fig 2.3.2 Scanning electron microscope image of a taste bud (centre) surrounded by papillae

Saliva in our mouths must first dissolve samples of food so that the taste buds can detect them and send messages to the brain. A single taste bud contains fifty to one hundred taste cells, which can detect all five taste sensations. Our taste buds also provide information on the intensity and pleasantness or unpleasantness of taste. Although all areas of the tongue are able to detect all taste sensations, some areas may be more sensitive to certain tastes.

Flavour

When we eat, our senses of smell and taste work together to detect flavour. As much as 80 per cent of what we perceive as flavour is actually smell. Flavour is largely the smell of gases emitted from food that has just been taken out of your mouth. When your nose is blocked, your sense of smell is not as good as usual. That's why food seems less tasty when you have a cold.

Likewise, pinching your nose will make food you don't like more tolerable. The tongue is most sensitive at temperatures between 20°C and 30°C. Sweet and sour tastes increase at higher temperatures, and bitter and sour increase at lower temperatures.

Touch

Most of us probably don't think of the skin as an organ, but it is. The average human adult has about 11 kilograms (exactly 10 886 grams) of skin. This makes it to be the largest organ of the human body, compared to the heart (2090 grams), lungs (1090 grams), brain (1330 grams) and liver (1560 grams).

The skin contains millions of nerve endings that send information about touch, pain, pressure and temperature to the brain. In humans, the touch receptors are more concentrated in the face, tongue, lips, fingertips and toes. Body hair also plays an important role in our ability to sense touch. A large number of receptors are found in the skin at the base of hair follicles.

Below the top protective layer of dead skin cells is a 'living' layer of skin. It has different nerve receptors located at varying depths. Thermo receptors respond to heat and cold, and there are about four times as many heat receptors as cold

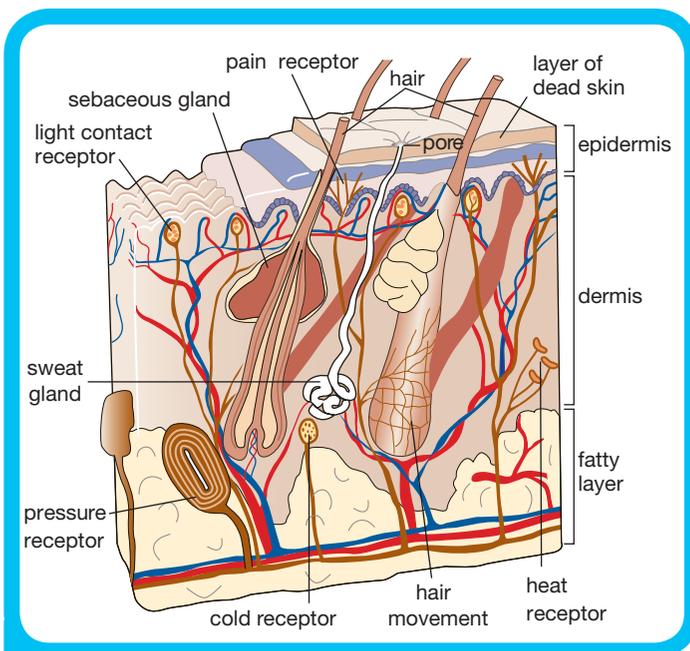


Fig 2.3.3 A cross-section of human skin

receptors. Pain receptors are located throughout the skin and can experience prickling pain (fast pain) or burning and aching pain (slow pain).

The sebaceous glands produce oil that helps keep the skin soft and stops it cracking. The sweat glands produce sweat, which, on reaching the surface, removes heat from the body when it evaporates.

Dogs do not regulate their body temperature by sweating. Instead, they use their tongues to cool down; this is called panting. Rapid panting at rates of up to 200 times per minute allows heat to be removed from the dog's body as moisture evaporates from the tongue.

Activity 4

Skin receptors

Aim

To investigate the sensitivity of your skin in various areas

Equipment

Toothpicks, tape, ruler, blindfold

Method

- 1 Attach two toothpicks to a ruler as shown.

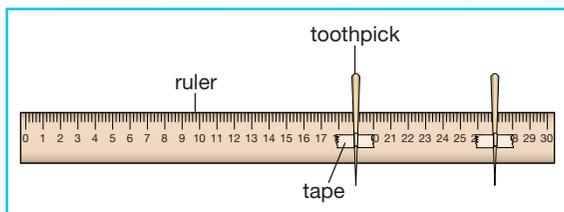


Fig 2.3.4

- 2 Make sure your partner cannot see while you touch both toothpick points to a region of skin. Ask your partner how many points they feel.
- 3 Move the toothpicks closer to each other and test again. Progressively move the toothpicks closer together until only one can be felt.
- 4 Test other regions of the skin the same way. Some possible areas to try are the back of the hand, palm, inside forearm, back of forearm, leg, foot, back of neck.
- 5 Swap jobs and have your partner test you.

Questions

- 1 Give each area of your skin a sensitivity rating.
- 2 Compare results with your partner.
- 3 Propose reasons why some areas are more sensitive than others.

Questions

Checkpoint

Smell

- 1 True or false?
 - a When you smell a substance, tiny parts of it have dissolved inside your nose.
 - b Olfactory cells are nerve cells in the nose.
- 2 Draw a diagram to demonstrate where the olfactory cells and olfactory nerves are in the nose.

Taste

- 3 Are papillae the same as taste buds? Explain.
- 4 State the senses that combine to help us appreciate flavour. How could you more easily eat a food or vegetable you don't like?

Touch

- 5 Starting from the surface, list in order the layers of the skin.
- 6 List five types of touch receptors.

Think

- 7 List a food that would give each of the different types of taste.
- 8 Copy and complete the following table.

Sense	Sense organ
Sight	
	The ear
Smell	
	The tongue

- 9 A chemical is added to normally odourless liquid petroleum gas (LPG) to make it smell unpleasant. Explain how this makes LPG safer.
- 10 Identify a profession or situation in which the senses of smell and taste are important.
- 11 Evaporation of sweat from the skin helps remove heat from the body. Describe how this happens.

UNIT 2.4

Responding

Introduction

Through your senses you are constantly receiving information from your surroundings. This information may be of many types: the smell of a classmate's tuna sandwich, the hot air near a Bunsen burner or the noise of a passing bus. When this information is received it could lead to a variety of responses: holding your nose, moving away from the flame or turning towards the bus.

Your responses enable you to react to changes around you, enhancing your chances of survival in a world full of potential threats.

Activity 5

Sweet and salty

Aim

To identify the threshold of a stimulus

Equipment

12 new small paper cups, 2–3 mL each of solutions of sugar of varying concentrations (0.001%, 0.005%, 0.01%, 0.05%, 0.1%, 0.5%), 2–3 mL each of solutions of salt (0.001%, 0.005%, 0.01%, 0.05%, 0.1%, 0.5%), waste jar for rinsings, bottled water for rinsing mouth

Method

- 1 Draw up a results table as shown here.

Concentration	0.001%	0.005%	0.01%	0.05%	0.1%	0.5%
Result for sugar						
Result for salt						

- 2 Sip the most dilute (0.001%) sugar solution. Can you taste the sugar? Record a '+' in the table if you can, or a '0' if you cannot.
- 3 Spit the sample into the waste jar.
- 4 Repeat the test with 0.005% sugar solution.
- 5 Continue tasting each solution of next higher concentration until you can taste the sugar. Try the next higher concentration to be sure of your results.
- 6 Thoroughly rinse your mouth using the bottled water.
- 7 Repeat the procedure using the salt solutions, once again starting with the most dilute.

Questions

- 1 The minimum intensity that causes a response is known as the threshold for the stimulus. State your taste threshold for sweetness.
- 2 State your taste threshold for saltiness.
- 3 Compare the class results. Is there a difference in the taste thresholds between males and females?
- 4 Justify the value of receptors in the body having thresholds.
- 5 a You knew what type of solution you were tasting. Evaluate whether this knowledge affected your judgement.
b Describe how you could modify the activity to overcome any problems.

Responding to stimuli

One of the fundamental characteristics of living things is that they respond to information received from their surroundings. This ability is needed to feed, escape, move, reproduce and keep warm or cool down. Humans respond to increased temperature by involuntarily sweating and increasing blood flow to the skin (making you look

'flushed'). Your behaviour changes too: you remove clothes and grab a cold drink.

Humans show an amazing ability to respond to changes in their surroundings. For instance, the body temperature of humans stays at approximately 37°C, and blood acidity or pH at about 7.38, regardless of whether you are in the deserts of

Africa, the jungles of South America or the icy Arctic zones. This maintenance of a constant internal environment despite changes in the surroundings is called homeostasis. Homeostasis allows cells to keep working efficiently, maintaining temperature, glucose and water levels within strict limits.

Stimulus–response model

Homeostasis requires a sequence of steps known as the stimulus–response model. The sequence begins when a sense receptor is stimulated. A stimulus is something that acts on a receptor, causing a change in the activity of an organism. Stimuli include heat, light, pressure, touch, sound, chemicals and water levels. Your body contains receptors to detect all these stimuli. When a receptor receives a stimulus, a message is sent to an effector. An effector is an organ, such as a gland or a muscle, that causes a response.

Stimulus	Location of receptor
Heat or cold	Thermoreceptors in the skin
Water levels in blood	Osmoreceptors in the brain and large arteries
Pressure and touch	Mechanoreceptors in the skin
Sound	Cochlear cells in the inner ear
Light	Photoreceptors in the retina of the eye
Chemicals	Chemoreceptors on the tongue and in the nose
Gravity	Semicircular canals in the ears

A simple example of the stimulus–response model is what happens when you burn your finger (the stimulus). Heat and pain receptors in your finger send messages via nerves to an arm muscle (the effector), causing the muscle to contract and pull your hand away from the flame (the response).

Feedback and coordination

Often this sequence of events involves some kind of feedback of information. The response generally affects the original stimulus in some way, so the organism is able to adjust its response. The total response of an organism is often complex, involving several parts of the body. For this to occur, some kind of coordination is required.

All organisms are coordinated in some way. Even a single-celled amoeba can respond to changes in temperature or pH. The response usually involves moving away from the stimulus. In most larger organisms there are a number of

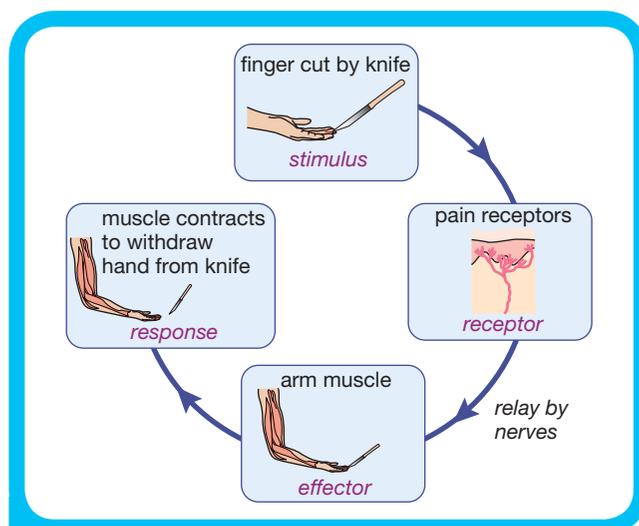


Fig 2.4.1 The stimulus–response model of what happens when you cut your finger

structures to detect, transmit, coordinate and respond to stimuli.

The control of carbon dioxide levels in your blood is an example of the stimulus–response model, which includes both feedback and coordination. Blood carbon dioxide levels may rise (the stimulus) after exercise. Special areas in some large arteries (the receptors) detect this rise and transmit messages to the brain (the coordinating centre). Messages are then sent from the brain to various muscles (the effectors) to produce an increase in breathing rate (the response). Rapid breathing causes a decrease in blood carbon dioxide levels. This decrease is detected (the feedback) and the breathing rate subsequently returns to normal.

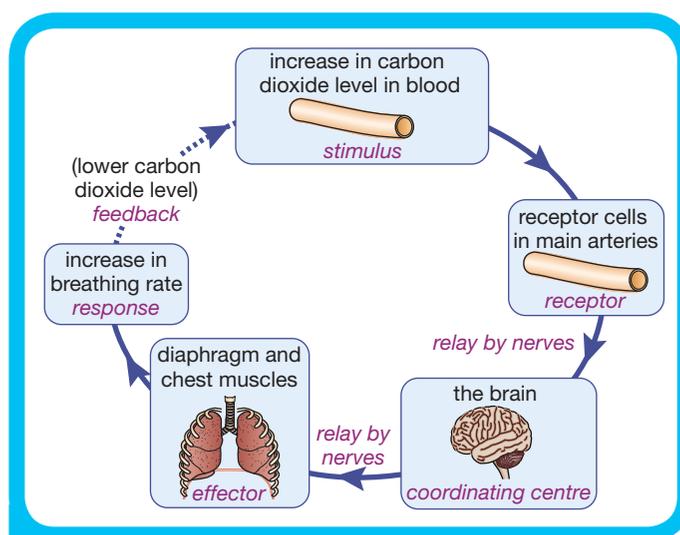


Fig 2.4.2 Control of carbon dioxide levels in blood

2.4 [Questions]

UNIT

Checkpoint

Responding to stimuli

- Define 'homeostasis'.
 - Explain why homeostasis is necessary.
- Identify three substances in the body whose levels are controlled by homeostasis.
- State the approximate value of the:
 - body temperature of a healthy human
 - pH level in the blood of a healthy human.

Stimulus–response model

- Distinguish between a receptor and an effector, giving examples of each.
- Match each receptor with the stimulus to which it responds.

Receptor	Stimulus
Cells of the retina	Gravity
Cells of the inner ear	Chemicals
Taste buds	Heat
Osmoreceptors in the brain	Light
Semicircular canals in the ear	Sound
Thermoreceptors in the skin	Water levels

Feedback and coordination

- Define the following terms:
 - feedback
 - coordination
- If the carbon dioxide level in your blood was to increase after exercise, identify:
 - where the receptors that detected this increase would be located
 - the coordinating centre that would receive messages
 - the structures that would act as effectors
 - the response you would notice.

Think

- List four pieces of information you are currently receiving from your surroundings.
- Describe the most usual response to a stimulus for single-celled organisms.
- Use the terms in the list below to label the diagram in Figure 2.4.3 (marked i to viii) showing control of body temperature: response, relay, feedback, stimulus, effectors, coordinating centre, receptor, relay

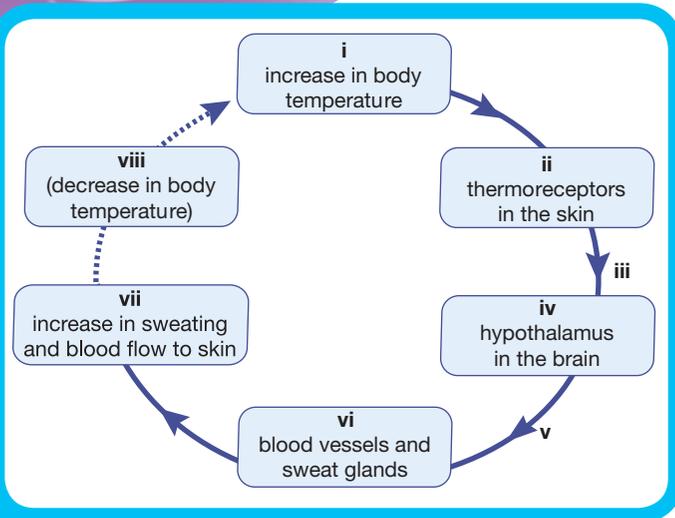


Fig 2.4.3

- Draw a diagram to illustrate the stimulus–response model that happens when you touch a hot stove.

[Extension]

Investigate

- The body's homeostatic control can fail in extreme temperatures. Body temperature may rise (hyperthermia) or fall (hypothermia).
 - Investigate either hyperthermia or hypothermia, listing its symptoms and likely causes.
 - Prepare a report explaining how to avoid these two conditions.
- Acidity is measured using the pH scale.
 - Investigate whether blood (pH 7.38) would be described as neutral, acidic or basic (alkaline).
 - Investigate what might cause a change in blood pH, and how the body responds to this.

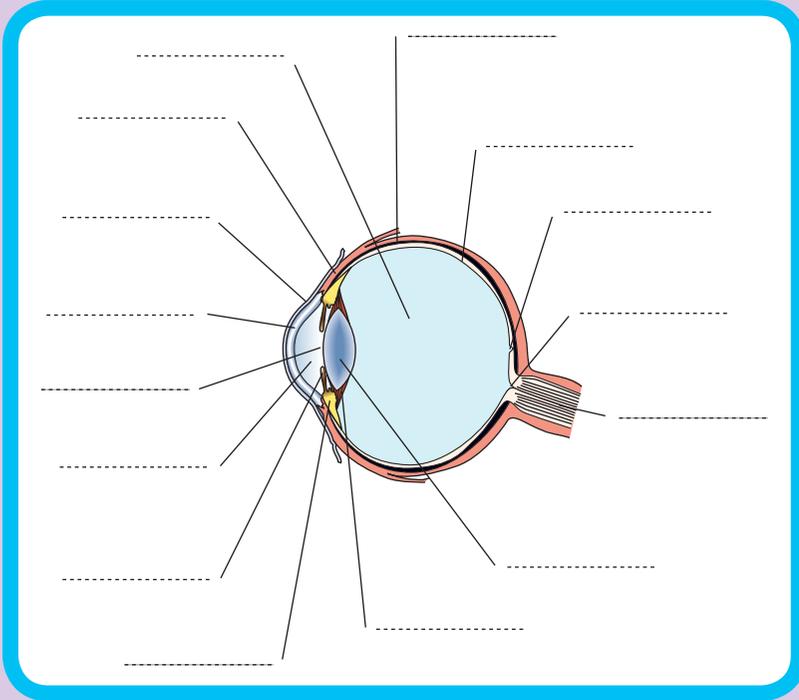


Fig 2.4.4

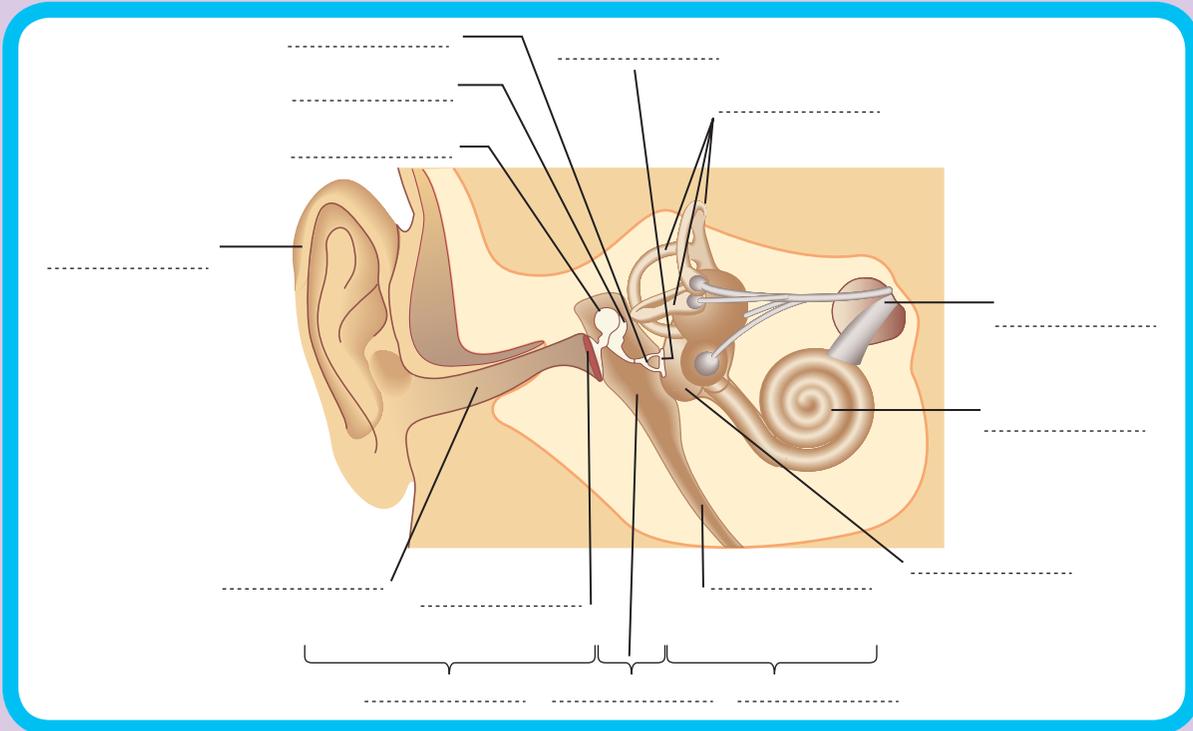
We wear fewer clothes in hot weather to avoid hyperthermia.

Chapter review

[Summary questions]



- 1 Copy and label the diagram of the eye shown here, using the following terms: aqueous humour, blind spot, choroid, ciliary muscles, conjunctiva, cornea, iris, lens, optic nerve, pupil, retina, sclerotic layer, suspensory ligaments, vitreous humour, yellow spot.
- 2 Describe the function of each of the following parts of the eye: iris, lens, retina, choroid.
- 3 **a** Identify the three main regions of the ear.
b State what each is filled with.
- 4 Describe the function of each of the following parts of the ear: eardrum, ossicles, semicircular canals.
- 5 List as many sense organs as you can.
- 6 Draw a diagram of a section of skin to demonstrate as many features as you can.
- 7 Explain how we detect smell.
- 8 Copy and label the diagram of the ear shown below, using the following terms: anvil, auditory nerve, cochlear, ear canal, ear drum, Eustachian tube, hammer, inner ear, middle ear, outer ear, oval window, pinna, round window, semicircular canals, stirrup.





- 9 a** State two reasons why organisms need to be responsive to their surroundings.
- b** Explain why response to a stimulus often requires coordination.
- 10** Demonstrate, using examples, what is meant by:
- a** a stimulus
 - b** an effector
 - c** a receptor
 - d** a response
- 11 a** Identify four stimuli to which you respond.
- b** State the type and location of the receptors that detect these stimuli.

[Thinking questions]

- 12** A pupil will dilate under certain conditions. Explain why and when this would occur.
- 13** Describe a condition of the eye (eg myopia) and how it can be corrected.
- 14** Describe how you could reduce the sensation of taking an unpleasant medicine.

[Interpreting question]

- 15** Evaluate the importance of our senses. How would we survive without one or all of them?

CHAPTER

3

Materials

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

- identify the properties of metals
- identify the properties of non-metals
- state that semi-metals have both metallic and non-metallic properties
- demonstrate the corrosion process using iron nails in conditions (eg iron nail in water, oil and air)
- perform reactions between metals and dilute acids and compare the rate of reactions
- identify alloy materials found around the school and community and state what metals they are made of, and their uses
- name the two main types of plastics
- name the materials used to make the plastics
- describe the two types of plastic
- draw the structures of the two types of plastics
- describe different kinds of textile fibres
- explain the advantages and disadvantages of plastics.

- 1 Why is it that gold can be found as a nugget but sodium can't?
- 2 What is slag and what has it got to do with iron?
- 3 Why do plastic objects often have a 'bump' or seam?
- 4 Why do we feel wet and clammy on hot days if we wear nylon but not if we wear cotton?

Specific learning outcomes

9.3.1.1, 9.3.1.2, 9.3.1.3, 9.3.2.1, 9.3.3.1, 9.3.4.1,
9.3.5.1, 9.3.5.2, 9.3.6.1, 9.3.6.2, 9.3.7.1, 9.3.8.1

Challenges



UNIT 3.1

Metals, non-metals and semi-metals

Introduction

When the Egyptians used metals such as gold in 2000 BC, they recognised that these metals had different physical properties from other materials. Whether they understood the differences between metals and non-metals is not known.

In 1789, Lavoisier classified the 31 known elements into four groups based on their chemical properties. These groups were gases, non-metals, metals and earths. Today's periodic table groups the elements into metals, non-metals and semi-metals (also known as metalloids).

What is a metal?

In the periodic table, metallic elements outnumber non-metallic elements four to one.

Properties of metals

- They allow heat and electricity to pass easily through them. They are excellent conductors of heat and electricity.
- All shine when polished or freshly cut. We describe metals as lustrous.
- They can be hammered into new shapes. Scientists call this malleable.
- Metals are ductile. This means that they can be stretched and drawn into long thin wires.
- They are solid at normal room temperature. (Mercury, however, is a liquid.)
- They have high densities. Most metals sink in water.
- All have atoms that form lattices rather than molecules.

About non-metals

Properties of non-metals

- All (except carbon) are either poor conductors of electricity or do not conduct at all (insulators).
- They have relatively low melting and boiling points and are usually liquids or gases at normal room temperature.

- They are brittle and tend to crumble into powders.
- They are dull, having little or no shine.
- Group 18 elements can exist as single atoms.
- Most other non-metallic elements form molecules containing two atoms. Some have more atoms than this, and a few form lattices.



Fig 3.1.1 Metals (from left to right): copper, mercury (liquid only) and magnesium



Fig 3.1.2 Non-metals (clockwise from top left): sulfur, bromine (liquid only), phosphorus, iodine and carbon

Those electrons again!

The strength with which an atom holds its electrons is called its electronegativity. Metal atoms have low electronegativity and non-metals have high electronegativity. Non-metals hold on more strongly to their outer electrons than metals do. In a ‘fight’ (or chemical reaction), metals lose their outer electrons to the non-metals so that they each end up with eight electrons in their outer shells. The metal forms a positive ion and the non-metal forms a negative ion. The name of the non-metal often changes too. The name of the non-metal now ends with *-ide*, as is shown in the following table.

Non-metallic atom	Name of atom	Ion formed	Name of ion
F	Fluorine	F ⁻	Fluoride
Cl	Chlorine	Cl ⁻	Chloride
Br	Bromine	Br ⁻	Bromide
O	Oxygen	O ²⁻	Oxide
N	Nitrogen	N ³⁻	Nitride

The odd couple: H and He

Hydrogen has only one electron, so it can either lose it to become the hydrogen ion, H⁺, or it can gain another one to become the hydride ion, H⁻. It can therefore act like a Group 1 or Group 17 element, depending on what it comes into contact with.

Helium’s two electrons fill its outer shell and therefore it acts similarly to the noble gases of Group 18. It could be placed in Group 2 but is usually placed in Group 18 because of family resemblances.

Semi-metals

The semi-metals, or metalloids, act like non-metals in most ways. They do, however, have some properties that are metallic: most importantly, they can conduct electricity.

Activity 1

Using metals to make non-metals

Aim

To make a non-metal compound from a metal

Equipment

Samples of magnesium, iron and copper, 2 M hydrochloric acid in a dropping bottle, test tubes and rack, matches, safety glasses

Method

- 1 Place the samples of metal in separate test tubes.
- 2 Use the dropping bottle to add sufficient hydrochloric acid to cover the metal in each.
- 3 If bubbles form, test the type of gas produced by placing a lit match near the mouth of the tube. You may need to place a stopper in the mouth to gather sufficient gas to test.

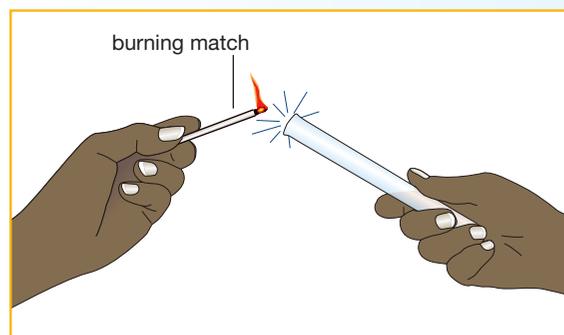


Fig 3.1.3 Making and testing a gas

- 4 Record your observations.

Questions

- 1 Identify the gas present if a lit match:
 - a causes a ‘popping’ sound
 - b flares up brightly
 - c is extinguished.
- 2 Classify the gases in Question 1 as elements or compounds.
- 3 Draw a conclusion about the reaction of metals with acids.



3.1 [Questions]

UNIT

Checkpoint

What is a metal?

- 1 State whether metal atoms form molecules or lattices.
- 2 Choose one metal from Figure 3.1.1 and describe some of its properties.

About non-metals

- 3 Explain the various atomic structures in which non-metals can exist.
- 4 Choose one non-metal from Figure 3.1.2 and describe some of its properties.

Those electrons again!

- 5 Identify which has a higher electronegativity: a metal or a non-metal.

The odd couple: H and He

- 6 Explain why H could be placed:
 - a in Group 1
 - b in Group 17
 - c by itself.
- 7 Helium could be placed in Group 2. Explain.
- 8 Explain why helium is normally placed in Group 18.

Semi-metals

- 9
 - a Give another name for the semi-metals.
 - b Name a property of semi-metals.

Think

- 10 Identify the ions that these atoms would probably form.
 - a Na
 - b S
 - c I
 - d P
 - e Al

- 11 Define the following words:

- a lustrous
- b malleable
- c ductile
- d brittle
- e electronegativity
- f semi-metal.

- 12 Identify the metal(s) that:

- a is the only metal that is a liquid at 25°C
- b are in Period 3
- c are in Group 14
- d would form +2 ions.

- 13 At normal room temperature, identify how many non-metals exist as:

- a solids
- b liquids
- c gases.

- 14 Identify three non-metallic elements that:

- a are gases at room temperatures
- b are in Group 15
- c are in Period 2
- d would be related to chlorine
- e would have larger atoms than those of oxygen.

- 15 Outline the likely charges of the ions that belong in Groups 1, 2, 13, 15, 16, 17 and 18.

Skills

- 16 Construct a table to classify the following properties into those that belong to metals and those that belong to non-metals: ductile, normally gas or liquid, dense, malleable, brittle, lustrous, excellent conductors, dull, poor conductors, normally solid.

UNIT 3.2

Corrosion of metals

Introduction

The steel body of a car eventually rusts away, but aluminium cans and gold jewellery stay ‘good’ forever. Why? They are all metals, aren’t they? Some metals are more reactive than others. Reactive metals corrode when exposed to water, air or other chemicals, usually forming metallic oxides. Pure sodium and potassium react with just about anything—their corrosion is very quick and often explosive! In contrast, iron corrodes very slowly, while gold is extremely stable and corrosion is rare.

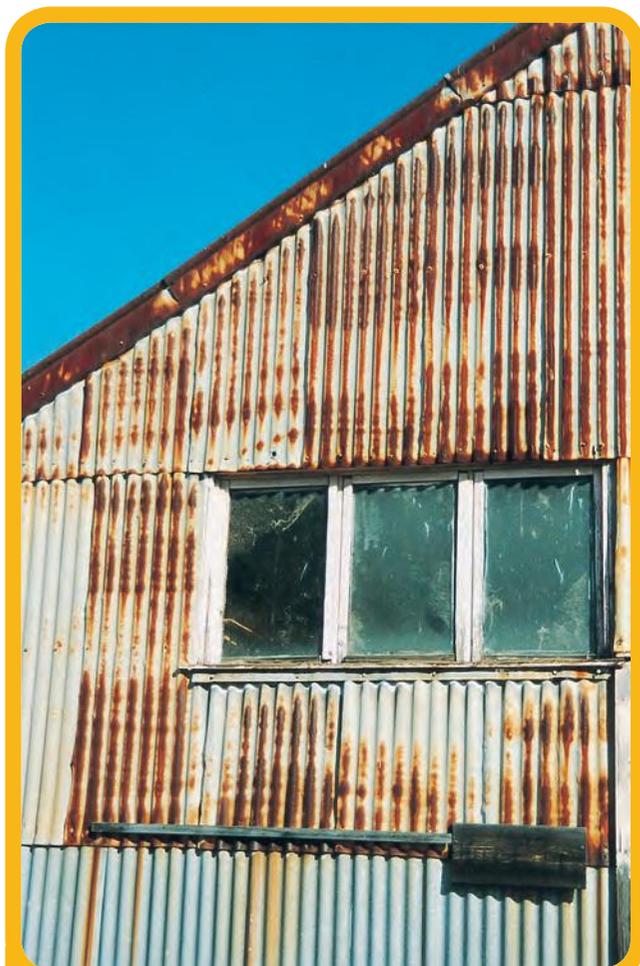


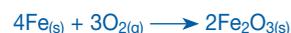
Fig 3.2.1

Rusted corrugated iron—a common sight in Honiara

Corrosion of iron and steel

Iron is common and cheap. Its alloy, steel, is extremely strong, making it the most commonly used metal on Earth—car bodies, high building frames, concrete reinforcing, pins and needles are all made from various grades of steel.

Unfortunately, most steels rust—they react with air and water to form a red coating of iron(III) oxide, Fe_2O_3 . Rust is flaky and easily comes off, allowing the rusting process to continue into the next layer. The iron or steel gets thinner, loses its strength and gradually returns to the compound that it was extracted from. Although an extremely complex reaction, it can be summarised as:



For rusting of iron to take place, both oxygen and water must be present as either liquid or vapour. The rusting process can be accelerated by salts or heat.

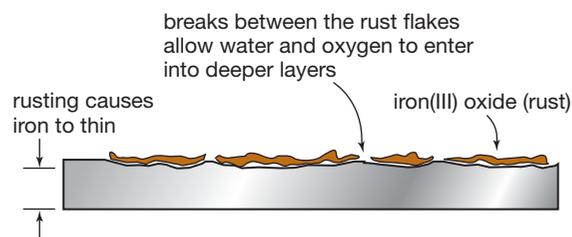


Fig 3.2.2

Rust is flaky and allows the rest of the iron to rust away too.

Corrosion protection

Stainless steel is an alloy that resists rusting and is used for surgical apparatus, body piercings and equipment in conditions of high heat and salt, such as in kitchens and on boats. Other types of steel can be protected by coatings that stop air and water from reaching the surface. A scratch or crack in the coating, however, allows rusting to start again.



Fig 3.2.3 A stainless steel toaster

Another method is to coat the surface or attach another more reactive metal. Galvanised iron is iron dipped in molten zinc. Zinc is more reactive than iron and will react instead of it. This is called sacrificial protection. Scratches and chips will not rust, as long as some zinc is close by. Nails and roofing materials are commonly made from galvanised iron. Reactive magnesium blocks are often bolted onto steel structures such as piers and deepwater gas rigs and oil rigs at sea. The magnesium sacrifices itself to protect the structure.

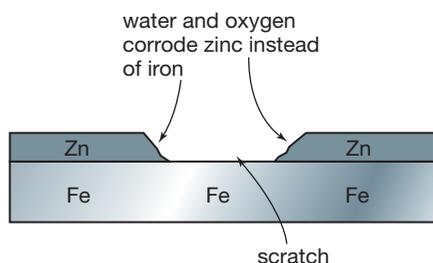


Fig 3.2.4 Zinc sacrifices itself to protect the iron it plates.

Aluminium: reactive but it doesn't corrode!

Aluminium is a very reactive metal and the surface reacts almost immediately with the air to form a fine layer of dull grey aluminium oxide, Al_2O_3 . Unlike rust, this layer does not flake and acts like a tightly bound layer of paint. Aluminium needs no further protective treatment.

Activity 2

Corrosion of iron

Aim

To investigate factors affecting the corrosion of iron

Equipment

5 iron nails (not galvanised), copper wire, magnesium ribbon, distilled water, salt (sodium chloride) solution, fine sandpaper or steel wool, 4 test tubes, test-tube rack, Bunsen burner, bench mat and matches, 250 mL beaker, peg or tongs, marking pen

Method

- 1 Polish each nail with sandpaper or steel wool.
- 2 Fill the 250 mL beaker with cold water.
- 3 Heat a nail in a blue Bunsen flame until red hot. Use the peg to drop it into the water. Record what happens.
- 4 Tightly wind the magnesium ribbon around a nail, and the copper wire around another nail.
- 5 Put both into test tubes containing salt water.
- 6 Put another two nails in the other two test tubes, marking which contains fresh water.
- 7 Leave for three or four days.
- 8 Draw each nail, showing the location of any reddish rust and any white corrosion on the magnesium or blue-green corrosion on the copper.

Questions

- 1 Work out which factors encourage rusting.
- 2 Describe the effect of heat on the rate of rusting.
- 3 List all the metals used, in order from most to least reactive.
- 4 Which test demonstrated sacrificial protection? Justify your answer.
- 5 Explain why one metal sacrificed itself and not the other.

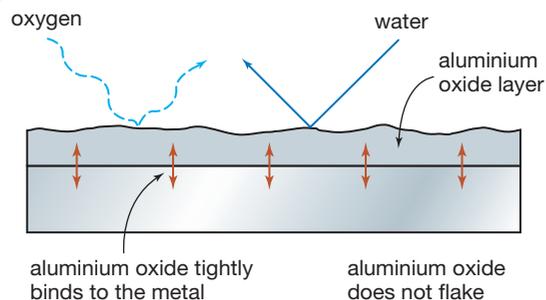


Fig 3.2.5 Aluminium oxide acts like the perfect paint layer—hard to scratch and non-flaky.

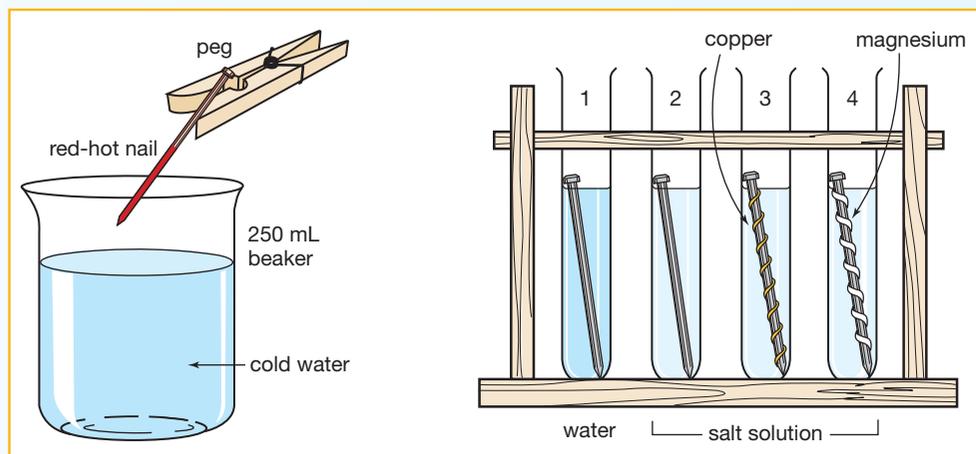


Fig 3.2.6

3.2 [Questions]

Checkpoint

Corrosion of iron and steel

- 1 List the substances required for iron to rust.
- 2 Construct the equation for the conversion of iron into rust.
- 3 State two things that speed up the rate at which iron rusts.

Corrosion protection

- 4 List two ways in which iron and steel can be protected from corrosion.
- 5 Describe what is meant by 'sacrificial protection'.

Aluminium: reactive but it doesn't corrode!

- 6 State the name of the corrosion-resistant coating formed on aluminium.

Think

- 7 Use the equation from Question 2 to help you construct a balanced equation for the corrosion of aluminium (Al) in oxygen (O_2) to form aluminium oxide (Al_2O_3).
- 8 Zinc doesn't rust but it does corrode. Explain.
- 9 The paint around a scratch on a car door will eventually bubble. Use your knowledge of the flaky nature of rust to explain why.
- 10 a Explain why the insides of cans of food are coated in tin or a thin layer of plastic.

- b You should never buy cans of food that are dented or scratched. Explain why.

- 11 Use the reactivity series to identify metals that would provide sacrificial protection to iron.
- 12 Galvanising gives better protection than painting an iron surface. Explain why.
- 13 Explain why iron rusts and crumbles, but aluminium just dulls.
- 14 Magnesium blocks attached to piers dissolve away over time. Outline what needs to happen when they dissolve.

Analyse

- 15 You need to protect a zinc structure from corrosion. Predict which metals you could bolt onto the zinc to protect it.
- 16 'Iron is the most valuable metal on Earth.' Justify this statement.
- 17 Three sheets of iron are each coated in a different metal: copper, magnesium and tin. Predict what will happen to each sheet if the coating is scratched.
- 18 Steel window frames would be a silly choice near the sea. Explain why.
- 19 The jewellery used in body piercing is surgical-grade stainless steel, platinum or gold. Explain why these metals, and not cheaper ones, are used.

UNIT 3.3

Reactions of metals with dilute acids

Introduction

A number of metals that do not react with water will react with dilute acids. The rate at which a metal reacts with acids depends on how many electrons there are on the outer shell. Metals in Groups 1 and 2 are more reactive than the transition metals.

Reaction of metals with acids

A number of metals react with dilute acids to produce a salt and hydrogen gas. The general word equation for this reaction is



Metals, such as magnesium, zinc, aluminium and iron, react readily with cold dilute hydrochloric acid or sulfuric acid to produce salts and hydrogen gas. The type of salt depends on the metal and acid being reacted. The two reactions given below illustrate this.



During the reaction between a metal and an acid, the metal dissolves and loses the electrons in its outermost shell to form a positively charged ion. The hydrogen ion from the acid gains electrons to form hydrogen gas, while the positively charged metal ion combines with the negatively charged ion from the acid to produce a salt.

Reactivity series of metals

Metals react with water, oxygen or dilute acids at different speeds. Some metals react faster than others, depending on the ease with which the metal can lose its outer electrons. Sodium, potassium and calcium react explosively with dilute hydrochloric and sulfuric acids. Copper, silver and gold do not react at all. The reactivity of the metals can be determined and ranked by reacting the metals with water, oxygen and dilute acid, and observing the rate at which the products are formed and the reactants are consumed.

The order of reactivity of the common metals, starting with the most reactive, is:

- potassium (most reactive)
- sodium
- calcium
- magnesium
- aluminium
- zinc
- iron
- lead
- copper
- silver
- gold (least reactive).

Activity 3

Metal reactivity

Aim

To compare the reactivity of metals

Equipment

Samples of copper, aluminium, magnesium, iron, zinc, steel wool, dilute hydrochloric acid, 5 test tubes

Method

- 1 Clean the metals using the steel wool.
- 2 Place a very small but similar amount of metals into each of five test tubes.
- 3 Very carefully add five drops of dilute hydrochloric acid into each of the test tubes, one at a time.
- 4 Take very careful note of the reaction of each metal to the acid.

- 5 Write notes as you observe each metal's reaction, stating whether the reaction is fast, medium or slow, or if there is no reaction.

Questions

- 1 What do you notice when the acid is added to the metal?
- 2 Which metals react with the acid?
- 3 Which metals do not react with the acid?
- 4 Which is the most reactive metal?
- 5 Which is the least reactive metal?
- 6 List the metals from the most reactive to the least reactive.

3.3 [Questions]

Checkpoint*Reaction of metals with acids*

- 1 State whether or not all metals react with water.
- 2 Write down the general word equation for the reaction between a metal and an acid.

Reactivity series of metals

- 3 Explain what is meant by the 'reactivity series of metals'.
- 4 List the two most reactive and two least reactive metals.

Think

- 5 Metals in Groups 1 and 2 are more reactive than the transition metals. Explain why.
- 6 Explain how a metal reacting with an acid forms into a positively charged ion.
- 7 Study the following chemical reaction.



- a Predict the product of the hydrogen ion in the hydrochloric acid after the reaction.
- b Predict what will happen to the electrons in the outermost shell of magnesium metal when it reacts with the acid.
- c Explain why the magnesium metal in the above reaction is likely to combine with the chloride ion in the acid to form a salt (MgCl₂) after the reaction.

UNIT 3.4

Pure metals and alloys

Introduction The metals gold and silver have been much prized since primitive times. Copper, its alloy bronze, and later iron and its alloy steel, replaced the stone spearheads and axes of early humans, improving their chances when hunting and waging tribal fights. Each newly extracted metal allowed technology to change. And society changed with them.

Pure metals

Very few metals can be used as pure elements because they are generally too soft to be made into anything useful. Copper and aluminium are two of only a handful of metals that can be used in their pure form.

Alloys

An alloy consists of a metal combined with one or more other elements. An alloy has properties that are different from those of its components. These new properties are usually an improvement over those of the main or base metal in the alloy. For example, brass is more durable than its base metal, copper.

Pure iron is extremely soft, but if small amounts of carbon are added, its strength increases dramatically. The alloy formed is steel. Mild steel has 0.5 per cent carbon, while tool steel has about 1 per cent. If the carbon content increases to between 2.4 per cent and 4.5 per cent, cast iron is formed. This is strong but brittle and breaks easily if hit or dropped. Stainless steel has chromium (20 per cent) and nickel (10 per cent) added to stop rusting.

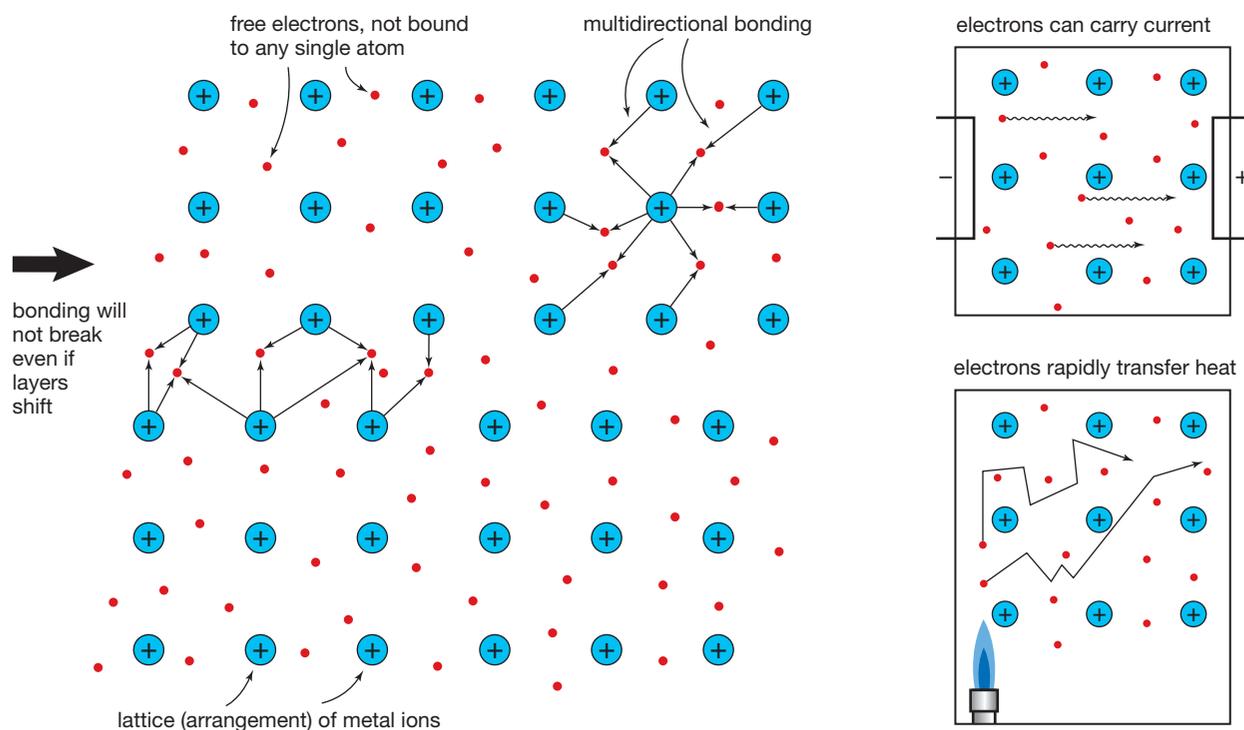


Fig 3.4.1

Metal atoms lose control of their outer-shell electrons, which are free to wander.

Pure metal	Element symbol	Uses	Properties that make it particularly suited to its use
Aluminium	Al	Overhead electricity cables, saucepans and cans, Alfoil	Excellent conductor of heat and electricity, extremely light, non-toxic
Copper	Cu	Electrical wiring	Excellent electrical conductor Easily drawn into wires
Sodium	Na	Nuclear reactor coolant	Conducts heat well Melts at 98°C, allowing molten sodium to flow along pipes in the reactor
Zinc	Zn	Coating for iron (galvanised iron)	Protects iron from rusting
Tin	Sn	Coating for steel cans for food, liquid etc.	Stops steel from rusting, non-toxic, unreactive
Mercury	Hg	Thermometers	Liquid at room temperature, expands rapidly when heated, leaves tubes clean once it retreats, leaving no traces
Lead	Pb	Flashing around windows and rooftops to stop water entry	Very soft and easily bent, resists corrosion

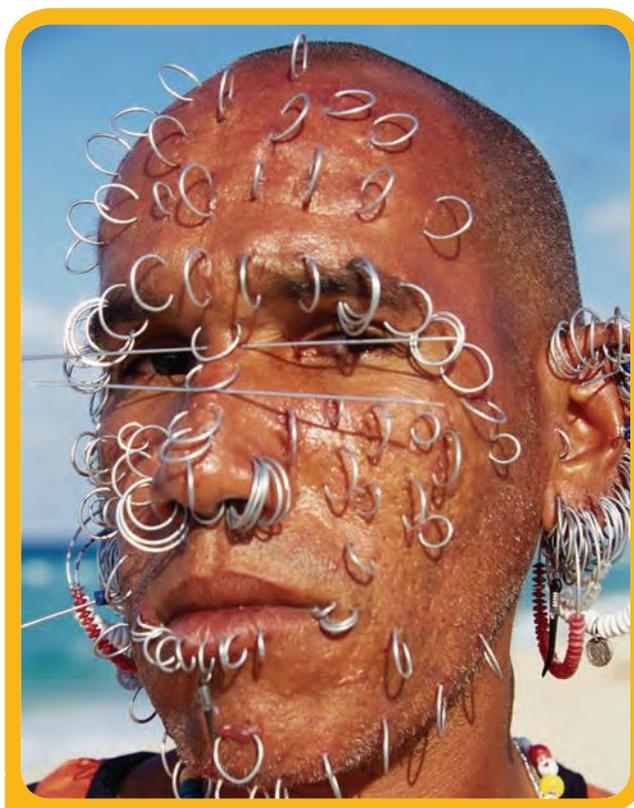


Fig 3.4.2

Jewellery used for body piercings is usually rust-resistant surgical-grade stainless steel but infection may still occur.

Pure gold jewellery would break if it was used for normal everyday wear. Instead, it is alloyed with silver or copper to increase its strength. The carat scale measures the amount of pure gold in jewellery, with pure gold rated as 24 carat. Jewellery is often 18 carat, meaning that it is 18/24 (three-quarters or 75 per cent) gold.

Some alloys and their composition and uses are listed in the following table.

Alloy	Composition	Uses	Advantages
Brass	70% Cu, 30% Zn	Household and nautical fittings, musical instruments	Appearance, limited corrosion, harder than pure copper
Bronze	95% Cu, 5% Sn	Statues, ornaments, bells	Appearance, little corrosion, harder than brass, sonorous (rings well when struck)
Duralumin	96% Al, 4% Cu, traces of Mg and Mn	Aircraft frames	Strong, light
Solder	60 to 70% Sn, 40 to 30% Pb	Joining metals together, electrical connections, low-friction bearings	Low melting point
Cupronickel	75% Cu, 25% Ni	'Silver' coins	Hard wearing, looks like silver, attractive
EPNS (electroplated nickel silver)	Cu, Ni, Ag	Plated onto cutlery, plates and bowls	Looks like silver, cheaper, resists corrosion
Alnico	Al, Ni, Co	Magnets	Aluminium is light, nickel and cobalt can be magnetised
Dental amalgam	Hg, Sn, Ag, Zn, Cu	Tooth fillings	Hardens slowly after being mixed



3.4

[Questions]

UNIT

Checkpoint

Pure metals

- Outline a factor that limits the use of pure metals.
- List two metals that can be used in their pure form.

Alloys

- Define the term 'alloy'.
- Alloys have advantages over their parent metals. Explain this statement using an example.

Think

- Are coins pure metals or alloys? Justify your answer.
- Explain why aluminium is the best metal to use for making overhead electricity cables, saucepans and foil.
- Read the following statements and state whether the item described is an alloy or a pure metal.
 - It is used as a coating for steel cans that will contain food and liquid. It stops steel from rusting. It is non-toxic and unreactive. Its symbol is Sn.
 - It is composed of aluminium (96%) and copper (4%), with traces of magnesium and manganese. It is strong and light, and is used for aircraft frames.
- The alloy dental amalgam is made up of mercury, tin, silver, zinc and copper. Explain why it is an ideal substance for tooth fillings.

Analyse

- State the base metal in a ferrous alloy. (Use element symbols to help you.)
- List the different types of steel, in order from the lowest carbon content to the highest.
- Use the information on page 45 to state what fraction and percentage of pure gold is in:
 - a 12-carat gold ring
 - a 9-carat gold nose stud
 - a 22-carat gold chain.

Skills

- The table below shows the stress that different alloys of copper and zinc can take before breaking. Construct a graph of stress (vertical axis) against the percentage of copper (horizontal axis).

Analyse your graph to answer the following questions.

- State the breaking stress of:
 - a 50/50 alloy of copper–zinc
 - an alloy of 20 per cent copper and 80 per cent zinc
 - an alloy containing 60 per cent zinc
 - pure copper
 - pure zinc.
- Identify the proportions of copper that make the alloy stronger than pure copper.
- Identify the proportions of zinc that make it weaker than pure zinc.
- Identify the strongest copper–zinc alloy.
- Identify the composition of three alloys that all break at a strain of $25 \times 10^6 \text{ N/m}^2$.

% Cu	0	10	20	30	40	50	60	70	80	90	100
Stress ($\text{N/m}^2 \times 10^6$)	19	16	12	8	5	32	58	40	23	21	33

UNIT 3.5

Plastics and fibres

Introduction

Nowadays we take plastics for granted, but before 1950, plastics were almost unheard of. Think of all the things that you wouldn't have if plastics had not been invented. Like metals before them, plastics changed technology and the way we build and use our world.

Plastic: carbon-based compounds

Carbon is a Group 14 element and each carbon atom can bond with up to four other atoms. This gives carbon the ability to form continuous lattices (eg diamond and graphite) and an amazing variety of molecules. Most molecules found in living organisms, fossil fuels, drugs, plastics and fibres contain atoms of carbon. This puts them into the same category—they are all organic compounds.

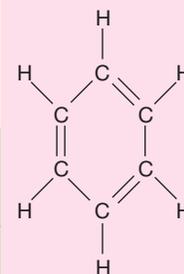
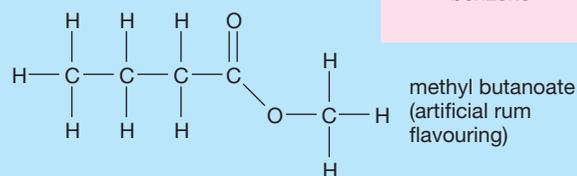
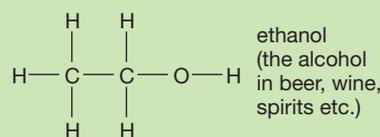
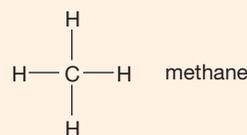


Fig 3.5.2 Some organic molecules made of carbon



Fig 3.5.1 Plastics are everywhere. Most packaging and many fibres are plastic.

The properties of plastics make them extremely useful for a wide variety of applications.

Plastics:

- are good thermal and electrical insulators, having no free electrons to conduct electricity or heat

- are strong and light and can be moulded into different shapes
- do not react with water or oxygen, making them weather- and rot-resistant. This is both a good and a bad property—outdoor furniture will not rot, but plastic packaging won't decompose when thrown out; plastics are not biodegradable
- become brittle over time if exposed to sunlight. Chemicals can be added, however, to make them more resistant
- can have other chemicals added to colour and reinforce them (eg glass fibres are added to a plastic resin to make fibreglass)
- sometimes react with or dissolve in other organic substances (eg turpentine, methylated spirits, petrol)
- can sometimes burn very easily, producing noxious fumes when they do—PVC produces hydrochloric acid fumes when it burns.

Plastic	Other names	Uses
Polythene	Polyethene	Milk crates, rubbish bins, buckets, plastic bags, cling wrap, soft squeeze bottles
Acrylic		Safety glasses, plastic screens
PVC	Polyvinyl chloride, polychloroethene	Waterproof clothing, guttering, pipes
Nylon		Brush bristles, fabrics, rope, carpets
Polystyrene		Without bubbles (unexpanded): yoghurt and margarine containers; with bubbles (expanded): insulation, Eskies, cups, packaging
Melamine		Unbreakable dishes
Urea formaldehyde		Electric switches and plugs
Phenol formaldehyde		Door handles, saucepan handles

Monomers and polymers

Plastics start with small molecules derived from the oil industry. A process called polymerisation combines them into larger molecules that make up plastic. The small molecules are called monomers and the big ones polymers. *Poly* is a Greek word that means ‘many’. Polyurethane is made from many urethane molecules, and polyethene is ‘many ethenes’. Imagine a monomer as a single ‘paperclip’. The polymer ‘polypaperclip’ would be a string of connected paperclips.

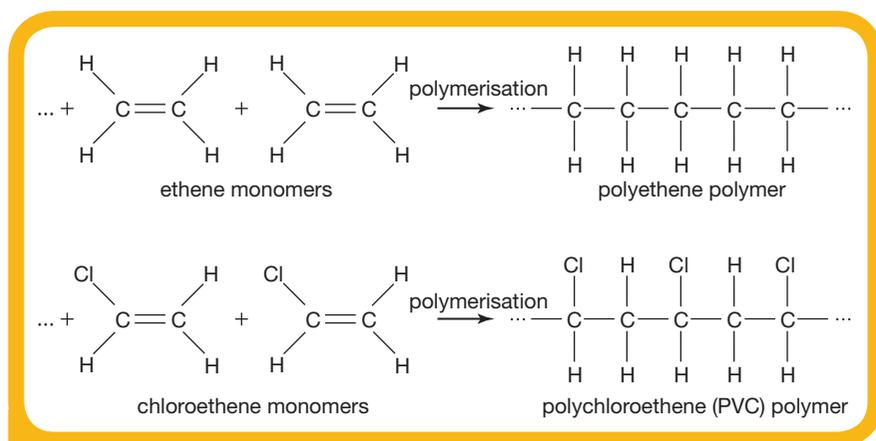


Fig 3.5.3

Many identical monomers join to make a polymer.

Thermoplastic and thermosetting plastic

When lightly heated, many plastics soften and can be remoulded into new shapes. When cool, they reset. These materials are called thermoplastic, examples being PVC, polythene and acrylic. These polymers arrange themselves into long parallel chains that slide over each other, allowing flexibility and stretching. If heated, they retain their basic structure but can slip over each other to fill whatever moulds they are poured into.

Thermoplastics are manufactured as powder, pellets or granules for shipping to other factories to be heated and moulded.

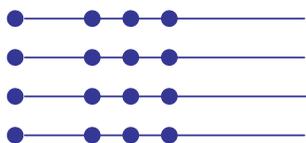
Thermoplastics are recyclable as they can be re-melted and remoulded many times. Recycling is an important way of managing plastics as it keeps them out of the environment. Plastics are not biodegradable, so they stay in the environment for hundreds, even thousands, of years. Plastic bags are a major concern for birds, animals and sea life since these creatures can become tangled in them or try to feed on them, with the bag subsequently blocking the animal’s digestive tract. Because plastic bags do not decay, they are released once more into the environment when the animal’s carcass decays.

Thermosetting plastics cannot be remoulded. The polymers have strong cross-linking bonds locking them into a giant molecular structure. Individual strands cannot be shifted without

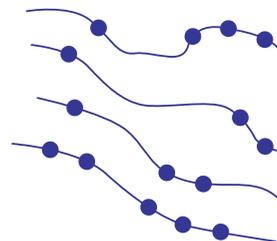
breaking part of the structure.

This makes thermosetting plastics hard (scratch resistant), brittle (will shatter if dropped) and rigid (not able to be bent). When heated, individual strands cannot move—thermosetting plastics will char (burn at the edges) but will not soften. They therefore need to be manufactured and moulded at the same time. Bakelite is an example of a thermosetting plastic.

Thermoplastic

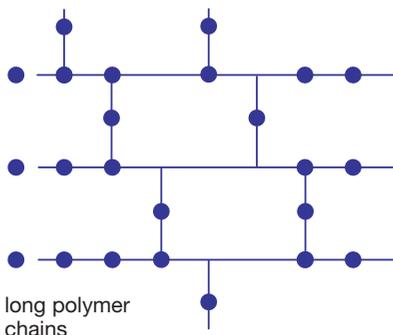


add heat
→

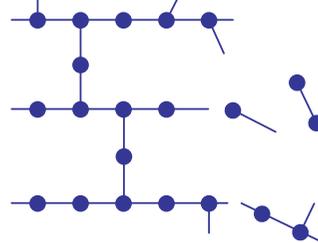


chains slip over each other and the plastic melts

Thermosetting



add heat
→



bonds break and the plastic decomposes (chars)

Fig 3.5.4

Thermosetting and thermoplastic

Activity 4

Identifying plastics

Aim

To identify properties of some common plastics

Equipment

Labelled pieces (each about 2 × 1 cm) of polythene, polystyrene, PVC, perspex, nylon, 'mystery' plastics, dissection board/bench mat, scissors, turpentine, nail polish remover, dilute hydrochloric acid (HCl), detergent, 250 mL beaker, tongs, access to meths burner set-up in fume hood

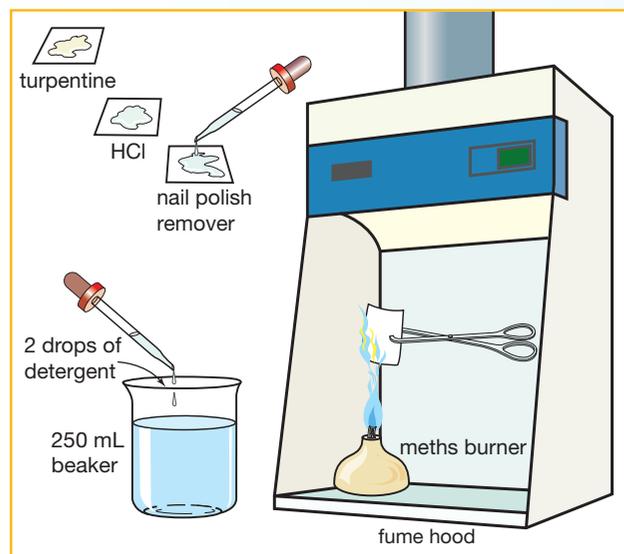


Fig 3.5.5

Method

- 1 Copy the table below. Your teacher may split you into groups to run all tests on one plastic only, or to run one test on all the plastics.

Polythene	Polystyrene foam	PVC	Perspex	Nylon foam
Appearance				
Flexibility				
Feel				
Ease of scratching				
Ease of cutting				
Description of cut				
Does it float?				
Effect of flame				
What dissolves it?				

- 2 Describe the appearance—is it transparent, translucent or opaque?
- 3 Describe its flexibility—does it bend or is it stiff?
- 4 Does it feel 'waxy'?
- 5 Does your fingernail or the scissors scratch it?
- 6 How hard is it to cut with scissors?

>>

- Are the cut edges smooth or jagged? Does the cut show bubbles or cells?
- Add two drops of detergent to a 250 mL beaker of cold water. Add a plastic—does it float or sink?
- Place a drop each of turpentine, HCl and nail polish remover onto three small squares of each plastic. Leave for 5 minutes and record whether each piece dissolved, went soft or remained hard.
- Break each plastic into smaller pieces and use tongs to hold a piece in a meths burner flame.

Warning! The meths burner must be in a fume hood. If no fume hood is available, do not do any burning tests. Do not smell any fumes or smoke.

- Did the burning produce smoke? If so, what colour was the smoke? What colour was the flame? Did molten plastic drop from it? Did the drops burn as they fell?
- Run tests to determine what each of the mystery plastics is.

Questions

- Identify each plastic as either thermoplastic or thermosetting.
- Identify the mystery plastics.
- Explain why the burning must be done in the fume hood and not in the lab.
- Explain what is produced from PVC when it is burnt.
- Deduce whether any plastics sink in, or react with, water.
- A sample of plastic kept burning once it was lit. Its flame was blue with a yellow tip. Identify the plastic.

Activity 5

Making casein plastics

Aim

To make a polymer called casein from milk. Casein is an early plastic that is still used for buttons and some wood glues. It is hardened industrially with formalin.

Equipment

Full-cream milk, vinegar, Bunsen burner, bench mat, tripod, gauze mat and matches, 100 mL measuring cylinder,

2 × 250 mL beakers, thermometer, glass stirring rod, elastic band, coarse cloth for straining, paper towel/filter paper, assorted moulds (bottle caps, moulded chocolate trays, etc.), fine sandpaper, tongs

Method

- Set up the Bunsen burner and tripod.
- Place 100 mL of milk in one of the 250 mL beakers. Warm gently until it reaches 50°C. Do not overheat.
- Add 10 mL vinegar and stir with the stirring rod.

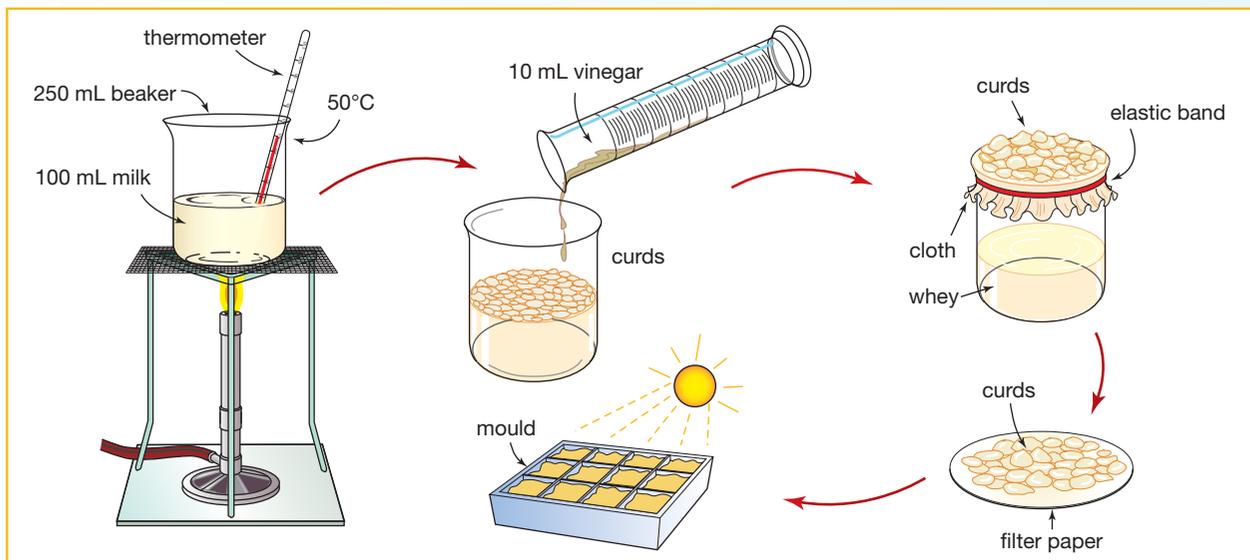


Fig 3.5.6



- 4 The milk should curdle to form white lumps of curds (casein) and yellowish liquid called whey.
- 5 Use the elastic band to secure the piece of cloth tightly over the other 250 mL beaker. Strain through the curds and whey.
- 6 Carefully remove the cloth and squeeze to remove as much liquid as you can.
- 7 Empty onto the paper towel/filter paper. Pat dry, then firmly press into moulds. Leave the casein to dry in the sunlight.
- 8 After a couple of days, remove the mould and polish with the sandpaper.
- 9 Use tongs to hold a small amount of the dry casein in a Bunsen flame. Does it melt, burn or char?

Questions

- 1 Deduce whether the casein plastic produced was thermosetting or thermoplastic.
- 2 State the purpose of the final test.
- 3 Identify a use of the casein.
- 4 Outline how casein is hardened industrially.

Natural and synthetic fibres

A fibre is any substance that can be woven or knitted into a fabric. There are two main types—natural and synthetic.

Natural fibres

Wool, mohair, silk, cotton, linen (flax), hair, fur and coir (the hairy covering of a coconut) are all natural fibres. They have had many uses for thousands of years.

In many of our traditional societies, making objects from plant fibres was an important activity. Items needed for hunting as well as for carrying and collecting food were made along with custom objects for use in religious ceremonies.

The parts of many plants provide fibre to make string, bags, rope, baskets, fishing nets or baskets, clothing and mats.

Fibres come from the following plant parts:

- the roots of certain species of plants, such as abalolo
- the leaves of plants such as coconut and banana
- the bark of trees and shrubs, such as some species of *Acacia* and native hibiscus.

After the plant parts have been collected, the fibrous material is extracted and separated.



Fig 3.5.7

A woman weaving a traditional basket out of plant fibre

Some materials are soaked in water until the non-fibrous tissue rots away. Chewing or scraping with a sharp rock or shell then flattens and softens the remaining fibres.

On some trees, such as the paperbark, little preparation is needed. The bark is simply peeled from the trees and used to make water containers, mats and liners for babies' baskets.



Fig 3.5.8 Softened thermoplastic is squeezed out of a multi-holed nozzle called a spinneret. A synthetic fibre is formed.

Synthetic fibres

Synthetic fibres are made entirely from chemicals and are usually stronger than natural fibres. Nylon, Terylene, Lycra, Kevlar, Spandex, Elastane, polyesters and acrylics are all synthetic fibres.

Synthetic fibres are produced by the extrusion of a polymer through a multi-holed head called a spinneret. Some use natural fibres as their building blocks. Wood and paper (a wood product) contain the natural polymer cellulose. If wood pulp is soaked in solutions of caustic soda (sodium hydroxide, NaOH), a sticky cellulose gum forms. When extruded, the gum forms a new fibre—viscose, acetate, tri-acetate and rayon all come from wood pulp.

Activity 6

Identifying fibres

Aim

To compare and contrast natural and synthetic fibres

Equipment

Labelled samples of fabrics (wool, cotton, linen, rayon, nylon, polyester), microscope, microscope slide and coverslip, pins or tweezers, metal tongs, matches, bench mat

Method

- 1 Remove an individual thread, about 2 cm long, from each fabric sample.
- 2 Place it on the microscope slide and use the tweezers or pins to tease the fibres apart.
- 3 Place a coverslip on top and inspect the fibres under the microscope.
- 4 In your workbook, sketch and label each fibre, taking note of its surface.
- 5 Cut/tear a strip about 2×1 cm from each fabric.
- 6 Use tongs to hold a strip over the bench mat. Hold a lit match under the strip. Record your observations for each fabric. Did it catch fire, melt or char? What colour were the flame and smoke? What was left?

Questions

- 1 Match your samples with the diagrams in Figure 3.5.9.

- 2 Deduce which fibres were natural and which were synthetic.
- 3 Explain why synthetic fibres have smoother surfaces than natural ones.
- 4 List the fabrics in order, from the safest near a flame to the most dangerous.
- 5 Clothing fires are more common among children than adults and more common among girls than boys. Suggest reasons why.
- 6 Recommend which fibres should be used for clothing for babies and young children.

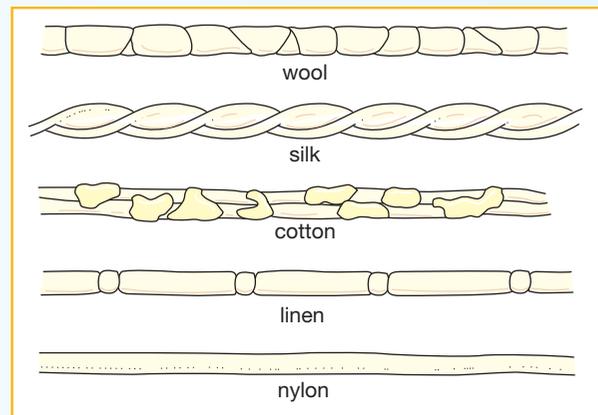


Fig 3.5.9 Fibres under the microscope

Length and strength

The molecules in a synthetic fibre are aligned along the thread, making them stronger than the plastics they came from. The fibre will be particularly strong if its molecules are long—the longer the molecule, the greater its attraction to others that lie next to it, and the stronger it will be. The fibre can still tear, though, since the end of each molecule represents a weak spot.

Monofilaments are made from molecules that are the same length as the fibre. There are no ends and therefore no weak spots. Fishing lines are monofilaments of nylon. Monofilament materials are extremely strong and flexible, making them ideal for uses where a tear or puncture would be catastrophic: Kevlar is a monofilament that is five times stronger than steel, but half the density of fibreglass. It is used in bulletproof vests, the sails of ocean-going yachts and the fuel tanks of Formula 1 racing cars. Ropes, fibre-optic cables, automotive hoses, belts and gaskets are often made of Kevlar. Goalie masks in hockey use a fibreglass/Kevlar mix.

Other properties

The rough surfaces of natural fibres give them a large surface area that can absorb and hold water and dirt. In contrast, the surfaces of synthetic fibres are smooth, making them stain-resistant, water-repellent and ideal for clothing. Drip-dry or wash-and-wear fabrics are synthetic. Synthetics are uncomfortable in hot weather, however, as they do not absorb sweat. Instead, sweat stays on your skin, making you wet and clammy. Natural fibres absorb sweat and keep your skin dry.

Synthetic fibres are thermoplastic and melt if heated: ironing must be done with care.

Other fibres

If synthetic fibres are heated strongly with no air present, they do not burn but char until all that is left is a fibre of pure carbon. Carbon fibre is extremely strong and when mixed with resins can be used for making lightweight and flexible structures ideal for bike frames and tennis racquets.

Glass fibre is produced by running molten glass into a perforated steel bowl (like the barrel of a washing machine). When spun fast, glass threads fly out and then cool in the air. When mixed with resins, fibreglass is produced.

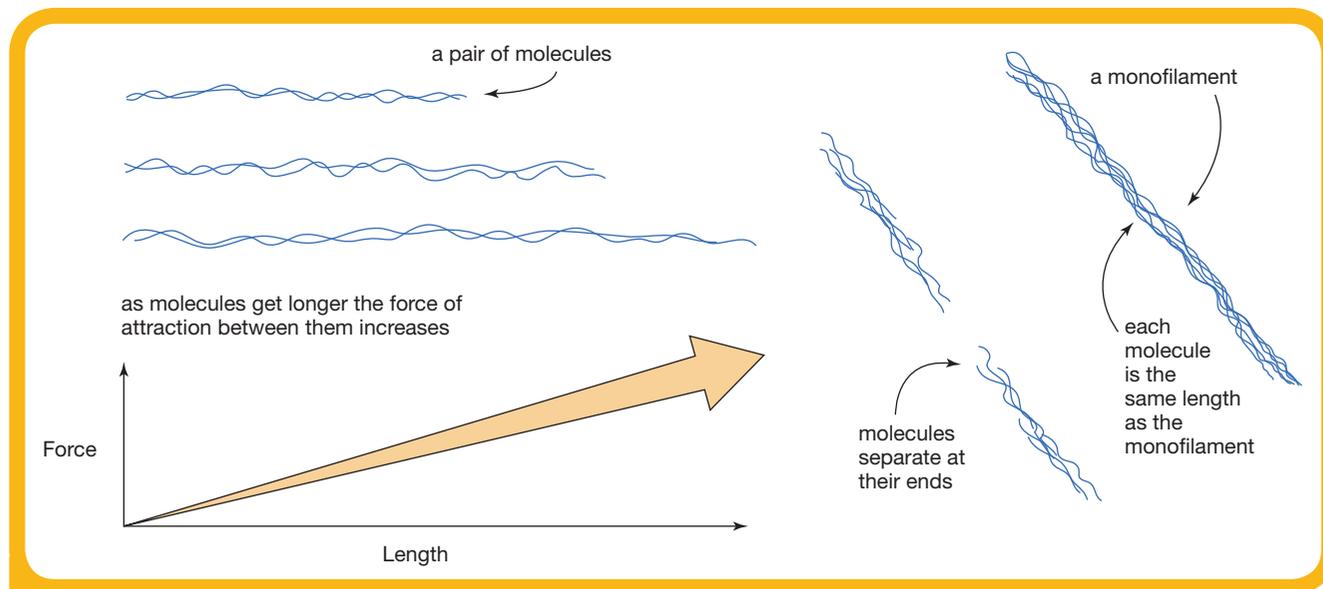


Fig 3.5.10

Longer molecules produce stronger fibres than shorter ones. The strongest are monofilaments.



3.5 [Questions]

UNIT

Checkpoint

Plastic: carbon-based compounds

- 1 State what is meant by an 'organic compound'.
- 2 List three examples of organic compounds.
- 3 List these facts about carbon (C):
 - a its group number
 - b its period
 - c the number of electrons in its outer shell
 - d the maximum number of bonds it can form
 - e two continuous lattices that it forms.

Monomers and polymers

- 4 Identify the correct terms in the following list to fill in the spaces below.

polymer, polymerisation, monomer, plastics

A small molecule capable of joining together in a long chain is called a _____. When small molecules join together they form a _____. Small molecules join together in a process known as _____ and result in the production of _____.

Thermoplastic and thermosetting plastic

- 5 Define the term 'thermoplastic'.
- 6 List three forms in which thermoplastics are manufactured.
- 7 Define the term 'thermosetting'.
- 8 List three properties of plastics made by thermosetting.

Natural and synthetic fibres

- 9 State whether the following statements are true or false.
 - a A fibre is any substance that can be woven or knitted into a fabric.
 - b Nylon, cotton and linen are all examples of natural fibres.
 - c Natural fibres are produced using a spinneret.

Length and strength

- 10 Use an example to demonstrate the usefulness of a monofilament.

Other properties

- 11 Outline three desirable and three undesirable properties of synthetics.
- 12 Explain why natural fibres are able to absorb and hold water.

Think

- 13 Contrast:
 - a the surface of a natural fibre with that of a synthetic fibre
 - b a monomer with a polymer
 - c thermoplastics with thermosetting plastics.
- 14 List examples of:
 - a five synthetic polymers
 - b three natural polymers
 - c three thermoplastic polymers
 - d one thermosetting polymer
 - e one monofilament.
- 15 A train could be considered a polymer. State what the monomer would be.
- 16 Explain how thermoplastics can melt and then reset on cooling.

Analyse

- 17 Would the production of thermosetting plastic powder be a good idea? Justify your answer.
- 18 Explain how the length of a molecule affects the strength of a fibre.
- 19 Where do fibres tend to break?
- 20 Explain why care must be taken when drying and pressing synthetic fibres.
- 21 Explain how cross-links stop thermosetting plastics from melting.
- 22 Evaluate the use of plastics in terms of their effect on society and the environment.

Chapter review

[Summary questions]

- 1 State an example of an alloy and its base metal.
- 2 State whether the additives in alloys are usually metals or non-metals.
- 3 Explain what semi-metals are.
- 4 Explain why magnesium is less reactive than potassium.
- 5 List the carbon content of:
 - a cast iron
 - b tool steel
 - c mild steel.
- 6 State how many carats are in pure gold.
- 7 If gold is 18-carat, state the percentage of gold present.
- 8 State a use for each of these materials:
 - a aluminium
 - b zinc
 - c cast iron
 - d Duralumin
 - e bronze
 - f haematite.
- 9 State one example each of:
 - a an alloy of copper
 - b an alloy of iron
 - c an impurity commonly added to iron
 - d a commonly used pure metal
 - e an ore
 - f a native metal
 - g a natural fibre
 - h a synthetic fibre made from wood products
 - i a monofilament fibre
 - j an organic solvent.
- 10 State the special name given to the corrosion of iron.
- 11 List four properties of a thermosetting plastic.

[Thinking questions]

- 12 Explain why stainless steel is ideal for use as replacement bone (hips, tooth implants, knees).
- 13 Corrugated iron (steel) is galvanised and is commonly used for roofing.
 - a Explain what will happen after all the zinc coating has corroded away.
 - b Explain whether the zinc can be replaced.
- 14 If car bodies are galvanised, propose reasons why they are also painted.
- 15 Identify problems associated with using plastic shopping bags.

[Interpreting question]

- 16 Aluminium metal is high on the reactivity series, yet is a commonly used metal. Use Figure 3.2.5 to explain why it does not rust.

9.4.1.1, 9.4.2.1, 9.4.3.1, 9.4.4.1, 9.4.4.2, 9.4.5.1, 9.4.6.1, 9.4.7.1,
9.4.8.1, 9.4.9.1, 9.4.10.1, 9.4.11.1, 9.4.12.1, 9.4.13.1, 9.4.13.2,
9.4.14.1, 9.4.15.1, 9.4.16.1, 9.4.17.1, 9.4.18.1, 9.4.19.1

Human body systems

CHAPTER

4

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

- identify five parts of the skeletal system and describe its three main functions
- describe three types of joints in the skeletal system
- understand that muscles are joined to the bone by tendons and bones are joined to each other by ligaments
- explain that muscles contract and relax to produce movements
- describe how antagonistic muscles operate
- identify parts of the body that have antagonistic muscles
- identify the parts of the male and female reproductive organs and describe their functions
- describe the physical changes occurring in male and female bodies at puberty
- draw diagrams to describe the menstrual cycle and the reproductive stages from fertilisation to birth
- identify reproductive problems in males and females and suggest ways of avoiding them
- differentiate between the central and peripheral nervous systems
- illustrate the difference between sensory neurons, motor neurons and interneurons
- state the function of the human brain
- explain the reflex arc of a nervous reaction
- define the following terms: hormone, endocrine gland, endocrine system and target organ
- identify from a diagram and describe the functions of endocrine glands and the hormones they produce.

- 1 How big is your heart?
- 2 Where can you feel your pulse?
- 3 Does heartburn really burn the heart?
- 4 Blood is red so how come our veins look blue?



UNIT 4.1

Skeleton and muscles

Introduction

The human skeleton contains over two hundred living bones and is an example of an endoskeleton—a skeleton that is inside a body. Insects, crabs and spiders are creatures that have

a skeleton on the outside called an exoskeleton. Worms and jellyfish have an internal liquid skeleton that keeps pressure on the surrounding muscles to maintain its shape.

Skeletons

There are three types of skeleton, and all living organisms have one of these three types.

- An endoskeleton is a skeleton inside the body. Humans, dogs and cats have endoskeletons.
 - An exoskeleton is a skeleton outside the body. Beetles, prawns and grasshoppers have exoskeletons.
 - A hydroskeleton is a skeleton made up of internal liquid that maintains its shape. Tapeworms, bluebottle jellyfish and starfish have hydroskeletons.
- The skeleton has three main functions.
- **Support:** Your skeleton stops you falling over and gives you shape. It keeps your organs in their correct positions.
 - **Protection:** Your skeleton protects your organs from damage. For example, the skull protects the brain and the spinal column protects the spinal cord.
 - **Movement:** Your skeleton works with your muscles and connective fibres to produce movement. Special joints allow various types of movement.

Bone structure

Bones need to be:

- very strong to hold your weight and the pressures of all the activities that you do each day
- flexible, otherwise they would break whenever you twisted
- light enough to allow you to carry the weight of all 200 of them

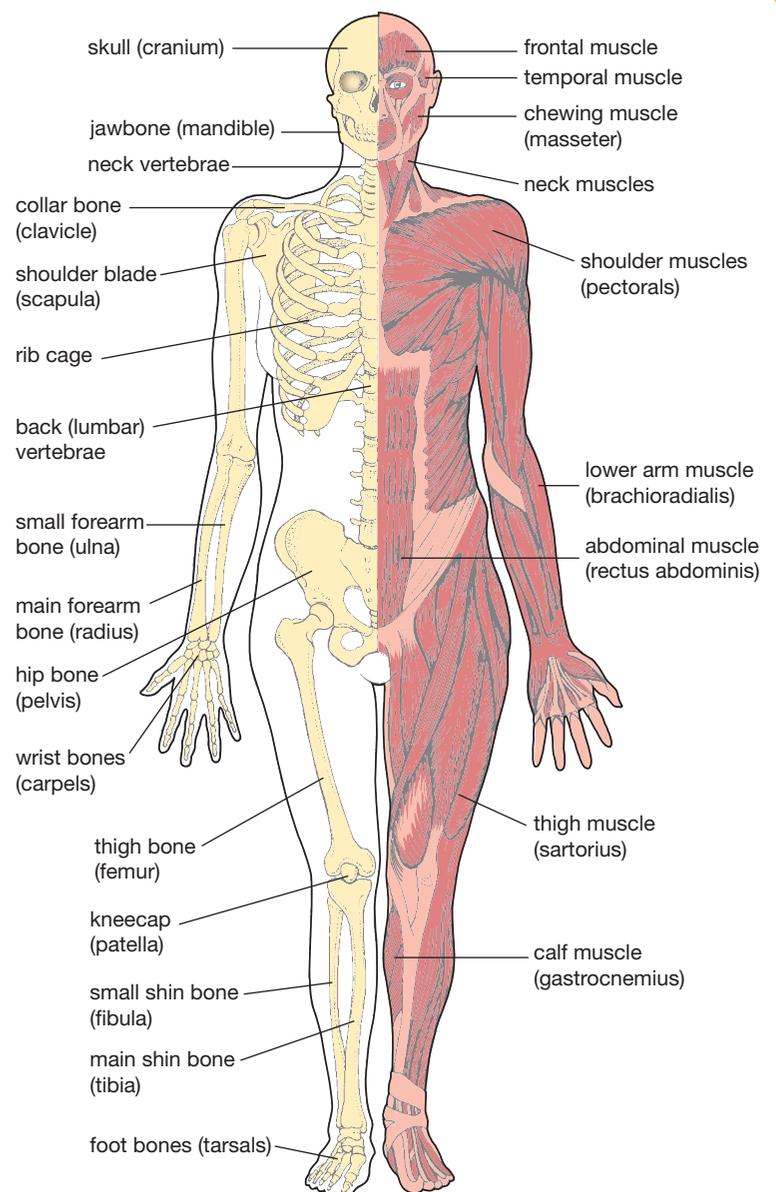


Fig 4.1.1 The human skeleton and muscular systems

- living, so that they can grow, repair and produce blood cells inside them.

Bone consists of living cells and blood vessels surrounded by calcium phosphate, which gives the bone its hardness, and collagen, which provides some flexibility. Bones can be thought of as strong tubes that contain bone marrow, which makes new blood cells. People suffering from the blood-cell disease leukaemia are sometimes given a bone-marrow transplant.

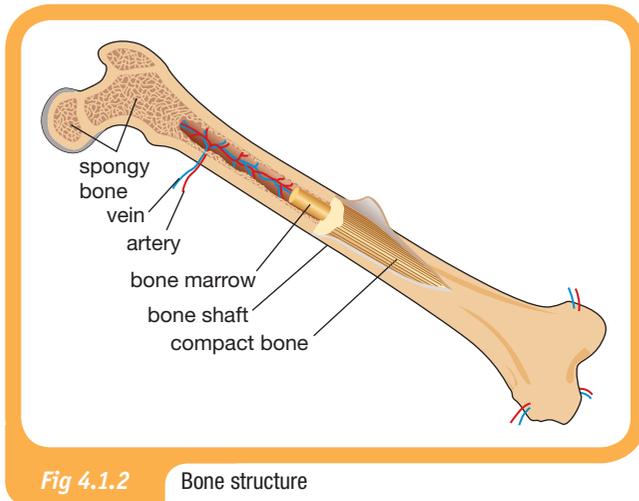


Fig 4.1.2 Bone structure

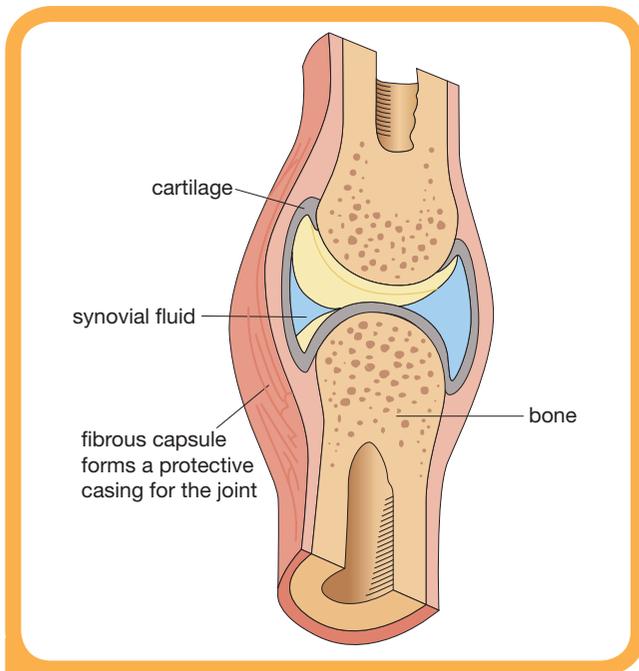


Fig 4.1.3 A joint contains several features.

Joints

Bones would soon wear down if they were allowed to rub on other bones in the joints, so the joints have built-in protection. Cartilage (gristle) is softer and more elastic than bone and has a slippery surface. It is found where bones rub together. A shark's skeleton is composed entirely of cartilage. Synovial fluid works with cartilage to reduce friction as bones move past each other. Ligaments are strong fibres that help hold bones in place.

There are several types of bone joint, including the hinge joint and ball-and-socket joint. A hinge joint is like the type of hinge that allows a door to open and close. The knee joint is a hinge joint. A ball-and-socket joint allows movement in all directions. The hip joint is an example of a ball-and-socket joint.

A snake's skeleton is a very simple one. It only has a skull, backbone and ribs—400 of them.

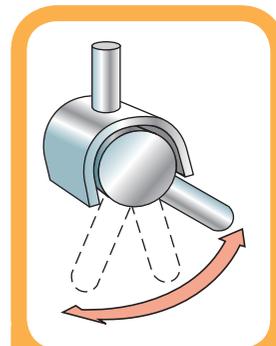


Fig 4.1.4 Hinge joint, such as an elbow



Fig 4.1.5 Ball-and-socket joint, such as a hip

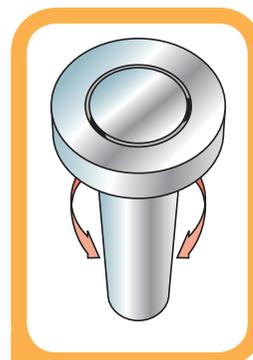


Fig 4.1.6 Pivot joint, such as the head swiveling on the top of the spine

Activity 1

Joints in the body

Aim

To classify the joints in the human body

Method

- 1 Work with a partner in this activity.
- 2 Refer to the human skeleton diagram to check your bone joints.
- 3 Draw up a data table like the one below.
- 4 Classify as many of the joints in your body as possible. One is done for you.

Joint in body	Type of joint
Between the bones of the fingers	Hinge joint

Questions

- 1 Without looking at your table or the textbook, list as many types of joints in the body as you can.
- 2 Look at human skeleton diagram carefully. Which do you think is the most common joint in the human body? Why?

Muscles

Muscles produce movement of joints and bones. They are attached to bones by special fibres called tendons. Tendons are made of collagen and may stretch a little to avoid snapping due to sudden movements. Muscles can contract (get shorter and fatter) or relax (become longer and thinner). Many muscles work in pairs, with one contracting while the other relaxes. These antagonistic pairs are arranged so one of the muscles can always contract to move a joint.

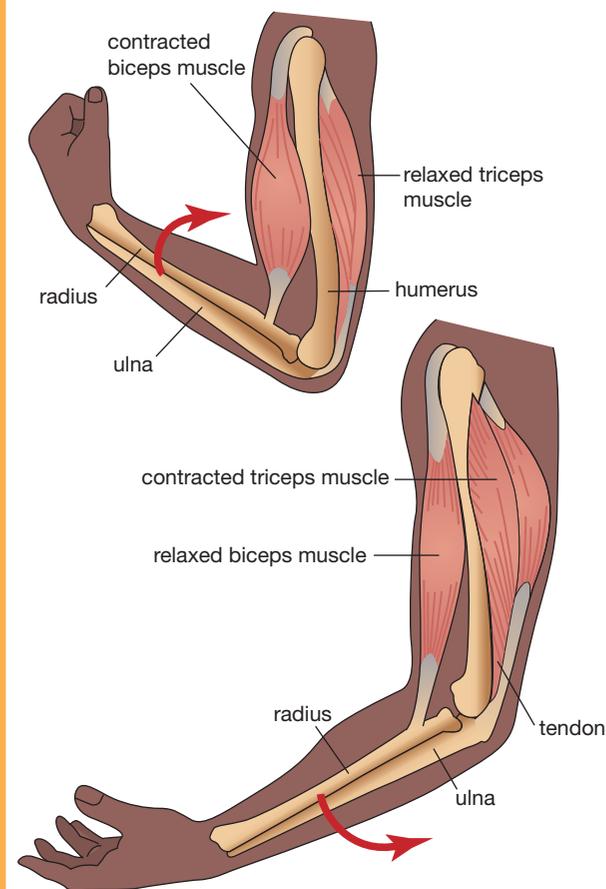


Fig 4.1.7

The biceps contracts to raise the arm, while the triceps contracts to straighten it—notice that when one of these muscles is contracted, the other is relaxed.

Muscles may be classified into two groups—voluntary and involuntary. Voluntary muscles are muscles that require a conscious decision to move them (such as biceps in your arm). Involuntary muscles are ones that move without you thinking about them (such as those that help you breathe).

Injuries and conditions

Bones and the fibres that work with them can be damaged in various ways.

Fractures and breaks

Bones may fracture or break if too much force is applied to them. In most cases, fractured or broken bones can be set and allowed to mend by themselves. In some cases, metal pins or plates are inserted to hold bones together while this happens.

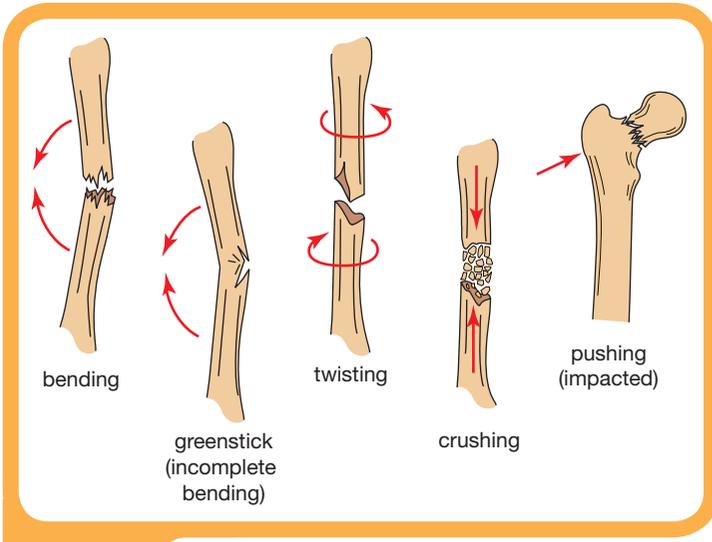


Fig 4.1.8 Bones may break in a variety of ways



Fig 4.1.10 Much bone is naturally spongy. This bone has become even more spongy and honeycombed due to osteoporosis.

Arthritis

There are hundreds of types of arthritis. Arthritis occurs when joints become inflamed. The most common is osteoarthritis, in which cartilage breaks down, making the joint stiff and painful. The next most common form of arthritis is rheumatoid arthritis, in which the membrane containing the synovial fluid becomes inflamed. This can affect the surrounding body tissues and cause aching muscles.

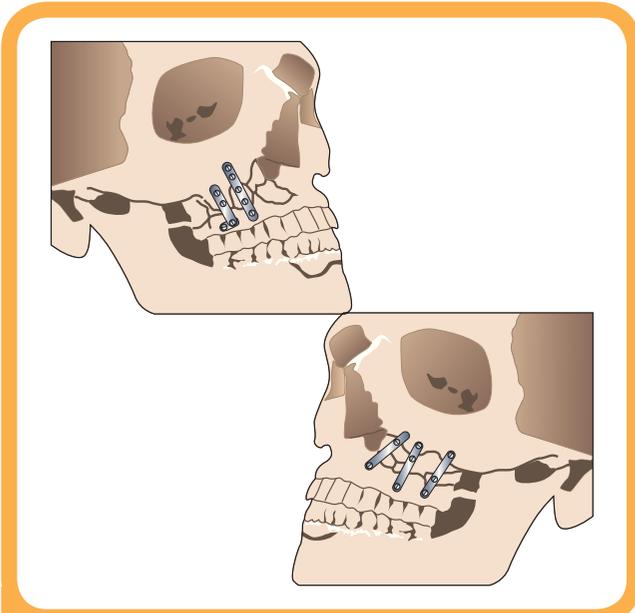


Fig 4.1.9 Metal pins hold a jawbone together while it heals.

Osteoporosis

Osteoporosis is a condition in which bones become less dense and hence more easily broken. It occurs more often in older people and affects about 30 per cent of men and 60 per cent of women.

A healthy diet that includes sources of calcium (such as milk, cheese and yoghurt) can help prevent osteoporosis later in life.



Fig 4.1.11 A footballer injures his anterior cruciate ligament in his knee.

Torn hamstring

A torn hamstring is a very common sporting injury. A torn hamstring may occur to the muscle at the rear of the thigh that connects the bottom of the knee to the pelvis. It may be torn by sudden movement (such as sprinting from rest), particularly if no warm-up has been done.

Sprains

A sprained ankle occurs when the ankle ligaments are stretched too far.

Ligament damage

Damage to ligaments in the knee can sideline a sportsperson for a year or more. The anterior cruciate ligament normally stops the knee bending the wrong way and is often damaged in sports such as football.

4.1 [Questions]

Checkpoint

Skeletons

- 1 What are three types of skeleton?
- 2 List the three main functions of your skeleton.
- 3 Are your bones alive?
- 4 What gives bones:
 - a hardness
 - b flexibility?
- 5 Why is bone marrow important?
- 6 List three types of bone joint. Give an example of each.
- 7 Where is synovial fluid and what does it do?

Muscles

- 8 What attaches muscles to bones?
- 9 What is the opposite of 'contract' when discussing muscles?
- 10 What is an antagonistic pair?
- 11 What are voluntary and involuntary muscles? Give examples of each.

Injuries and conditions

- 12 Does osteoporosis affect more males or females?
- 13 Name two types of arthritis.

Think

- 14 Give an example of an organ protected by your:
 - a skull
 - b pelvis
 - c ribs.
- 15 What is the difference between ligaments, tendons and cartilage?
- 16 Suggest why you should stretch and warm up before playing sport.

[Extension]

Investigate

- 1 Give the scientific name for each of the following:
 - a kneecap
 - b shoulder blade
 - c collar bone
 - d thigh bone.
- 2 Where would you find:
 - a a fibula
 - b a radius
 - c tarsals
 - d a tibia?

UNIT 4.2

Human reproductive systems

Introduction

The reproductive system makes the continuation of life possible. From adolescence onwards, humans feel a strong sexual drive. This desire to reproduce is driven by hormones produced in the reproductive system. You need to understand how this system works and how it affects your body as you grow and develop.

The male reproductive system

Sperm are produced in the two testes. The testes are located in a sac called the scrotum, which hangs outside the body. This keeps the testes cooler than the normal body temperature of 37°C. The cooler temperature allows maximum sperm production. The testes also produce the male sex hormone testosterone. This hormone gives a man his secondary sexual characteristics: increased musculature, the deepening of voice at puberty, the growth of hair on his body and face, and the tendency to go bald.

Most of each testis is made up of tiny, tightly coiled tubes called seminiferous tubules. Many hundreds of millions of sperm are formed in these tubes each day, but they take several weeks to reach maturity. Once formed, the sperm are moved along the tubes by cilia—hair-like structures attached to the walls of the tubes, which beat back and forth. The sperm are stored in another part of the testis, in a group of coiled tubes called the epididymis. It is here that they become fully developed and start to ‘swim’ in fluid released from the walls of the tubes.

Each testis is connected to the urethra by the sperm duct, or vas deferens. The urethra is the tube that runs along the length of the penis. This tube also connects to the bladder and is used to empty it of urine. As the sperm travel from the sperm duct to the penis, they pass by glands that add more fluid to the mixture. The major glands are the prostate, seminal vesicle and Cowper’s glands. This mixture of fluid and sperm is called semen. Although both semen and urine pass along the urethra, it is not possible for both to pass through at the same time.

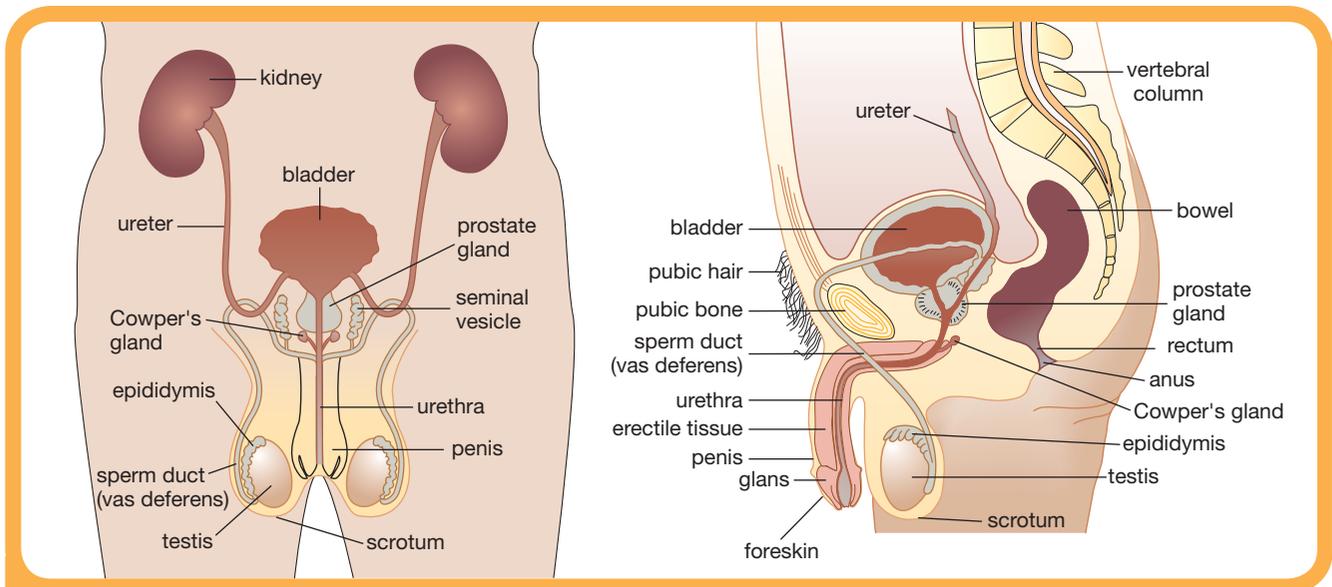


Fig 4.2.1 The human male reproductive system

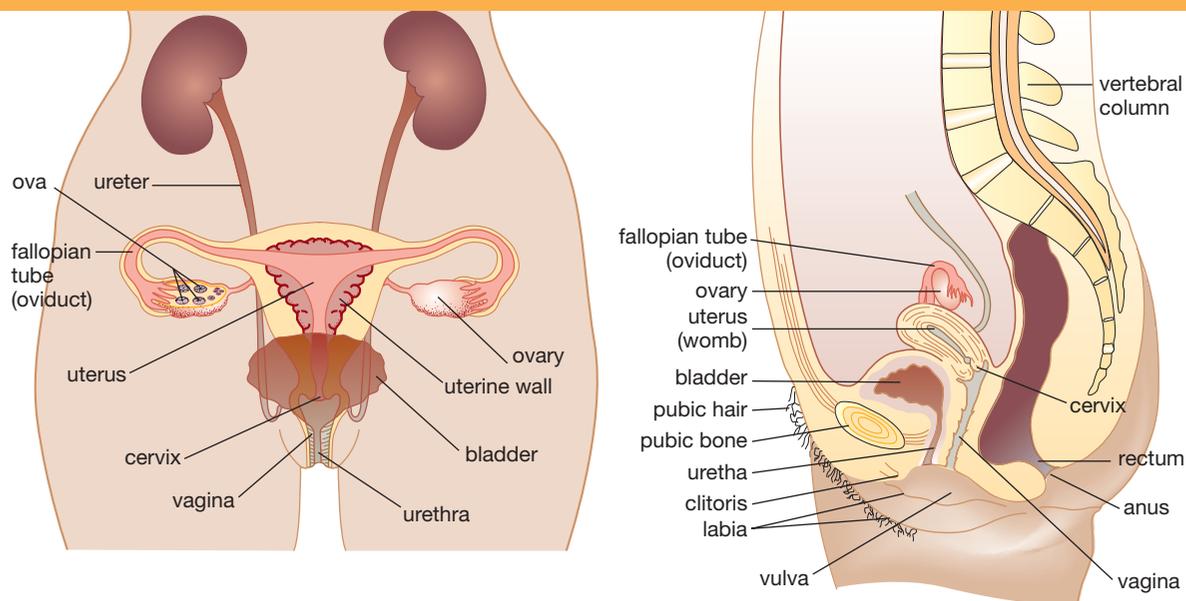


Fig 4.2.2 The human female reproductive system

The female reproductive system

Ova (eggs) are produced by the two ovaries, which also produce female hormones, mainly oestrogen and progesterone. Whereas males constantly produce new sperm throughout their lives, all of the female's eggs are formed in her ovaries before birth. A human female newborn has about 500 000 eggs in each ovary, but only a few hundred of these ever become fully formed.

The release of eggs and hormones from the ovary occurs in a cycle called the menstrual cycle. At the start of every menstrual cycle (day 1), an immature egg, contained in a small sac of cells called a follicle, starts to develop. The follicle and egg get bigger until about day 14 of the cycle, when the egg becomes mature. The egg then bursts from the follicle into the ovary cavity. From here, the egg moves into the fallopian tube or oviduct, moved along by cilia and muscular contractions.

While the egg is in the fallopian tube, it is capable of being fertilised for a period of 12 hours after ovulation. It then disintegrates. During each menstrual cycle it travels to the uterus regardless of whether it has been fertilised or not.

From the start of every menstrual cycle, the lining of the uterus becomes thicker with an increased blood supply, in preparation for receiving the fertilised egg. If the egg has been



Fig 4.2.3 Every month a new scar is formed on the ovary, due to follicle formation. These pictures show the ovary of a 3-year-old girl and a 27-year-old woman.

fertilised, it implants in the wall of the uterus and starts to develop. A change in hormones tells the body to keep the uterine lining, so menstruation does not occur. The female is then said to be pregnant. Menstruation is the shedding of the uterine lining. It is also known as a period and occurs when the egg is unfertilised on about day 28 of the cycle. The lining of the uterus consists of blood, mucus and cell remains.

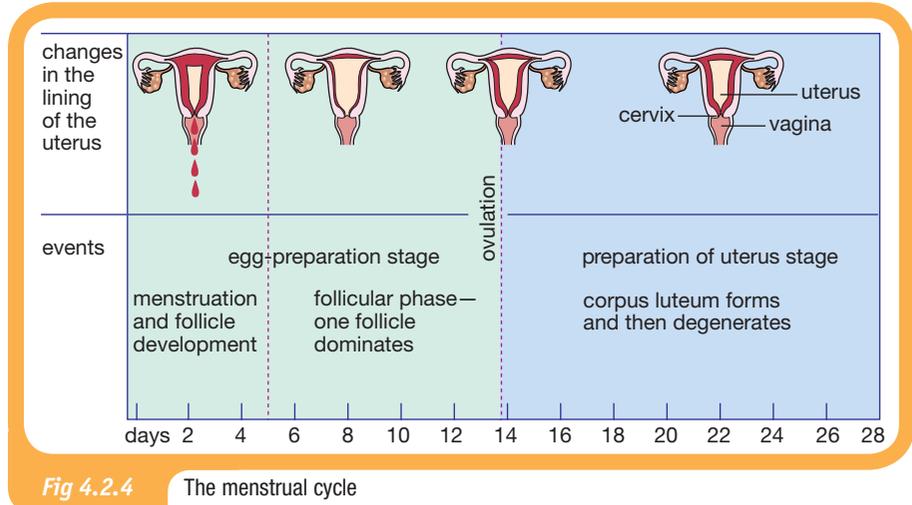
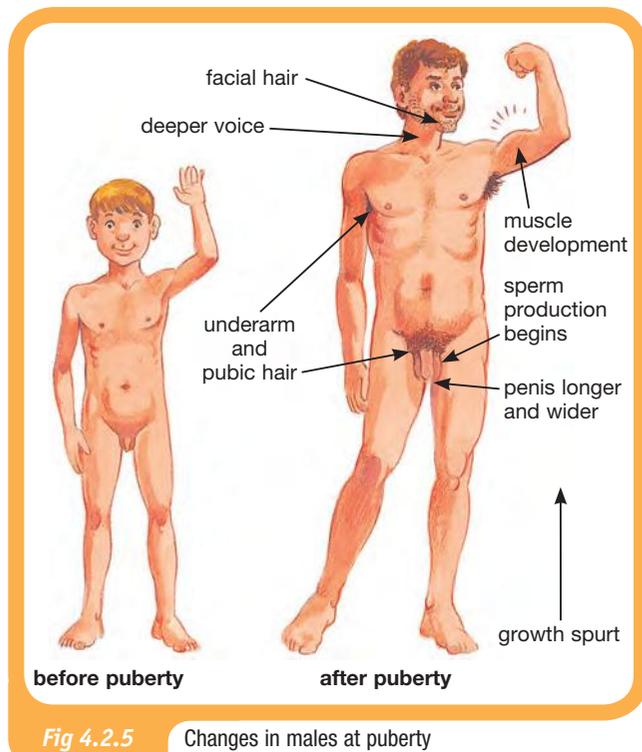
After many cycles, no more eggs are released. This stage is called menopause and commonly occurs in humans between the ages of 40 and 50.

Puberty

Puberty is the time when males and females become capable of sexual reproduction. Puberty can start at different ages, but usually no earlier than 10 years of age. It is normally over by 17 years of age. Before puberty, the reproductive organs are present, but are not fully developed or functional.

Changes in males at puberty

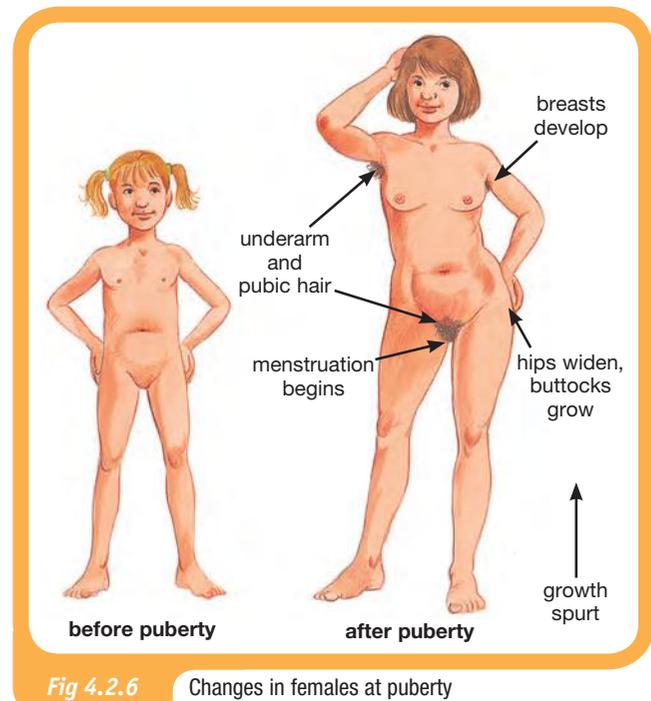
The hormone testosterone begins to be secreted by the testes from the start of puberty and causes many changes. Testosterone stimulates the development of the genital organs and secondary sexual characteristics such as facial pubic, underarm, leg and chest hair, increased muscle mass and bone structure, and a lower voice. The testes develop and begin sperm production.



Changes in females at puberty

The major female hormone is oestrogen, which causes maturing of the eggs and makes the lining of the uterus thicken with blood. Oestrogen is also responsible for the outward changes seen in females at puberty.

Like males, females experience a growth spurt around the time of puberty. Breasts and buttocks develop and hips become wider, the reproductive organs grow and mature, and pubic hair and underarm hair develop. At some stage, menstruation begins. This first period is called the menarche.



Activity 2

Changes in male and female reproductive organs

Aim

To identify the parts of the male and female reproductive systems

Equipment

Large sheet of paper, crayons or coloured pens

Method

- 1 Construct a life-sized outline of a boy and a girl on a large sheet of paper.

- 2 Draw and label all the parts of the reproductive systems.
- 3 List and label the changes that occur to each during puberty.

Questions

- 1 List the major similarities between males and females that occur during puberty.
- 2 List the major differences between males and females that occur during puberty.

4.2 [Questions]

Checkpoint

The male reproductive system

- 1 Explain why the testes are located outside the male body.
- 2 Identify the major glands of the male reproductive system.
- 3 State what semen is made up of.

The female reproductive system

- 4 State the number of eggs present in an ovary at birth and how many become fully formed.
- 5 What regulates the menstrual cycle?
- 6 Identify where in the female body the egg is fertilised.
- 7 Explain how the body knows not to menstruate when pregnancy occurs.
- 8 Describe what the lining of the uterus consists of.
- 9 Identify when menopause occurs.

Puberty

- 10 Define the term 'puberty'.
- 11 State two changes that occur in females and two that occur in males at puberty.

Think

- 12 a Identify the major male and female hormones.
b State what each hormone does in the body.

Skills

- 13 The following graph shows the average heights of boys and girls. Use it to answer the following questions.
 - a State the average height of an 8-year-old boy.

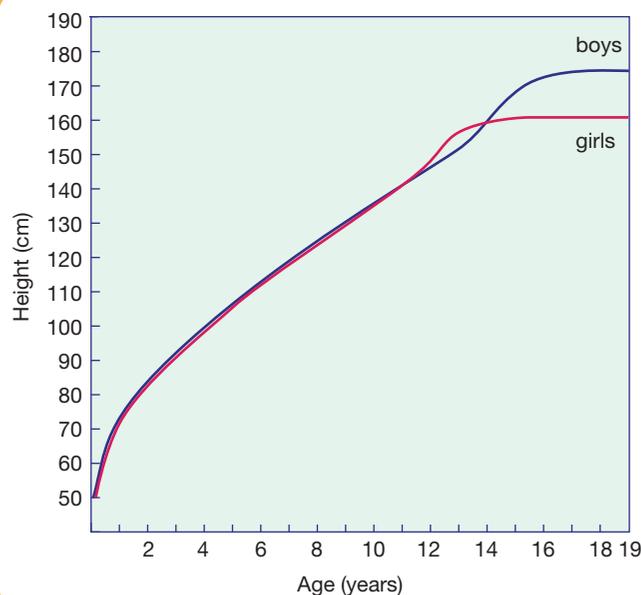


Fig 4.2.7 Average heights for boys and girls

- b State the average height of an 11-year-old girl.
- c According to this graph, state the ages that puberty occurs between.
- d 'Boys are taller than girls.' Assess whether this statement is true, false or a bit of both. Explain your reasons.

UNIT 4.3

From gamete to birth

Introduction

The first cell of a new baby is formed when the egg and sperm combine during fertilisation. This one cell goes through an amazing nine months of growth to become a human baby. During this time the cell grows and divides to form all the different organs and structures of the body. In this unit you follow the reproductive process from fertilisation to the birth of a new baby. This time is known as the gestation period.

Copulation and fertilisation

Sperm are brought into contact with the female egg through sexual intercourse, sometimes called copulation. The penis becomes erect when the male is sexually aroused, and is inserted into the female's vagina. Semen is pushed (ejaculated) into the vagina. A male will normally release several hundred million sperm in this process. Once inside the vagina, the sperm 'swim' towards the fallopian tubes. Only a few hundred will make it as far as the egg. The others will die.

If an egg is encountered, the sperm will surround it, although only one sperm will eventually fertilise it.

After one sperm has entered the egg, the surface of the egg changes to stop any more getting in. Any sperm left outside the egg will eventually die, although they can live for up to two days in the female—so it is possible for women to become pregnant two days after sexual intercourse!

Fraternal twins result when two separate eggs are fertilised. They are the most common type of twins and don't look any more alike than any two brothers or sisters. Identical twins result when a single fertilised egg splits in two. Because these twins come from the same egg and sperm, they are genetically identical. Some scientists believe that a third type may be possible. Half-identical twins could be conceived if the mother's egg splits before fertilisation and each half is then fertilised by a different sperm. This could explain why some fraternal twins look so alike.

Contraception

Most animals mate only to reproduce. Humans are unusual because we also mate for pleasure. To prevent unwanted pregnancies, contraception is used. Most methods of contraception are used by women, but some are used by men, including a contraceptive pill similar to that taken by many women. Some types of contraception are listed in the following table.



Fig 4.3.1

Male condoms

Name	How it works	Advantages	Disadvantages	Failure rate
The pill	Consists of hormones that stop ovulation. A pill is taken at the same time each day for 21 days, followed by 7 days' break.	Easy to use, and can protect against problems such as cervical cancer. May make periods lighter and improve acne.	Shouldn't be used by smokers or people with circulatory problems as there is a risk of blood clots.	Low if taken as directed, but vomiting, diarrhoea and some antibiotics can reduce its effectiveness. This risk is reduced with some newer types of pill.
Condom	Rubber sheath that fits over the penis and stops semen entering the vagina	No side-effects, although rare allergic reactions do occur. May protect against many sexually transmitted diseases.	Reduced sensation and spontaneity	If the condom is of high quality and is used properly, the failure rate is low. Actual failure rate is higher due to unskilled use and tearing of low-quality condoms.
Cap and diaphragm	Rubber devices that fit over the cervix. They stop sperm from entering the uterus.	Few side-effects	Reduced spontaneity. Increased risk of bladder infections	Low, especially if used with a spermicide (chemical that kills sperm). They should be replaced yearly and inspected regularly for holes or cracks.
IUD	This is fitted by a doctor and sits inside the uterus for up to 8 years. Stops sperm entering the uterus.	Once inserted, no further maintenance is required.	Can result in infection and heavier, painful periods. It offers no protection from sexually transmitted diseases.	Low



Fig 4.3.2 Types of contraception

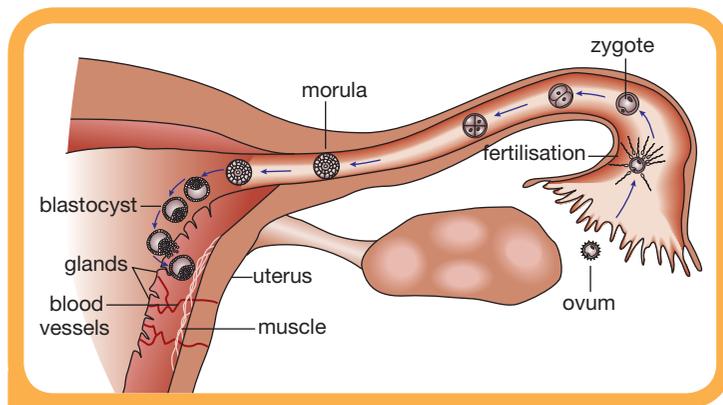


Fig 4.3.3 This sequence—from fertilisation to implantation—takes about a week to complete.

How a zygote becomes a baby

After the zygote (the fertilised ovum) has formed in the fallopian tube, it begins a five-day journey to the uterus. Along the way, the zygote divides several times to form new cells. By the time it reaches the uterus, it has become a clump of up to eighty cells, called the morula. In the uterus the cells continue to divide, forming a fluid-filled ball called a blastocyst.

Up until this time, all required nutrients have come from the original egg. Now that more nutrients are required, the blastocyst buries itself in the lining of the uterus and starts to absorb nourishment from it. This is called implantation.

The blastocyst produces a hormone that keeps the lining of the uterus thick and prevents menstruation. As the cells in the blastocyst multiply, they start to move around and become different from each other. In about eight weeks, the beginnings of all the major body systems will form and the heart will already be beating. For these eight weeks, the developing individual is known as an embryo.

After eight weeks, the embryo becomes a foetus. The foetus is protected by a pool of amniotic fluid, surrounded by the amniotic membrane. Oxygen and nutrients come from the placenta via the umbilical cord.

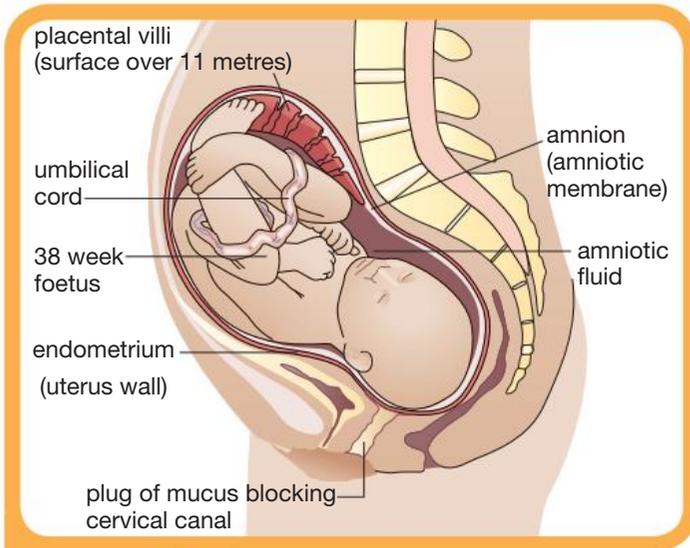


Fig 4.3.4 Inside a pregnant woman

Approximately 280 days (close to nine months) after fertilisation, birth occurs. The cervix relaxes, or dilates, to let the baby through. In some cases, the membrane around the baby splits and amniotic fluid rushes out of the woman's vagina. This is called the 'breaking of the waters'. The uterus contracts strongly at regular intervals. This is known as labour. Eventually, the baby is pushed out head-first. After the birth, the placenta is delivered and the umbilical cord is cut. Your belly button marks the place where your umbilical cord was once attached. The baby starts to breathe air for the first time as it is born. Crying helps to clear fluid from its lungs.

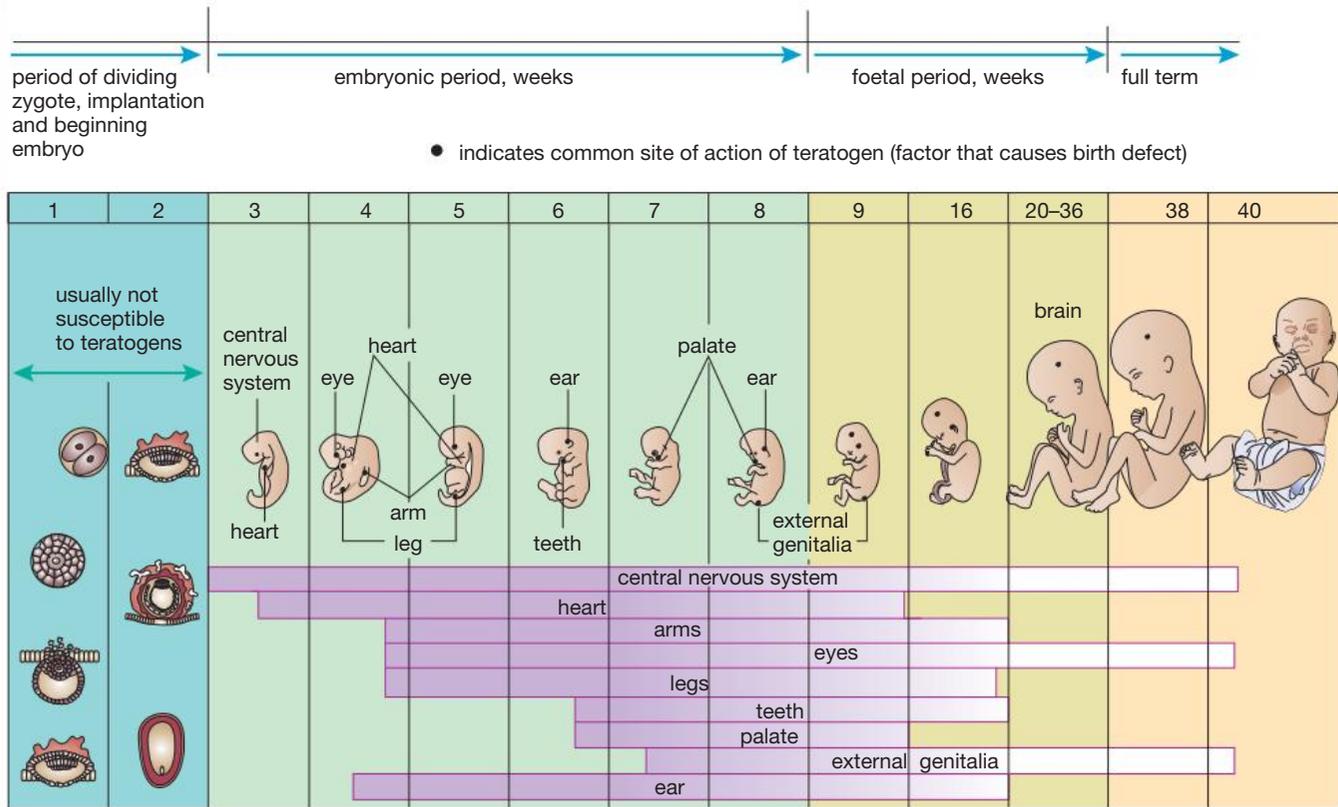


Fig 4.3.5 Development in gestation

The mother's health in pregnancy

While the foetus is developing, its health is almost entirely dependent on the health of the mother. The pregnant woman must pay close attention to her lifestyle and nutrition in order to give the foetus the greatest chance of developing normally. It is especially vulnerable in the embryonic stage, when the body systems start developing.

Nutrition

It is normal and desirable for women to gain 9 to 13 kilograms in pregnancy. Pregnant women don't need to eat too much more than usual, but it is important that all the nutritional needs of the developing baby are met.

One important nutrient is folate. It is recommended that women take 0.5 mg of folate per day at least one month before pregnancy and for the first trimester (first three months of pregnancy). This level is easily obtained through diet, and so supplements are normally not necessary. Folate prevents 70 per cent of neural tube (spinal) defects. These are problems that occur as the nervous system is forming. Spinal defects occur in about one in 500 pregnancies. The pregnant woman's reserves and intake of iron and calcium must be enough not only for her own needs but also for those of the foetus.

Tests during pregnancy

Ultrasound scanning can detect things like the heartbeat, how many foetuses are present, how old the foetus is and if there are any obvious problems or defects.

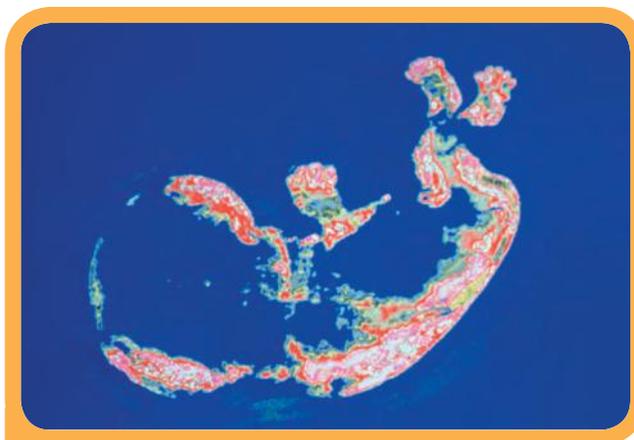


Fig 4.3.6 Ultrasound image of a baby

A blood test is taken to measure the level of alpha-fetoprotein in the mother's blood. A high level of this substance indicates problems and further tests will be carried out.

An amniocentesis can be performed at 15 to 17 weeks of pregnancy to detect abnormalities. Guided by ultrasound, a needle is inserted through the abdomen and a sample of amniotic fluid is removed. Although a fairly safe procedure, it does carry a small risk of injury to the foetus.

Chorionic villus sampling can be used between 10 and 12 weeks of pregnancy. In this procedure, a sample of placental material is taken. Like amniocentesis, this method carries a small risk for the foetus.

Drugs

Because the new baby's blood supply is linked to its mother's, anything taken in by the mother has the potential to cause harm to the baby.

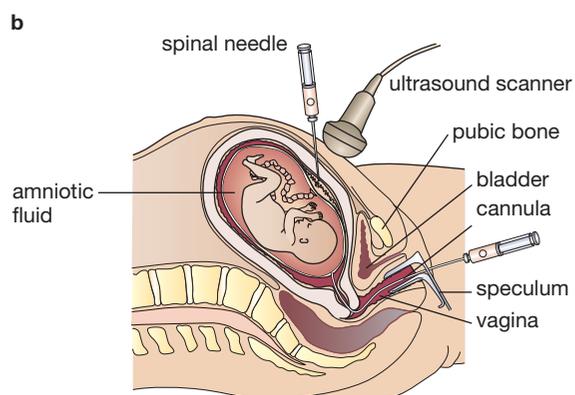
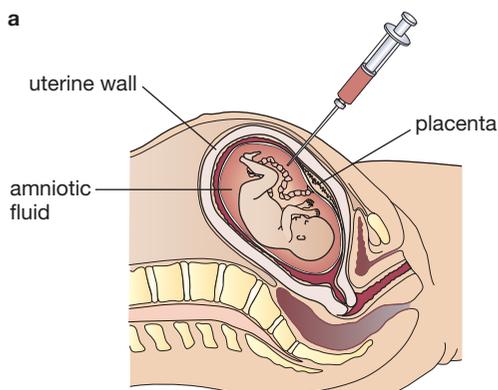


Fig 4.3.7

a Amniocentesis **b** Chorionic villus sampling. Two methods are shown here: the transcervical procedure, which is done through the vagina and cervix; and the transabdominal procedure, which is done through the abdomen.

Research has consistently shown that women who smoke, drink or do both during pregnancy are more likely to produce children with mental and/or physical abnormalities than women who don't smoke or drink. Children of these mothers are also more likely to die during their first week of life. Smoking affects the circulation of blood to the baby, and the children of smokers are more likely to be underweight and have reduced mental abilities than the children of non-smokers.

Other substances that cause harm include:

- hallucinogens (eg LSD)—there is a risk of miscarriage and deformities
- heroin—the foetus can become addicted
- cortisone—can cause deformities
- antibiotics—may cause problems.

These are not the only substances that can have negative effects. It is best to avoid taking any drug—legal or illegal—during pregnancy unless it is advised by a doctor.

Other considerations

Some diseases, such as rubella (German measles), can cause serious deformities in the child if contracted by a pregnant woman in the first trimester. Toxoplasmosis can cause damage to the eyes and nervous system of the foetus.

Some researchers claim that negative emotions experienced by the mother may also affect her body systems and hence the foetus. Emphasis should be on reducing anxiety and stress wherever possible.

4.3 [Questions]

UNIT

Checkpoint

Copulation and fertilisation

- 1 Define 'copulation'.
- 2 State the number of sperm released in one ejaculation.
- 3 State the number of sperm that penetrate the egg.
- 4 **a** Identify the two types of twins.
b Explain how each is produced.
- 5 **a** Describe two different types of contraception from the table on page 67.
b Compare the advantages and disadvantages of each type.

How a zygote becomes a baby

- 6 Differentiate between a zygote, a morula and a blastocyst.
- 7 Describe how the foetus is protected inside the mother.

The mother's health in pregnancy

- 8 Identify four things that can harm the embryo/foetus.
- 9 Describe two tests that can be performed to find out if there is anything wrong with the foetus while it is still in the womb.
- 10 Explain why folate is important during pregnancy.

Think

- 11 Smoking constricts blood vessels and causes circulation problems. Explain how this could affect the foetus.
- 12 Explain why it is good to hear a newborn cry loudly.

Analyse

- 13 Men sometimes have vasectomies when they don't want any more children.
 - a** Identify the tube that is cut to stop any sperm entering the vagina.
 - b** Vasectomies do not always work. Explain why this is the case.
- 14 A woman is expecting a baby in February.
 - a** Predict when you think she knew she was pregnant.
 - b** Describe how she could have found out.

UNIT 4.4

Reproductive problems

Introduction

Our reproductive systems are vulnerable to many diseases and problems. Some are deadly and some are just irritating. These problems can include:

- diseases and infections that can easily pass from person to person through sexual contact. These are called sexually transmitted infections (STIs) and sexually transmitted diseases (STDs)

Sexually transmitted diseases

While AIDS is the most feared and life-threatening sexually transmitted disease, there are many others that can cause serious illness. Most are treatable, but can leave permanent damage. The best cure is prevention. The only way to be completely safe is to avoid all sexual contact. If you do choose to have sex, the use of condoms can greatly reduce your chances of becoming infected with some diseases. Other forms of contraception give little or no protection from STDs.

If you notice any unusual symptoms, you should see a doctor as soon as possible. The longer an infection is left in your system, the more damage it

- other diseases that are not 'caught', such as prostate cancer in males, and ovarian and cervical cancer in females. Regular tests can detect these cancers early, which increases the person's chance of survival
- painful periods and ovarian cysts. These can also occur when the reproductive system does not work properly
- infertility, where the male or female reproductive system does not work properly. This makes pregnancy difficult or impossible to achieve.

Some of these problems can be fixed or cured, while others are still being researched to determine their causes.

can do and the harder it becomes to treat. Some diseases have few symptoms and some people will not even know they have them. Chlamydia has few symptoms and can cause infertility. Syphilis is potentially deadly and begins with sores called chancres. All symptoms soon disappear, however, and victims may incorrectly think they are 'cured'. Regular check-ups can identify any problems early.

Disease	How is it spread?	Symptoms	Treatment
AIDS (viral, caused by HIV)	Sexual contact, exchange of body fluids (eg blood, semen)	Flu-like symptoms shortly after infection, then often nothing for years. Eventually breaks immune system down and results in many infections.	No cure. Some drugs can slow the disease.
Herpes (viral)	Contact with active sore	Causes sores on mouth or genital region. Fever, itching	No cure. Some drugs can reduce the symptoms.
Gonorrhoea (bacterial)	Oral, genital, anal sex	May have no symptoms or can cause painful urination and a yellowish discharge in both men and women. Can cause infertility.	Antibiotics
Syphilis (bacterial)	Sexual contact or mouth. Enters through any break in skin.	Open, painless sore (chancre). If left untreated, can then develop a rash and finally infection of body organs.	Antibiotics, as long as it has not progressed too far
Chlamydia (bacterial)	Sexual contact	No symptoms or may have painful urination and discharge. Can cause infertility.	Antibiotics



Fig 4.4.1

This engraving from seventeenth-century Europe shows a patient with syphilis undergoing a treatment with powder. Fortunately, better treatments are available today. Many people used to go mad from the disease.

Infertility

Both men and women can be infertile—unable to have children. Infertility may be caused by an infection, or by radiation, or the cause may be unknown. Some people come to accept this situation, or choose to adopt a child. For those who wish to have their own child, there are other options available.

In-vitro fertilisation

In-vitro fertilisation, or IVF, is one way of fighting infertility. In-vitro literally means ‘in glass’ and the baby produced is sometimes referred to as a

test-tube baby. This is because in IVF, eggs are fertilised in a container in the laboratory outside the woman’s body. First, the woman’s ovaries are stimulated to get them to release many eggs at once instead of the usual single egg. These eggs are then retrieved from the ovary. The eggs are placed in a special solution at body temperature (37°C) until they are ready to be fertilised.

Fresh sperm are added to each egg and allowed to incubate overnight. The next day, each egg is examined to check whether it has been fertilised. The fertilised eggs are then allowed to develop for another couple of days in the laboratory.

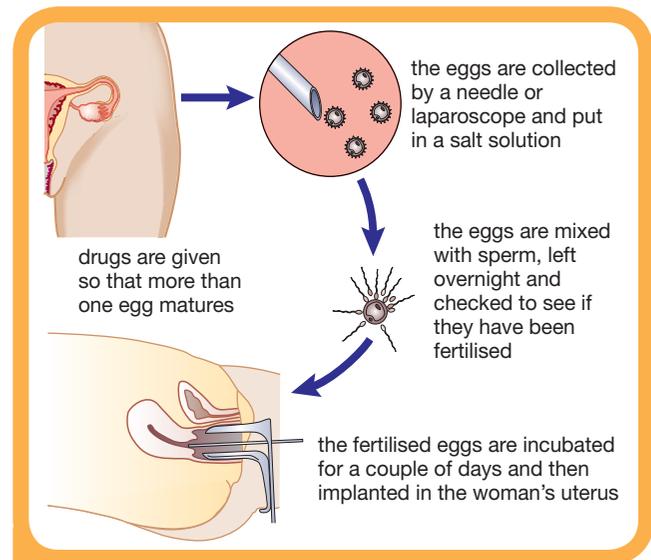


Fig 4.4.2

The steps in IVF treatment—there are many variations on this basic technique.

Usually several embryos are transferred at once through a small tube into the uterus. While the transfer of multiple embryos increases the chance of success, it also increases the chance of multiple foetuses developing.

[Questions]

Checkpoint**Sexually transmitted diseases**

- 1 Describe how you can protect yourself from sexually transmitted diseases.
- 2 Describe how gonorrhoea is spread and how is it treated.

Infertility

- 3 Identify two things that can cause infertility.
- 4 Explain why IVF often results in multiple pregnancies.

Think

- 5 Identify one part of the male reproductive system commonly affected by cancer.
- 6 Identify one part of the female reproductive system commonly affected by cancer.
- 7 Evaluate the importance of regular check-ups if you have multiple sex partners.

Analyse

- 8 State three reasons why the number of new cases of most sexually transmitted diseases is increasing in many countries despite contraception being used more widely.
- 9 Evaluate the importance of contraception to society.

[Extension]

Investigate

- 1 Design a poster promoting safe sex. What is safe sex, and why is it important?
- 2 Research other reproductive problems not discussed here. For example, how do ovarian cysts arise and how are they treated? Present your findings as a leaflet to be placed in a medical centre.
- 3 Investigate a sexually transmitted disease and outline:
 - a the signs and symptoms
 - b how the disease is spread
 - c how the spread of the disease can be controlled
 - d how widespread the disease is
 - e any cures or treatments
 - f current research into this disease.

Discuss how to present your information with your teacher.

UNIT 4.5

Nervous control

Introduction

Your nervous system controls and coordinates all parts of your body. It is the most complex of all your body systems and, despite many years of research, it is the least understood. Here is some of what we know.

The nervous system

The nervous system has two parts:

- the central nervous system (CNS)
- the peripheral nervous system (PNS).

The brain and spinal cord make up the CNS.

The CNS acts as the control centre, receiving messages from all parts of the body. It examines the information received, and then sends out messages to tell different parts of the body what they should do.

The PNS is made up of sensory receptors and nerves. These continuously inform the CNS of changing conditions, and transmit the decisions made by the CNS back to effector organs. Messages are passed through the nervous system by neurons. These are specialised cells that transmit and receive messages in the form of electrical impulses.

Neurons

A neuron has the usual features of any cell found in an animal. It has a nucleus, cytoplasm and cell membrane, but it also has a number of other specialised parts. Small threads called dendrites are arranged around the cell body. Dendrites make contact with other cells and receive information from them. The axon is a long, thin thread that carries information away from the cell. A white fatty substance called myelin often encases the axon, insulating it (much like the plastic coating on an electrical wire) and allowing messages to pass quickly along it. The information is carried by electrical impulses that travel at speeds between 1 and 100 metres per second. Neurons are grouped

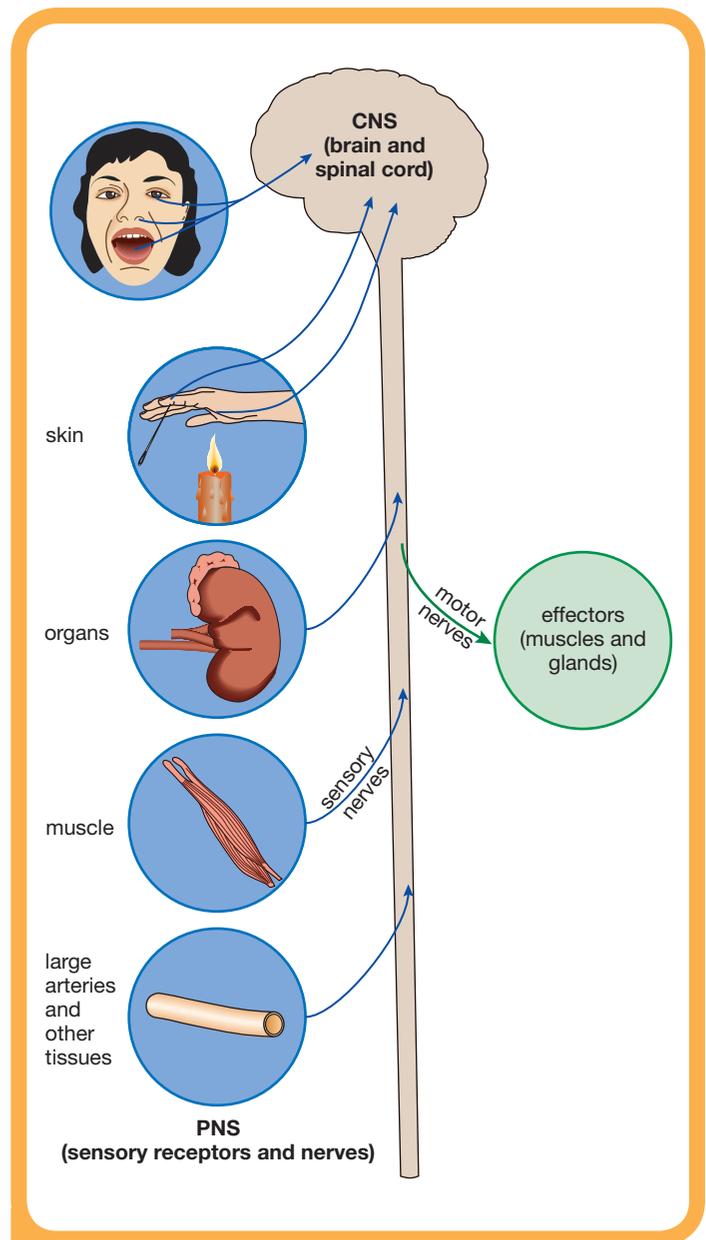


Fig 4.5.1

The human nervous system

together in bundles called nerves, in much the same way that an electrical cable is made up of smaller wires bound together.

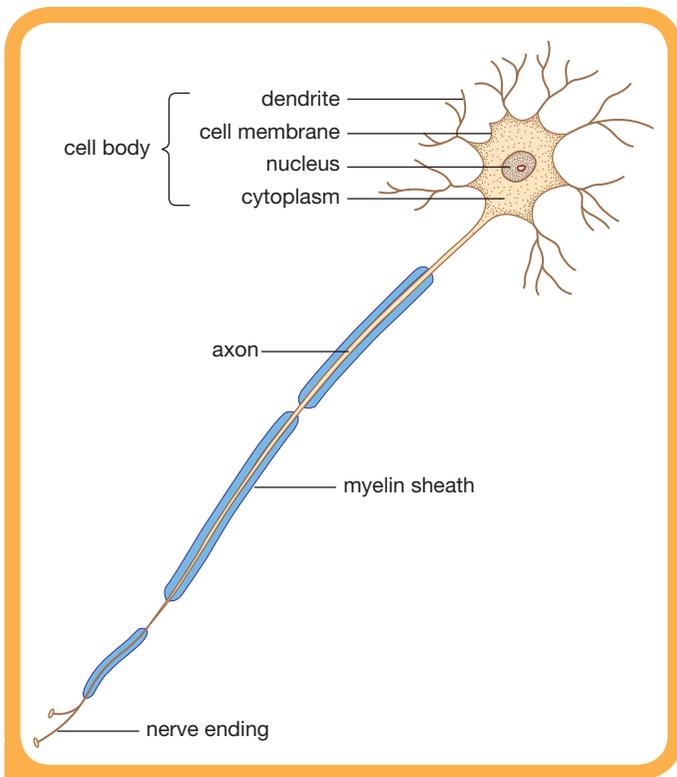


Fig 4.5.2 A typical neuron

Types of neurons

Some neurons, called sensory neurons, have specialised endings sensitive only to stimuli such as heat and light. These form part of the body's larger sense organs (eyes, ears etc.), which function by collecting different energy forms. The sensory neuron then converts this energy into an electrical impulse. In this way, cells in the retina convert light energy to electrical energy. Another type of neuron, the connecting neurons or interneurons, transfer these electrical messages within the CNS. A third type, motor neurons, transfer messages from the CNS to effector organs such as muscles.

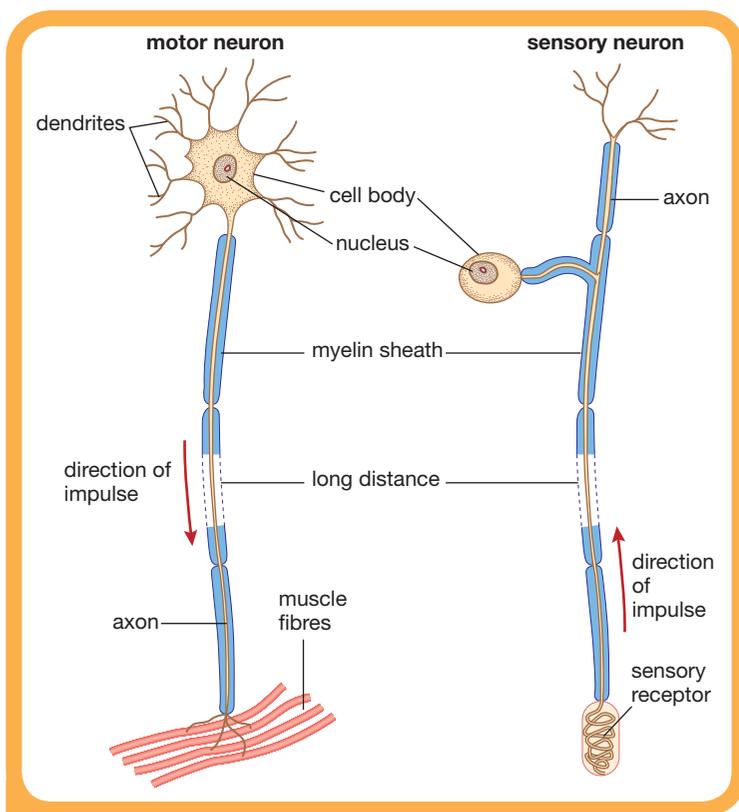


Fig 4.5.4 Two types of neurons—motor and sensory

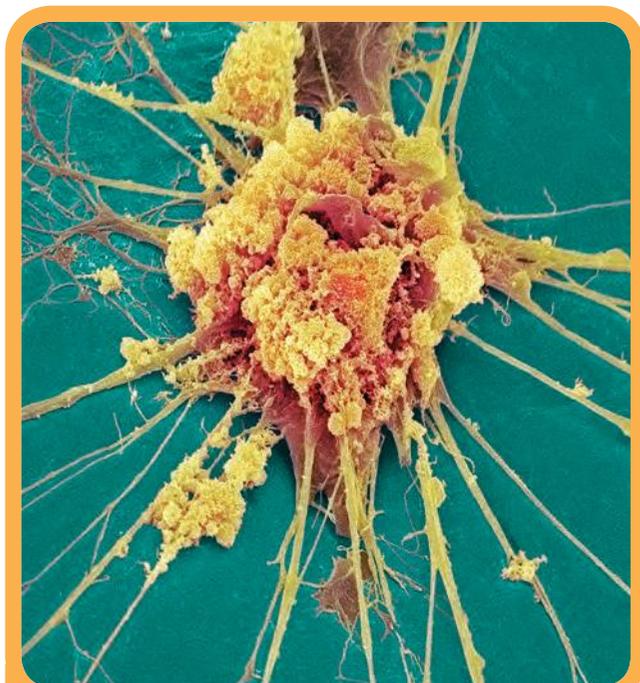


Fig 4.5.3 A scanning electron microscope image of a neuron (light brown) showing the thick axon and several thin dendrites

The synapses

Between neurons are small gaps called synapses. Messages cross these synapses, but not as electrical impulses. The message is carried chemically by special compounds called neurotransmitters. When an impulse reaches a synapse, neurotransmitters are released and quickly move across the gap. They bind to sites on the other side, restarting the electrical impulse. The neurotransmitter is then broken down so that new messages can be received.

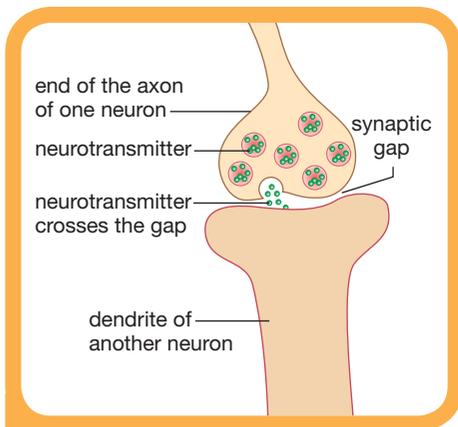


Fig 4.5.5 Crossing a synapse

About fifty different neurotransmitters have been identified. Many drugs and poisons affect neurotransmitters. Curare is a poison used by Native South Americans on arrow tips. It blocks reception of the neurotransmitter acetylcholine, preventing messages from getting to muscles, stopping breathing and other movements. Some insecticides work by preventing the breakdown of acetylcholine, so messages are constantly received, resulting in continuous muscle spasms. Another neurotransmitter, noradrenalin, is associated with alertness. Another is dopamine, associated with emotions. Drugs such as amphetamines, cocaine and ecstasy increase production of these neurotransmitters. This results in an increased state of alertness and heightened emotions, along with high blood pressure, irritability and, later, depression and insomnia.



Fig 4.5.6 Pain relief using acupuncture

So why do we have synapses? If neurons touched each other it would be something like turning on one switch and having every light in the house come on at once. Synapses are similar to a switchboard, allowing messages to be directed to the correct places. It is also thought that synapses in the brain play an important part in learning and memory.

The brain

The brain is soft, wrinkly tissue with a mass of about 1.4 kilograms. Each of its twenty-five billion neurons is connected to as many as 1000 others, and there are as many as one hundred million million synapses. These neurons do not exist as a tangled mess. They form neuron networks, with neurons arranged in specific circuits. Not even the largest, most complicated computer comes close to the complexity of the human brain. It is hardly surprising then that scientists are still discovering what actually happens when we are thinking, experiencing sadness or trying to remember what happened yesterday.

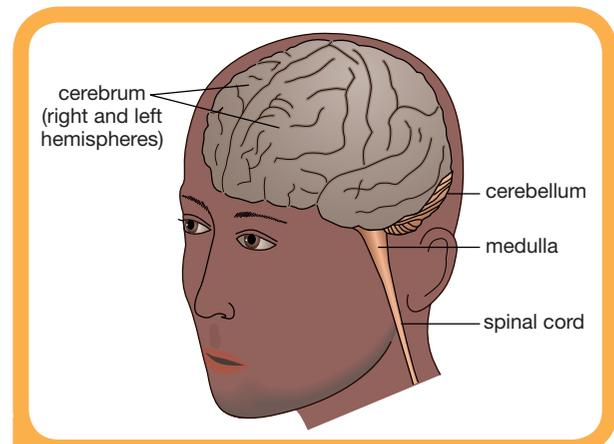


Fig 4.5.7 The human brain

The brain has three main structural parts: the cerebellum, medulla and cerebrum. The cerebellum controls complex muscular movements such as cycling, walking and running. The medulla controls vital activities you do not have to think about, such as breathing and heartbeat. The cerebrum makes up 90 per cent of the brain's volume. It is divided into right and left hemispheres. The surface has many folds, creating a large surface area with billions of neurons. These are a grey colour.

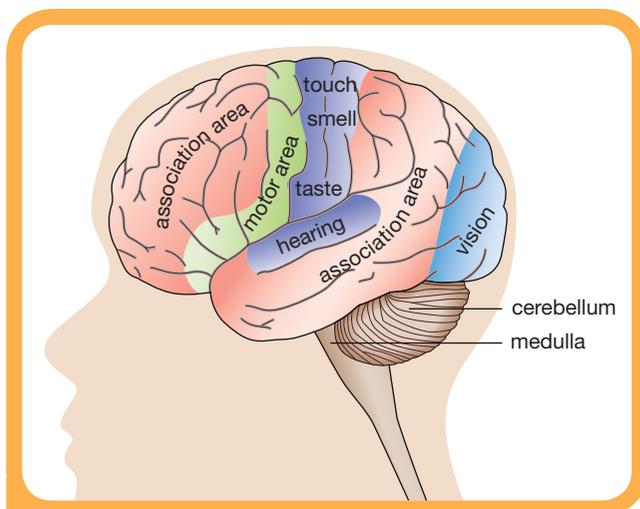


Fig 4.5.8 The cerebrum controls many functions.

The cerebrum is responsible for complex thoughts. The right side is responsible for artistic, musical, intuitive and perceptual abilities. The left takes care of language, learning mathematics and logical thinking. Some regions (the sensory areas) are concerned with receiving and interpreting impulses from sense organs. The motor areas control muscles. The association areas are concerned with memory and thinking.

Protecting the brain

Your brain is so important that the body protects it very carefully. It is protected by the bony case of the skull and by layers of connective tissue called meninges. It also has a jacket of fluid around it called cerebrospinal fluid (CSF) to cushion against bumps and shocks.

The base of the brain is connected to the spinal cord. It too is protected by a bony case, the backbone, and cushioned by cerebrospinal fluid. The spinal cord transmits messages between the brain and the PNS, and controls some actions that do not require thinking.

Nervous reactions

Actions that need to be carried out automatically and without thinking are very fast because they involve only a few neurons. They use a pathway known as a reflex arc, which does not involve the brain directly (see Figure 4.5.9). Examples of reflex actions are blinking, sweating, shivering, coughing and the knee-jerk reaction. For example, if you prick your finger with a pin (the stimulus), pain receptors in the skin send a message via a sensory nerve to the spinal cord. The message crosses synapses to a motor nerve, which carries the message to muscles (the effector).

A message may be sent to the brain, but only to keep it informed of what is happening. A secondary response might be a cry of pain. The brain may also store information so that next time you avoid touching the pin.

More complex actions require messages to be sent to the brain, decisions made and responses sent back to various effectors. Some learnt actions may become so automatic that they appear to be reflexes. For a nine-month-old baby, eating, especially with a spoon, requires conscious effort. As the years pass, pathways that control this process become so well established that the action appears to be automatic.

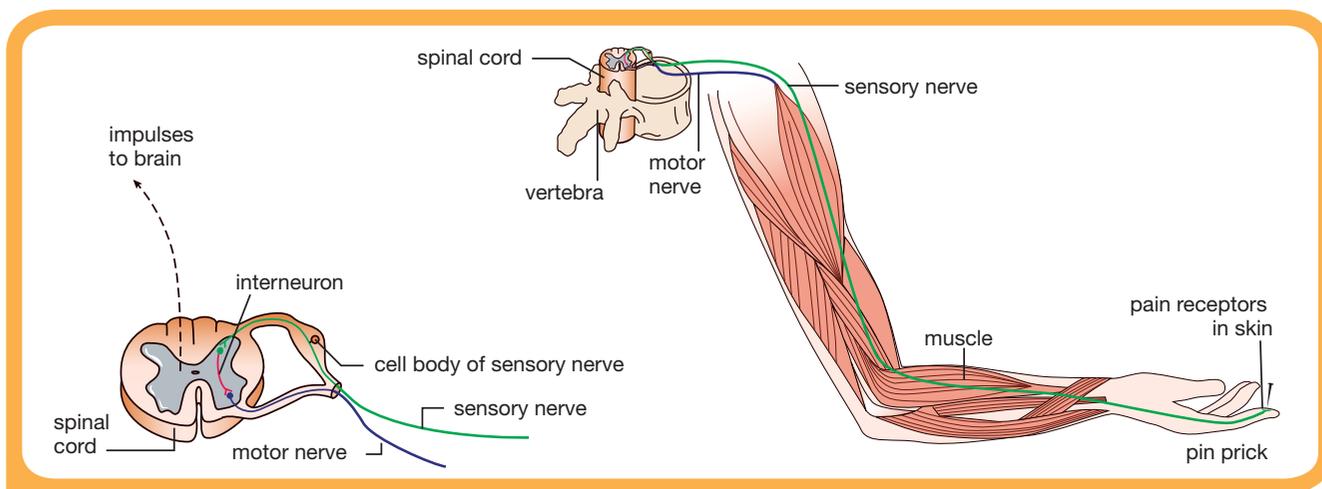


Fig 4.5.9 A reflex arc

Activity 3

Memory I

Aim

To investigate how we memorise words

Equipment

Three lists of words, each printed on separate cards (A, B and C) (your teacher will supply these cards—do not look at them until the activity begins)

Method

- 1 The subject reads the list of words on card A until they can recall them perfectly (with no mistakes). Record the time taken to develop perfect recall.
- 2 Repeat the procedure using card B, then card C.

Questions

- 1 Which list is memorised most quickly?
- 2 Propose reasons why this was the quickest.
- 3 Propose some other factors that might influence the speed at which the subject learns.
- 4 Evaluate your results and their implications for how you should memorise material for a test.

Activity 4

Memory II

Aim

To investigate the effect of distractions on memory

Equipment

Two stanzas of a poem, printed on separate cards

Method

- 1 The subject reads the first stanza until they can recall it perfectly (with no mistakes). Record the time taken to develop perfect recall.
- 2 Repeat the procedure using the second stanza, but this time make distracting noises such as singing, banging occasionally, and so on. Record the time taken to develop perfect recall.

Questions

- 1 Compare the times taken to learn each stanza.
- 2 Account for any difference in the times.
- 3 Identify other factors that might influence the speed of learning.
- 4 Evaluate the implications of your results for where you should study.

4.5 [Questions]

UNIT

Checkpoint*The nervous system*

- 1 **a** Identify the two parts of the nervous system.
b Describe what each part consists of and the main function of each.
- 2 Compare the neuron with other cells in the body.
a How is it like other cells?
b How is it different?
- 3 Distinguish between a neuron and a nerve.
- 4 Distinguish between sensory neurons, motor neurons and interneurons.
- 5 Describe the function of neurotransmitters.
- 6 **a** Explain why synapses are necessary.
b State two disadvantages of synapses.

The brain

- 7 **a** Identify the three main structural parts of the brain.
b State the major functions of each.

- 8 Label the diagram shown here, using the following words: cerebellum, medulla, spinal cord, cerebrum.

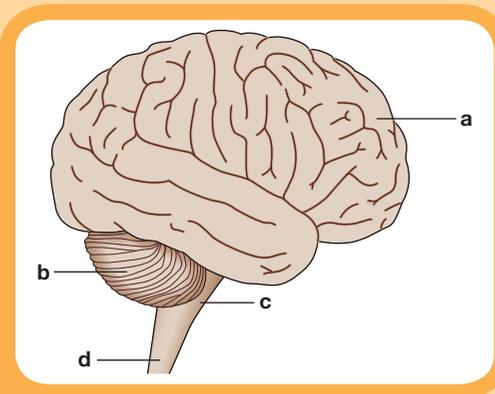


Fig 4.5.10

- 9 Identify which part of the brain:
 - a** you use to think complex thoughts
 - b** controls breathing
 - c** gives you sensations of touch.
- 10 State three ways in which the brain is protected from injury.

Nervous reactions

- 11 Identify which of the following are reflex actions:
coughing, sneezing, reading, cycling, writing, blinking.
- 12 State one reflex action that occurs when:
- a bright light is shone in your eyes
 - food enters your windpipe
 - you are hungry and you smell food
 - you spend a long time in the sun on a hot day.

Think

- 13 a Identify the type of neuron shown in Figure 4.5.11.
b Identify and label parts i to v.
- 14 Arrange the following list of events in the correct order to describe a reflex action. Write your answer as a flow chart.
- An impulse is sent along a sensory neuron to the brain.
 - An impulse is sent along a motor neuron to iris muscles.
 - A bright light is shone in the eye.
 - Iris muscles contract, causing the pupil to narrow.
 - Receptors detect a change in light intensity.

Analyse

- 15 Identify which side of your cerebrum is most active in helping you answer these questions.
- 16 List two conscious acts that are so automatic that they may appear to be reflex actions.

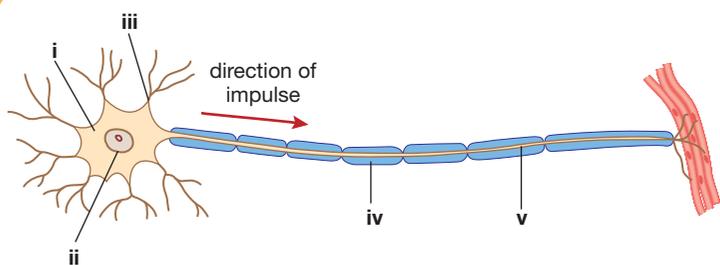


Fig 4.5.11

[Extension]**Investigate**

Investigate the effect of caffeine, marijuana or alcohol on the CNS and perform a role-play to teach other students about your findings.

UNIT 4.6

Chemical control

Introduction

The endocrine system uses chemical messages called hormones to transfer information around the body. These hormones are responsible for controlling many changes that occur in our bodies, most notably those that occur during puberty. Hormones also control many other processes in our bodies, such as the storage and release of glucose into the blood. Even plants use hormones to send messages. Hormones are a very important part of our chemistry.

the hormone to the receptor starts changes in the cell's activities.

It can be difficult to remove and isolate hormones because they are only secreted in very small quantities. The concentration of hormones in the blood is very low, about equal to dissolving a sugar cube in a swimming pool. When hormones pass through the liver they are broken down and converted to relatively inactive substances, which are excreted by the kidneys. One test for pregnancy involves measuring the levels of these hormonal breakdown products in urine.

Hormones and how they work

Scattered throughout your body are endocrine glands that produce chemicals called hormones. Although the endocrine glands may work together, they are not controlled from one central location like the nervous system is. Hormones regulate functions such as growth and development, water balance, sexual reproduction and the rate of chemical reactions in cells (see the table on the page 81).

Hormones travel all around your body but act only on particular target cells. Target cells respond only to their particular hormone and are 'blind' to all others. How do hormones know which is the target cell? A hormone has a specific shape that fits chemically into a receptor on the target cell's membrane. This is like placing pieces in a jigsaw puzzle, as shown in Figure 4.6.2. The bonding of

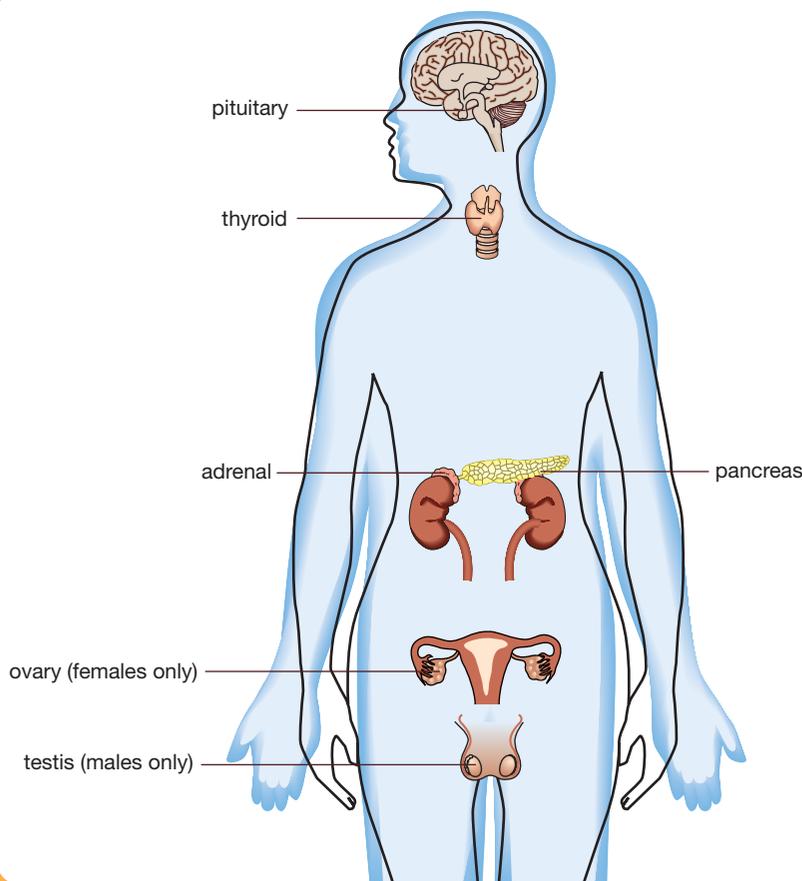


Fig 4.6.1

Major human endocrine glands

Glands and hormones

Name of gland or organ where the gland is found	Names of some of the hormones produced	Functions controlled by the hormone
Adrenals	Adrenalin	Readiness or flight or fight
Ovaries	Oestrogen Progesterone	Female sexual development and the menstrual cycle Control of ovary and uterus in pregnancy
Pancreas	Insulin and glucagon	Blood glucose levels
Pituitary	Growth hormone (HGH) Antidiuretic hormone (ADH) Stimulating hormones	Cell growth and development Water balance Direct other glands to release hormones
Thyroid	Thyroxin	Rate of chemical reactions in cells
Testes	Testosterone	Male sexual development and sexual activity

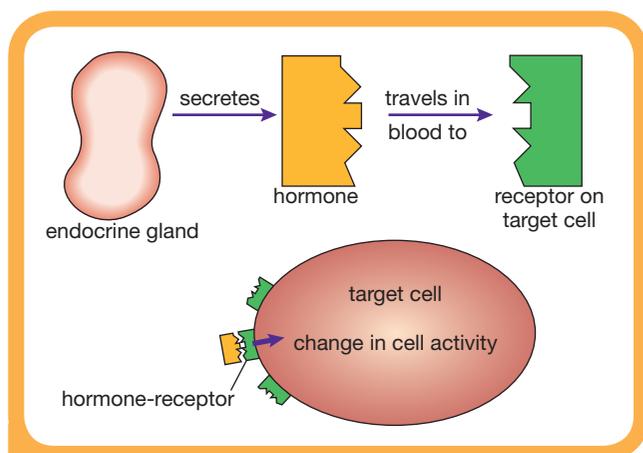


Fig 4.6.2 The action of hormones

Why hormones?

Why does the body use hormones as messengers as well as nervous impulses? Nerve transmissions are very fast. Circulation of hormones takes time. It can take minutes, hours or even days for the level of a hormone in blood to reach a peak. Concentrations

are small, but when the hormone affects a cell, the effect is usually relatively long-lasting. This reduces the amount of hormone needed. Hormones provide an ideal mechanism for control of widespread and long-term activities.

Often a response to a stimulus will involve both systems. The nervous system sends a quick response when you are frightened. Messages are transferred quickly along neurons, reaching an effector to cause an almost immediate and brief reaction. The endocrine system also responds, but more slowly and over a longer period. Adrenalin (known as the fight-or-flight hormone) is released from the adrenal glands and causes various effects. The heart beats faster, breathing rate increases, blood is diverted to the muscles, pupils dilate, hairs on the skin stand on end and the brain becomes more alert. Your heart pounds and you get that sinking feeling in your stomach. The overall effect is to increase the speed of your reaction to the fright.



The nervous system provides rapid messages.

Hormones provide slower messages.

Fig 4.6.3 Fast and slow control

Controlling growth

Hormones control longer-term activities such as reproduction, growth and development. One gland, the pituitary, can be considered to be the master gland: not only does it release hormones but it also instructs many other glands to release their hormones as well. The pituitary receives messages directly from the hypothalamus in the brain and thus provides a vital link between the nervous and endocrine systems.

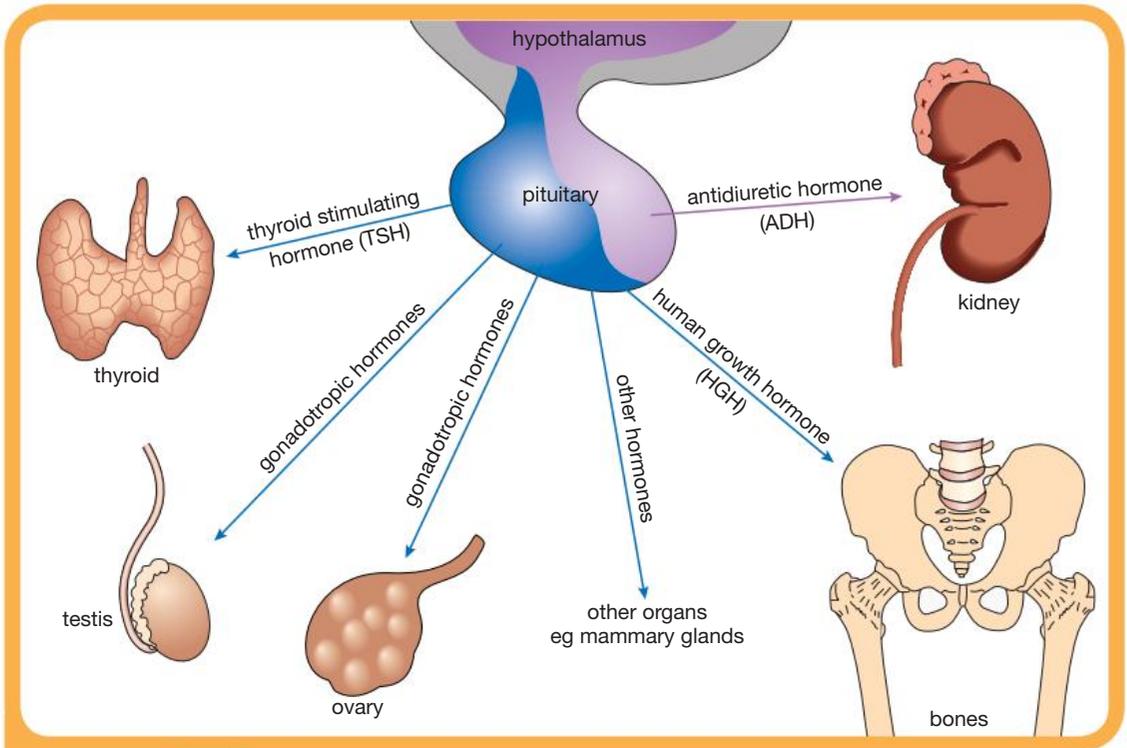


Fig 4.6.4 The pituitary is the 'master' gland.

One sequence of events involves the hypothalamus, pituitary and thyroid glands. Under instruction from the hypothalamus, the pituitary releases thyroid-stimulating hormone (TSH). This causes the thyroid gland to release thyroxine.

Thyroxine controls the speed of cell reactions and therefore influences growth. A deficiency of thyroxine in infancy results in cretinism, or stunted physical and mental growth. This can be cured in its early stages by administering thyroxine.

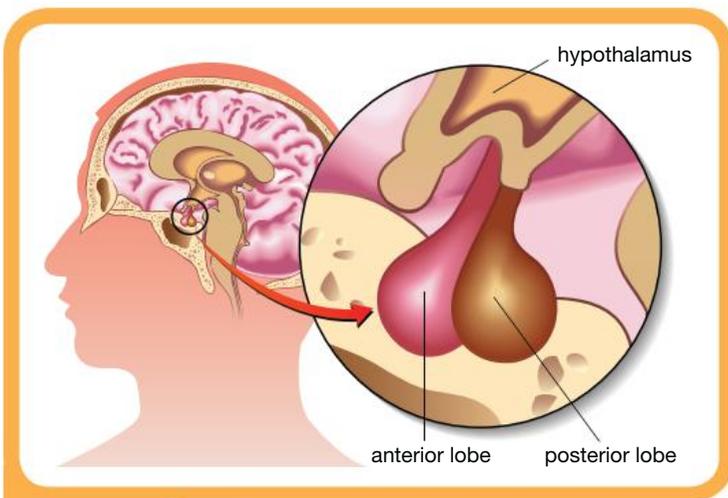


Fig 4.6.5 The pea-sized pituitary gland is located at the base of the brain.

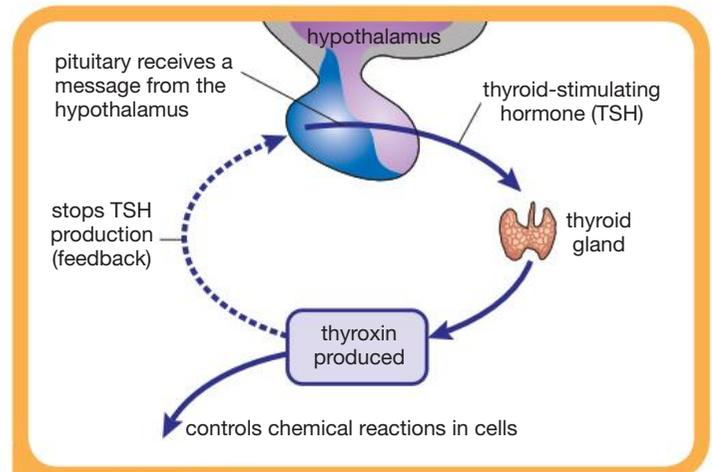


Fig 4.6.6 Thyroxine released from the thyroid gland influences growth.



Fig 4.6.7 Goitre results from iodine deficiency.

Iodine is an essential component of thyroxin. A deficiency of iodine can cause a goitre or enlargement of the thyroid gland. Goitres were once common in areas where the soil lacked iodine, but iodised salt (salt with added iodine) has largely solved this condition.

Another hormone produced by the pituitary is human growth hormone (HGH), which influences total body growth. Lack of HGH in childhood can lead to dwarfism. Though small, people with this



Fig 4.6.8 Gigantism and dwarfism can result from abnormal levels of HGH. Some people have grown to over 2.7 m tall, while others may be less than 0.6 m tall.

condition have normal intelligence and are well proportioned. If diagnosed early, injections of HGH can be given to children suffering from lack of HGH. Too much HGH in childhood leads to gigantism, producing an abnormally tall person.

Controlling glucose levels

Many substances must be kept at a constant level within the body. Cells need a continuous supply of glucose to produce energy, and inadequate levels may result in low energy and possible cell death. Blood glucose levels are usually maintained in a very narrow range by the action of two hormones, insulin and glucagon, both produced by the pancreas (found just below your stomach).

If blood glucose levels increase, for example after eating chocolate, insulin is released. This stimulates storage of glucose in the liver, and increases uptake and use of glucose by cells. Blood glucose levels then drop, inhibiting further release of insulin. Glucagon works in a similar way. In response to low blood glucose levels it directs the liver and cells to release glucose.

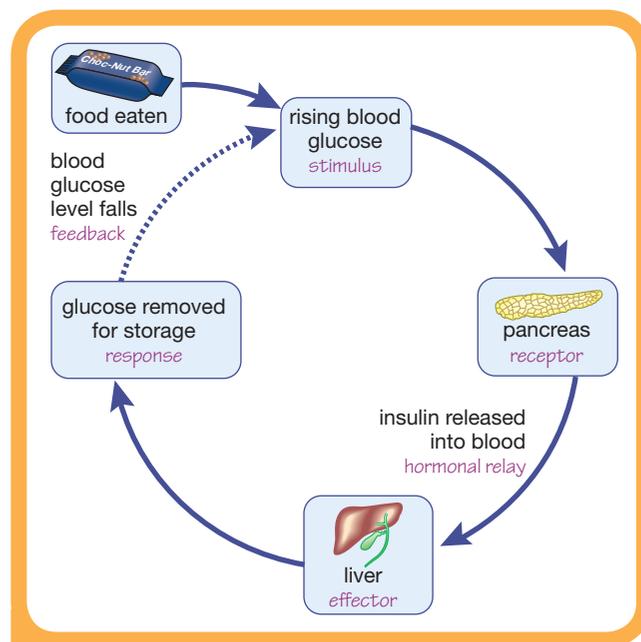


Fig 4.6.9 Control of blood glucose

Diabetes

Thousands of people in Solomon Islands suffer from diabetes mellitus, a disease in which blood glucose levels are not maintained within the required range. There are two basic types of diabetes.



Fig 4.6.10 Type I diabetes requires regular insulin injections.

- Type I, or insulin-dependent diabetes (about 15 per cent of cases), in which the pancreas is defective. High blood glucose levels result because the pancreas does not produce enough insulin. This may result in glucose in the urine as the body tries to rid itself of its excess. Long-term effects of excess glucose include damage to vital organs such as the kidneys. Treatment involves the use of daily insulin injections.
- Type II, or non-insulin-dependent diabetes, in which not enough insulin is produced, or cells do not respond correctly to insulin. Treatment involves a special diet, an exercise program, use of drugs and possibly insulin injections.

Pheromones

Hormones are not the only chemicals that influence the behaviour of animals. Chemicals called pheromones may also dramatically affect behaviour. Many insects use pheromones to attract mates, often from several kilometres away. These chemicals are effective in very small amounts. The female silk moth carries enough pheromones in her abdomen to stimulate more than one billion males. These sex-attractant pheromones act on the CNS, producing immediate behavioural changes.

Other types of pheromones act more slowly, affecting growth and development. Termite queens use pheromones to stop larvae developing into new queens. Ants use pheromones to mark food trails. Larger animals also use the scent of pheromones

to communicate. Dogs and possums, for example, mark out their territories by spraying urine. Their particular scent tells others to keep out.

Activity 5

Plant tropism

Aim

To investigate tropism in plants

Equipment

6 shoots of the plant *Tradescantia*, 6 test tubes, melted paraffin wax, water, a darkened area and a well-lit area to place plants

Method

- 1 Place one shoot in each of the six test tubes, add water and seal them with paraffin wax.
- 2 Set up three test tubes as shown in Figure 4.6.11, and place them in a well-lit area.
- 3 Set up another three test tubes as shown in Figure 4.6.11, and place them in a darkened area.
- 4 Observe any changes in the plants after two hours.

Questions

- 1 Sketch the shoots in the six test tubes after two hours.
- 2 What type of tropism is shown in the experiment? Explain your answer.
- 3 Explain why it was necessary to place the tubes in both light and dark.

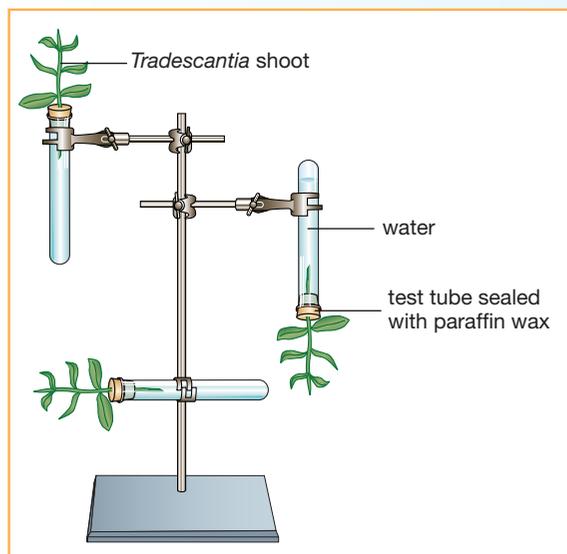


Fig 4.6.11 Investigation of a plant tropism

Plant hormones

Plants also produce hormones that regulate their growth, flowering, fruit production and ripening, and seed germination. A tropism occurs when a plant grows towards or away from a stimulus. Phototropism occurs when a plant grows towards light. It shows that chemicals are responsible for the plant's response to light. Some of the experiments used are illustrated in Figure 4.6.12.

How do hormones bring about phototropism? The tips of growing shoots produce hormones. They then pass backwards from the tip, stimulating cells to elongate. If the shoot is exposed to light from one side, on the exposed side the hormone is destroyed. Hormone concentration on the shady side is therefore greater. Cells on the shady side will elongate more rapidly than on the sunny side, causing the shoot to bend towards the light. The particular hormone causing this response is one of a group of hormones known as auxins.

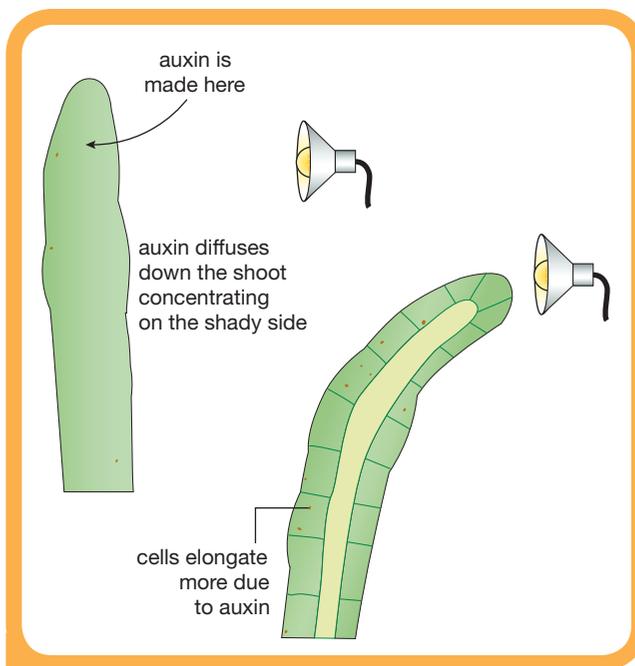


Fig 4.6.13 The action of auxins in phototropism

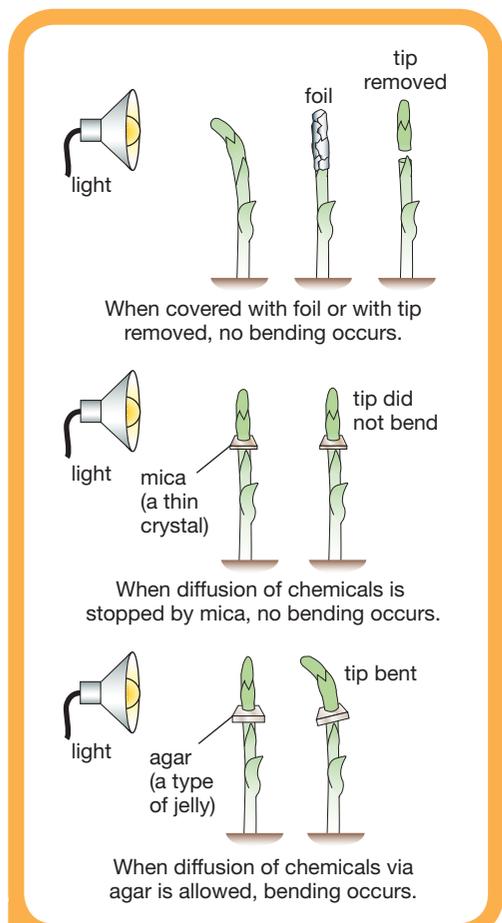


Fig 4.6.12 Experiments examining phototropism

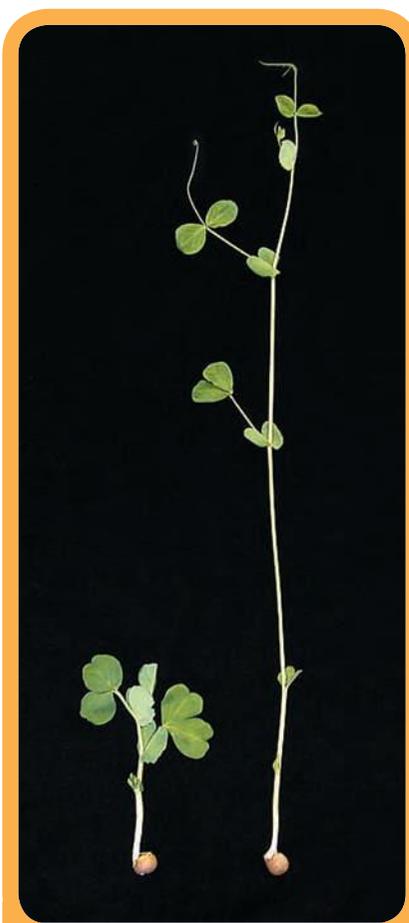


Fig 4.6.14 The dramatic effect of one plant hormone

Auxins are not the only plant hormones. A group of plant hormones called gibberellins control plant growth and have a role in fruit development and seed germination. The dramatic effect of these hormones is seen in the growth of the seeds in Figure 4.6.14. The plant treated with gibberellins grew dramatically compared with the untreated seed.



4.6

[Questions]

UNIT

Checkpoint

Hormones and how they work

- Describe what hormones are.
 - State where they are produced.
 - Describe how they are transported.
- Outline how hormones recognise their target cells.

Why hormones?

- Describe how a response to a stimulus may use both the nervous and endocrine systems.

Controlling growth

- Identify which endocrine gland could be called the 'master' gland. Explain why.
- Outline the hormones involved in growth and their effect on the body.

Controlling glucose levels

- Using Figure 4.6.9 as a guide, draw a flow chart to show the body's response to a decrease in blood glucose levels.
- Explain the causes of diabetes.

Pheromones

- Define a pheromone and a hormone.

Plant hormones

- A plant will grow towards a light source. Explain how the hormones known as auxins cause this.

Think

- Figure 4.6.15 shows several endocrine glands labelled with the letters K to P. Identify (using the letters K to P) which gland produces a hormone that controls:
 - blood glucose levels
 - female reproductive functions
 - rates of chemical reactions in cells
 - water levels within the body
 - readiness of the body for action
 - deepening of the male voice at puberty.

Analyse

- Construct a table to compare the nervous and endocrine systems. Your table should include comparisons of the nature of the message produced, how the message is distributed, speed of delivery and length of response produced.

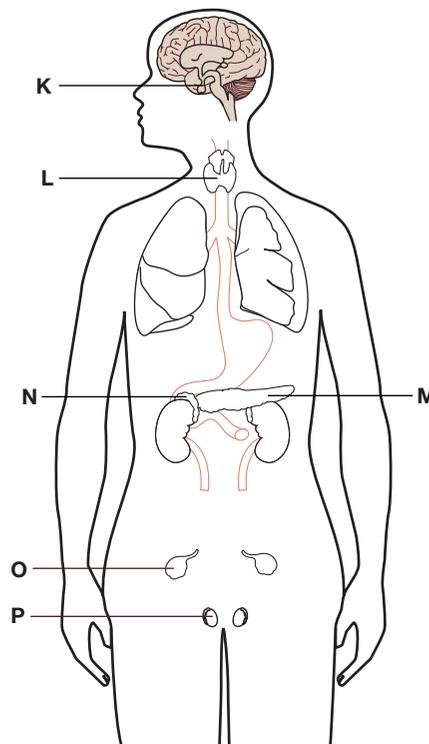


Fig 4.6.15

[Extension]

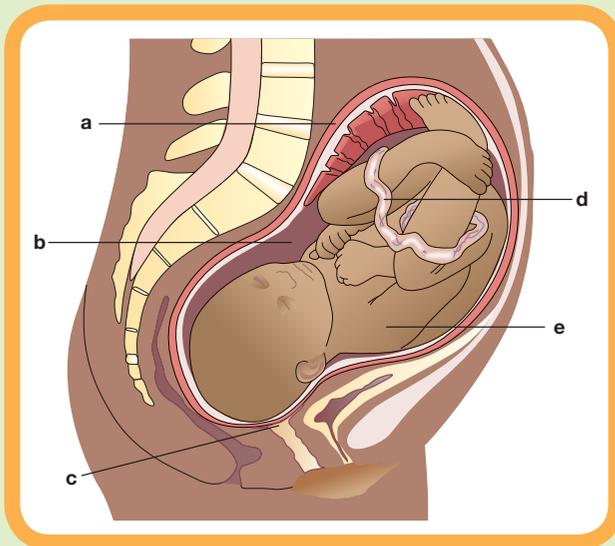
Investigate

- Investigate more about diabetes, including:
 - how the insulin used by people with diabetes is obtained
 - treatments for insulin-dependent people with diabetes that would eliminate the need for daily insulin injections.
- Examine the role of juvenile hormone in the moulting and metamorphosis of insects. How might knowledge of this hormone be used to control insect pests?
- Investigate one commercial use of plant hormones, such as the use of gibberellins on grapes and in the brewing industry, the use of auxins as a rooting hormone in plant propagation, or the use of hormones to produce flowers at the 'wrong' time of year.
- Design an experiment to investigate the response of plant roots to gravity.

Chapter review

Summary questions

- What type of skeleton does each of the following have?
 - beetle
 - dog
 - grasshopper
 - tapeworm
 - prawn
 - bluebottle jellyfish
- Classify each of the following muscles as voluntary or involuntary:
 - triceps
 - heart muscle
 - jaw muscle
 - the muscle controlling your pupil in the eye (ciliary muscle)
 - muscle that move food through your digestive system
 - hamstring.
- Arrange these terms in order of occurrence: foetus, zygote, fertilisation, implantation, embryo, gametes.
- Look at the following diagram and label parts a–e.



- State how long gestation takes in humans. Give your answer in days and months.
- Identify where fertilisation takes place in humans.
- Describe the conditions needed for maximum sperm production.
- State one advantage of the young developing in the mother's body.

- Match each of the following reproduction terms with its correct definition.

Terms	Definitions
Ovum	Ring of muscle separating uterus and vagina
Ovaries	Male sex organs that make sperm cells
Ovulation	Male sex cell
Oviduct	Area where sperm cells are stored
Uterus	Consists of seminal fluid and sperm
Cervix	Process of releasing an ovum once a month
Vagina	Area where the embryo implants and grows
Sperm	Female sex cell
Testes	Nourishes and activates sperm cells
Scrotum	Passageway for menstrual flow and birth of a baby.
Epididymis	Sperm is also deposited here.
Seminal fluid	Tube that 'catches' the ovum
Semen	Pocket of skin that holds the testes
	Female sex organ that produces ova

- Demonstrate, using examples, what is meant by:
 - a stimulus
 - an effector
 - a receptor
 - a response.
- Identify four stimuli to which you respond.
 - State the type and location of the receptors that detect these stimuli.
- Draw a labelled diagram to illustrate the structure of a typical neuron.
- Match the parts of the brain to the functions listed.

Part	Function
Cerebellum	Controls involuntary actions such as breathing
Medulla	Centre for sight, hearing and speech
Meninges	Controls muscle movements while you are cycling
Cerebrum	Protect the brain from injury

- Neurons do not touch each other. They have small gaps between them.
 - State the name of these small gaps.
 - Describe how neural messages cross these small gaps.
- Clarify what is meant by a reflex action.
 - Identify three of your own reflex actions.
 - Explain why reflex actions need to be very fast and how they achieve these speeds.
- State three activities in humans that are controlled by hormones.
 - State three activities in plants that are controlled by hormones.

>>

Thinking questions

- 17 List the changes that testosterone causes in males at puberty.
- 18 Describe one contraceptive method, including how effective it is and why.
- 19 List three things a mother-to-be could do that would harm a growing foetus.
- 20 Explain how you can protect yourself against genital herpes.
- 21 Propose how the risk of multiple pregnancies by IVF can be reduced.
- 22 Glucose levels in your blood are carefully controlled so they remain within certain limits.
 - a State the name of this careful control.
 - b Explain why it is necessary to control blood glucose levels.
 - c Identify which coordinating system (nervous or endocrine) is most involved in controlling glucose levels.
 - d Identify the name of the condition in which this control is defective.
- 23 Determine whether the following statements about the endocrine system are true or false.
 - a Chemicals are used to deliver messages.
 - b Messages are passed along neurons.
 - c Messages are delivered more slowly than in the nervous system.
 - d Responses to stimuli are rapid.
 - e Activities are controlled from one central location.
- 24 Match the hormones to the functions they control.

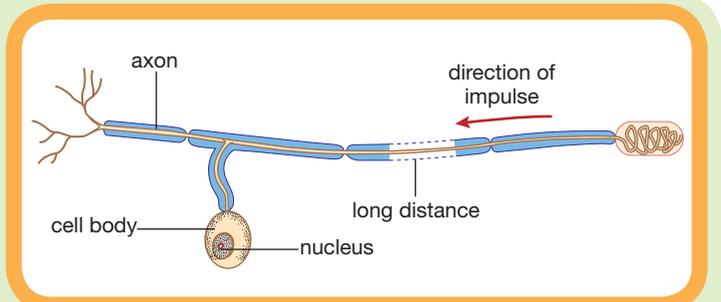
Hormones	Functions
ADH	Blood glucose levels
Testosterone	Female reproductive functions
Insulin	Rate of chemical reactions in cells
Oestrogen	Water levels within the body
Thyroxin	Readiness of the body for action
Adrenalin	Deepening of the male voice at puberty

- 25 Match these endocrine glands to a hormone they produce.

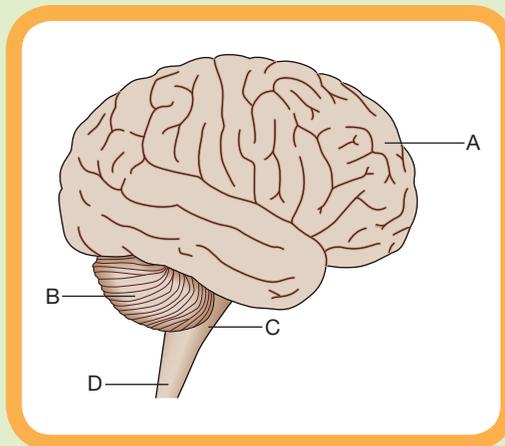
Gland	Hormone
Adrenal	Oestrogen
Pancreas	Adrenalin
Pituitary	Testosterone
Thyroid	Insulin
Ovaries	ADH
Testes	Thyroxin

Interpreting questions

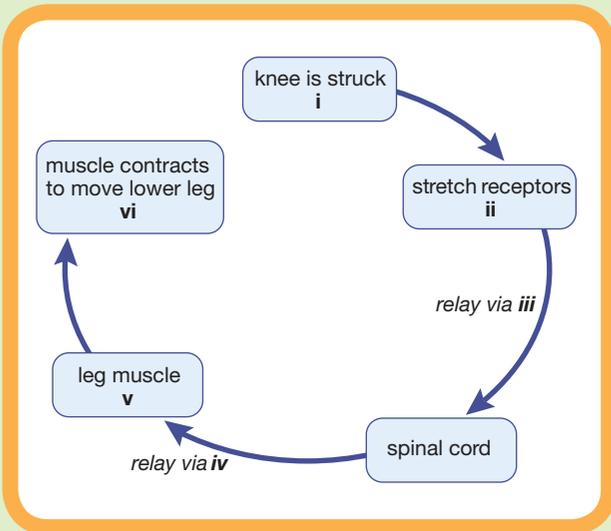
- 26 a Identify the type of neuron (sensory, motor or interneuron) shown in the diagram below.
b Explain your choice.



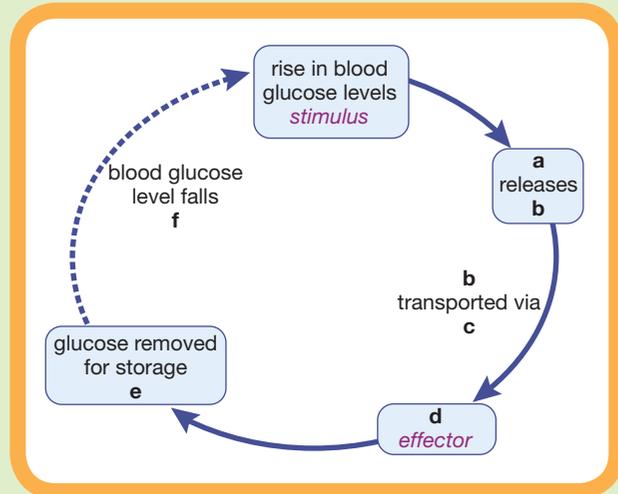
- 27 A simple diagram of the CNS is shown below, labelled A to D. Use these letters to identify which part:
 - a is the centre for decision making
 - b controls the heartbeat
 - c transmits messages from the PNS to the brain
 - d receives and interprets messages from the eyes and ears.



28 The diagram below shows the reflex arc for what happens when your knee is struck lightly with a hammer. Use the following terms to complete the missing labels i to vi: response, stimulus, sensory, nerve, motor, nerve, receptor, effector.



29 The diagram below shows control of glucose levels in the body. Complete the missing labels a to f.



30 a Define 'tropism'.
b Describe two examples of tropisms.

Specific learning outcomes

9.5.1.1, 9.5.2.1, 9.5.3.1, 9.5.3.1, 9.5.4.1, 9.5.5.1, 9.5.5.2

Human effects on ecosystems

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

- identify human activities that cause environmental problems in your community
- identify types of pollution in your school or local community
- conduct research to investigate an introduced species in Solomon Islands and describe its negative impact on local species—examples of introduced organisms are toads, Indian mynas, tilapia and rain-tree
- name at least one local species that is in danger of extinction, for example leatherback sea turtle
- explain the purpose of conservation
- identify methods or ways of conservation, both short-term and long-term.

- 1 What do you know about ecosystems?
- 2 List some types of ecosystems around you.
- 3 What type of ecosystem near your home is most affected by human activities?
- 4 Can you suggest any ways of reducing the impact of human activities on the environment?

Challenges



UNIT 5.1

Human effects on ecosystems

Introduction

For thousands of years, most people lived and worked in small villages. Populations were small. The natural resources around them were all they needed to survive. People used simple handmade tools. They lived in simple dwellings lit and warmed by fire. Clothes were hand-made and food was hunted and gathered from the local surroundings. The waste produced was easily absorbed back into the environment through the natural cycles. In the mid-1700s, the Industrial Revolution began in Europe. By the mid-1850s, many small villages had become industrial towns. Machine-made goods were in demand. The railway was developed and new types of wastes and pollutants were produced in large quantities. Humans had changed the environment forever.

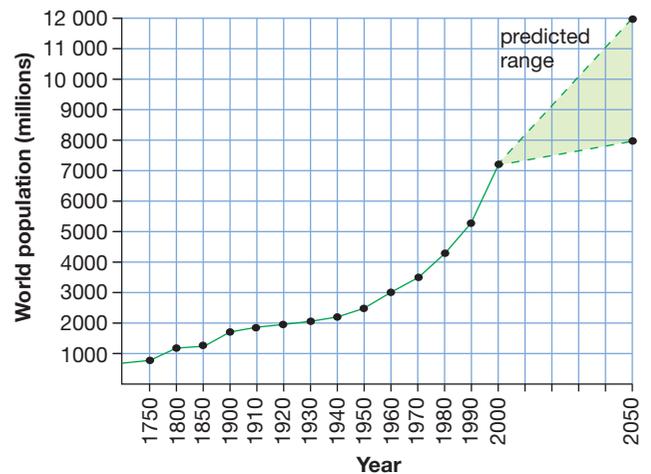


Fig 5.1.1

As the human population increases, the demands to produce food, energy and shelter and living requirements increase. This results in a decrease in area for plant and animal habitation.

Activity 1

A climate in a beaker

Aim

To make a mini-climate in a beaker

Equipment

A large glass bowl, jar or beaker, some aluminium foil, ice cubes, some paper tapers, matches

Method

- 1 Place half a cup of water in the beaker, swirl it around to wet the sides of the beaker and then tip it out.
- 2 Drop a lighted taper into the base of the beaker. Cover the open top with the aluminium foil and make an indentation. Place the ice cubes in the depression you have made.
- 3 Record what happens as the air temperature inside the beaker falls due to the layer of cold air immediately under the foil. When the smoke particles and the moisture in the air get trapped together near the surface, they form smog. The smog cannot escape from the beaker, and as it cools it falls back toward the base.

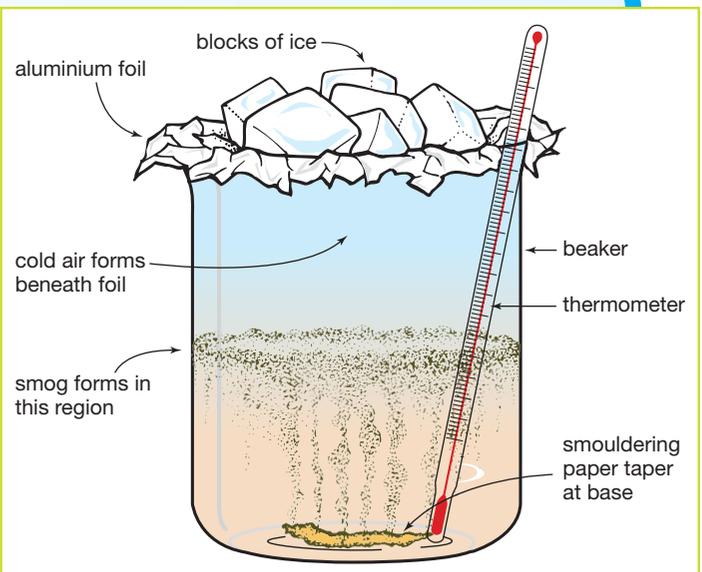


Fig 5.1.2 Using a beaker to illustrate how smog forms in cities

>>

Questions

- 1 Propose a reason why smog occurs more in cities that have rivers running through them.
- 2 Smog forms more in winter than in summer. Explain why.
- 3 The inside of the beaker was wet first. Explain why.
- 4 Draw conclusions about the accuracy of this re-creation of city smog and a climate.

Pollution

A pollutant is anything that makes the environment unfit or unhealthy for the organisms that live there.

Pollutants affect the atmosphere, the land and the water. Some pollution may arise from natural causes such as volcanic eruptions. However, most pollution is the result of human activity.

Air pollution

Industrial activity releases a stream of pollutants into the atmosphere. These include sulfur dioxide, nitrogen dioxide, carbon monoxide, carbon dioxide, hydrogen sulfide, dust and smoke. Cars and trucks release hydrocarbons, lead, nitric oxide and carbon monoxide. In the presence of sunlight, these chemicals react to form a variety of new pollutants such as ozone and nitric acid, and organic compounds such as formaldehyde. In large cities, this is often seen as smog.

Water pollution

The waterways and oceans of the world have become polluted from a variety of sources, such as:

- sewage, which contains contaminants such as soap, detergents and other cleaning agents from washing machines, dishwashers and bathing facilities, as well as human wastes from toilets
- agricultural fertilisers, which add nitrogen and phosphorus to the ecosystem. These fertilisers find their way into both run-off water and groundwater. They end up in the rivers, bays and oceans
- sediment produced when clearing land for housing developments and farming. The clearing causes erosion, and soil particles are washed into the waterways, causing silting
- salinisation, caused by rises in groundwater levels due to the cutting of trees to plant crops and the use of irrigation on farms. As the water table rises, it brings with it dissolved salts from the rock surfaces. This increases the salinity of the groundwater, making it unusable for many plant species
- inorganic chemicals, released by industry directly into waterways and into the soil. They are then carried by groundwater into the waterways. Chemicals released into the atmosphere are absorbed by rain droplets and fall as acid rain.

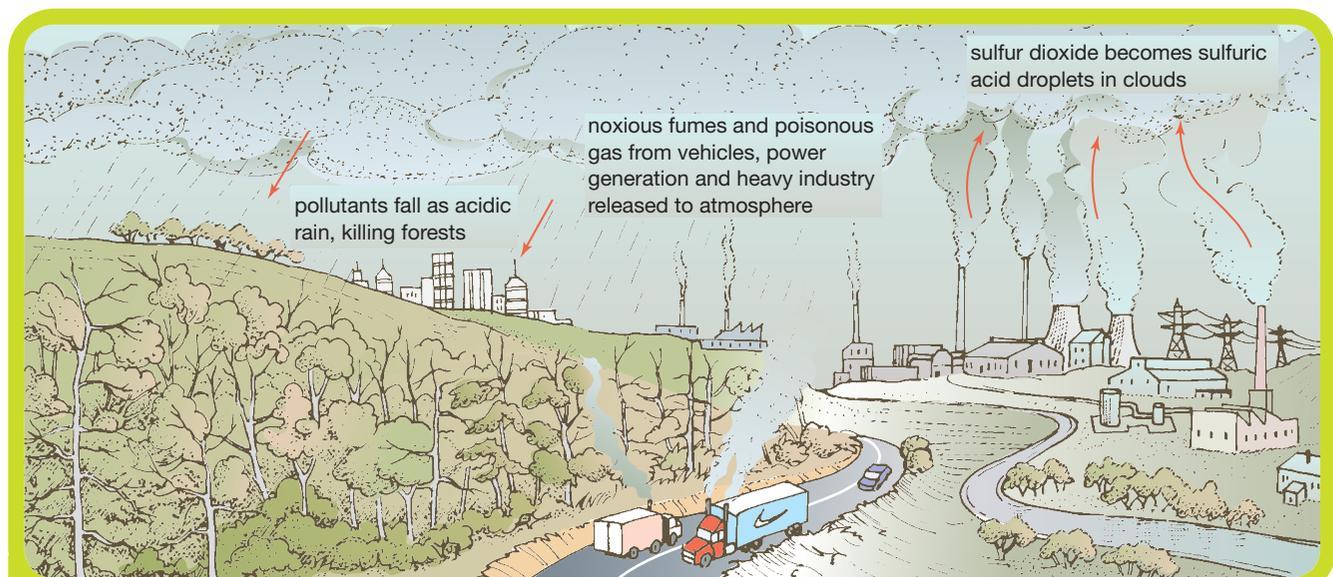


Fig 5.1.3

A deadly mixture is produced when poisonous gases and exhaust fumes from cars and trucks combine in the atmosphere with oxygen and water vapour. These poisons are carried back to the ground as acid rain, killing lakes, forests and the organisms that live there.

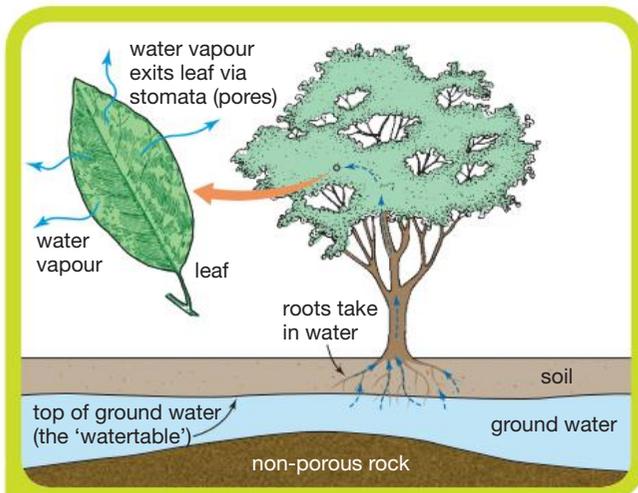


Fig 5.1.4 Trees suck the water out of the ground, releasing it back into the atmosphere through their leaves in a process called transpiration.

Soil pollution

Soil pollution is referred to as soil degradation. Over 65 per cent of soil degradation is caused by overgrazing and deforestation. Overgrazing is the degradation of land caused by allowing more animals to graze or feed in an area than the area can sustain.

Deforestation is the large-scale removal of trees to allow for more grazing land. Trees act like giant

straws, sucking the water out of the ground and releasing it back into the atmosphere through their leaves in a process called transpiration. This keeps the underground water table at a lower level. When trees are removed, the water level rises, bringing with it dissolved salts. Remaining trees and plants will die if this 'salty' water gets near the surface.

Removal of plant life exposes the soil to strong winds and heavy rainfall. This results in uncontrolled soil erosion, and the land is destroyed.

About 10 per cent of the Earth's surface has been reduced to desert. This is called desertification.

Global warming

Every day the Sun shines on Earth, delivering large amounts of energy. Much of that energy is absorbed by the plants, rocks, buildings, soil and sea. Some of it is released back into the atmosphere as heat. This heat would eventually escape into space if something didn't stop it. However, certain gases in the atmosphere naturally trap this heat, keeping the atmosphere warm. This is called the greenhouse effect: the atmosphere acts like a giant greenhouse, keeping the temperature just right for life.

Gases known as greenhouse gases are released whenever fossil fuels such as coal, gas, petrol and oil

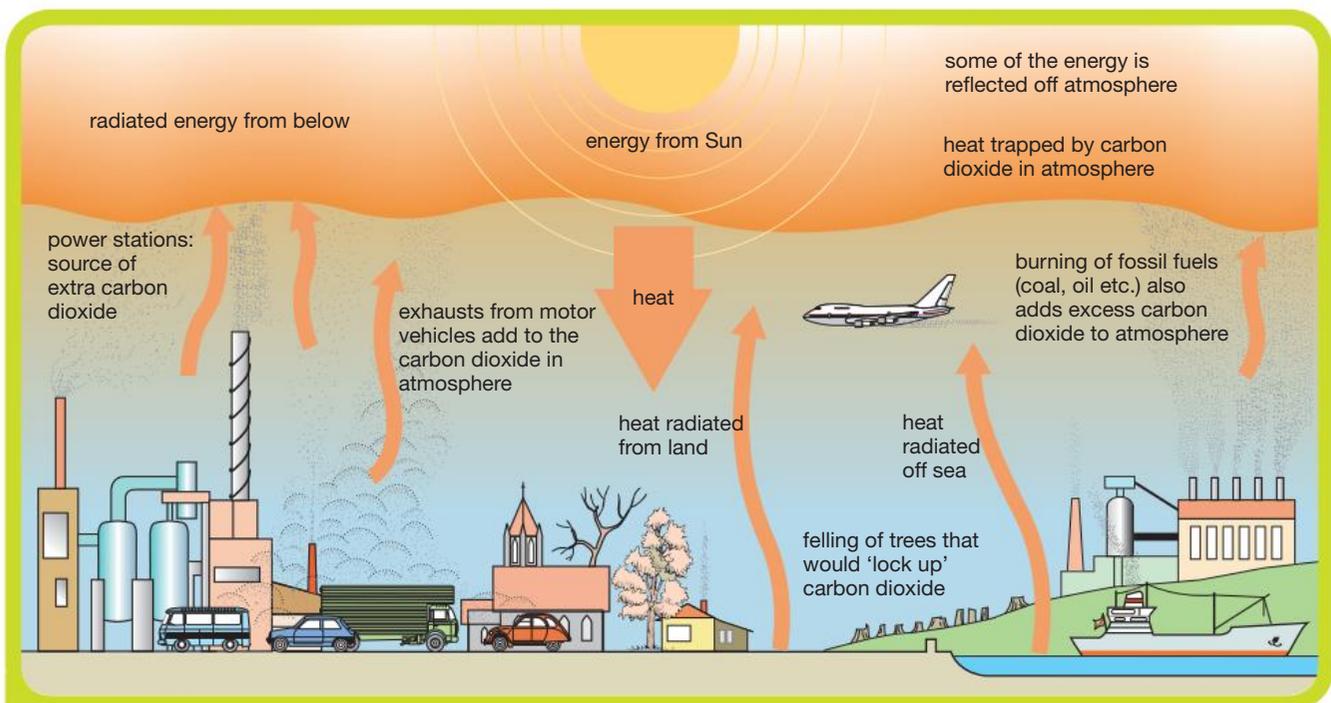


Fig 5.1.5 Heat is trapped between the blanket of greenhouse gases (carbon dioxide, water vapour, methane, nitrous oxide and ozone) and the Earth's surface, causing a global increase in temperature.

are burnt. The main greenhouse gases are carbon dioxide, methane, nitrous oxide, ozone and water vapour. The amount of these gases in the atmosphere is significantly higher today than in the past. Increased industrialisation has caused more heat to be trapped. This is called the enhanced greenhouse effect. It leads to global warming. Over the last 100 years the average atmospheric temperature has risen more than 0.6°C. This has caused the sea level to

rise by several centimetres. If greenhouse gases continue to be released into the atmosphere, we can expect further increases in both temperature and sea levels. Flooding of coastal regions could become common, destroying many ecosystems and the organisms that live in them. Places that humans inhabit are at risk, too; for example, the island of Vanikoro and the Roviana region in Western Province in Solomon Islands.

Activity 2

Simulating global warming

Aim

To observe the effect of an invisible 'blanket' on heat escape from a system

Equipment

2 small fruit juice cartons ('poppers'), 2 thermometers, 1 pair of scissors, at least 4 microscope slides, sticky tape

Method

- 1 Cut a square hole in the large flat side of each of the poppers. The hole should be just smaller than the width of two microscope slides.
- 2 Place two microscope slides over the hole of one of the poppers, and stick it into place using the sticky tape to seal the hole. Place the thermometers through the straw holes on each of the poppers. Seal around them with sticky tape to prevent heat escaping.
- 3 Allow about 5 minutes for the temperature inside the poppers to stabilise. Record the temperature inside both poppers.
- 4 Place the poppers and the thermometers on a sunny window sill.
- 5 Record the temperature inside each of the poppers every 5 minutes.

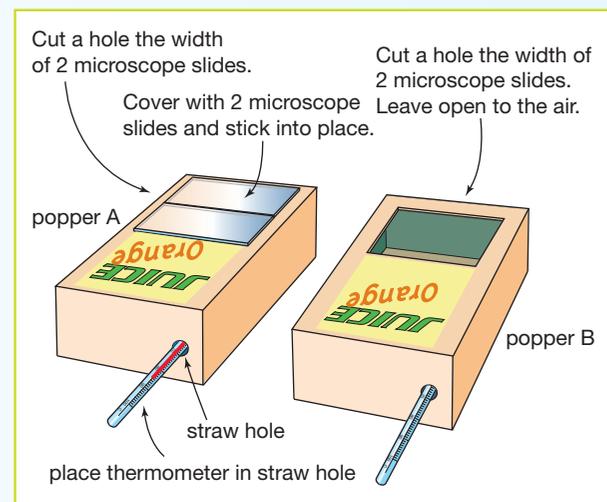


Fig 5.1.6 An illustration of global warming using two 'poppers'

Questions

- 1 Predict the outcome of the experiment.
- 2 Describe what happened to the temperature inside the popper in which the microscope slides covered the hole.
- 3 Compare your results with what is happening to the Earth.

Introduced species

Animals and plants such as the pig, Giant African snail and tamarisk tree were brought to the Pacific, including Solomon Islands, by the early settlers. They are now causing huge problems for our native plants and animals. Pigs, for example, dig up large areas of land, damaging native plants and destroying the habitats of many birds and animals. European carp brought into fish farms in some Pacific Island countries now inhabit creeks and

ivers. Carp feed by taking in mouthfuls of the muddy river bottom, then spitting them out. The dirt and the small organisms contained in the mud are then suspended in the water, where the carp can catch and eat them. This method of feeding causes great damage to water plants. Their shallow root systems are made unstable because of the removal of the mud.



Fig 5.1.7 Illustration of Guadacanal giant rat (*Zyomys pedunculatus*)

Endangered species

Much of Solomon Islands' unique wildlife and plant life is becoming endangered. This means that if no active steps are taken, these plants and animals are in danger of extinction. Those species that are now no longer living on our planet are said to be extinct.

Factors that threaten our native wildlife include:

- predation by introduced species such as foxes and cats
- competition with introduced species such as goats and cattle
- the destruction of their habitats when cities, towns, roads and mines are built.

The following table gives some examples of animals and plants that are endangered or extinct in Solomon Islands.

Mammals	There are 53 mammal species comprising bats, rats and possums. Of these, 20 are threatened. The Guadacanal giant rat, the emperor rat and the Santa Cruz tube-nosed bat are likely to be extinct.
Endangered marine mammals	There are 5 species of turtles, of which 3 are endangered.
Birds	There are 94 birds, 16 of which are classified as endangered or threatened. Two are extinct (<i>Gallinula salomonis</i> and <i>Microgoura meeki</i>), two are critically endangered (<i>Gallinula syvestri</i> and <i>Pseudobuweria becki</i>), 14 are vulnerable and 23 are near-threatened.
Plants	Several tree species, including ebony, rosewood, rattan and some palms are endangered. Ebony is listed as critically endangered.

Conservation

Conservation is aimed at keeping alive all the plants and animals that live together in a specific habitat. This is done by keeping the habitat undisturbed and free of human interaction.

Both short- and long-term conservation actions are required to maintain the biodiversity of a particular habitat. For example, consider the impact of an oil spill. Conservationists work hard in the short term to remove the oil from any ocean-going mammals, turtles and birds that may be affected. Steps are taken to stop the oil from spreading further. Skimmer booms are used to remove the oil from the surface of the water. In the long term, laws regarding the transportation of oil are made so that future spills will be avoided.



Fig 5.1.8 Illustration of a Santa Cruz tube-nosed bat

When we work to conserve one species in an ecosystem, we are helping to conserve all of the other species in that ecosystem because of their interactions with each other.

Why conserve?

Humans rely on the living organisms around them. Plants provide us with the oxygen we breathe and food for us to eat. They also provide food for the animals we eat. Plants and fungi provide the materials for many of the drugs in pharmacy shops we use when we are ill. It is estimated that of the 400 000 to 500 000 different species of known plants on the Earth, only 10 per cent have been studied for their chemical components. Who knows what future cures are to be found in the plants and animals we are destroying today?



The future really comes down to the values and attitudes of the Solomon Islands people. Some still view the land in the same way as the European settlers—as a resource for humans to use or exploit;

for example, clearing huge areas of flat lands for oil palm and coconut plantations. Others view the land as something to be respected and conserved. We will have to find the right balance.



Fig 5.1.9 What does each illustration suggest about effects on the environment?

Fig 5.1.10 What sort of relationship do you have with the land?

[Questions]

Checkpoint

Pollution

- 1 Define the term 'pollution'.
- 2 List three common air pollutants found in today's industrialised cities.
- 3 Some pollutants become even more dangerous in the presence of sunlight. List three products of the combination of air pollutants with sunlight.
- 4 Identify the environmental threat caused by greenhouse gases.
- 5 Identify five sources of water pollution.
- 6 Outline the two main causes of soil degradation.

Introduced species

- 7 Use an example to outline a problem for the Solomon Islands environment caused by an introduced species.

Endangered species

- 8 List three factors that have put many species of Solomon Islands' unique wildlife in danger of extinction.

Conservation

- 9 Explain the term 'conservation', describing how helping one species in a community helps the others.
- 10 List three reasons why it is important for human beings to conserve the plants and animals in their environment.

Think

- 11 Propose reasons for the life span of a tree in a rural area being longer than the life span of the same species of tree in an urban centre.
- 12 Use an example to explain how overgrazing and deforestation cause soil degradation.
- 13 Explain why a more diverse community is more likely to survive than a less diverse community.
- 14 Use an example to demonstrate how new human technology has affected the environment.
- 15 Describe the short-term and long-term measures that may be taken to stop an oil spill from spreading.
- 16 Contrast an endangered species with an extinct species.
- 17 Describe ways of reducing the effects of global warming.

Skills

- 18 Use a diagram to demonstrate the greenhouse effect.
- 19 Use the graph in Figure 5.1.1 to predict three effects on the environment of the population increase expected by the year 2050.

[Extension]

Investigate

- 1 Research the effects of the Industrial Revolution.
- 2 Research one animal and/or plant that is currently endangered. Summarise your findings, including the following:
 - a the meaning of the term 'endangered'
 - b what has caused this animal and/or plant to become endangered
 - c the numbers left in their natural environment now
 - d what steps are being taken to increase their numbers
 - e the expected outcome.
- 3 Research a habitat that is endangered and produce a brochure or pamphlet for visitors to the habitat. Choose from:
 - a disappearing rainforests
 - b endangered coral reefs
 - c increasing salinity on farmlands
 - d disappearing wetlands.
- 4
 - a Explain what is meant by a 'captive breeding' program.
 - b Discuss the importance of zoos and captive breeding programs for many species.
 - c Write a letter to the editor of a newspaper to explain your views on captive breeding.
- 5 Which introduced species has proven to be the most damaging and the hardest to control in Solomon Islands? Explain your answer.

Class debate

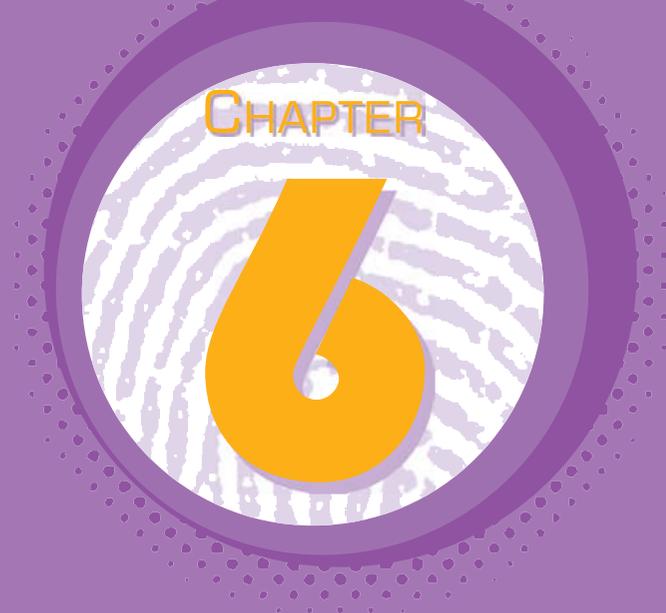
The class separates into two groups:

- Group A—those that think new technology should be allowed to continue in an uncontrolled fashion, with human needs and wants being more important than the health of the environment
- Group B—those that think more controls should be put into place to protect the environment, to the extent that technology takes a backseat role to the environment. Students should have the opportunity to collect articles (newspapers, periodicals, internet sources) to support their views.

Creative writing

You are a lawyer who has been asked to prosecute a company that has been caught in the act of releasing thousands of litres of poisonous waste into a local creek. Your task is to speak out on behalf of the environment and the future of the creek. Discuss the effects of dumping this waste, and explain why the company should clean up the mess.

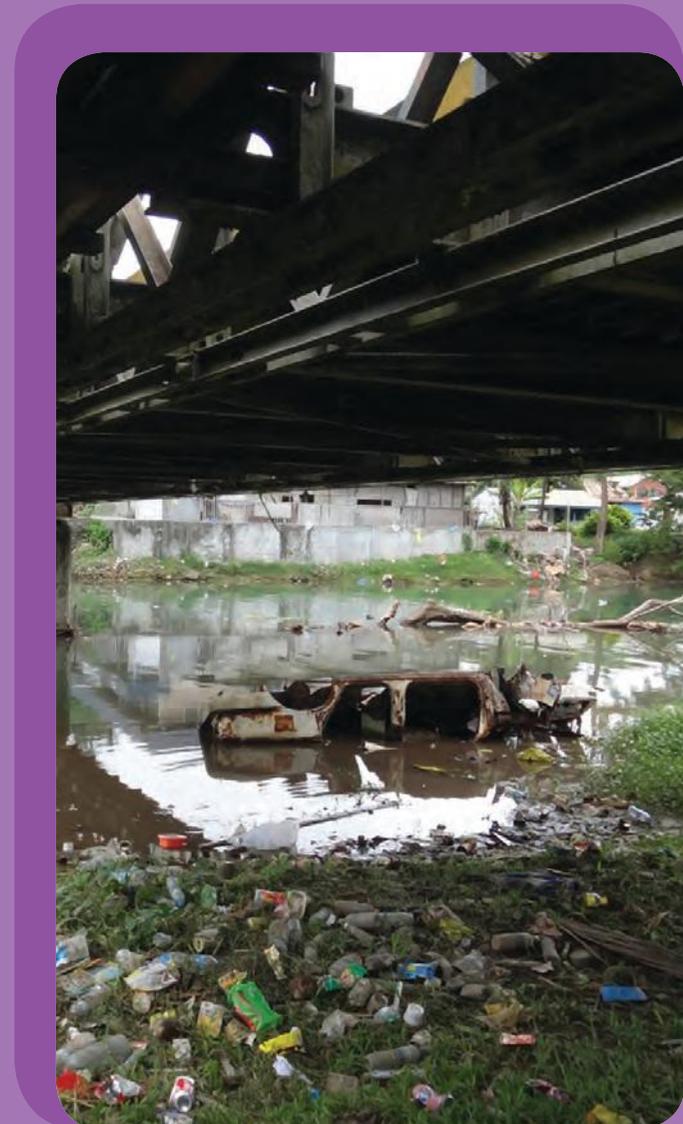
Environmental issues: Global and local



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

- 1 name the greenhouse gases
- 2 explain the role of greenhouse gases in the atmosphere
- 3 explain the causes and effects of increased concentration of greenhouse gases in the atmosphere
- 4 describe ways in which we can help to reduce greenhouse gas concentrations
- 5 state the effects of El Niño in the South American, Australian and the Pacific regions.
- 6 state that ozone is a gas that occurs naturally in the stratosphere
- 7 explain the cause of ozone layer depletion
- 8 explain the effect of ozone-layer depletion on living organisms
- 9 define the term 'climate change'
- 10 define the term 'resilience'
- 11 suggest ways to adapt to the changing environment caused by climate change
- 12 identify specific means of climate change adaptation in Solomon Islands and other Pacific countries
- 13 identify one national or international forum on environmental degradation and climate change, and describe how the forum dealt with a specific environmental issue that will affect Solomon Islands and other Pacific Island countries.

- 1 Most people like warm weather, so why is global warming a concern?
- 2 Is El Niño a type of Mexican food or a change in weather patterns?
- 3 Can you identify some radioactive materials at your home or school?
- 4 Radiation can both cause cancer and be used to treat it. How?
- 5 What is an 'alternative energy'?
- 6 Identify ways in which we can adapt to climate change.



UNIT 6.1

Global warming

Introduction

A house with closed doors and windows on a hot sunny day can be unpleasant inside. The temperature can reach 40°C even when the temperature outside is only 30°C. Heat enters the house easily but much of the heat cannot escape. The greenhouse effect is the same as this 'hot house' effect but it affects the whole of the Earth.

The greenhouse effect

The greenhouse effect is caused mainly by the gas carbon dioxide (CO₂), together with other trace gases in the atmosphere. These gases, commonly called greenhouse gases, provide a 'blanket' around the Earth that keeps the Earth warm. Too little carbon dioxide, and the planet would be too cold to sustain life. Too much, and the resulting high temperatures would also be unsuitable for life. The greenhouse effect is natural and is required for the continued survival of all living things on Earth.

How does it work?

Carbon dioxide and other gases in the atmosphere behave like the glass in a greenhouse of plants. Energy from the Sun reaches the Earth (or plants) as electromagnetic waves with a short wavelength. These waves are able to pass through the atmosphere (or glass). The energy is absorbed by the Earth (or plants) and re-emitted into the atmosphere as long-wavelength radiation. Carbon dioxide (or glass) blocks the transmission of long-wavelength radiation, stopping it from reaching space (or going out of the greenhouse). Much of this energy is therefore trapped in the atmosphere, warming the Earth to a temperature suitable for life. If not for the greenhouse effect, the Earth would be about 30°C colder on average.

Activity 1

The greenhouse effect

Aim

To simulate the conditions required for the greenhouse effect

Equipment

Small cardboard box (eg a shoebox), 2 thermometers or temperature probes and datalogging equipment, sheet of glass or polythene plastic, lamp

Method

- 1 Assemble the apparatus as shown in Figure 6.1.1. You will need to cut out a piece of cardboard from the shoe box lid to divide the apparatus into two sections, as shown.
- 2 Turn on the lamp and measure the temperature at regular intervals (eg every minute) for 10 minutes.
- 3 Turn off the lamp, but continue to measure temperature for another 10 minutes.
- 4 If time permits, investigate the effect of an additional layer of glass or plastic.

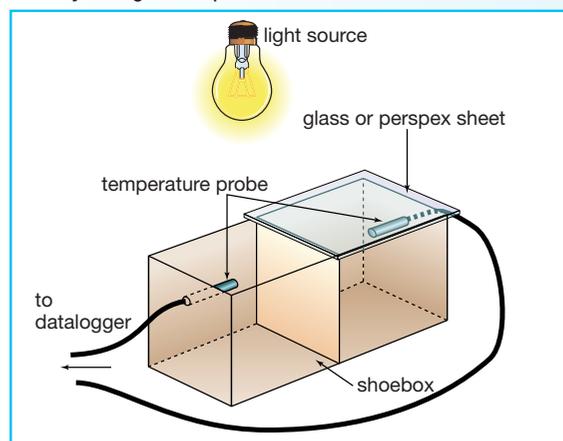


Fig 6.1.1

Questions

- 1 Construct a graph showing temperature versus time for each section of the box.
- 2 Summarise any differences in the temperature patterns in each section.
- 3 Describe what takes the place of the glass or plastic sheet in the global greenhouse effect.
- 4 Identify what adding another layer of glass or plastic represents if modelling the Earth.

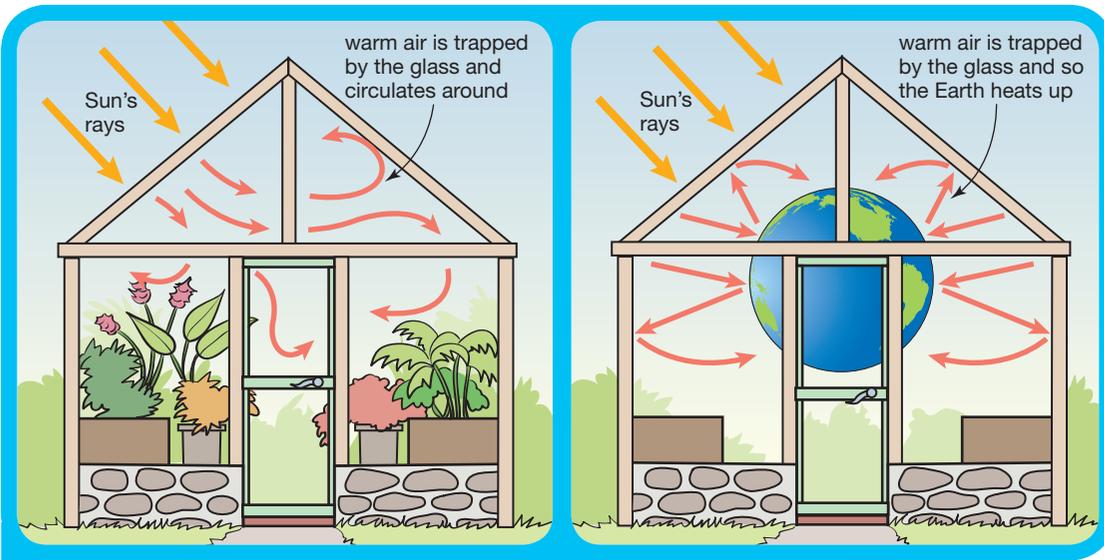


Fig 6.1.2

a A typical greenhouse. When the Sun's energy enters, it is trapped inside the glass. The air inside becomes warmer.

b A model of the greenhouse effect. The greenhouse gases act as the glass, keeping the air around the Earth warmer.

The enhanced greenhouse effect

Over the past century, the levels of greenhouse gases in the atmosphere, particularly carbon dioxide, have increased. The blanket of greenhouse gases in the Earth's atmosphere has effectively become thicker. This results in the enhanced greenhouse effect, where the same amount of heat energy is coming in from the Sun, but less is escaping back into space. The enhanced greenhouse effect is leading to global warming, increasing the average temperature of Earth.

Greenhouse gases: where do they come from?

The main greenhouse gas is carbon dioxide. Carbon dioxide is naturally cycled through the environment during photosynthesis and respiration. Over Earth's history the amount of carbon dioxide in the atmosphere has stayed fairly stable, as it is both absorbed into living systems and released back into the atmosphere.

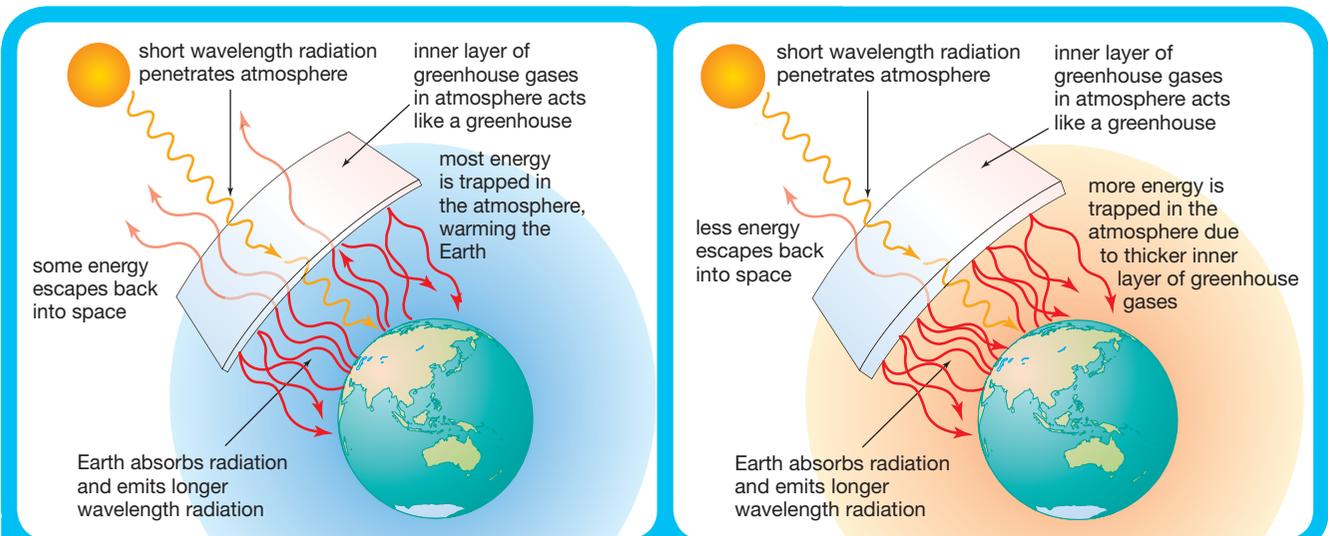


Fig 6.1.3

a The 'natural' greenhouse effect is necessary for survival of living things.

b The enhanced greenhouse effect will lead to global warming.



Fig 6.1.4

These cars contribute to carbon dioxide in the atmosphere by releasing fumes through their exhausts. Deforestation also contributes to carbon dioxide levels because there are fewer trees left to absorb the carbon dioxide in the air.



Carbon dioxide revolution

The factories, steamships and locomotives of the Industrial Revolution needed fuel to fire their boilers. This came mainly in the form of timber or coal. The modern world also needs fuel.

Coal, and the other main fuels, gas, petrol and oil, are termed 'fossil fuels', as they are made from the fossilised remains of long-dead plants and animals. Carbon dioxide is released whenever fossil fuel is burnt. In effect, burning 'unlocks' carbon that has been stored in the Earth for millions of years, producing CO₂ as it does so. Car exhausts, coal and gas power stations and industry are leading producers of carbon dioxide. The clearing of land (deforestation) by burning forests has a double effect. Not only are greenhouse gases released when forests burn, but the destroyed trees are no longer available to store carbon dioxide.

With our modern demand for fuel and electricity, humans are making more carbon dioxide—about 27 billion tonnes per year—than ever before. Some is absorbed, but the rest builds up in the atmosphere. Of this 27 billion tonnes of carbon dioxide output, about:

- 7 billion tonnes are absorbed by oceans
- 7 billion tonnes are taken up by forests
- 13 billion tonnes accumulate in the atmosphere each year.

Other gases

Although carbon dioxide is the main greenhouse gas, others are:

- methane (CH₄), which is produced when vegetation breaks down in the absence of oxygen—for example in rice paddies and rubbish tips, and when cattle (or you!) burp or pass wind. Methane is twenty-one times more effective than carbon dioxide in blocking the escape of radiant heat from Earth. Luckily, less methane than carbon dioxide is produced
- nitrous oxide (N₂O), which is produced from burning forests, car exhausts and artificial fertilisers
- CFCs or chlorofluorocarbons which, until recently, were used in aerosol spray cans, refrigerators and air conditioners, to clean circuit boards and in the manufacture of polyurethane foam used in packaging. They are now banned in many countries and are becoming less commonly used worldwide
- surface ozone, which is generated as part of photochemical smog, produced by the action of sunlight on motor vehicle and industrial pollution.

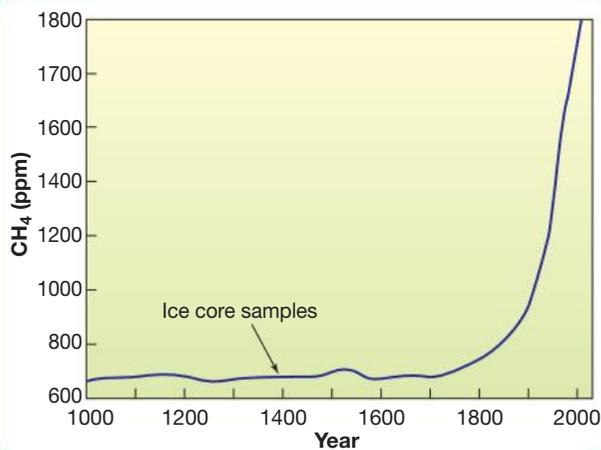
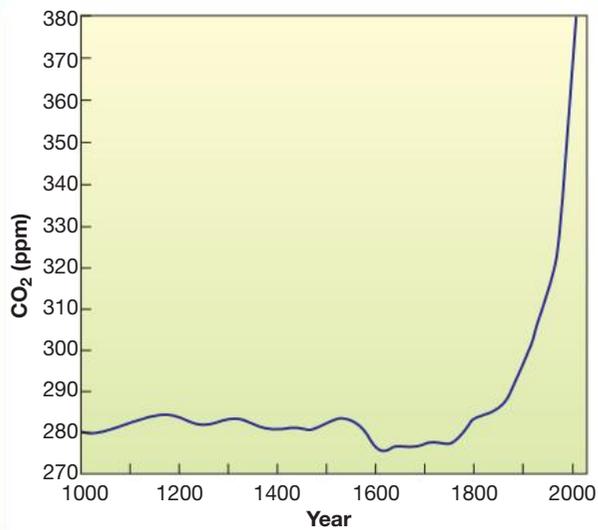


Fig 6.1.5

Concentrations of carbon dioxide and methane between the years 1000 and 2004. Source: CSIRO

Hanging around

Greenhouse gases remain in the atmosphere for many years. Carbon dioxide persists for more than 100 years, and methane remains for 11 years. You can see why we need to take action now to reduce emissions.

Evidence in the ice

Scientists collect ice cores from Antarctica by drilling into the ice. The deeper the ice, the older the ice is, as new snow falls on top each year. When the snow falls, air bubbles are trapped in the ice. Analysis of these trapped gases reveals the

Activity 2

Icebergs

Aim

To investigate the effect of melting ice on water level

Equipment

Ice cubes (4–6), cold water, beaker

Method

- 1 Place some ice cubes (representing icebergs) in the empty beaker.
- 2 Add the cold water to the beaker and mark the water level on the outside.
- 3 Allow the beaker to warm until the ice has melted.
- 4 Compare the water level to that initially marked on the beaker.

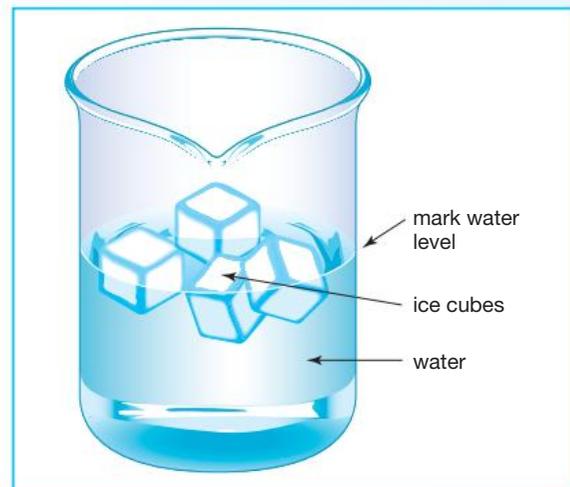


Fig 6.1.6

Questions

- 1 Deduce whether the melting of floating icebergs contributes to a rise in sea levels.
- 2 Consider whether the melting of 'land ice', such as the ice caps of Antarctica, would contribute to a rise in sea levels.

amount of carbon dioxide present in the atmosphere in the past. So far scientists have drilled down 3.27 kilometres, which means they have data about carbon dioxide levels going back approximately 900 000 years.

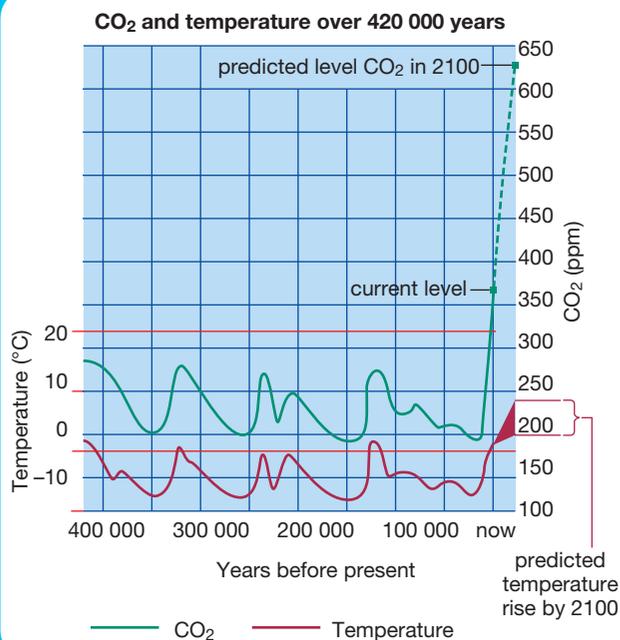


Fig 6.1.7

Carbon dioxide levels over the past 420 000 years. The graph shows a prediction for the year 2100 if carbon dioxide levels continue to increase at the current rate.

The graph in Figure 6.1.7 shows carbon dioxide levels in the Earth's atmosphere over the past 420 000 years. It is normal for the level of carbon dioxide to go up and down, but the amount of carbon dioxide in the atmosphere is now at its highest level ever. Notice that the Earth's temperature changes when the amount of carbon dioxide in the air changes. The troughs on the temperature graph represent the ice ages, when average temperature was up to 6°C lower than today. The peaks show when warmer periods occurred on the Earth.

The future

Predicting the temperature rise

Over the past 100 years or so, the Earth's average surface temperature has increased by about 0.5°C and a further increase of between 1°C and 4°C is expected by the end of this century. Such a rise, though seemingly small, is enough to raise sea levels by an estimated half a metre—possibly up to a metre—and cause flooding of low-lying coastlines due to the increase of water in the oceans and melting of land ice. Many of the island nations in the Pacific and Indian oceans would virtually disappear.

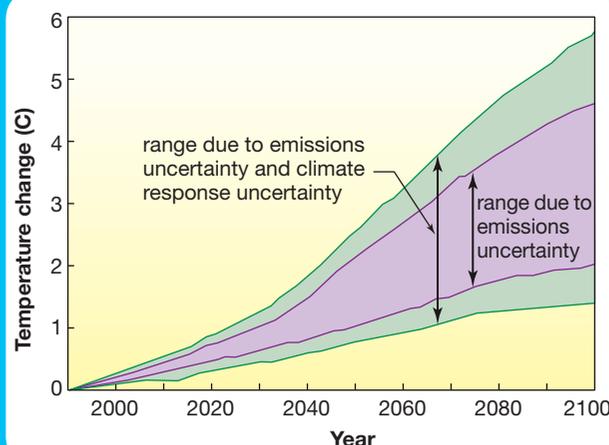


Fig 6.1.8

Predicted global warming compared to 1990

Predicting local effects

We do not fully understand the implications of global warming for society and the environment. Some regions will be drier and some wetter. Some will be cooler but most will be hotter. We can also expect more storms, droughts, floods, hurricanes and temperature extremes.

Scientists predict that the following changes may occur.

- The melting of much of the polar ice caps will raise sea levels, flooding coasts, cities and some entire island countries.
- Liquid water expands slightly when warmed and so the oceans will expand, also raising sea levels, causing further flooding.
- There will be increases in the numbers of wild storms and cyclones. Cyclones could move further south.
- There will be more droughts and heatwaves.
- There will be more bushfires.
- There will be less rain and snow. Managing and saving water will become more important.
- Habitats will change, causing the extinction of some animals and plants.
- Increased temperatures may cause bacteria to grow faster, causing more disease in humans and other organisms.
- Some plants may grow faster with higher temperatures. This would be good for farmers, but less rain may mean that fewer plants grow and fewer varieties can survive.
- Increased heat may cause more heatstroke and illness.

El Niño and La Niña

Other factors adding to weather extremes are El Niño and La Niña. In normal weather patterns the Pacific Ocean is warmer because trade winds blow from the east (South America) to the west (east coast of Australia) and the temperature in the South American ocean is cooler, creating high humidity in the Pacific. When this air rises, heavy precipitation is produced over the north-west Pacific (Indonesia), leaving the eastern Pacific dry.

In an El Niño event, which occurs every three to four years, the trade winds (westerly direction) slow down and the warm waters of the Pacific Ocean change direction, migrating easterly.

Humid air follows the warm water eastward, causing heavy rainfall and associated flooding in the west coasts of South American countries and drought in Indonesia and Australia around the Christmas periods. In Solomon Islands, the effects of El Niño are increased temperatures and greater frequency of cyclones.

La Niña is similar to El Niño but its effects are devastating, as the trade winds are stronger than normal, causing the surface of the Pacific Ocean to be colder than average. A La Niña event occurs after an El Niño event.



Fig 6.1.9

Will this storm damage become a more common sight in the future?

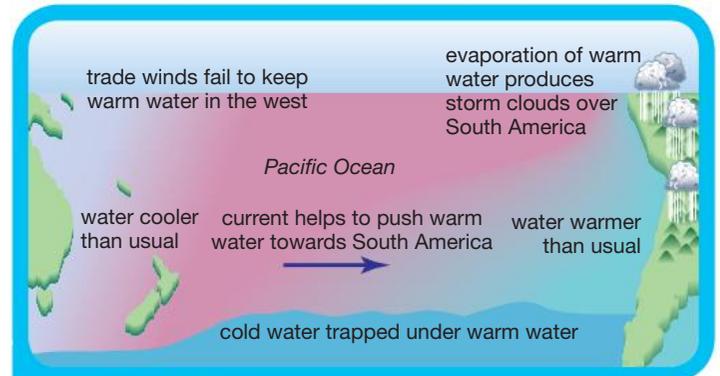


Fig 6.1.10 The El Niño effect

6.1 [Questions]

UNIT

Checkpoint

The greenhouse effect

- 1 State the name of the main gas responsible for the greenhouse effect.
- 2 Explain why greenhouse gases are useful to the Earth.
- 3 Explain how greenhouse gases trap heat from the Sun.
- 4 Outline how the temperature of Earth would change if there were no greenhouse gases.

Greenhouse gases: where do they come from?

- 5 Explain the enhanced greenhouse effect.

- 6 Clearing land can enhance the greenhouse effect. Explain how.
- 7 State the amount of carbon dioxide now being released.
- 8 List all the greenhouse gases.
- 9 How long do greenhouse gases persist in the atmosphere?

Evidence in the ice

- 10 Scientists use ice cores to determine the levels of greenhouse gases in the past. Explain how air becomes trapped in the ice.
- 11 Using Figure 6.1.7, outline how the levels of carbon dioxide in air bubbles in ice cores have changed in the past 420 000 years.

>>

- 12 Using Figure 6.1.7, describe the relationship between the level of carbon dioxide in the atmosphere and the Earth's temperature over the past 420 000 years.

The future

- 13 What was the average temperature rise over the past 100 years: 0.3°C, 1°C, 0.5°C or 5°C?
- 14 The effects of global warming on the weather are largely uncertain. List three possible effects.

El Niño and La Niña

- 15 Explain what is meant by the term 'El Niño'.
- 16 Outline two effects of El Niño in Solomon Islands.

Think

- 17 Methane blocks the escape of radiant heat much more than carbon dioxide does. Explain then why carbon dioxide and not methane is considered the main greenhouse gas.
- 18 Imagine that all greenhouse gas emissions stopped today. What impact would this have on concentrations of greenhouse gases in the atmosphere? Explain your answer.
- 19 Discuss how global warming might cause greater rainfall.
- 20 Many believe that the technology exists to produce cars that travel twice as far on each tank of fuel. Assuming that such technology does exist, propose reasons why such cars are not being manufactured.

Analyse

- 21 Given adequate rainfall and suitable temperatures, kumara (sweet potato) yields may actually increase in response to higher carbon dioxide concentrations. Assess why.
- 22 Analyse whether population control would reduce global warming.

Skills

- 23 Copy and complete the following table to summarise the main greenhouse gases, their chemical formulas and their sources.

Greenhouse gas	Chemical formula	Sources

- 24 The following question relates to the graphs of carbon dioxide and methane concentrations in the atmosphere in Figure 6.1.5.
- Describe atmospheric levels of each gas between the years 1000 and 1400.
 - Identify when the amount of carbon dioxide and methane in the atmosphere suddenly increased.

- Estimate the rise in CO₂ and CH₄ concentrations between the years 1800 and 2000.
- Express your answers to part c as percentages.

- 25 A single cow emits 280 litres of methane as burps and farts every day. The number of cattle in Solomon Islands is about 3000. Estimate the volume of methane they emit:
- per day
 - per year.
- 26 Carbon dioxide emissions per person for several countries are listed below.
- Construct a column graph showing this information.
 - Use these figures to deduce which countries produce the most or least carbon dioxide per person.

Country	Carbon dioxide emissions 2010–14 (tonnes per capita)
Solomon Islands	0.4
Papua New Guinea	0.5
Fiji	1.5
New Zealand	7.2
United Kingdom	7.9
Japan	9.2
Canada	14.7
Australia	16.9
United States	17.6

- 27 Use the temperature change graph in Figure 6.1.7 to answer the following questions.
- There are two pairs of lines on the graph due to two factors affecting temperature rise. Describe what they are.
 - Assess the range of the global average temperature rise (compared to 1990) in:
 - 2040
 - 2080.

[Extension]

Investigate

- Research and construct a map showing the countries or islands most at risk of partially or totally disappearing due to rises in sea levels.
- Research El Niño, La Niña and the Southern Oscillation.
 - Explain how each of these is thought to be linked to global warming.

UNIT 6.2

The ozone layer

Introduction

The ozone layer is vital to life on Earth. It acts as a shield, absorbing 90 per cent of the harmful ultraviolet radiation from the Sun. This radiation is harmful for humans and can cause skin cancer as well as damage to plants if too much radiation is absorbed.

What is ozone?

Ozone is a gas that occurs naturally in the stratosphere at about 20 to 30 kilometres above the Earth's surface. When people refer to oxygen, they usually mean the oxygen we use when we breathe. This type of oxygen, O_2 , consists of molecules each made of two oxygen atoms. Ozone, O_3 , is another naturally occurring form of oxygen, the molecules being made of three oxygen atoms. Ozone is a colourless gas that has a very pungent odour. Although ozone performs a vital role in the stratosphere, at ground level it is a pollutant. It is poisonous, causing eye, nose and throat irritation and lung damage, and has even been found to cause asthma.

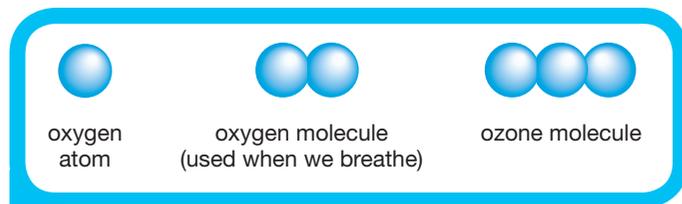


Fig 6.2.1

Oxygen atoms, O , may combine with each other to form oxygen, O_2 , or ozone molecules, O_3 .

The ozone layer

Ozone is created when UV light splits oxygen molecules in the stratosphere into single oxygen atoms. These single oxygen atoms then join other oxygen molecules to form triplets of oxygen atoms, or ozone molecules.



Ultraviolet light also splits ozone molecules, so ozone is continually being created and destroyed, with UV light being absorbed in the process. The region of the stratosphere in which ozone is thinly distributed is called the ozone layer.

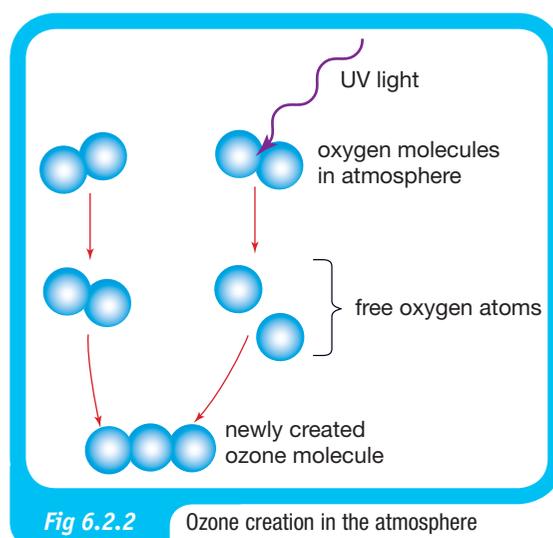


Fig 6.2.2

Ozone creation in the atmosphere

Chlorofluorocarbons

Chlorofluorocarbons (CFCs) were invented in the 1920s and were once called 'wonder chemicals' because they were non-poisonous, odourless, stable and cheap to produce. Until recently they were used extensively as propellants for aerosol sprays and as coolant gases in refrigerators and air conditioners. They also made the bubbles within polystyrene and other foam packaging. We now know that CFCs are greenhouse gases and can destroy ozone. They do this by drifting upwards into the stratosphere where they break down, releasing chlorine. Each chlorine molecule released this way reacts with ozone molecules, breaking them apart into oxygen molecules and oxygen atoms. The chlorine acts as a catalyst and is not part of any new substance formed. It is then free to go on and destroy more ozone molecules!

Common ozone-depleting gases and their average life in the atmosphere

Gas	Chemical formula	Average life in atmosphere (years)
CFC-11	CCl_3F	65
CFC-12	CCl_2F_2	110
CFC-13	CClF_3	160
Freon (Halon 1301)	CF_3Br	110
Nitrous oxide	N_2O	130
Methane	CH_4	11

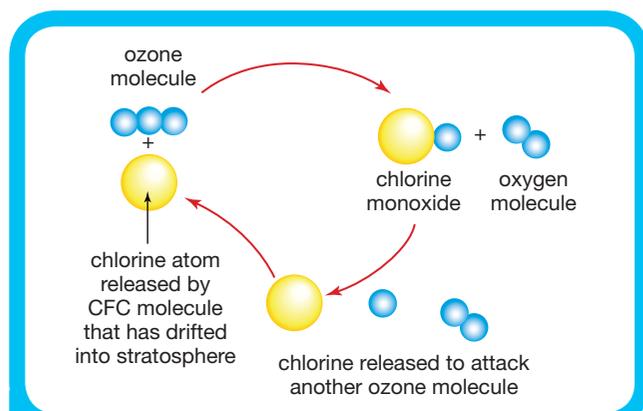


Fig 6.2.3 Chlorine atoms continue a cycle of ozone destruction.

Other ozone attackers

CFCs are not the only ozone destroyers.

- Nitrogen oxides also speed up ozone destruction. These gases are produced when jet aircraft engines burn fuel. Supersonic aircraft fly higher and inject these gases directly into the stratosphere.
- The space shuttle releases ozone-attacking hydrogen chloride when its boosters fire during launch. Each launch releases 68 tonnes of hydrogen chloride gas (gaseous hydrochloric acid!) into the atmosphere.
- Volcanoes also release hydrogen chloride.
- Lightning causes reactions that split ozone molecules.

The hole story

The 'thickness' of the ozone layer is measured in Dobson units, or DU. Remember that the ozone is spread throughout a region of the stratosphere, so the term 'thickness' is somewhat misleading. In considering ozone layer 'thickness', we imagine all the ozone brought down to ground level and concentrated into a pure ozone layer. One hundred Dobson units corresponds to a layer of pure ozone one millimetre thick at ground level.

Remote-sensing satellites collect data on the amount of ozone in the stratosphere. If all the ozone molecules in the ozone layer were brought to ground level, it would form a layer averaging only 500 DU (5 mm) thick.

A value of less than 220 DU is considered to be an ozone 'hole'. The ozone hole situated over Antarctica was discovered by British scientist Dr Joseph Farman in 1985. The Antarctic ozone hole appears at around the end of winter in August each year, and is most pronounced by the end of October, when the ice breaks after the Antarctic winter. At this time chlorine is very effective at breaking down ozone molecules. In November, winds carry ozone-rich air from other regions over the Antarctic, repairing the hole, but leaving lower ozone levels over Australia and New Zealand.

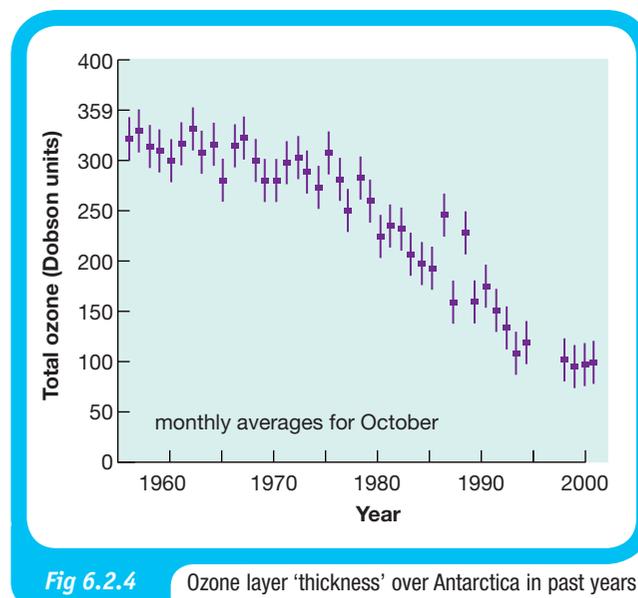


Fig 6.2.4 Ozone layer 'thickness' over Antarctica in past years

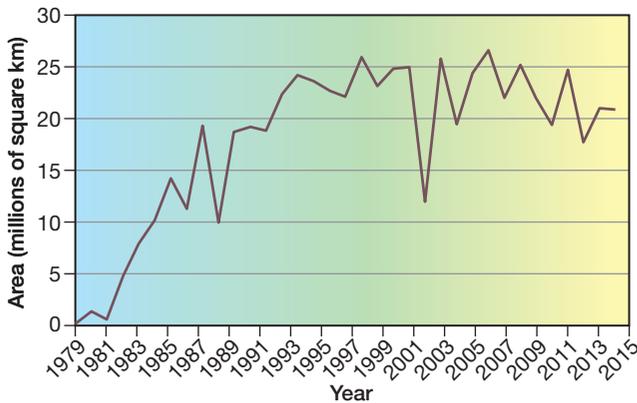


Fig 6.2.5 The size of the ozone 'hole' between 1979 and 2014

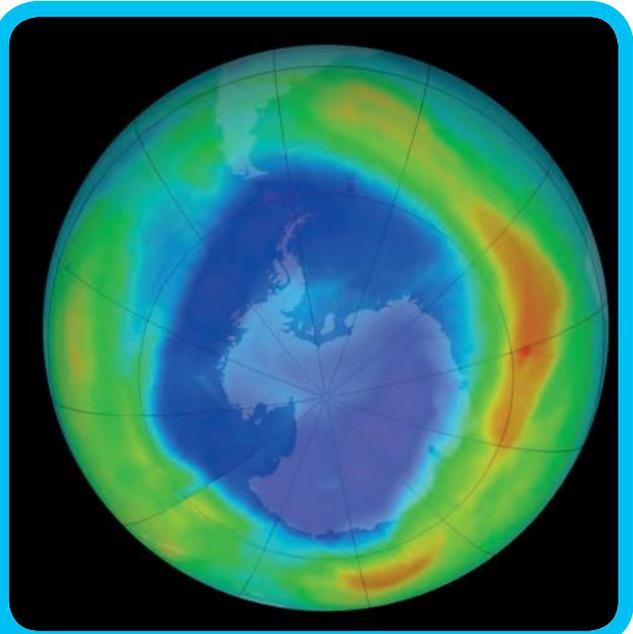


Fig 6.2.6 A NASA satellite image of the ozone 'hole', taken on 4 September 2013. Blue denotes regions of low ozone concentration.

The future

One hundred nations agreed in the Montreal Protocol of 1987 to either stop manufacture of, or limit their use of, CFCs by 2000 or earlier. Unfortunately, many developing countries still use CFCs, as they are cheap and easy to make. However, there is some evidence that the reduction in the use of CFCs is starting to have an effect.

Recent monitoring has indicated that the ozone hole is now not as big as the record hole in September 2006. It is hoped that international cooperation to repair the damage is working.

6.2 [Questions]

UNIT

Checkpoint

What is ozone?

- 1 State where ozone can be found in the atmosphere.
- 2 Draw a diagram to demonstrate the difference between oxygen and ozone.
- 3 List two physical properties of ozone.
- 4 Outline the harmful effects of ozone.

The ozone layer

- 5 Use a diagram to demonstrate how ozone is formed in the upper atmosphere.
- 6 Define 'ozone layer'.

Chlorofluorocarbons

- 7 List three properties of CFCs.

- 8 Use a diagram to describe how CFCs destroy ozone.
- 9 List four ways in which CFCs have been used.
- 10 Identify the element in CFCs that does the actual damage to ozone.
- 11 Apart from CFCs, describe other ways in which ozone can be destroyed.

The hole story

- 12 State the name and abbreviation of the units for measuring ozone.
- 13 Explain how much ozone is described by 100 DU.
- 14 Identify the level of ozone measurement that indicates an ozone 'hole'.
- 15 The Antarctic ozone hole varies throughout the year. Identify the time of year when the ozone layer is the thinnest.



Think

- 16 List some harmful and beneficial effects of UV radiation.
- 17 A thinner ozone layer could affect food supplies. Suggest reasons why.
- 18 The term 'ozone hole' is not entirely correct. Explain why.
- 19 The ozone hole is not directly over Solomon Islands but we are still concerned about it. Discuss why.
- 20 High levels of UV can reduce the number of plankton (microscopic plants and animals in the oceans). Predict some possible consequences of this.
- 21 Identify a way of telling whether a spray can is ozone-friendly.

Analyse

- 22 Use Figure 6.2.5 to identify:
 - a the largest area of the ozone hole recorded
 - b when this record-sized hole occurred.
- 23 Explain why there are short lines extending on each side of the points on the graph in Figure 6.2.4.

[Extension]**Investigate**

- 1
 - a Investigate specific types of eye damage caused by UV radiation.
 - b Produce a brochure aimed at increasing the public's awareness of the risk of UV exposure to the eyes.

Action

- 2
 - a Construct and report on a survey of chemicals used as propellants in spray cans.
 - b Assess whether the ozone layer is at risk from these products.
 - c Ozone-friendly chemicals are being used in place of CFCs. Investigate two of these chemicals and evaluate their effectiveness.

UNIT 6.3

Nuclear radiation

Introduction

Sunlight is a form of radiation, as are radio waves. The term 'radiation' refers to energy in the form of fast-moving particles or electromagnetic waves. Nuclear radiation is radiation that comes from the nucleus of an atom. Controlled nuclear radiation can be very useful. It can treat medical conditions, such as some cancers, and can be used to generate electricity. It can also be extremely dangerous if it leaks accidentally from nuclear waste from medical use or from power plants.

Radiation and radioactivity

There are ninety-two protons in the nuclei of uranium atoms. They are all positively charged and each one repels the others. Logic says they should fly apart and the nucleus should disintegrate into ninety-two parts. But this doesn't happen. Protons in a nucleus stay together because of a powerful force, called the nuclear force. Nuclear force acts between all particles in a nucleus and is more than sufficient to hold the nuclei of small atoms together. When a nucleus becomes very large, however, the nuclear force might not be strong enough to hold the nucleus together and bits might break off. In doing so, the nucleus gets smaller and more stable. Nuclear radiation is the energy and the particles that are released from the nucleus in its break-up. An element whose atoms emit nuclear radiation is said to be radioactive. Uranium and most of the elements after it in the periodic table (atoms of higher atomic number) are radioactive.

Atoms and isotopes

Atoms with the same number of protons belong to the same element. Isotopes are atoms of the same element that have different numbers of neutrons in their nuclei.

For example, all lithium atoms have three protons. Ninety-three per cent of all lithium atoms have three neutrons. The rest have four. Hence lithium has two isotopes, which we can write as:

MASS NUMBER = number of protons + neutrons



ATOMIC NUMBER = number of protons

Uranium atoms always have ninety-two protons. The most common isotope has 146 neutrons, a less common isotope has 143 neutrons and a few have 142 neutrons. Hence we can write them as:



Not surprisingly, a radioactive isotope is called a radioisotope. When referring to a radioisotope, we often give just its mass number. Because all uranium atoms are radioactive, the radioisotopes of uranium could be written as uranium-234, uranium-235 and uranium-238. Actinium, astatine, carbon, francium, thorium, protactinium, polonium, radon and radium are all radioactive elements and, like uranium, occur naturally. Many synthetic or 'artificial' elements are also radioactive.

Hydrogen has three isotopes. Approximately 99 per cent is 'normal' (stable and not radioactive), 1 per cent is deuterium (stable but toxic in high doses) and a few are tritium. Tritium is unstable—it is a radioisotope.

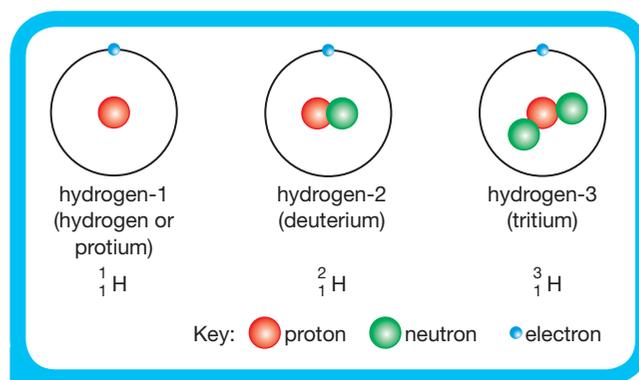


Fig 6.3.1 Three isotopes of hydrogen

Marie and Pierre Curie

Polish-born Marie Curie and her French-born husband Pierre Curie are famous for their pioneering work with uranium and other radiation-emitting elements. Marie Curie was first to use the term 'radioactivity'. The couple shared the 1903 Nobel Prize for physics with Henri Becquerel. In 1911, Marie Curie became the first person to win two Nobel Prizes when she was awarded the Nobel Prize for chemistry for her discovery of radium and polonium. Pierre Curie was killed in an accident with a horse-drawn vehicle in 1906 and Marie died of leukaemia in 1934, probably as a result of working so closely with radioisotopes for most of her life.



Fig 6.3.2 Marie Curie

Three types of nuclear radiation

When a radioisotope emits radiation, it usually transforms into another element. We say it has undergone radioactive decay. There are three main types of radioactive decay, each emitting a different type of radiation:

- alpha radiation
- beta radiation
- gamma radiation.

Alpha radiation

One way in which radioactive nuclei can get smaller and more stable is by throwing out a cluster of two protons and two neutrons. This cluster is known as an alpha particle (denoted by α), but is really just a helium nucleus, ${}^4_2\text{He}$.

Uranium-238 emits an alpha particle and in doing so decays into thorium-234, as shown in Figure 6.3.3.

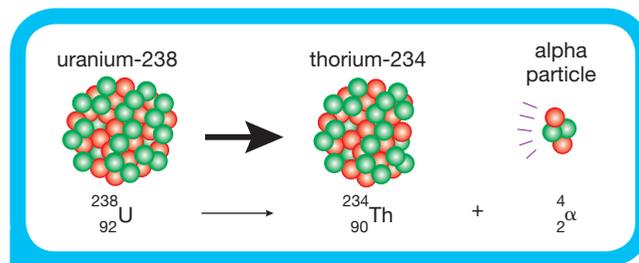


Fig 6.3.3 Alpha decay

The equation is balanced, with the same number of protons and neutrons on each side. You can check by adding up the mass numbers on the product side of the reaction: they add up to 238, the same as we started with. Likewise, the atomic numbers add up to 92.

Alpha particles move at speeds of up to one-tenth the speed of light. Alpha decay can be thought of as nuclear fission, since a parent nucleus splits into two daughter nuclei.

Beta radiation

When there is an imbalance of neutrons and protons in a nucleus, a neutron may change into a proton and an electron. The newly created electron is called a beta particle (denoted by β), which is then emitted from the nucleus.

Carbon-14 is a radioisotope that decays into a new element, nitrogen, by emitting a beta particle from its nucleus. We can represent this decay as in Figure 6.3.4.

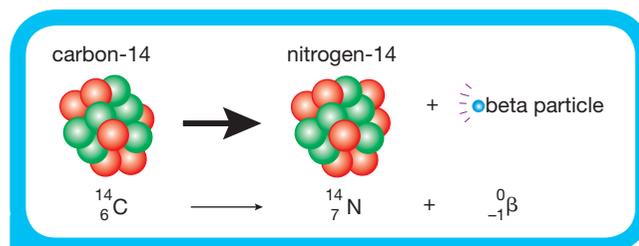


Fig 6.3.4 Beta decay

An extra proton has been created from a neutron, so the atomic number of the atom increases from 6 to 7, meaning that a new element has been formed. The mass number of the beta particle is zero since it really is just an electron, and they have negligible mass. The -1 at the bottom indicates the negative charge on a beta particle. Once again, the atomic numbers give the same total ($6 = 7 + -1$).

Beta particles move at speeds of up to nine-tenths the speed of light and so pass through materials better than alpha particles.

Gamma radiation

Both alpha and beta radiation consist of particles. Earlier it was mentioned that radiation may also be in the form of electromagnetic waves or rays. Sometimes when an alpha particle or beta particle is emitted from a nucleus, the new nucleus is still unstable, and emits extra energy in the form of a gamma ray to become more stable. A gamma ray (denoted by γ) is a burst of high-frequency electromagnetic radiation that has no mass or charge. Gamma rays are more powerful than X-rays.

The beta decay of iodine-131 is accompanied by gamma emission, as shown in Figure 6.3.5.

Like all electromagnetic radiation, gamma rays move at the speed of light (300 000 km/s). Their incredible speed means they penetrate materials even more than beta particles.

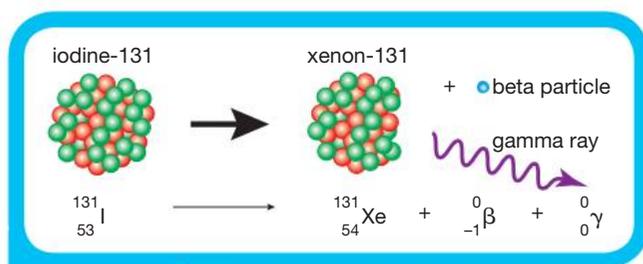


Fig 6.3.5 Gamma decay

Half-life

The time required for half of the atoms in any given quantity of a radioactive isotope to decay is the half-life of that isotope. Each particular isotope has its own half-life.

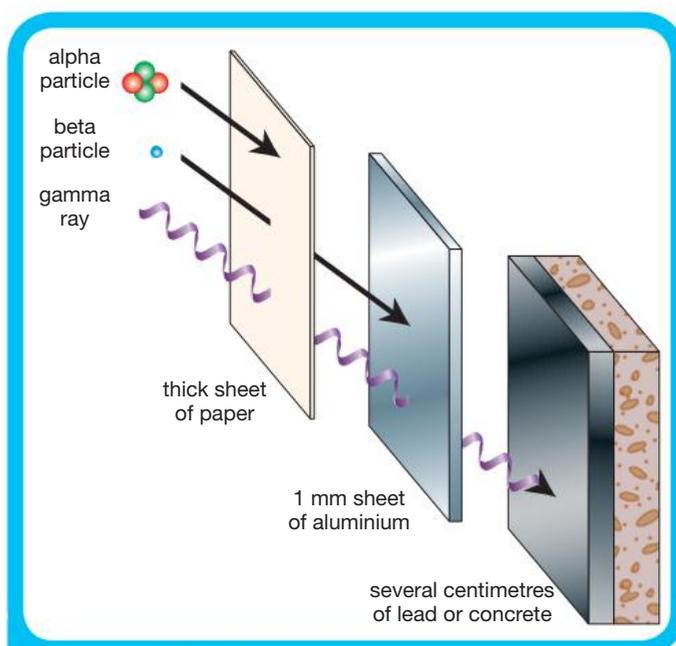


Fig 6.3.6

The penetration abilities of alpha, beta and gamma radiation. Alpha particles are stopped by a thick sheet of paper or human skin; beta particles are stopped by a thin sheet of aluminium; and most gamma rays are stopped by a thick layer of lead or concrete, though some still get through.

Some common radioisotopes and their half-lives

Radioisotope	Half-life
Radon-222	4 days
Iodine-131	8 days
Cobalt-60	5.3 years
Americium-241	460 years
Carbon-14	5730 years
Plutonium-239	24 000 years
Uranium-238	4.5 million years

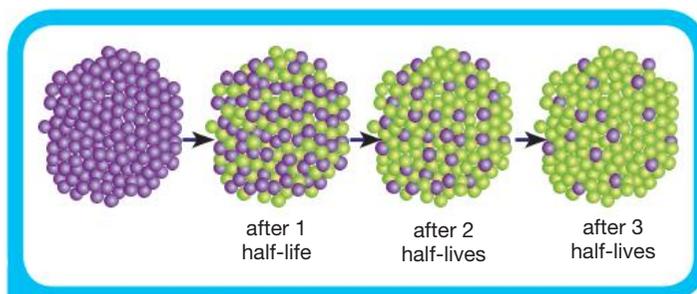


Fig 6.3.7

The number of atoms of a radioactive element in a sample halves after each half-life. How many radioactive atoms would you expect to remain after one more half-life?

A 1 kg sample of pure uranium-238 would decay over time to leave the following amounts:

Time	Mass of U-238 in sample
0 years	1 kg
4.5 million years	500 g
9 million years	250 g
13.5 million years	125 g
18 million years	62.5 g

Sources of nuclear radiation

Nuclear radiation may be produced artificially by bombarding atoms with neutrons or other subatomic particles. Most radiation we receive comes from natural sources, however. The Earth is continually being struck by solar radiation and cosmic radiation produced, for example, by collapsing stars. Terrestrial radiation originates from substances in the Earth's crust. The decay of natural underground uranium produces radioactive radon gas, which we inhale in the air we breathe.

Effects of radiation

Alpha, beta and gamma radiation are sometimes called ionising radiation because of their ability to ionise (knock electrons off) atoms or molecules, causing them to become charged. Charged atoms or molecules are called ions. Alpha particles have high ionising ability, while beta and gamma radiation have low ionising ability. Because ions attract other atoms and molecules, they are more likely to become involved in chemical reactions. If these radiations hit body cells, they may cause chemical reactions that can:

- destroy cells—this may appear as a 'burn'. Cells on that site may not be replaced
- cause abnormal cell growth—this may appear as a tumour or cancer.

Measuring radiation

Nuclear radiation may be detected using a Geiger counter. Gas molecules within a tube are ionised by any radiation that enters. The resulting ions produce a pulse of electrical current that is fed to a small speaker and counter. The speaker makes a clicking sound with each pulse of current.

People working in areas of high radiation levels, such as at nuclear facilities or medical staff, wear special detectors called dosimeters.

Radiation by source

Source	Approximate percentage of annual radiation received
Terrestrial (from natural radioactive underground deposits)	75%
Solar and cosmic (from space)	13%
Medical (from medical procedures and X-rays)	10%
Manufactured (from burning coal, electromagnetic devices, fallout from weapons testing)	2%



Fig 6.3.8 A researcher using a Geiger counter to monitor radiation levels

There are several units for measuring nuclear radiation doses. One of the main units is sieverts (Sv). The table below refers to millionths of a sievert, or microsieverts (μSv).

Biological effects of nuclear radiation

Dose (μSv)	Short-term effects	Long-term effects
Less than 10 000	None	Possible effect on unborn babies
10 000 to 100 000	None	Unborn babies likely to develop leukaemia
100 000 to 500 000	Cell damage	Increased likelihood of cancer (including leukaemia)
500 000 to 1 000 000	Radiation sickness—symptoms include nausea, vomiting, diarrhoea, hair loss, internal bleeding; white blood cell count drops	Greater likelihood of developing cancer
1 000 000 to 8 000 000	Severe radiation sickness, possible death within a month	Very high probability of developing cancer

Note: sievert represents the equivalent biological effect of the deposit of a joule of radiation energy in a kilogram of human tissue.

Uses of nuclear radiation

Nuclear medicine

Nuclear radiation is not always bad. Radioisotopes can cause cancers but are also used in nuclear medicine to diagnose and treat them. Radiotherapy involves directing high, localised doses of radiation to cancer sites by using an external focused beam or a surgical implant, or by the patient swallowing a radioactive medicine. Rapidly dividing cells, such as cancerous cells, are more sensitive to nuclear radiation than other cells—they self-destruct if their DNA is damaged. Unfortunately, some nearby healthy cells are also killed, leading to short-term illness and side-effects.

Nuclear medicines are also used to give images of internal organs, blood vessels and bones. Gamma-emitting radioactive tracers are swallowed or injected and tend to collect in particular parts of the body. They are then detected by a gamma ray camera placed outside the body. The gamma rays coming from inside the body are then converted to an image. For example, iodine-123 concentrates in the thyroid gland and so may be used to help diagnose thyroid conditions.

Industrial applications

Nuclear radiation can be added to liquids or gases flowing in pipes to trace leaks or check for fractures. The thickness of metal or rubber sheets can be verified by measuring the amount of radiation transmitted through the material.

Carbon dating

All living things contain radioactive carbon-14. It is continually decaying but is constantly being replenished. While the organism is alive the percentage of carbon-14 it contains will remain constant.

When an organism dies, the amount of carbon-14 reduces due to its continuous beta decay into nitrogen-14. In contrast, the amount of normal non-radioactive carbon (carbon-12) stays constant. The approximate age of once-living matter can be determined by comparing the amounts of both types of carbon in it and then using a graph such as the one shown in Figure 6.3.10.

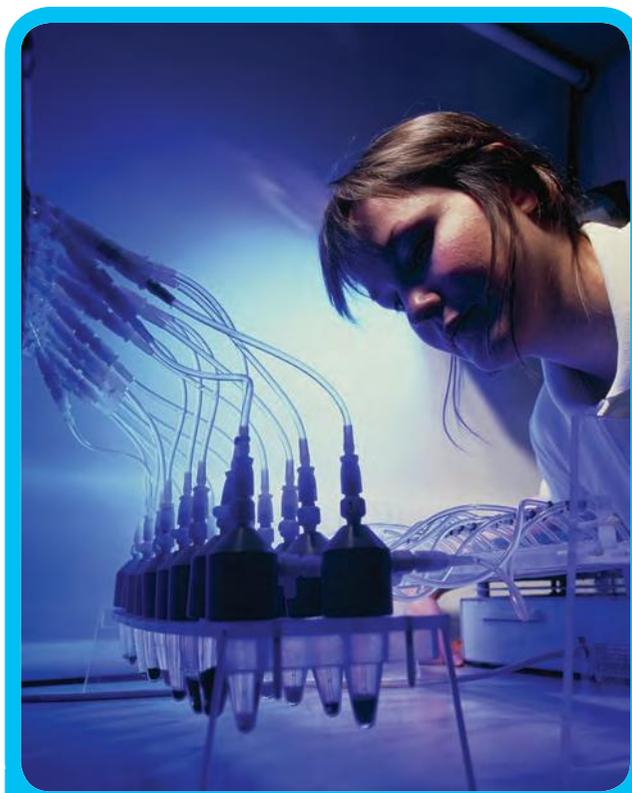


Fig 6.3.9 Samples of bone being prepared for radiocarbon dating

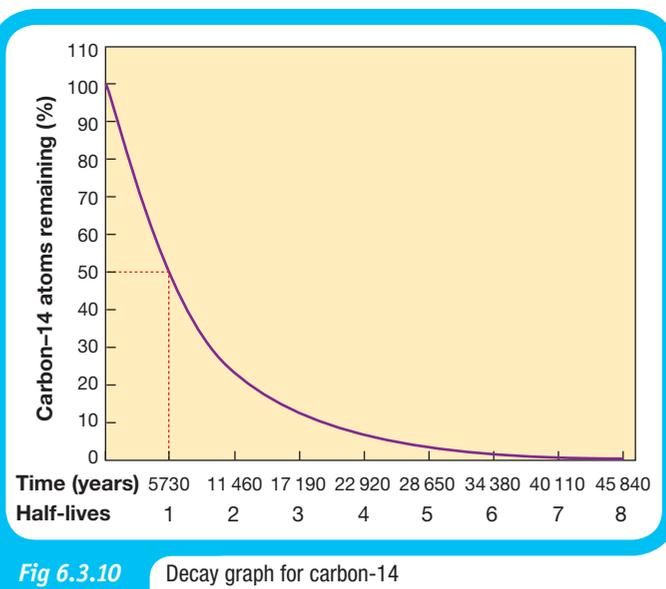


Fig 6.3.10 Decay graph for carbon-14

Dirty bombs

A dirty bomb is not a traditional nuclear bomb. It is basically any bomb that has radioactive material such as nuclear waste in it. This radioactive material is spread as very fine particles across large areas when the bomb explodes, floating in the air and contaminating water and food. It would be impossible to clean up the radioactive material and it could cause contamination problems for hundreds of years. It has been suggested that terrorist organisations could use dirty bombs and therefore it is important that radioactive waste is tightly controlled to ensure it does not fall into the wrong hands.

Other uses

Food that has been exposed to gamma radiation lasts much longer than normal, without becoming

radioactive itself. Bacteria and fungi are killed by the radiation, but vitamins may also be destroyed and new chemicals might be created within the food. For this reason, many consumers are uncomfortable with the idea of food irradiation.

Nuclear radiation is also used to sterilise medical and surgical equipment. Needles used by diabetics are sterilised in this way.

Radioisotopes can be injected into or fed to animals in order to trace their movement using radiation detectors, or to trace the movement of nutrients through the food chain.

Fertilisers with added radioisotopes are used to study the uptake of nutrients by crops.

Radioactive material left over from nuclear power generation is used to make nuclear bombs and ammunition that can pierce the heavy armour of tanks.

6.3 [Questions]

Checkpoint

Radiation and radioactivity

- Copy and modify the following statement so it is correct.
Radiation can be fast-moving _____ or electromagnetic _____.
- State the type of force that acts on particles in the nucleus of an atom to hold them together.

Atoms and isotopes

- Define 'radioisotope'.
- List four radioactive elements.

Three types of nuclear radiation

- List the three main types of radiation.
- Identify the type of nuclear radiation that:
 - is the same as in a helium nucleus
 - can pass through paper but not aluminium
 - is not made of particles
 - requires the conversion of a neutron into a proton and an electron
 - is the product of nuclear fission.
- Contrast the speeds and penetrating abilities of the three radiation types.

Half-life

- Explain the meaning of 'half-life'.

- Iodine-131 has a half-life of eight days. Calculate the amount left from a 2 kg sample after:
 - eight days
 - sixteen days
 - twenty-four days.

Sources of nuclear radiation

- List two natural ways in which radiation is produced.
- Radon gas is present in our atmosphere. Outline how it is produced.

Effects of radiation

- Explain why ions produced by radiation are more likely to affect our cells than other atoms.
- Nuclear radiation may be detected in several ways. Describe two of these.

Uses of nuclear radiation

- List two uses of nuclear radiation in industry.
- State an advantage and a disadvantage of food irradiation.
- Describe what is meant by a 'dirty bomb'.

Think

- Explain why radiotherapy harms cancer cells more than healthy cells.
- Outline how nuclear radiation is used to obtain images of internal organs.



Analyse

- 19 Would an alpha particle emitter be suitable for measuring the thickness of cardboard in a packaging manufacturing plant? Explain your answer.
- 20 Propose two reasons why alpha particles are never injected for medical diagnosis.
- 21 Propose a reason why hair cells are often damaged during radiation therapy.
- 22 In the Gulf War, ammunition made of depleted uranium was used to pierce tanks. Burning uranium from such ammunition forms tiny particles that may be inhaled. Explain why this is of concern even today, more than 10 years after the war.
- 23 Explain why young children are more likely to be affected by radiation doses than adults.

Skills

- 24 Modify the following nuclear reactions so that they are complete.
 - a ${}_{84}^{218}\text{Po} \longrightarrow \text{--- Pb} + \frac{4}{2}\alpha$
 - b ${}_{11}^{24}\text{Na} \longrightarrow \text{--- Mg} + {}_{-1}^0\beta$
 - c ${}_{54}^{133}\text{Xe} \longrightarrow \text{--- Xe} + \gamma$
 - d ${}_{26}^{59}\text{Fe} \longrightarrow \text{--- Co} + {}_{-1}^0\beta + \gamma$
- 25 Calculate the fraction of a sample of pure radon-222 that would remain after twelve days.
- 26 A fossil is found to contain one-sixteenth of the amount of carbon-14 of a living specimen. Calculate the age of the fossil.

[Extension]

Investigate

- 1 There are many units for measuring nuclear radiation including gray, rem, rad, curie, becquerel and roentgen. Explain what one of these really means, and give the abbreviation for the unit.
- 2
 - a The Shroud of Turin has been claimed to be the burial cloth of Jesus Christ. Explain how carbon dating has been used to date the Shroud.
 - b Use this evidence to make your own deduction about the age and authenticity of the Shroud.
- 3
 - a Investigate dirty bombs and how they work.
 - b Discuss whether this type of terrorist attack is likely, supporting your information with evidence.

UNIT 6.4

Climate change and Solomon Islands

Introduction

Climate change will affect different parts of Solomon Islands in different ways. Coastal communities will face different problems from Island communities, and people living in towns will experience different changes from those living in remote rural areas. It is important that we understand how climate change will affect Solomon Islands, so that we can begin to plan for the future.

Effects of climate change in Solomon Islands

Sea-level rise

Low-lying communities in Solomon Islands are very vulnerable to sea-level rise. Scientists predict that the sea level may rise by as much as one metre by 2100. As the sea level rises, problems such as erosion become worse, possibly causing damage to roads, houses, gravesites and other infrastructure.



Fig 6.4.1

The frequency of extreme high tide events is increasing in places such as Roviana Lagoon in Western Province.

Saltwater intrusion

Saltwater intrusion is a serious problem for coral islands. As the sea level rises, salt water infiltrates the underground fresh water on these islands, which will mean communities have less fresh water and their food gardens will be affected.

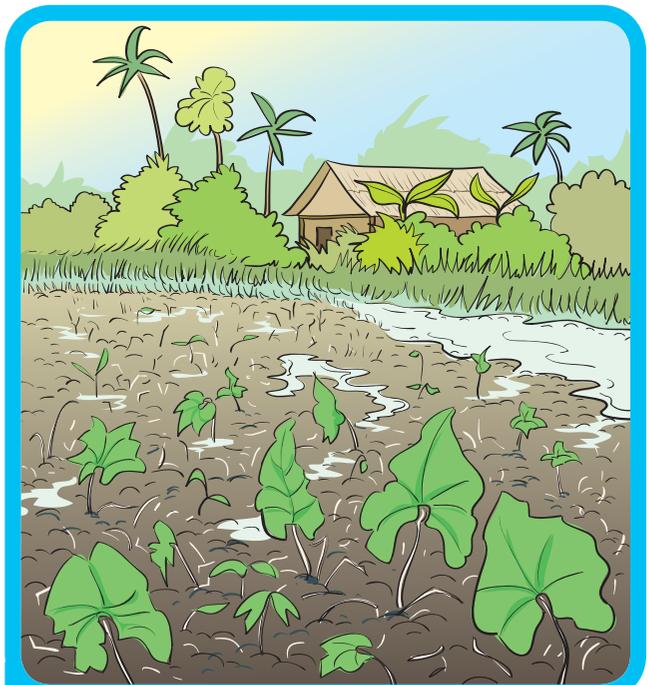


Fig 6.4.2

Saltwater intrusion is already threatening food crops in Solomon Islands, especially in low-lying coastal areas of the main islands and atolls such as Ontong Java.

Coastal erosion

Coastal erosion is already a problem for many coastal communities and it is expected to worsen with sea-level rise and an increase in extreme weather events such as cyclones. Erosion happens when the sea rises higher and takes away the sand from the beach.

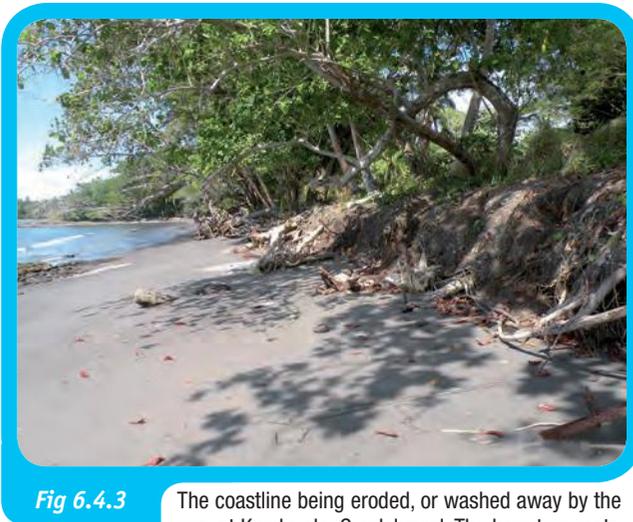


Fig 6.4.3 The coastline being eroded, or washed away by the sea, at Kondovele, Guadalcanal. The bare tree roots indicate where the sea has washed away the soil.



Fig 6.4.4 Growing local crops above the ground to avoid saltwater in Lau Lagoon, Malaita Province

How we can adapt to climate change

Adaptation to climate change is about finding ways for people to adjust to the environmental changes that are happening around them. The aim of adaptation is for the population to survive and flourish in their environment, despite the challenges of climate change. Adaptation initiatives may be undertaken at a national, provincial or community level.

The Solomon Islands Government, under the direction of the Ministry of Environment, Conservation and Meteorology, developed the National Adaptation Programmes of Action (NAPA), which sets out the priority areas for climate change adaptation in Solomon Islands.

While many of the projects and plans that came out of the NAPA process are national or provincial projects, communities can develop their own local adaptation plans.

People think that climate change adaptation is a complex technical process. In fact, communities have been adapting to changes in the environment for centuries.

Agriculture

Food can be grown above the ground to avoid contamination by salt water. Figure 6.4.4 shows slippery cabbage and taro being grown in a canoe garden bed.

Freshwater supplies

In times of drought or when freshwater supplies have been affected by salt water, rainwater tanks can be used to collect fresh water. This is a good adaptation measure for communities on coral atolls who are affected by saltwater intrusion.



Fig 6.4.5 Using water tanks to collect fresh water in Reef Islands, Temotu Province

What we can do to reduce the effects of climate change

There has been an increase in greenhouse gases over the past 100 years because of actions by humans. There are more cars, more factories and more trees being cut down. This is resulting in climate change and both land and sea surface temperatures are expected to be hotter in the future. The process of reducing the greenhouse gases in the atmosphere is called climate change mitigation.

Solomon Islands needs bigger countries with higher greenhouse emissions, like Australia, to agree to a fair, ambitious and legally binding agreement to reduce greenhouse gases in climate change negotiations as part of the United Nations Framework Convention on Climate Change.

While our country contributes only minimal greenhouse gases to the atmosphere, we are initiating measures to enhance our energy efficiency and decrease our reliance on fossil fuels through solar and other renewable energy sources.



Fig 6.4.6 Carbon dioxide emissions from industrial processes

We can reduce the amount of greenhouse gases in the atmosphere by removing them through 'sinks'. While we breathe in oxygen and breathe out carbon dioxide, trees do the opposite: they breathe

in carbon dioxide and breathe out oxygen. Because of this, forests are often called the 'lungs of the Earth'. Mangroves also take out greenhouse gases from the atmosphere. Solomon Islands is covered in forests, so protecting our forests and reforesting cleared areas are important mitigation measures.

Solomon Islands supports the stabilisation of atmospheric greenhouse concentrations at well below 350 parts per million (carbon dioxide equivalent). The current concentration of carbon dioxide is already 387 parts per million. If we do not quickly reduce this level, the consequences of climate change could be disastrous.

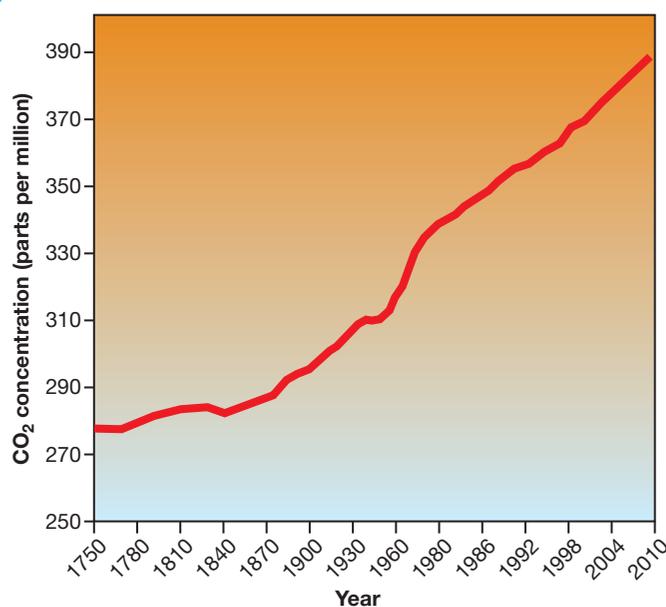


Fig 6.4.7 Global increase in global atmospheric concentration of carbon dioxide (in parts per million) from 1870 to 2000



6.4 [Questions]

UNIT

Checkpoint

Effects of climate change in Solomon Islands

- 1 Explain the term 'climate change'.
- 2 List three effects of climate change in Solomon Islands.

How we can adapt to climate change

- 3 Explain the term 'adaptation' in relation to climate change, giving a local example to support your answer.
- 4 Describe ways in which we can adapt to the effects of climate on:
 - a food production—in low areas of sea-water intrusion
 - b freshwater supply—in drought and when freshwater supplies are affected by salt water.

What we can do to reduce the effects of climate change

- 5 Explain the term 'climate change mitigation'.
- 6 Does our country produce greenhouse gases? Give reasons for your answer.

Think

- 7 Do you think the April 2014 flood, which killed more than 100 people living along the Mataniko River, is an effect of climate change? Explain your answer.

Analyse

- 8 The National Adaptation Programmes of Action (NAPA) of the Ministry of Environment, Conservation and Meteorology (MECM) is setting out the priority areas for climate change adaptation nationwide. Propose an adaptation priority activity for communities living along the eroding shorelines.
- 9 Forests are called the 'lungs of the Earth'. Explain this statement.

[Extension]

Investigate

Produce a brochure aimed at increasing the public's awareness of the importance of:

- reforesting cleared areas
- planting mangrove trees along the shorelines.

Chapter review

[Summary questions]

- 1 List three main greenhouse gases.
- 2 List three ways in which greenhouse gas emissions could be reduced.
- 3 List some possible future consequences of continued global warming.
- 4 Use a diagram to identify the location of the ozone layer.
- 5 Identify an ozone-unfriendly element.

[Thinking questions]

- 6 There are many older refrigerators still in use that contain CFCs. Explain how these CFCs could still end up being released into the atmosphere.
- 7 Propose reasons why it is more difficult for less-developed countries to comply with the Montreal protocol.
- 8 If we are going to decrease our reliance on fossil fuel in Solomon Islands, what alternative options could supply our energy needs?
- 9 The table below shows the activity of a sample of polonium-218 measured at 1-minute intervals for 20 minutes. Construct a graph showing activity (vertical axis) versus time (horizontal axis), and draw a curve of best fit through the data.
 - a How much time did it take for the initial activity to halve?
 - b How long after this did it take for the activity to halve again?

- c How long after this did it take for the activity to halve a third time?
- d Calculate the average of the half-lives determined in parts a, b and c.
- e Predict the count rate at the end of another 30 seconds.

[Interpreting questions]

- 10 Sulfur has an atomic number of 16. Calculate the following numbers for the atom formed after sulfur-35 undergoes beta decay:
 - a atomic number
 - b mass number.
- 11 Radium (atomic number 88, mass number 226) undergoes radioactive decay and changes into radon (atomic number 86, mass number 222). Assess the type of radiation that radium emits.
- 12 Construct a balanced equation for the chemical reaction for Question 11 (the symbol for radium is Ra, and for radon is Rn).
- 13 Xenon-133 has a half-life of 2.3 days. Calculate how much would be left of an 8 gram sample of xenon-133 after almost a week.

Time (mins)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Activity (counts per minute)	200	161	127	115	86	67	56	33	31	22	17	15	13	11	7	7	5	4	3	2	2

More chemical reactions

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

- 1 describe four common chemical reactions that occur around us
- 2 perform the following chemical reactions and write word equations for each reaction performed: burning of wood; burning of paper; metal and oxygen; acids and bases; acids and carbonates
- 3 write balanced chemical equations for simple chemical reactions
- 4 explain how our lives depend on chemical reactions such as cellular respiration and photosynthesis.

- 1 Write chemical formulas for water, carbon dioxide and hydrochloric acid.
- 2 Can matter be created or destroyed? If so, how?
- 3 How can you get two flames from a Bunsen burner?
- 4 Can ethanol be dangerous to your health?



UNIT 7.1

Writing chemical equations

Introduction

Chemical reactions occur around us all the time. A colour change or release of heat are signs that a chemical change is probably taking place. Chemical reactions can be very simple or highly complex. It is easy to record our observations of chemical reactions, but we also need to be able to represent what is going on at a chemical level. The easiest way to represent reactions is to use chemical equations.

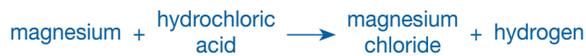
Chemical equations and formulas

Chemical equations take the form:



The substances present at the start of a reaction are called the reactants, and the new substances formed are called the products.

Chemical equations can be written as either word equations or balanced formula equations. For example, the reaction between magnesium and hydrochloric acid may be represented as the word equation:



or as a balanced formula equation:



Whichever way we write it, the reaction probably looks something like that shown in Figure 7.1.1.

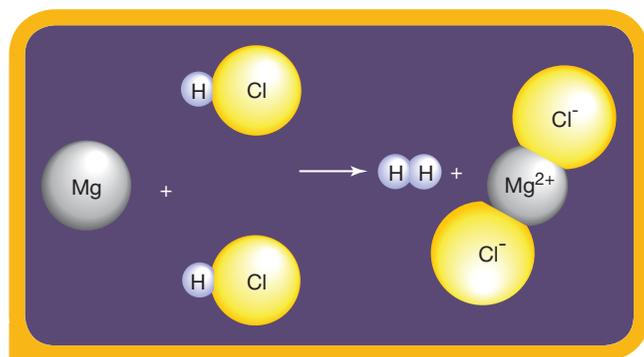


Fig 7.1.1

The reaction between magnesium and hydrochloric acid

Activity 1

Studying a reaction

Aim

To make quantitative observations of the reaction of magnesium metal and an acid

Equipment

Magnesium strips, 1 M sulfuric acid, large beaker, small filter funnel, 100 mL measuring cylinder, cling wrap, gloves, lab coat, safety glasses

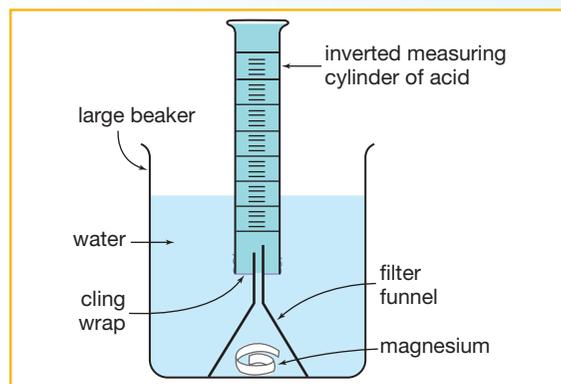


Fig 7.1.2

Method

- 1 Cut a 4 cm long strip of magnesium. Place it under the filter funnel in the beaker.
- 2 Fill the beaker with water until it covers the filter funnel.
- 3 Fill the measuring cylinder with acid and cover the top tightly in cling wrap.
- 4 Carefully invert the measuring cylinder on top of the filter funnel. Let the neck of the filter funnel pierce the cling wrap.
- 5 After the bubbling seems to have stopped, measure the volume of gas collected in the measuring cylinder.

Questions

- 1 Construct a word equation and the balanced formula equation for this reaction. The products are hydrogen, H_2 , and magnesium chloride, MgCl_2 .
- 2 Calculate the volume of hydrogen gas that you would expect to have been produced if you had used instead:
 - a an 8 cm strip of magnesium
 - b a 1 cm strip of magnesium.

By now you should be able to write the symbols for many elements and the chemical formulas of many common compounds. You need to be able to write correct chemical formulas, or none of your equations will be correct.

Facts

Here are a few facts you may have forgotten.

General

- An element consists of only one type of atom, for example Fe, O₂ and S₈.
- A compound consists of two or more different atoms, chemically bonded together, for example H₂O, H₂SO₄ and CO₂.
- Ions are charged particles. Positive ions are formed when metal atoms lose electrons, eg Na⁺, Mg²⁺ and Al³⁺. Negative ions are formed when non-metal atoms gain electrons, for example Cl⁻, S²⁻ and N³⁻.
- A polyatomic ion or radical is a charged particle made up of more than one type of atom, for example NH₄⁺, SO₄²⁻ and CO₃²⁻.

Metallic bonding

- The bonding within metals (eg iron (Fe), gold (Au) and calcium (Ca)) is called metallic bonding.
- All metals are solid at 25°C, except mercury (Hg), which is liquid.

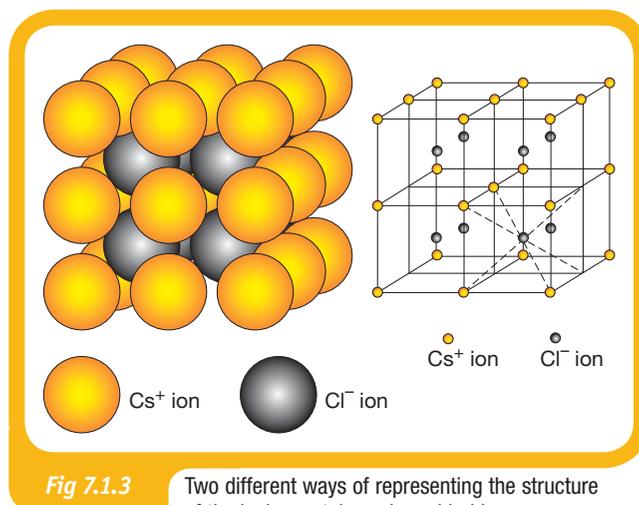
Covalent bonding

- Covalent bonding is the sharing of electrons and occurs only between non-metals and other non-metals, such as carbon (C) and oxygen (O), sulfur (S) and hydrogen (H), nitrogen (N) and fluorine (F).
- A molecule is composed of non-metals and is the smallest number of atoms that exist bonded together in a stable form. Atoms of the noble gases (Group 18) exist by themselves and are called monatomic. For carbon dioxide (CO₂), a molecule consists of one carbon atom and two oxygen atoms covalently bonded together. This molecular formula represents the number and type of atoms in the compound.

- A diatomic molecule consists of two non-metal atoms covalently bonded together. Elements that exist as diatomic molecules are the gases hydrogen (H₂), oxygen (O₂), nitrogen (N₂), fluorine (F₂) and chlorine (Cl₂), the liquid bromine (Br₂), and solid iodine (I₂).

Ionic bonding

- Ionic bonding almost always involves metals combined with non-metals. Ionic compounds are crystalline solids, unless dissolved in water as an aqueous solution.
- The formula of an ionic compound is not a molecular formula, since ionic compounds form large crystal lattices, not molecules. Instead the formula shows the ratio of ions in the crystal. For example, the ionic compound magnesium oxide has the formula MgO. This doesn't mean that one atom of magnesium and one atom of oxygen move around together; it just means that in any sample of magnesium oxide, the ratio of magnesium ions Mg²⁺ to oxide ions O²⁻ is 1:1. A small crystal may contain a thousand magnesium ions and a thousand oxide ions, while a larger crystal may contain a million magnesium ions and a million oxide ions. Either way, the formula is simply MgO.



Sometimes more than one of a polyatomic ion is needed in a formula. This is when brackets are used, for example Fe₂(SO₄)₃, Ca(OH)₂, (NH₄)₂CO₃.

Balancing chemical equations

Let's take another look at the reaction between magnesium and hydrochloric acid.



The small numbers (like the '2' in H_2) are called subscript numbers. These show how many of that type of atom or ion are in the formula. If there is no subscript number after an atom or ion, it means there is only one of that atom or ion in the formula. Brackets with more subscript numbers simply multiply everything inside. Take these examples:

- H_2O has 2 hydrogen (H) atoms and 1 oxygen (O) atom.
- MgCl_2 has 1 magnesium ion (Mg^{2+}) and 2 chloride ions (Cl^-).
- $\text{Ca}(\text{OH})_2$ has 1 calcium ion (Ca^{2+}) and 2 hydroxide ions (OH^-). The brackets indicate that overall there are 2 hydrogen (H) atoms and 2 oxygen (O) atoms.
- $\text{Fe}_2(\text{SO}_4)_3$ has 2 iron (Fe^{3+}) ions and 3 sulfate ions (SO_4^{2-}). The brackets indicate overall that there are 3 sulfur (S) atoms and 12 oxygen (O) atoms.

You cannot change subscript numbers. These numbers are determined by the place of each element in the periodic table. If you change subscript numbers then you are actually creating new chemicals! Water (H_2O), for example, is the safe liquid we drink and wash in. H_2O_2 is also a clear and colourless liquid but is a very strong corrosive bleach called hydrogen peroxide. See what happens if you change the subscript numbers?

The larger numbers in front of formulas indicate or show how much of each chemical is being used and how much is being produced in the reaction. These are the numbers we can change to balance an equation. The Law of Conservation of Matter states that 'matter can be neither created nor destroyed; it can only be changed from one form to another'. This means that there must be the same number of each type of atom on each side of the equation. The atoms are simply being rearranged by the reaction. The unbalanced equation for the above reaction is:



There is one magnesium on each side of the equation, so they are already balanced.

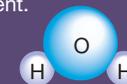
Putting a '2' in front of a formula means two of that species

eg 2HCl means



The smaller subscript numbers are different. They show how many of each type of atom are present.

H_2O represents



CH_4 represents

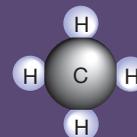


Fig 7.1.4

What do the numbers in chemical equations mean?

However, while there is only one hydrogen atom on the left reactant side, there are two on the right product side. These can be balanced by doubling the amount of HCl we use. A large '2' is added in front of the HCl, giving us two hydrogen atoms on both sides.



This also balances the chlorines. When an equation is balanced, the mass of the products is equal to the mass of the reactants. Nothing has been destroyed and nothing new has been created. All the atoms have just been rearranged. This is known as the Law of Conservation of Mass, and is another way of stating the Law of Conservation of Matter.

Activity 2

Conservation of mass

Aim

To investigate conservation of mass in a chemical reaction

Equipment

Solid calcium carbonate, 0.5 M hydrochloric acid, 200 mL conical flask, balloon, spatula, 100 mL measuring cylinder, lab coat, safety glasses, access to an electronic balance

>>

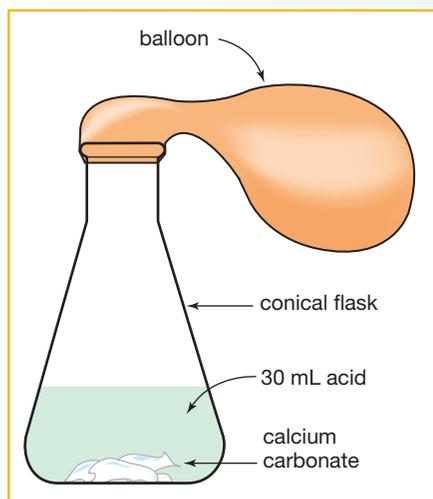


Fig 7.1.5

Method

- 1 Measure out approximately 0.2 g of calcium carbonate into the conical flask.
- 2 Measure out 30 mL of hydrochloric acid into the measuring cylinder.
- 3 Place the conical flask, measuring cylinder and balloon on the balance and record their total weight.
- 4 Pour the acid into the conical flask and quickly place the balloon on top.
- 5 When the reaction is complete, reweigh the flask (with balloon attached) and empty measuring cylinder.

Questions

- 1 Construct a word equation and balanced formula equation for this reaction.
- 2 Assess whether your results agree with the Law of Conservation of Mass.
- 3 If your results do not agree with the law, propose reasons why.

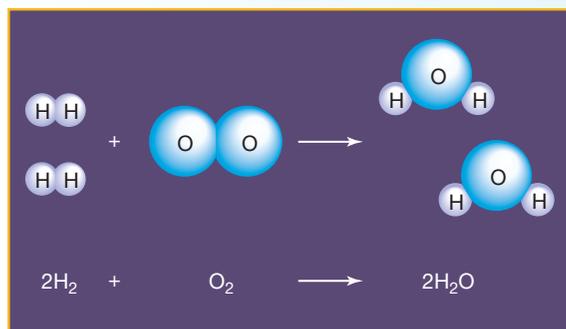


Fig 7.1.6 A balanced equation has the same number and types of atoms on each side of the equation.

The easiest way to balance equations is to follow steps. To show this we will use another example.

Sodium carbonate is added to nitric acid, producing sodium nitrate, water and carbon dioxide.

- Step 1: Write the word equation for this reaction.



- Step 2: Find the formula for each substance in the word equation.
Sodium carbonate is Na_2CO_3 and nitric acid is HNO_3 .

Sodium nitrate is NaNO_3 , water is H_2O and carbon dioxide is CO_2 .

- Step 3: Use these formulas to write an unbalanced formula equation.



- Step 4: Balance each element, one by one, until there are the same numbers of each type of atom on both sides.

Sodium (Na): Two on the left, but only one on the right. Put a big '2' in front of the formula for sodium nitrate (NaNO_3):



Carbon (C): One on each side. No balancing required.

Oxygen (O): Six on the left, but nine on the right. Placing a big '2' in front of the formula for nitric acid (HNO_3) solves the problem:



The other way to balance for oxygen would have been to put a '2' in front of the formula for sodium carbonate. This would have solved the oxygen problem, but it would have unbalanced the numbers of sodium and carbon.

Hydrogen (H): There are now two on each side, so no more balancing is required.

- Step 5: Double check the numbers of atoms on each side to make sure your final equation is correct.



Reactant side: 2 Na, 1 C, 9 O, 2 H, 2 N

Product side: 2 Na, 1 C, 9 O, 2 H, 2 N

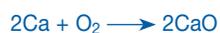
Problem solved! Sometimes a bit of trial and error is required before you successfully balance an equation.



Fig 7.1.7 Normally we think of nitrogen as a gas but it can also be cooled down to make it into a liquid.

Which state are we in?

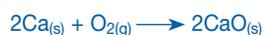
The reaction between calcium and oxygen, forming calcium oxide, may be represented as:



But what form is each chemical in? Are they solid or liquid, a gas or dissolved in water? In order to complete the picture of the reaction, we use more subscripts to indicate the physical states of the reactants and products. These were briefly introduced in Chapter 3 of *Solomon Islands Science Year 8*. The subscripts used are:

- (s) for a solid substance
- (g) for a gas
- (l) for a pure liquid
- (aq) to show that a substance is in aqueous solution (ie dissolved in water).

Including states, the above reaction would look like this:



All the details of the reaction are now clear. Two atoms of solid calcium react with one molecule of gaseous oxygen, producing two solid calcium oxide ion clusters. This gives a lot more information than before. From this point on, try to write all your chemical equations including state subscripts.

Unless told otherwise, you should always write the states of reactants and products as they occur at Standard Laboratory Conditions (SLC)—25°C and ‘normal’ 1 atmosphere pressure.

For example, at SLC, mercury (Hg) is a liquid and sulfur (S) a yellow solid. They react to form mercury sulfide (HgS), the reaction being:

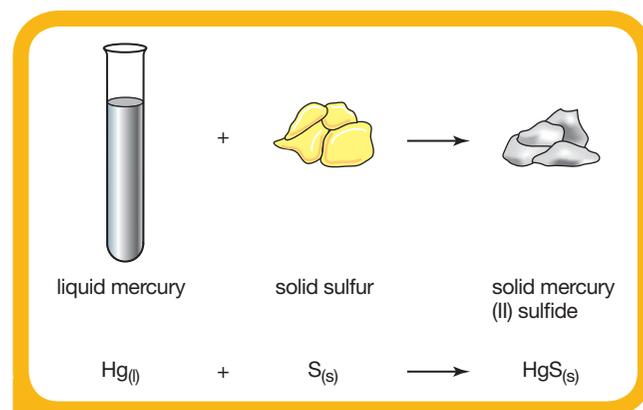
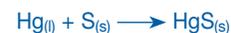


Fig 7.1.8 Compounds have very different physical properties from the elements that made them.



7.1

[Questions]

UNIT

Checkpoint

Equations and formulas

- 1 Name the main parts of a chemical equation.
- 2 State what '+' and '→' mean in chemical equations.
- 3 List the three main types of chemical bonding.

Balancing chemical equations

- 4 State the Law of Conservation of Matter.
- 5 Explain how the Law of Conservation of Mass applies to chemical equations.

Which state are we in?

- 6 State the name and abbreviation used to show the state of matter of chemicals in chemical equations.
- 7 State the Standard Laboratory Conditions of temperature and pressure.

Think

- 8 Compare the use of subscript numbers in chemical equations with the use of larger-sized numbers.
- 9 Contrast $\text{NaCl}_{(s)}$ with $\text{NaCl}_{(aq)}$.
- 10 Identify the molecules in the list below.
 - a CO_2
 - b H_2O
 - c NaCl
 - d Li_2CO_3
 - e N_2
 - f CaO
 - g Ar
- 11 Calcium forms the ion Ca^{2+} and chlorine forms the chloride ion, Cl^- . Identify the correct ionic formula for calcium chloride.
 - A CaCl
 - B Ca_2Cl
 - C CaCl_2
 - D Ca_2Cl_2
- 12 Explain why Na_2SO_4 is not a molecular formula, but H_2O is.
- 13 Identify the equation that is correctly balanced.
 - A $\text{HNO}_3 + \text{MgO} \longrightarrow \text{Mg}(\text{NO}_3)_2 + \text{H}_2\text{O}$
 - B $2\text{HNO}_3 + \text{MgO} \longrightarrow \text{Mg}(\text{NO}_3)_2 + \text{H}_2\text{O}$
 - C $2\text{HNO}_3 + 2\text{MgO} \longrightarrow 2\text{Mg}(\text{NO}_3)_2 + \text{H}_2\text{O}$
 - D $2\text{HNO}_3 + 3\text{MgO} \longrightarrow \text{Mg}(\text{NO}_3)_2 + \text{H}_2\text{O}$
- 14 Identify the equation that is not balanced.
 - A $\text{C}_5\text{H}_{12} + 8\text{O}_2 \longrightarrow \text{CO}_2 + 6\text{H}_2\text{O}$
 - B $\text{Mg} + 2\text{HCl} \longrightarrow \text{MgCl}_2 + \text{H}_2$
 - C $2\text{Zn} + \text{O}_2 \longrightarrow 2\text{ZnO}$
 - D $4\text{Al} + 3\text{O}_2 \longrightarrow 2\text{Al}_2\text{O}_3$

Skills

- 15 At Standard Laboratory Conditions, oxygen exists as $\text{O}_{2(g)}$. Construct the formula for each of these substances at SLC, including the appropriate state: (aq), (l), (s) or (g).
 - a water
 - b carbon dioxide
 - c dilute sulfuric acid
 - d calcium chloride
 - e neon
 - f hydrogen
 - g magnesium carbonate crystals
 - h dilute nitric acid
- 16 For each of the following substances, state:
 - i the chemical formula
 - ii the type of bonding as metallic, ionic or covalent.
 - a magnesium
 - b strontium sulfate
 - c oxygen gas
 - d carbon monoxide
 - e calcium chloride
 - f sulfur dioxide
 - g sodium
 - h argon
- 17 Modify the following equations so that they are balanced.
 - a $\text{P}_4 + \text{O}_2 \longrightarrow \text{P}_2\text{O}_5$
 - b $\text{KClO}_3 \longrightarrow \text{KCl} + \text{O}_2$
 - c $\text{BaO} + \text{HNO}_3 \longrightarrow \text{Ba}(\text{NO}_3)_2 + \text{H}_2\text{O}$
 - d $\text{Pb}_3\text{O}_4 \longrightarrow \text{PbO} + \text{O}_2$
 - e $\text{Pb}(\text{NO}_3)_2 \longrightarrow \text{PbO} + \text{NO}_2 + \text{O}_2$
- 18 Modify these equations so that they are balanced. Include any missing states.
 - a $\text{H}_{2(g)} + \text{O}_{2(g)} \longrightarrow \text{H}_2\text{O}$
 - b $\text{Na} + \text{Cl}_2 \longrightarrow \text{NaCl}_{(s)}$
 - c $\text{CaCO}_{3(s)} \longrightarrow \text{CaO}_{(s)} + \text{O}_2$
 - d $\text{CH}_4 + \text{O}_2 \longrightarrow \text{CO}_2 + \text{H}_2\text{O}_{(g)}$
 - e $\text{HNO}_3 + \text{Ca}_{(s)} \longrightarrow \text{Ca}(\text{NO}_3)_2(aq) + \text{H}_2$
- 19 Jessica heated some bright blue copper(II) nitrate crystals in a test tube. She noticed brown nitrogen dioxide gas being produced. A glowing splint held at the top of the test tube re-lit, proving that oxygen gas was also produced. A fine black solid, copper(II) oxide, was left in the test tube.
 - a State the reactants and the products.
 - b Construct the word equation for this reaction.
 - c Construct the balanced chemical equation, including states.
- 20 For each of the following reactions, construct:
 - i the word equation
 - ii the balanced formula equation, including states.



- a Dilute hydrochloric acid reacts with grains of sodium hydroxide. Water and sodium chloride are the products.
- b Ammonia (NH_3) gas is produced when nitrogen gas is added to hydrogen gas.
- c Carbon monoxide gas combines with oxygen to form carbon dioxide gas.
- d Solid iron combines with chlorine gas to produce solid iron(III) chloride.
- e Dilute sodium hydroxide solution is added to dilute sulfuric acid. Sodium sulfate and water are produced.
- f Ammonium nitrate dissolves in water to produce ammonium and nitrate ions.
- g Hydrochloric acid reacts with calcium metal. A solution of calcium chloride is produced, through which rise bubbles of hydrogen.

Analyse

- 21 David added some dilute hydrochloric acid to some solid limestone (calcium carbonate) in a beaker. When he weighed the products after the bubbling had stopped, he noticed that there had been a reduction in mass. Explain why his results did not seem to agree with the Law of Conservation of Mass.
- 22 Solid sodium reacts with oxygen to produce solid sodium oxide. The following experimental data were obtained for the reaction between sodium and oxygen, producing sodium oxide.

Mass of sodium reacting (grams)	Mass of oxygen reacting (grams)	Mass of sodium oxide produced (grams)
2.00	0.70	2.70
3.00	1.04	4.04
4.00	1.39	5.39

- a Construct a word equation for this reaction.
- b Construct an unbalanced chemical equation for the reaction, then balance it.
- c Modify the equation to include the states of the reactants and products.
- d Explain how the above results prove the Law of Conservation of Mass.

[Extension]

Investigate 'green chemistry'.

- a Describe what is meant by 'green chemistry'.
- b Outline some examples of what is being done in the study of green chemistry.
- c Present your information as a poster to convince the general public that green chemistry is important for society and the environment.

UNIT 7.2

Naming compounds

Introduction

In the early days of chemistry, there was no system for the naming of compounds. Chemists used common names, such as bicarb of soda, quicklime, milk of magnesia, Epsom salts, spirits of salt and laughing gas, to describe compounds. As the number of named compounds increased it was obvious that if such common names were used, confusion would result. In order to solve the problem, a scientist named Lavoisier established the principles for a systematic naming process.

However, there are some familiar compounds that are always referred to by their common names. The systematic name for H_2O , for example, is never used. What would you prefer to call it: dihydrogen monoxide or water?

There are two types of compounds (ionic and covalent) that require naming, and different rules apply for naming each type.

Activity 3

Action of heat on ionic and covalent compounds

Aim

To investigate the effect of heat on various compounds

Equipment

Solid samples of various ionic and covalent compounds that do not produce toxic fumes on heating (eg wax—candle or paraffin), graphite, sodium chloride, potassium nitrate, Bunsen burner, heat mat, metal spatulas, wooden pegs, safety glasses, lab coat

Method

- 1 Draw up a suitable table to record your results. The table below is an example.

Substance	Ionic or covalent	Melts on heating?
Sodium chloride		
Wax		
Potassium nitrate		

- 2 Take a small amount of your first sample on the metal spatula. Hold it in the hottest part of the Bunsen burner flame for no more than 5 seconds.
- 3 Record your results.
- 4 Thoroughly clean the spatula. Ask your teacher for an appropriate or proper disposal method for the sample.
- 5 Repeat steps 2 to 4 for your other samples.

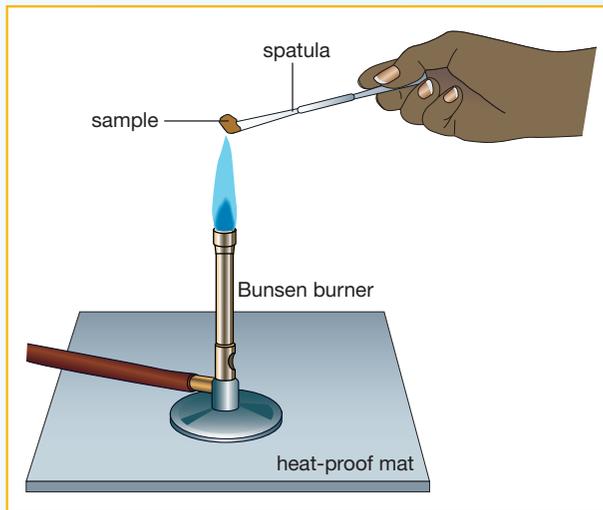


Fig 7.2.1

Questions

- 1 Write a paragraph summarising your results.
- 2 Explain your observations in terms of the strengths of bonds between ions or molecules.
- 3 Assess whether the following substances would have high or low melting points.
 - a sulfur (covalent)
 - b magnesium carbonate (ionic)
 - c iodine (covalent)
 - d lithium nitrate (ionic)

>>

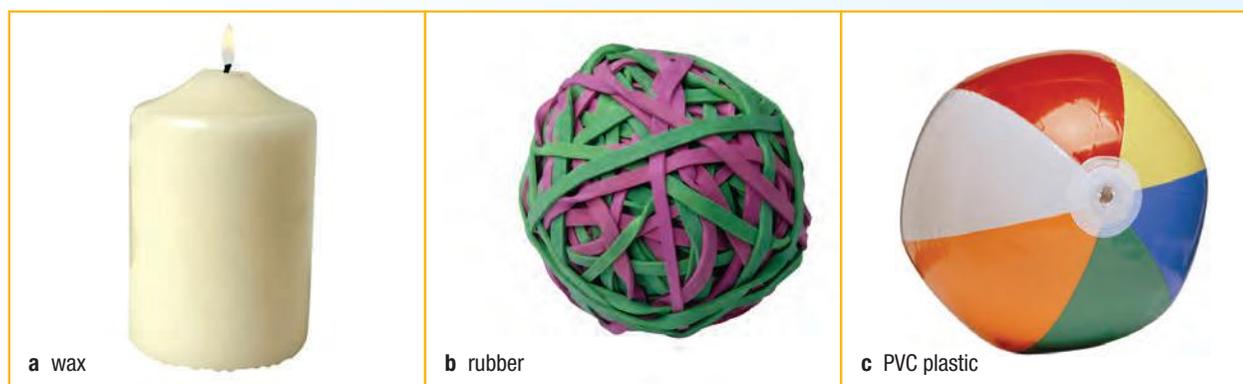


Fig 7.2.2 Some covalent compounds

Ionic compounds

As you learnt earlier, ions form when atoms gain or lose outer-shell electrons. Whereas atoms are neutral, ions are charged. If an atom loses electrons, then its ion is positive (there are more protons than electrons). If an atom gains electrons then the charge of its ion will be negative (there are more electrons than protons). Ionic compounds form when positive and negative ions attract each other and are linked or joined together by electrostatic attraction—the attraction between opposite charges. These strong links are called ionic bonds. Ionic compounds are also called salts. In almost all cases the positive ion is a metal.

When the ions come together to form compounds, they combine in a ratio that gives the compound a total charge of zero. There must be enough negative charges to balance the positive charges and vice versa.

Sodium and chloride ions combine in a 1:1 ratio because sodium ions have a +1 charge and chloride ions have a -1 charge. Add these charges together: $+1 + (-1) = 0$. Thus, one of each ion join to give a compound with a total charge of zero. The formula is NaCl, and the name of this compound is sodium chloride.

To name ionic compounds, simply follow these rules:

- The positive ion is named first and the negative ion second.
- A simple positive ion takes its name from its parent element. For example, Na^+ is called sodium.

- A simple negative ion is named by taking the first part of the parent element's name and adding the suffix *-ide*. Cl^- was originally a chlorine atom but is now an ion and is given the new name chloride. Likewise, Br^- (originally bromine) is called bromide, O^{2-} (originally oxygen) is called oxide and N^{3-} (originally nitrogen) is called nitride.

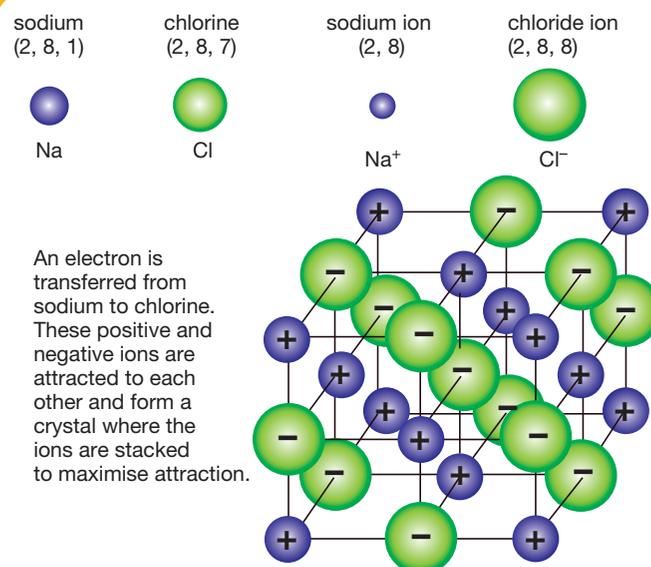


Fig 7.2.3

The formation of sodium chloride

Note that the charges of the ions are not included in compound formulas, but the numbers of each ion (the subscript numbers) are included.

These subscript numbers indicate how many of each ion are in the formula. For instance, MgCl_2 indicates that there is one magnesium ion and two chloride ions in the formula. No charges appear in the overall formula because, once they are balanced, there is zero charge.

Positive ion and electron configuration	Negative ion and electron configuration	Formula	Name
Mg^{2+} (2,8)	Cl^- (2,8,8)	MgCl_2	Magnesium chloride
Na^+ (2,8)	O^{2-} (2,8)	Na_2O	Sodium oxide
Al^{3+} (2,8)	S^{2-} (2,8,8)	Al_2S_3	Aluminium sulfide
Ca^{2+} (2,8,8)	N^{3-} (2,8)	Ca_3N_2	Calcium nitride

Metal ions

You will recall that:

- Metals in Group 1 (the alkali metals) always form ions with a +1 charge.
- Metals in Group 2 (the alkaline earth metals) always form ions with a +2 charge.
- Metals in Group 13 always form ions with a +3 charge.
- Metals in Group 14 often have a +4 charge but can also have a charge of +2. Assume +2 unless you are told otherwise.
- Transition metals have a variety of ionic charges or multiple charges, but most form ions with a +2 charge.

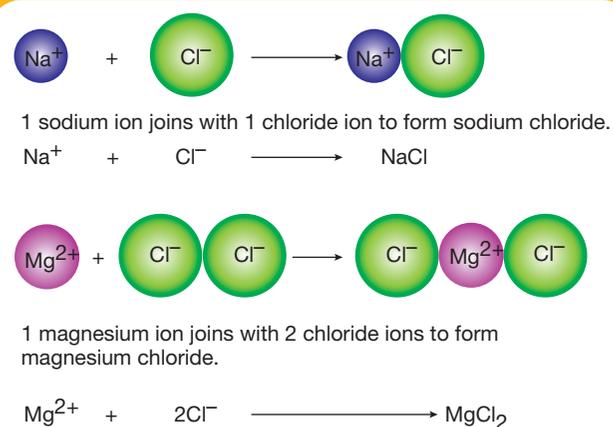


Fig 7.2.4 Formulas of ionic compounds must be balanced so that the net charge on the compound is zero.

- If a metal has more than one common ion, the charge it takes is shown with Roman numerals. For example, copper(I) = Cu^+ , copper(II) = Cu^{2+} , iron(II) = Fe^{2+} , iron(III) = Fe^{3+} .
- The metals in Groups 15 and 16 also have charges that can vary.

Non-metal ions

You will remember that:

- Elements in Group 17 (the halogens) always form ions with a -1 charge.
- Elements in Group 16 always form ions with a -2 charge.
- Elements in Group 15 always form ions with a -3 charge.
- Non-metal elements in Group 14 (carbon and silicon) may form -4 ions.
- Elements in Group 18 (the noble gases) either have full outer electron shells or are happy with eight electrons in their outer shells. They are extremely stable and do not form ions.

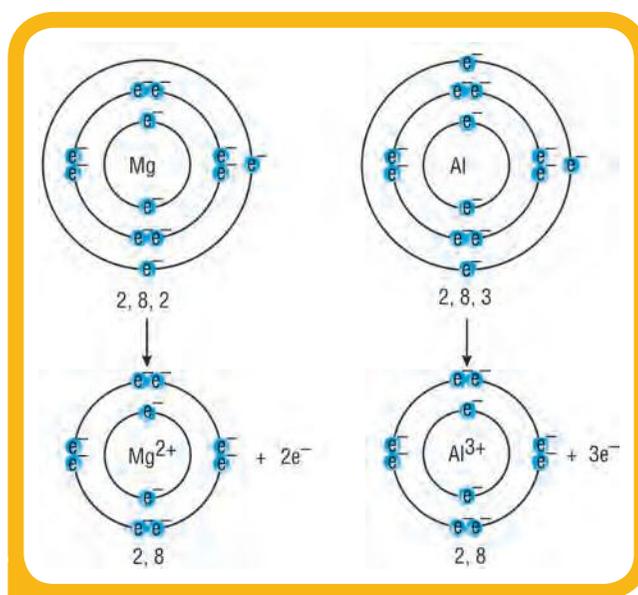


Fig 7.2.5 These atoms lose electrons to get a noble gas electronic configuration.

Polyatomic ions or radicals

Some ions are made up of more than one type of atom and are called polyatomic ions or radicals. These ions have special names. The following table shows some of the more common ones.

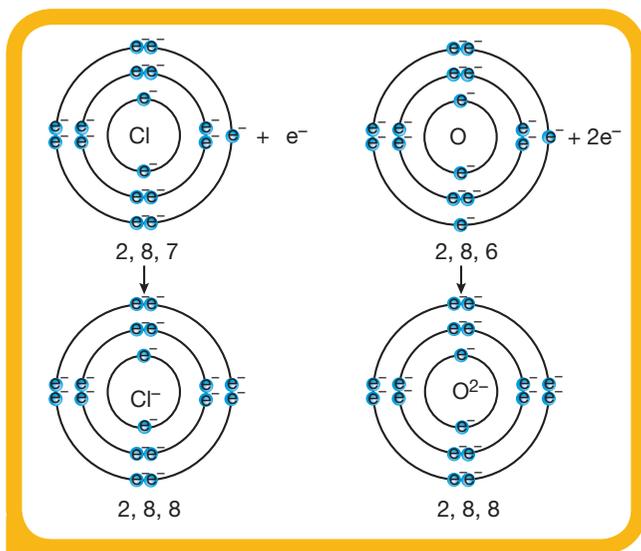


Fig 7.2.6 These atoms gain electrons to get a noble gas electronic configuration.

Ion name	Formula
Hydroxide	OH ⁻
Sulfate	SO ₄ ²⁻
Carbonate	CO ₃ ²⁻
Hydrogen carbonate	HCO ₃ ⁻
Ammonium	NH ₄ ⁺
Nitrate	NO ₃ ⁻

When more than one polyatomic ion is required in a formula, brackets are used. For example, in sodium sulfate, Na₂SO₄, only one sulfate ion is needed to balance the charge so no brackets are needed. For aluminium sulfate, Al₂(SO₄)₃, three sulfate ions are required so brackets are used.

Covalent compounds

Covalent compounds form when atoms bond by sharing outer-shell electrons. They form when non-metals come together. In these bonds, no electrons are transferred. Instead, atoms share pairs of electrons in order to gain a noble gas electron configuration. These links are called covalent bonds. Figure 7.2.7 shows how pairs of electrons are shared in an ammonia (NH₃) molecule.

The naming of covalent compounds is similar to ionic compounds, even though there are no ions present. The following rules apply:

- The first element in the chemical formula is named first, using the element's full name.
- The second element in the formula is named as if it were a negative ion.

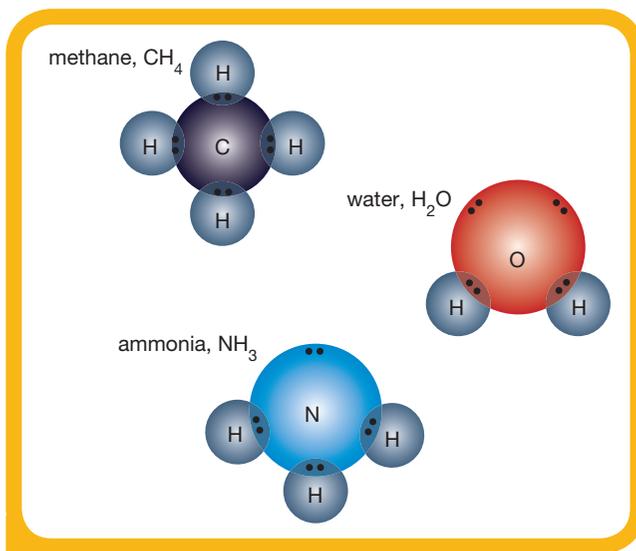


Fig 7.2.7 These covalent compounds show atoms sharing electrons to gain noble gas electronic configurations.

- Prefixes are used to show the numbers of atoms present (see the table below).
- If the first element exists as a single atom, no prefix is used. For example, CO₂ is called carbon dioxide.
- To avoid awkward or bad pronunciation, the final 'o' or 'a' of the prefix is often dropped or left out. For example, CO is called carbon monoxide, not carbon mono-oxide.

Some examples of covalent compounds and their names are:

- CO₂ = carbon dioxide
- CO = carbon monoxide
- N₂O₅ = dinitrogen pentoxide
- CCl₄ = carbon tetrachloride
- NH₃ = ammonia
- CH₄ = carbon tetrahydride (commonly known as methane).

Number of atoms	Prefix
1	no prefix or mono-
2	di-
3	tri-
4	tetra-
5	pent-
6	hex-
7	hept-
8	oct-
9	non-
10	dec-



Fig 7.2.8 Some ionic and covalent compounds that you might know

UNIT 7.2

[Questions]

Checkpoint

Ionic compounds

- 1 Explain what happens when a positive or negative ion is formed.
- 2 Identify what holds the ions together in ionic compounds.
- 3 **a** Define the term 'polyatomic ion'.
b Identify an example of a polyatomic ion, naming the atoms found within it.

Covalent compounds

- 4 Name the following covalent compounds.
a CO_2 **b** N_2O_5 **c** H_2O

Think

- 5 Differentiate between ionic bonding and covalent bonding.
- 6 Construct chemical formulas for:
 - a** sodium bromide
 - b** magnesium sulfide
 - c** calcium fluoride
 - d** lithium nitride.
- 7 Construct formulas for these compounds containing polyatomic ions:
 - a** sodium sulfate
 - b** magnesium hydroxide
 - c** strontium carbonate
 - d** lithium nitrate
 - e** ammonium oxide.

- 8 Construct formulas for the following and classify each as either ionic or covalent compounds:

- a** iron(III) chloride
- b** iron(II) chloride
- c** copper(I) nitrate
- d** oxygen dichloride
- e** copper(II) nitrate.

Analyse

- 9 Calculate the total charge of:
 - a** four sodium ions
 - b** eight manganese(IV) ions
 - c** three nitride ions.
- 10 Explain what would happen if there were no rules for naming chemicals.

[Extension]

Investigate

Find out what kind of atoms are present in:

- a** paper
- b** lime used to chew with betel nut
- c** sugar.

Chapter review

[Summary questions]

- 1 Explain what the Law of Conservation of Mass means with regard to reactants and products.
- 2 Explain the purpose of using a chemical equation.
- 3 Write a chemical equation demonstrating or showing the following features: reactants and products, states of each substance, correctly written formulas, and numbers balancing the equation.
- 4 Define the term 'SLC'.
- 5 State one thing that could make a reaction go faster, besides using a catalyst.
- 6 State the two types of chemical compounds.
- 7 Name the scientist who designed the system for naming chemical compounds.
- 8 Fill in the blanks in the table below.

Substance	Ionic or covalent	Melts on heating?
Sodium chloride		
Wax		

[Thinking questions]

- 9 Which of the following two formulas is a molecular formula: SO_2 or Na_2SO_4 ? Explain your answer.
- 10 Modify the following chemical equations so that they are balanced.
 - a $\text{Al}(\text{OH})_3 + \text{HNO}_3 \longrightarrow \text{H}_2\text{O} + \text{Al}(\text{NO}_3)_3$
 - b $\text{H}_2\text{O} + \text{K} \longrightarrow \text{H}_2 + \text{KOH}$
- 11 Explain how an ion is formed.
- 12 If an atom gains electrons, the charge of its ion will be negative. Explain why.
- 13 Explain how an ionic compound is formed.
- 14 Explain how a covalent compound is formed.
- 15 Use diagrams to show how pairs of electrons are shared in:
 - a a methane (CH_4) molecule
 - b a water (H_2O) molecule
 - c an ammonia (NH_3) molecule.

Mining and energy sources in Solomon Islands

CHAPTER

8

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

- 1 describe the materials in the Earth's crust that produce minerals
- 2 name the ores and minerals found in Solomon Islands
- 3 describe two types of gold-mining methods in Solomon Islands
- 4 state the advantages and disadvantages of each type of mining
- 5 demonstrate important steps in the process of extracting gold, aluminium, iron or nickel from its ore
- 6 state the value of gold exported from Solomon Islands in the years 1998 to 2012
- 7 state how much the government and land owners received from the export of gold from 1998 to 2012
- 8 discuss the negative and positive impacts of mining in Solomon Islands
- 9 explain that gold and other minerals found in Solomon Islands are non-renewable resources
- 10 list the main fossil-fuel-producing countries in the world
- 11 explain that the 'energy crisis' is the situation in which the world's fossil fuel deposits are running out
- 12 describe alternative sources of energy
- 13 describe the sources of nuclear energy
- 14 describe the positive and negative effects of nuclear radiation.

- 1 What is a mineral?
- 2 Differentiate between renewable and non-renewable resources.
- 3 Why can gold be found as a nugget but sodium can't?
- 4 What is the energy crisis?
- 5 Explain what a fossil fuel is.
- 6 What is alternative energy?



UNIT 8.1

Minerals and mining

Introduction

Metals have been used for thousands of years, the first to be used being metals such as gold. Unlike gold, most metals are not found as pure elements, but as compounds of oxygen. They need to be 'released' from their oxygen before they can be used. Gold Ridge in Guadalcanal is the first major gold-mining development for Solomon Islands. There are several minerals in the rocks of Solomon Islands although many may not be present in sufficient concentration or quantity to justify the costs of mining them.

elements, as either nuggets or veins of the metal trapped in rock such as quartz. They just need a little cleaning or the surrounding rock removed. Native elements are so stable and unreactive that they have survived without reacting with the chemicals of the air, soil or water.

Metals in the crust

Metals make up only a quarter of the Earth's crust. Oxygen and silicon make up the rest. The oxygen does not exist as a gas, but is chemically combined with metal atoms as solid oxides.

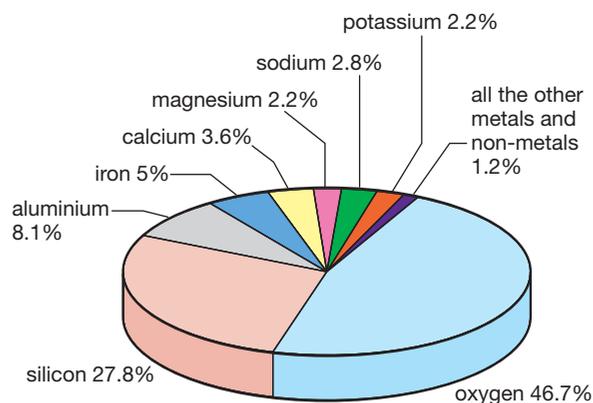


Fig 8.1.1

The percentage abundance of elements in the Earth's crust. Oxygen is by far the most abundant, being combined with metals as oxides or with silicon as silicon dioxide in sand or silicates.

Native elements

Native elements can be either non-metals, like carbon and sulfur, or metals, like silver, platinum, copper and gold. The metals can be found as pure

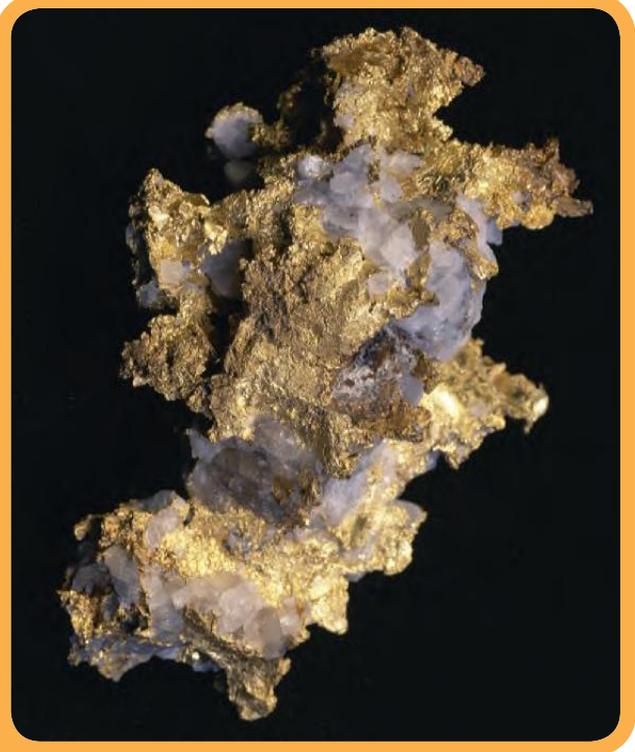


Fig 8.1.2

A vein of pure gold trapped in quartz

Minerals and ores

All other metals are found combined with other elements as compounds.

Minerals are rocks containing large amounts of a particular metal. If there is sufficient metal to make it worth mining, it is called an ore.

Mining produces valuable metals and creates jobs. Sometimes, however, mining is not worth the expense or the negative effects on society and the environment.

All minerals possess a definite chemical structure. They are inorganic compounds, for example quartz (SiO_2) and pyrite (FeS_2). Pyrite is found in association with the gold at Gold Ridge on Guadalcanal.

To be classified as a mineral, the material must occur naturally, be inorganic, exist as a solid at natural temperatures, and have a definite chemical structure. All rocks are made of one or more minerals. Even the grains within very fine-grained sedimentary rocks are made from one or more minerals.

All minerals originate from magma under the Earth's crust and are formed as magma cools. The type of mineral formed depends on the particular composition of the magma and conditions at the time of cooling.

The mining process

Underground mines are used for the mining of deep ores but there are problems of water penetration, possible collapse, venting of poisonous and explosive gases and the provision of fresh air for the miners to be managed.

If the ore is close to the surface, open-cut mining is easier. Soil is removed and the ore is dredged out, creating benches, or steps, that spiral into the hole. These are also used as access roads for trucks to bring the ore to the surface. Open-cut mines cause problems such as unsightliness, pollution of surrounding areas with dust, pooling of water and the destruction of land above the ore. The land has to be repaired after mining ceases.

The useful ore minerals are often mixed with unwanted rocks. After the ore is separated from waste rock, the metal is extracted from the ore.

Concentration of the ore

Impurities and waste called gangue are mined with the ore. The mined material is crushed by rollers or by large steel balls that fill a large rotating drum called a ball mill. Gravity and sieves separate some

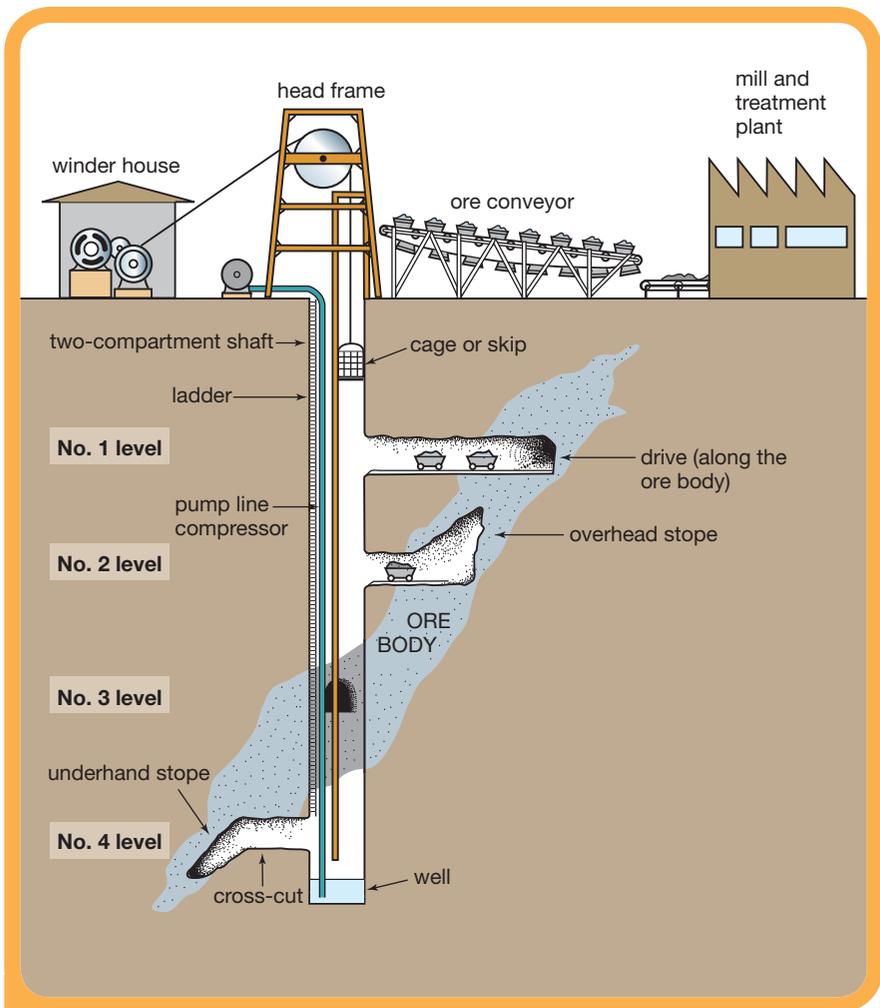


Fig 8.1.3 Structure of an underground mine



Fig 8.1.4 An open-cut mine showing benches and environmental degradation

of the gangue, with the remainder then separated by froth-flotation. In this technique, the crushed ore floats away on a frothy emulsion of oil and water, leaving the gangue behind. The ore is now ready for extraction.

The reactivity series

Metals are extracted from their ores depending on their position in the reactivity series. The reactivity series is a list of metals, in order of reactivity from highest to lowest. When metals react, they lose electrons to form positive ions. Some metals lose their electrons more easily than others. These metals are reactive and are harder to extract. Different extraction techniques are required, depending on the metal's position in the reactivity series.

As we move up the reactivity series:

- the chance of metals reacting with chemicals becomes greater
- the metals become less stable
- there is less chance of finding the metals in their natural state
- the compounds of the metals become more stable and more difficult to break down
- the extraction process becomes more difficult and more expensive.

Extraction

There are two main ways to extract metals from their ores: by electrolysis and by heat.

Extraction by electrolysis

Electrolysis is such a powerful method that it could be used to extract any metal from its ore. It uses a huge amount of electricity, however, and is used only when there is no cheaper method available.

A voltage is applied to a molten sample or solution of the ore and the positive metal ions move to the negative electrode. When it gets there, the ion is forced to take back its outer-shell electrons to form metal atoms that then plate the electrode.

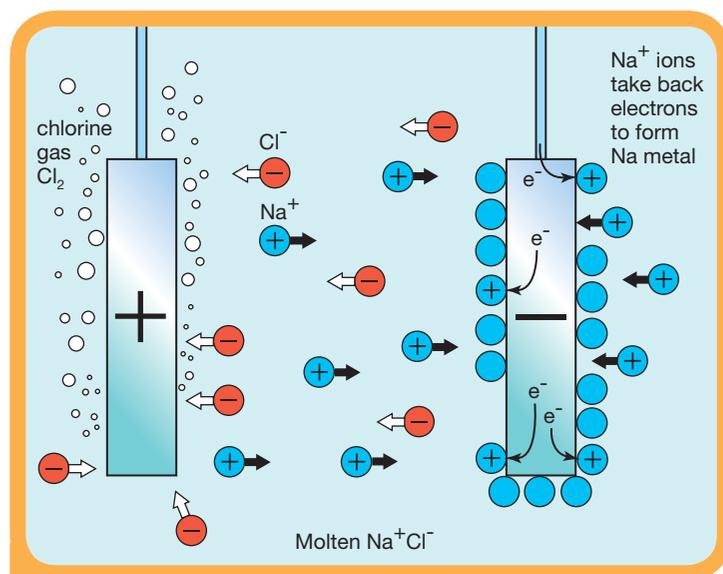


Fig 8.1.6

The extraction of sodium from molten rock salt by electrolysis

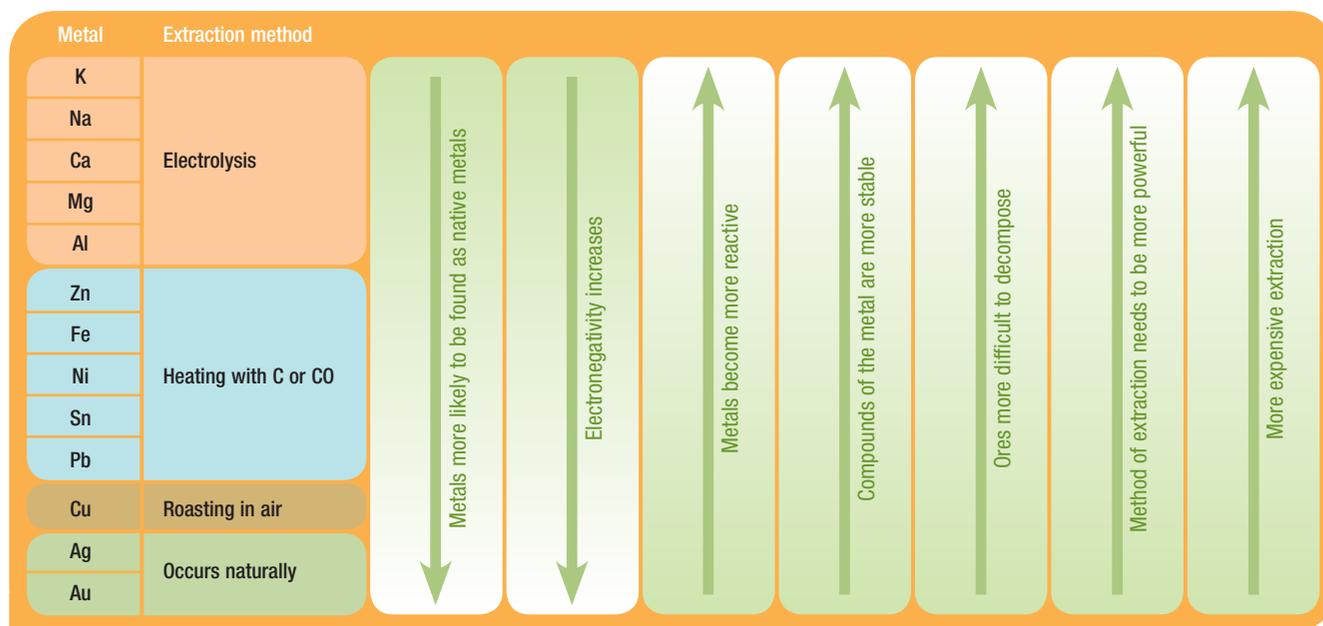


Fig 8.1.5

Extraction methods used for some metals

Sodium is made by electrolysis of sea water or, more commonly, rock salt. The salt is melted to break the salt crystals into its ions, then converted into pure elements by electrolysis.

At the negative electrode:



and at the positive electrode:



Overall,



Activity 1

Electrolysis of copper

Aim

To extract solid copper from a solution

Equipment

1 M sulfuric acid, black copper oxide, spatula, 50 mL beaker, glass stirring rod, Bunsen burner, tripod, gauze mat, bench mat and matches, 12 V power pack, globe, electrodes and connecting leads, filter paper/paper towel

Method

- 1 Pour approximately 20 mL of 1 M sulfuric acid into the beaker.

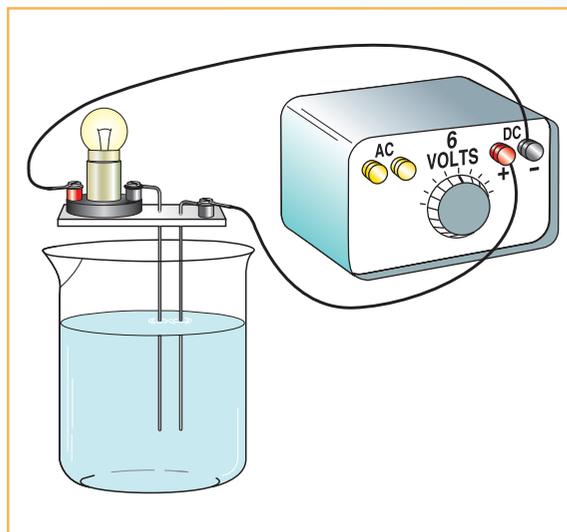


Fig 8.1.7

- 2 Add a small spatula of black copper oxide.
- 3 Carefully warm over a yellow Bunsen burner flame. Stir with the glass rod until all the copper oxide is dissolved and the solution is blue. Do not boil.

- 4 Remove the beaker from the tripod and place on the bench mat.
- 5 Connect up the circuit as shown in Figure 8.1.7. Set the power pack on 6 V DC and allow it to run for a couple of minutes.
- 6 Draw a diagram of the set-up. Mark the electrode being copper plated. What is happening at the other electrode and to the colour of the solution?
- 7 Turn off the power and remove the electrodes. Carefully remove any pure copper onto filter paper/paper towel.

Questions

- 1 Explain whether copper formed at the positive or negative electrode.
- 2 Explain what happened to the blue colour of the solution.
- 3 In this experiment, copper ions in the solution are taking back electrons to form copper atoms. Describe the evidence for this.
- 4 Construct a balanced chemical equation for what is happening to the copper ions.
- 5 Propose a reason why electrolysis is never used commercially to produce copper.
- 6 Aluminium can only be extracted by electrolysis. Propose a reason why copper and not aluminium was used in this experiment.

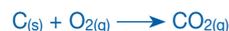
Extraction by heat

Heat is sometimes sufficient to extract the pure metal. This is called smelting. The more reactive metals, such as lead, iron and zinc, need carbon or carbon monoxide (CO) to help the conversion along.

To extract iron, coke (a source of carbon), limestone (CaCO_3) and iron ore (Fe_2O_3) are heated in a blast furnace.

Smelting of iron occurs as a series of chemical reactions.

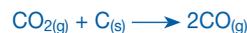
First, the coke reacts to form carbon dioxide:



Limestone then decomposes, forming calcium oxide and more carbon dioxide:



Carbon dioxide reacts with more coke, forming carbon monoxide:



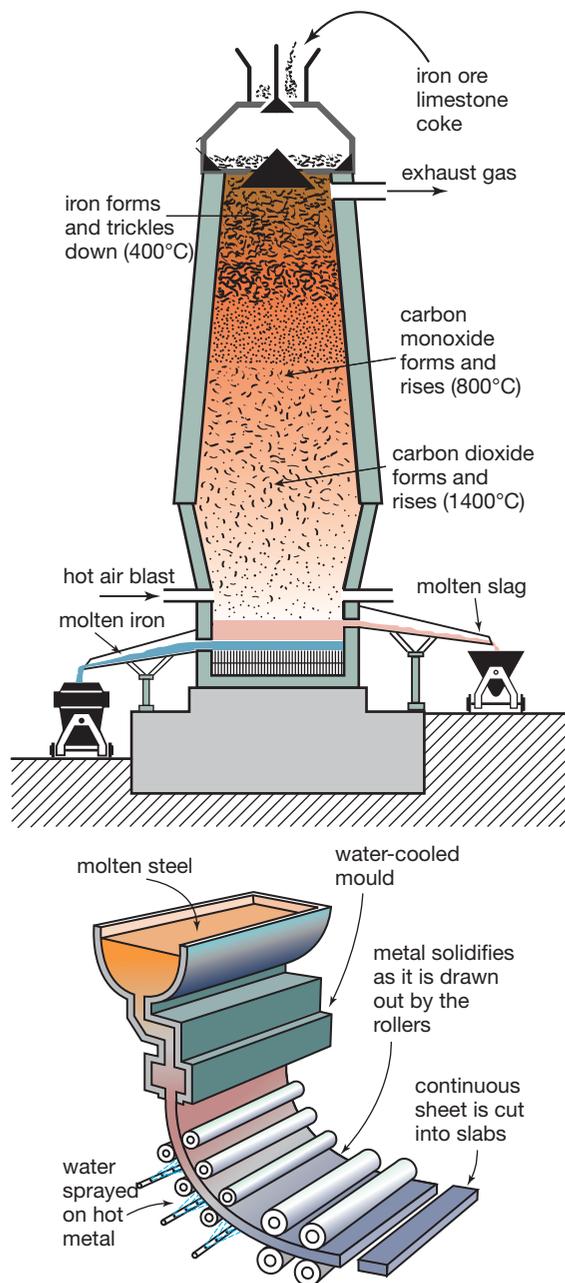
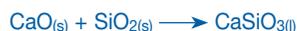


Fig 8.1.8 Smelting iron in a blast furnace and rolling it into shape

This reacts with the iron ore to form molten iron, which then runs to the bottom of the furnace:



Waste calcium oxide reacts with sand in the iron ore, forming calcium silicate:



Calcium silicate is called slag and floats on the molten iron.



Fig 8.1.9 Steel-making in action

More stable metals only need roasting in air. Most copper is extracted by roasting copper(I) sulfide, found in an ore called copper pyrites:



Activity 2

Chocolate-chip mining

Aim

To investigate the process of mineral extraction

Equipment

Chocolate-chip biscuits, electronic scales, sieves, beakers, measuring cylinders

Method

- 1 Examine a chocolate-chip biscuit. The biscuit represents a sample of ore that contains chips of an extremely valuable mineral called chocolate.
- 2 In groups, check the equipment available to you and then develop a method to efficiently extract the chocolate chips from the waste material (the rest of the biscuit).
- 3 Write down your method.
- 4 Construct a table similar to that shown on the next page.
- 5 Measure the mass of the chocolate-chip biscuit. Enter your measurement in the table.
- 6 In groups, develop a method for measuring or estimating the volume of a biscuit in cubic centimetres or millilitres. Enter the volume in the table. >>

- 7 After the extraction, measure the mass and volume of both the extracted chocolate chips and the waste material.
- 8 Refine your technique, improving it where necessary.
- 9 If time and the number of biscuits allow, try your new technique.
- 10 Collect the results from at least two other groups and enter their data into the table.

Questions

- 1 Compare the mass of each group's biscuit and the masses of the chocolate chips extracted.
- 2 Was the composition of each sample of ore (each biscuit) the same?
- 3 Compare the volume of the waste material after extraction with the volume of the biscuit at the start.
- 4 Would the waste material after extraction fill the hole left when the biscuit was originally 'dug up'?
- 5 In this activity, what represented the:
 - a ore
 - b mineral
 - c gangue?

Mass of biscuit (g)	Volume of biscuit (mL or cm ³)	Mass of chocolate chips after extraction (g)	Volume of chocolate chips after extraction (mL)	Mass of waste material (g)	Volume of waste material (mL)

Mining in Solomon Islands

Solomon Islands has small mineral deposits by world standards, so it is not a hot-spot for prospecting or mining companies. Guadalcanal, Isabel and Choiseul have the greatest occurrence of minerals. Currently, the only mining development is in Gold Ridge, Guadalcanal. Solomon Islands is a high risk destination for mining capital. Improving the investment climate would reduce the risk for potential investors.

Mineral occurrence—Solomon Islands

Province	Mineral
Guadalcanal	Gold (Gold Ridge), copper (Mbetilonga, Koloula, Poha)
Isabel	Nickel (Jejevo, Takata, San Jorge)
New Georgia	Bauxite (Tirua, Hiriro), copper (Ezefie, Mase and Humbe Rivers)
Choiseul	Chromite (Siruka), copper (Manggo), alumina (Vaghena), nickel (East Choiseul)
Makira	Traces of gold, copper and zinc
Malaita	Industrial minerals and suggestions of diamond

Ores, their chemical composition and the metal extracted

Ore	Chemical composition	Metal extracted
Bauxite	Aluminium oxide, Al ₂ O ₃	Aluminium, Al
Chalcopyrite	Copper iron sulfide, CuFeS ₂	Copper, Cu
Galena	Lead sulfide, PbS	Lead, Pb
Haematite	Iron oxide, Fe ₂ O ₃	Iron, Fe
Pitchblende	Uranium oxide, U ₃ O ₈	Uranium, U
Rutile	Titanium oxide, TiO ₂	Titanium, Ti
Sphalerite	Zinc sulfide, ZnS	Zinc, Zn



Fig 8.1.10 Major ore deposits in Solomon Islands



Fig 8.1.11 Gold Ridge mine in Guadalcanal

Before mining begins, many important questions need to be asked:

- How much ore is there and how concentrated is it?
- How deep is the ore? What type of mine is needed?
- Is the site close to existing ports and rail lines?
- Is there a population centre nearby from which workers can be employed?
- Who owns or controls the land? If they live there, will they be happy to shift? What compensation is appropriate?
- What water and air pollution will it cause?
- What damage will be done to the environment and how can it be minimised?
- What will be the cost of building the mine and the processing plants, and repairing the environmental damage?
- What is the current and expected future price of the metal?
- What profit is expected?

The Solomon Islands economy is largely dependent on a few primary commodities, such as timber and fish. However, in 2011, minerals contributed 16.3 per cent of export revenue and in 2012, 23.6 per cent. Gold mining has provided a source of income over the recent years, but the total value has decreased since 2013.

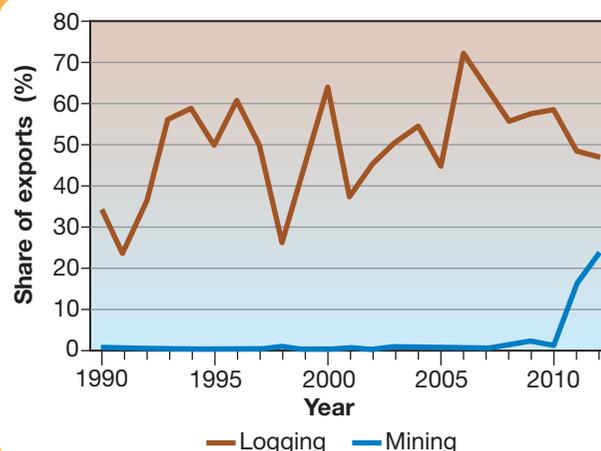


Fig 8.1.12 Logging and mining as a percentage of total exports, Solomon Islands, 1990–2012

Value of gold export in Solomon Islands—2010–2014

Year	Value (\$)
2010	\$25 729.00
2011	\$518 002.00
2012	\$855 111.00
2013	\$623 640.00
2014	\$210 627.00

The growth of mining brings a range of issues for Solomon Islands.

- There may be a temptation to heavily rely on mining income, leading to labour distortions
- Weaknesses at the macro-economic level may be worsened by mining income. The level of infrastructure and technology currently in the country is unable to successfully integrate mining infrastructure and technology if introduced.
- Underlying discussions and disagreements over land is the fundamental issue of who controls the land and makes decisions—often these are dressed as environmental concerns or indigenous rights versus investors.
- Land used for mining is land lost to hunting, conservation, forestry development, burial sites and other forms of land use.
- There are conflicts between customary law and modern law on mining, for example the ownership of minerals, and security of tenure.
- Unlike in other countries where mine closure is part of the initial negotiations, there is little discussion on mine closure.



Fig 8.1.13 Aluminium cans in Solomon Islands are collected and reprocessed.

Recycling versus mining

Metals that make up less than 0.1 per cent of Earth's crust are considered to be scarce. Silver (abundance 0.00001 per cent) and gold (0.0000005 per cent) are rare and therefore expensive, but some of our most commonly used metals are considered rare too: copper (0.007 per cent), mercury (0.00005 per cent), zinc (0.013 per cent), lead (0.0016 per cent) and tin (0.004 per cent). Luckily, iron is relatively common, since iron consumption is currently nine times that of all the other metals put together. Metals are non-renewable resources and all will eventually run out.

Metal	Element symbol	Amount used per year (millions of tonnes)	Estimated year at which known reserves of the metal will run out
Iron	Fe	800	2110
Aluminium	Al	12	2350
Copper	Cu	8	2040
Zinc	Zn	4.5	2060
Lead	Pb	4	2020
Tin	Sn	0.25	2035–2055

Recycling of aluminium is common, because the production cost of new aluminium is twenty times more than the cost of recycling it. Recycling of many metals is often too expensive to make it worthwhile. The difficulty of separating the iron from tin in food cans makes it far too expensive to recycle iron at the moment.

8.1 [Questions]

UNIT

Checkpoint

Metals in the crust

- 1 What is the most abundant element in the Earth's crust?
- 2 What percentage of the Earth's crust is made up of silicon?

Native elements

- 3 Clarify what is meant by a 'native element'.
- 4 List four examples of native elements.
- 5 State two forms in which native elements may be found.

Minerals and ores

- 6 Modify the following statements to make them correct.
 - a Metals that are not native elements are found as alloys.
 - b Rocks containing large amounts of ores are known as minerals.
 - c A mineral contains sufficient metal to mine.
- 7 Use the table on page 142 to list three ores and the main metal they contain.
- 8 A mining company decides not to mine a particular metal. State three factors that might have led to this decision.

The mining process

- 9 List the problems of an underground mine.
- 10 Construct a diagram showing the structure of an underground mine.
- 11 From the following list of words, identify the correct terms to fill in the spaces below.
sieves, extraction, froth flotation, ball mill, gangue, crushed, gravity
Mined material is _____ by rollers or steel balls within a _____. Impurities known as _____ are separated by _____, _____ or _____. The remaining ore is now ready for _____.
- 12 Define the term 'reactivity series'.
- 13 State the reason why some metals are more reactive than others.
- 14 List three metals that can only be extracted by electrolysis.
- 15 Use a diagram to explain how sodium is extracted from sodium chloride by electrolysis.
- 16 State a disadvantage of using electrolysis for extraction of metals.
- 17 List three metals that can be extracted by heat.
- 18 State the chemical formula for slag.

Mining in Solomon Islands

- 19 Where is the only mining development in Solomon Islands?
- 20 In which Solomon Island provinces does the mineral nickel occur?
- 21 What proportion of export revenue did minerals contribute to the Solomon Islands economy in 2012?
- 22 Outline three issues that the growth of mining may raise for Solomon Islands.

Recycling versus mining

- 23 State whether the following statements are true or false.
 - a Metals are known as renewable resources.
 - b Iron is the most common metal in the Earth's crust.
 - c Metals that make up less than 0.1% of the Earth's crust are scarce.
- 24 State one disadvantage and one advantage of recycling metals.

Think

- 25 Explain why a reactive metal atom like sodium (Na) has a very stable metal ion, Na^+ .
- 26 State which metal(s):
 - a are extracted by electrolysis
 - b are extracted in a blast furnace
 - c are extracted by roasting in air
 - d are native.
- 27 Contrast the following:
 - a slag and gangue
 - b mineral and ore
 - c electrolysis and smelting
 - d stable and reactive.
- 28 Explain why metals higher up the reactivity series are more likely to be found as ores than as native elements.

Analyse

- 29 Use the words below to complete the flow chart in Figure 8.1.14, summarising the process of mining an ore and extracting the metal it contains.
 exploration, electrolysis, gangue, froth flotation, crushing, native metal, roasting slag, blast furnace, open-cut, underground

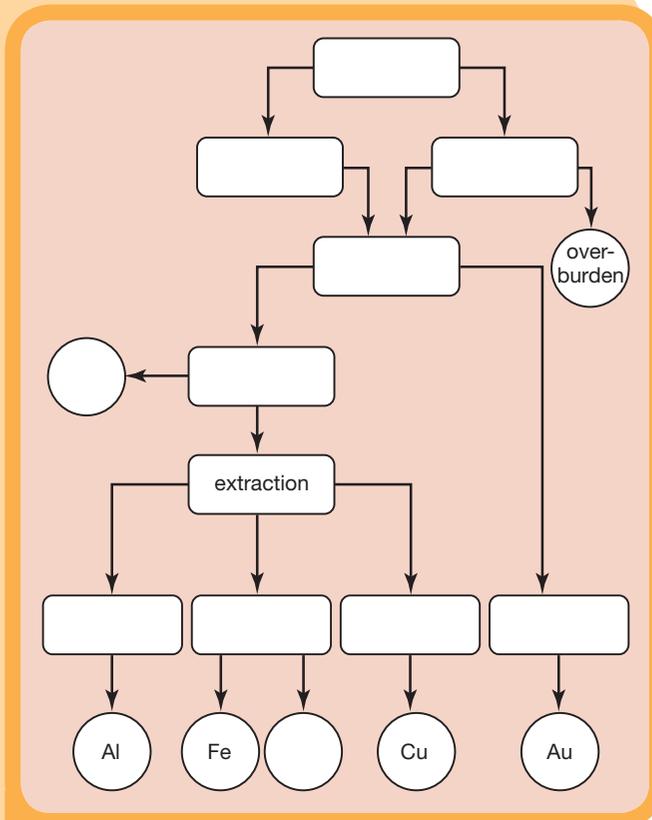


Fig 8.1.14

Skills

- 30 Construct a bar graph showing the elemental composition of the Earth's crust.
- 31 a Construct a timeline showing when copper, lead, iron, zinc and aluminium were first extracted.
 b Use the reactivity series to explain why different metals were discovered at different times in history.

[Extension]

Investigate

- 1 Research how car bodies can be recycled for their metals. Construct a poster aimed at convincing the public that recycling car bodies is a useful idea.
- 2 Research how to pan for gold and design an instruction sheet.

UNIT 8.2

Energy sources: Fossil fuels

Introduction

More than 90 per cent of our energy for living comes from under the ground. Most of the energy comes from coal, oil and natural gas. We use energy for transport, comfort, convenience and entertainment. We even use energy to make our own food from natural and synthetic (human-made) materials. In Solomon Islands most of our energy comes from fossil fuels. A fuel is a substance that is burnt in order to release energy.

Fossil fuels are non-renewable, and carbon emissions from burning fossil fuels contribute to climate change, as well as present a potential pollution hazard to the environment.

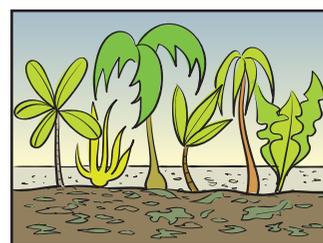
Coal

The coal that we use today was formed millions of years ago from the remains of plants buried by sediments. In ancient forests, which were warm and humid, layers of dead trees and other plants built up on the forest floor before they could rot. As the land sank, these layers of vegetation were covered with water, which deposited sediments of gravel, sand, mud and silt. Over millions of years the weight of the sediments and high temperatures removed much of the water from the plant remains. These plant remains are known as peat. As the peat was compressed and the moisture driven out, it became brown coal or lignite. In some places, more layers of sediment built up on top of the brown coal. This caused more and more moisture to be driven out and black coal, or anthracite, was formed.

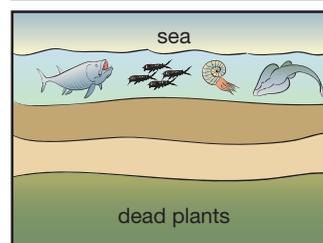
After mining, coal is used to generate electricity. Some coal can be used to produce gas in areas where natural gas is not available. Coal can also be used to produce oil.

Oil and natural gas

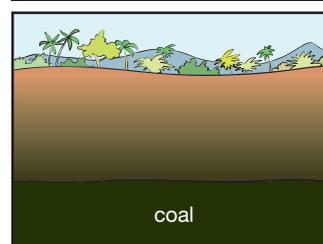
Oil and natural gas are believed to have formed from the remains of tiny plants and animals that lived in the sea. The bodies of these organisms were trapped in sediments on the seabeds. As the



Before the dinosaur age, the formation of coal started in swampy areas with giant plants dying.



Over millions of years the dead plants were covered by water, dirt and sediments.



Sediments turned to rock. Heat and pressure turned the plants into coal.

Fig 8.2.1 How coal was formed over millions of years

remains broke down, chemical changes took place. These changes, along with great pressure and high temperatures, produced oil and gas. The oil and gas were trapped between grains of sediment. The grains were compressed further so the oil and gas were forced upwards or sideways. Eventually, the oil and gas became trapped between layers of rocks.

Oil is mainly used as a fuel for transport and industry. Oil refineries convert the crude oil obtained from below the ground into a variety of useful fuels. These include petrol for cars, kerosene for jet planes, diesel for ships and trucks, and heating oil for homes. Small amounts of oil are used to generate electricity and produce gas. Natural gas is used for heating. A very small amount is used for cooking.

Sea animals and small plants decay, are buried under the ocean floor and covered by layers of sand and silt over millions of years.

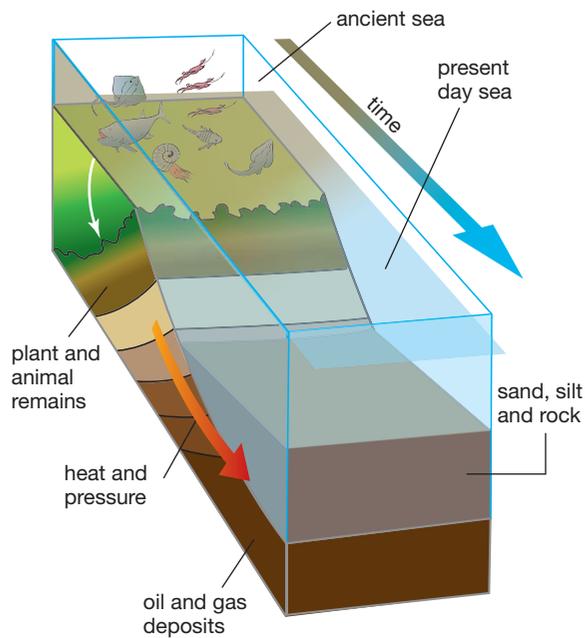


Fig 8.2.2 The formation of oil and gas

Fuel sources in Solomon Islands

Energy supports the full spectrum of socio-economic development. In nearly all Pacific countries, diesel generators are the main source of electricity generation, and for several countries they are the only source. Diesel oil is a fossil fuel.

Pacific countries' distance from the major oil-producing areas means that the costs of transporting diesel to islands are high, compounding the already high energy prices.

In Solomon Islands, all fuels have to be imported, amounting to about 30 per cent of the country's total imports. The small import quantities, long transportation routes, and frequently transshipments, result in high costs of petroleum products. The power generation infrastructure in Solomon Islands is based almost entirely on diesel fuel. Kerosene is the main source

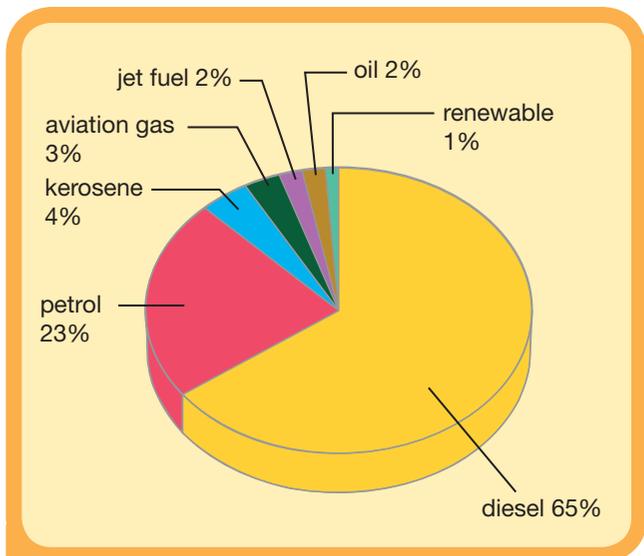


Fig 8.2.3 Fuels used in Solomon Islands since 1995

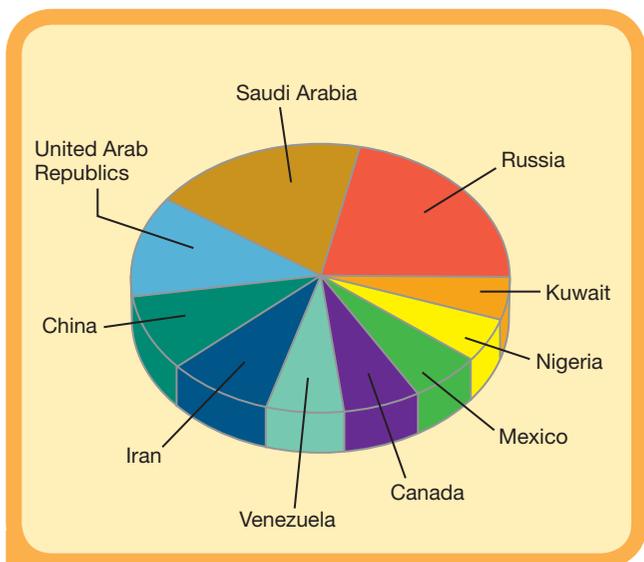


Fig 8.2.4 Major global producers of crude oil

of home lighting and wood for cooking. In 2009, 98.7 per cent of rural households used an open fire for cooking and 79 per cent used a kerosene or spirit lamp for lighting.

Figure 8.2.3 shows the fuels used in Solomon Islands since 1995.



8.2

[Questions]

UNIT

Checkpoint

Coal

- 1 What is coal?
- 2 Explain the difference between coal and peat.
- 3 Give three uses of coal.

Oil and natural gas

- 4 Make a list of the ways in which oil is used.
- 5 List two important factors in the formation of oil and gas.
- 6 What is crude oil?
- 7 What is natural gas used for?

Fuel sources in Solomon Islands

- 8 What does Solomon Islands use as its main power-generating fuel?
- 9 List two types of fuel imported by Solomon Islands.

Think

- 10 How is coal formed?
- 11 How are oil and natural gas believed to be formed?
- 12 Why are coal, oil and natural gas called fossil fuels?

Analyse

- 13 Figure 8.2.3 shows the fuels used in Solomon Islands since 1995. Explain why Solomon Islands imports such a high percentage of diesel.

Skills

- 14 Copy the following table and, using Figure 8.2.3, fill it out.

Imported fuel	Percentage	Uses
Diesel		
Petrol		
Kerosene		
Aviation gas		
Jet fuel		
Oil		
Renewable		

[Extension]

Investigate

- 1 Create a poster to show how coal is formed.
- 2 Conduct research on how crude oil is processed to form products such as petrol, kerosene, diesel and oil.

UNIT 8.3

Nuclear and other energy sources

Introduction

The world has an impending energy crisis. We need to quickly find alternative sources of energy, as fossil fuels will run out in the next fifty years if we continue to use them at current rates.

Nuclear energy

Many countries have invested heavily in nuclear energy. Nuclear energy is an alternative energy source to fossil fuels. Although not a renewable resource, it provides vast amounts of energy from a small amount of fuel. For example, one kilogram of uranium ore can produce as much energy as one kilogram of coal and does so with far less of the greenhouse gas carbon dioxide being released.

Fission

When uranium-235 absorbs a stray neutron, it becomes extremely unstable, and something very interesting happens. Instead of releasing an alpha or beta particle or a gamma ray, the uranium-235 isotope splits into two smaller atoms along with two or three neutrons. Heat energy is released in the process. The splitting of an atom is called fission. Lone or 'stray' neutrons are produced this way in the atmosphere by cosmic rays.

Chain reaction

Normally, the extra neutrons released by the fission of uranium-235 escape the sample or are absorbed by the more stable and more numerous uranium-238 atoms (natural uranium contains only about 0.7 per cent uranium-235).

A chain reaction will occur, however, if these neutrons strike other uranium-235 atoms. This causes more fission and more neutrons, which then hit more uranium-235 atoms, which then release even more neutrons ... and so it goes on and on. Huge amounts of energy are released in a fraction of a second. For a chain reaction to 'take off', the uranium sample needs careful preparation by:

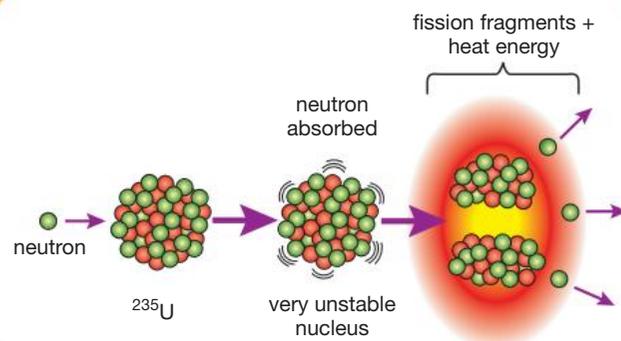


Fig 8.3.1 Nuclear fission

- enriching it so that it contains 2.5 per cent or more uranium-235
- forming it into a shape to prevent too many neutrons escaping without first interacting with other atoms (spherical is good), or
- making it large enough (the required mass is called the critical mass).

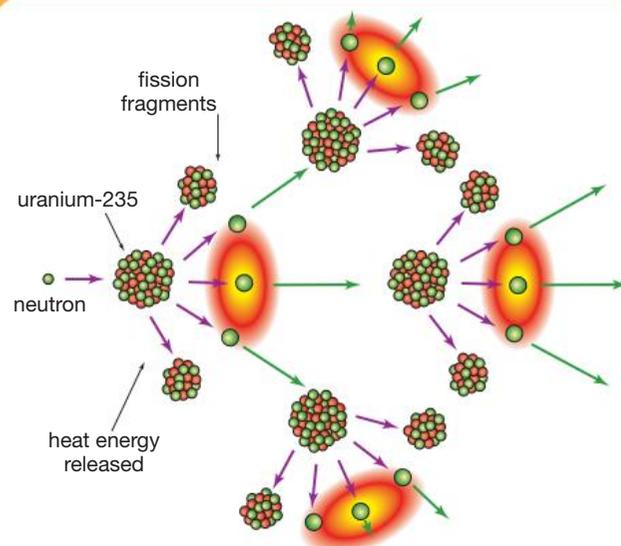


Fig 8.3.2 A fission chain reaction

Other energy sources

There are many alternatives to fossil fuels and nuclear energy that will meet our energy needs in the future.

One of those alternatives, nuclear fusion, is in fact another form of nuclear energy. Nuclear fusion occurs when two small nuclei combine, or fuse, releasing an enormous amount of energy as they do so. An example of nuclear fusion is the combination of a deuterium nucleus and a tritium nucleus to form helium.

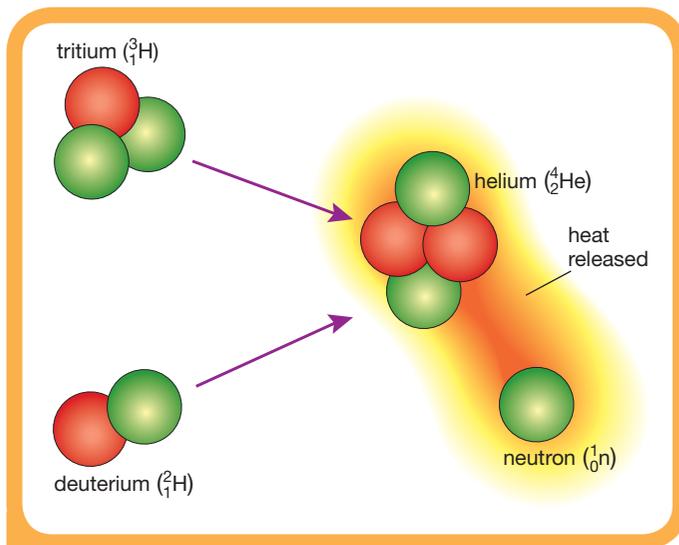


Fig 8.3.3 An example of a nuclear fusion reaction

Nuclear fusion has a couple of big attractions—no radioactive waste products are created, and there is a vast supply of deuterium in the ocean. However, temperatures of millions of degrees are needed to force two positively charged nuclei together, and temperatures of hundreds of millions of degrees are needed to keep it going. It is nuclear fusion reactions that power the Sun. Even if we could generate a sustained fusion reaction, how could it be contained?

Current research involves the use of a powerful toroidal (doughnut-shaped) magnetic field within a device called a tokamak to hold the superheated deuterium. The word 'tokamak' is from the Russian word for toroidal. If the costs and difficulties involved in sustained fusion generators are overcome, fusion may provide the bulk of the world's energy in the future.

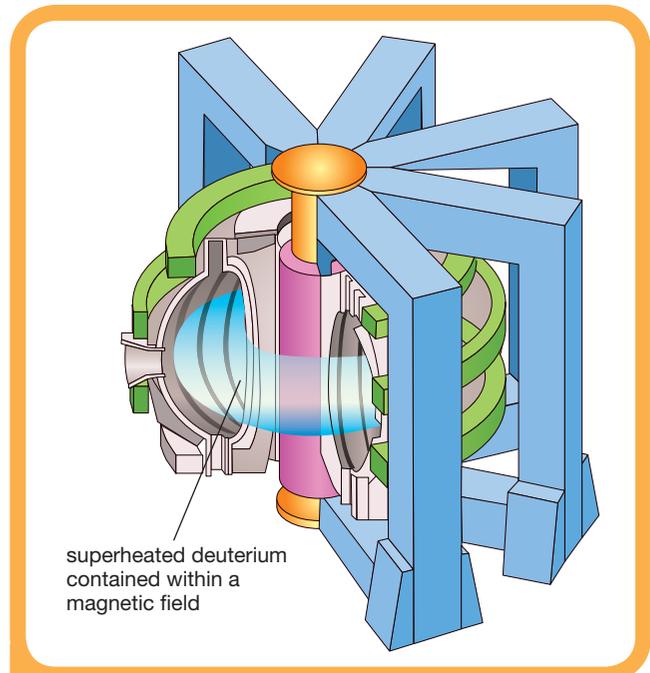


Fig 8.3.4 An experimental tokamak fusion reactor

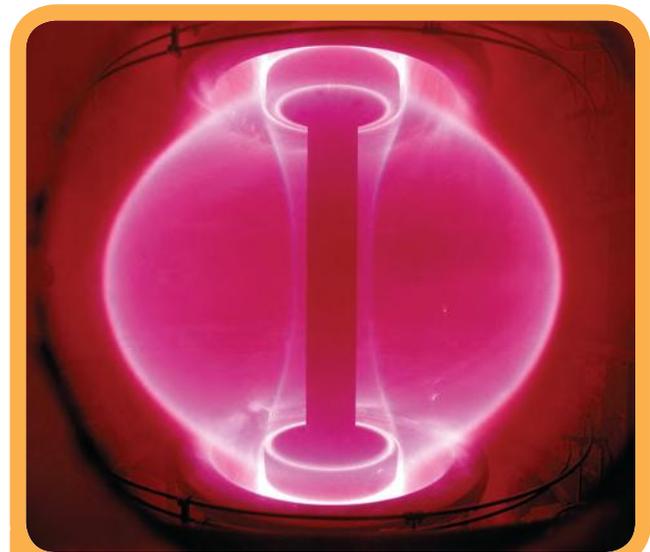


Fig 8.3.5 Spherical ball of plasma (pink) inside a tokamak

Other alternative sources of energy that offer potential for the future are:

- solar
- wind
- hydro-gravitational, wave or tidal
- geothermal
- ocean-based
- biomass.

Alternative energy sources in Solomon Islands

There is a clear need for cleaner, cheaper, more accessible, sustainable sources of energy across the Pacific and in Solomon Islands. Alternative fuel sources have the potential to improve energy security, provide greater access to energy services, and decrease vulnerability to price volatility—all of which are positive for sustainable economic growth.

Solar energy

As Solomon Islands lies near the equator, there is considerable solar energy potential. There are a number of small-scale and demonstration projects in the islands, including solar home systems funded by government since 2011. The Government of the Republic of China (Taiwan) has supplied solar home systems for the fifty constituencies under the project and solar systems for rural schools since 2009. Italy and Turkey have complemented the Government of Solomon Islands program to provide solar lighting for rural-based schools.

On 28 September 2012, the government launched a two-year pilot project on installation of home solar systems for 2000 households in the country that required each household to pay the cost of installation (including transportation) and operation and maintenance costs over the two-year



Fig 8.3.6 Solar panels

period. This project was funded under the Pacific Environmental Fund provided by the Government of Japan to the Pacific Islands countries.

A solar lighting scheme allowed recipients to pay for installations via non-fiscal means, for example with crop production.

Wind energy

Wind energy production would be a costly option, because of the variable winds in Solomon Islands, together with the need to design equipment for typhoon conditions. Four wind towers are expected to be installed at four locations around the country in order to determine the wind resource potential of the islands.



Fig 8.3.7 Wind towers

Hydropower

There is substantial hydropower potential in Solomon Islands. The government has developed a database of over 100 sites for possible small hydro development, of which 62 have an estimated overall capacity of 11 MW. A Japan International Cooperation Agency study estimated the total hydroelectric potential of the country to be 326 MW. A feasibility study conducted by the Government, with support from the World Bank and the Government of Australia, proposed a 15 MW hydropower development on the Tina River near Honiara, with an annual electricity production of 60 GWh.

Feasibility studies on the Tina River hydropower scheme proposed for Honiara is continuing. Feasibility studies were conducted by the end of 2012 on five small-scale hydro schemes for provincial centres to reduce use of diesel-based power generation in these towns.

The two main geothermal areas are the Nggurara and Paraso Bay geothermal fields, with hot spring temperatures in the 30–90 degrees Celsius range.

In March 2012, the government issued a licence to Kentor Energy Pty Ltd to prospect for geothermal resource on the island of Savo (off-shore from Honiara). The company commenced investigative survey work in October 2012 with the objective of supplying power into the main grid (via submarine cables) by 2016 if the project is viable.

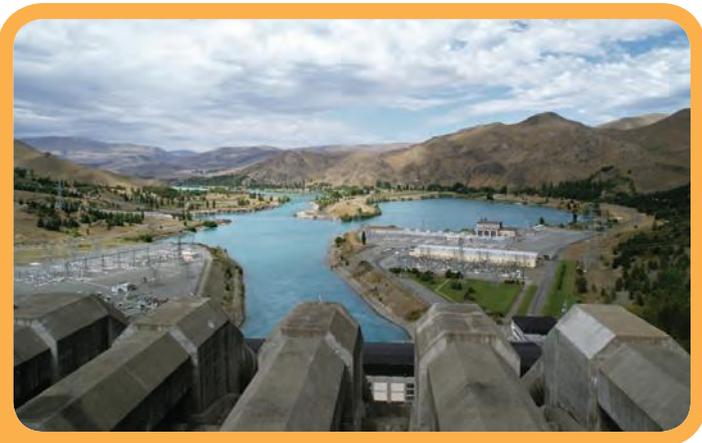


Fig 8.3.8 Hydropower plant

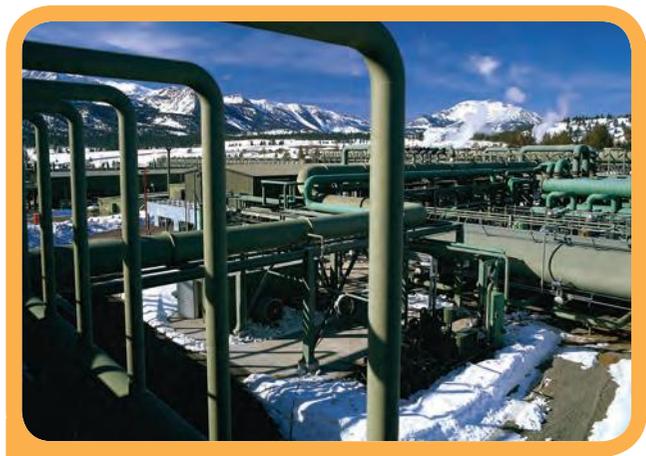


Fig 8.3.9 Geothermal plant

Ocean-based

The sea-wave energy potential of Solomon Islands has not been assessed. Extrapolating from results for Fiji and Vanuatu, annual average wave power could be roughly 14 kW/metre of wave front, with a wide range varying by site. A good amount of annual sea-wave energy is 20–40 kW/metre of wave front.

Geothermal energy

Geothermal energy is heat energy that comes from deep within the Earth where the temperature is so high that rocks are molten. Mud pots and hot springs are common in areas where magma is close to water near the Earth's surface.

In Iceland, four out of five homes are heated by geothermal energy. In New Zealand, geothermal power stations use steam from under the ground to drive turbines to produce electricity.

In Solomon Islands, there are indications of exploitable geothermal resources in at least four locations, with an estimated potential of 10 MW.



Fig 8.3.10 Special buoys are used to capture wave, tidal and ocean energy on a wave farm. This is a potential energy source for Solomon Islands.

Biomass

Solomon Islands is heavily forested. Palm oil and copra are major agricultural commodities. Traditional biomass use is still relatively widespread in the unelectrified regions of the country. A large palm oil plantation closed in 1999 due to ethnic tensions but has since re-opened and has increased its production. In the mid-1980s, copra output exceeded 40 000 tonnes, enough to produce an equivalent of 28 ML of distillate, sufficient to displace about half of current diesel fuel imports. Economic opportunities for biomass for power generation are, however, very limited. No dedicated study has been conducted on the potential for biomass power generation in the islands.



Fig 8.3.11 Biomass power plant

8-3 [Questions]

Checkpoint

Nuclear energy

- 1 Use a diagram to explain the term 'nuclear fission'.
- 2 In a chain reaction, huge quantities of energy are released. Outline how this happens.

Other energy sources

- 3 Use a diagram to demonstrate how nuclear fusion occurs.
- 4 State the main advantage of nuclear fusion.
- 5 Explain why using nuclear fusion is technically difficult.
- 6 List three other types of alternative energy.

Alternative energy sources in Solomon Islands

- 7 Name the two alternative energy sources that are already available in Solomon Islands.
- 8 Does Solomon Islands have a good source of ocean-based, sea-wave energy generation?

Think

- 9 Copy and modify the following statements so they are all true.
 - a Uranium provides much more energy per kilogram than coal.
 - b Unstable atoms absorb radiation.
 - c Natural uranium contains 93 per cent uranium-235.
 - d A critical mass of uranium-235 is one that will not start a chain reaction.
 - e Fission is the splitting of an atom.
- 10 a What is geothermal energy?
b How is geothermal energy used in New Zealand?

- 11 How is uranium used to produce electricity?
- 12 Compare solar energy to geothermal energy.
- 13 Discuss whether we should be investing in nuclear power or other alternative energy sources for the future.

[Extension]

Action

- 1 There are many alternative energy sources apart from nuclear power. Work in small groups, with each group selecting a different type of alternative energy source.
 - a Describe how energy is produced in this way.
 - b Assess the efficiency of this energy source.
 - c Outline the advantages and disadvantages of your alternative energy source.
 - d Evaluate whether this energy source would be suitable for use in the future.
 - e Present your information as an oral presentation.
- 2 Have a class debate to discuss whether nuclear energy should be used.

Investigate

- 3 a Research a significant nuclear accident such as Chernobyl (in Ukraine), the Three Mile Island disaster in the United States or the leak at Britain's Windscale (now called Sellafield) plant.
b Propose a set of safety rules that would prevent this type of accident in the future.

Chapter review

[Summary questions]

- 1 State two methods of extracting minerals from ores.
- 2 Compare the formation of coal and oil.
- 3 Explain what a fossil fuel is.
- 4 List the four main fossil fuel producers in the world.
- 5 What is the ore that aluminium is extracted from?

[Thinking questions]

- 6 Which energy sources are mostly used to generate electricity?
- 7 What are the three main underground sources of energy?
- 8 Why is coal exploration carried out even though it is expensive?
- 9 Contrast nuclear fission with nuclear fusion.
- 10 Explain the similarities and differences between electrolysis and heating as methods of metal extraction.
- 11 The growth of mining in Solomon Islands brings with it a range of issues. Identify and discuss these issues.

[Interpreting questions]

- 12 Find out what happens to uranium ore before it is used in a nuclear power station.
- 13 Where does the energy come from that is released when coal, natural gas and oil are burned?
- 14 Explain what is involved when electrolysis is used as a method of metal extraction.
- 15 Why are metals classified as non-renewable resources?

Communication technology

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

- describe transverse and longitudinal waves
- explain the properties of waves with the aid of a diagram
- identify wavelengths and frequencies from the electromagnetic spectrum (ie from smallest to largest wavelength)
- describe the electronic equipment that uses the following waves: gamma rays, X-rays, ultraviolet rays, visible light, infrared light, microwaves, radio waves
- understand what analogue and digital signals are and explain their uses.



Specific learning outcomes
9.9.1.1, 9.9.2.1, 9.9.3.1, 9.9.4.1, 9.9.5.1

- 1 What do AM and FM on the radio dial stand for?
- 2 Describe frequencies and wavelength.
- 3 How do mobile phones find each other?
- 4 Describe an appliance that uses electromagnetism.
- 5 Who invented the telephone?
- 6 What is a digital message made up of?

Challenges

UNIT 9.1

Waves in communication

Introduction

Visible light is only one section of a wide variety of waves known as the electromagnetic spectrum. While visible light allows us to see, other invisible forms such as X-rays enable us to see into the body without invasive surgery. Other invisible forms give us the radiant heat of sunlight and the basis of most communication, from radio to TV to mobile phones. It's fairly easy to visualise ocean waves or ripples caused by a stone dropped in a pond, or even those in a slinky, but what exactly are the waves that make up light and the electromagnetic spectrum?

Activity 1

Waves in a slinky

Aim

To investigate the movement of waves in a slinky

Equipment

A slinky, masking tape, stopwatch, floor or corridor space in which to generate waves between points 5 to 10 metres apart

Method

- 1 With a partner, stretch a slinky to a length of 5 metres or so without permanently deforming it.
- 2 Use masking tape to mark points along the slinky every metre or two.
- 3 Generate a horizontal transverse wave as shown, carefully observing the masking tape labels as the wave passes them.
- 4 Generate a small wave and measure the time it takes to get to the other end. Calculate the speed of the wave.
- 5 Keeping the slinky stretched by the same amount, generate a bigger wave and calculate its speed.
- 6 Generate waves at a high frequency and calculate their speed.
- 7 Repeat for waves of low frequency.

- 8 Investigate what happens when waves are generated simultaneously from both ends of the slinky:
 - a on the same side
 - b on opposite sides.

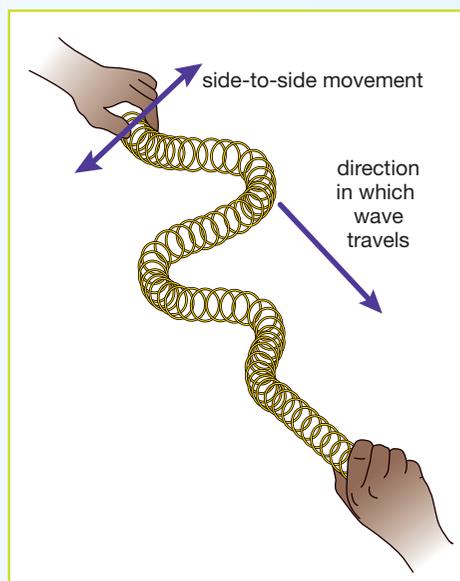


Fig 9.1.1

Questions

- 1 Describe the direction in which the masking tape labels move compared with the travelling wave.
- 2 Describe whether the wave speed is affected by:
 - a the size of the wave
 - b the frequency of the waves.
- 3 Describe what happens when waves meet:
 - a on the same side of the slinky
 - b on opposite sides of the slinky.
- 4 If time permits, investigate longitudinal waves produced by bunching up and releasing the coils.

Two kinds of waves

There are several different types of waves, but the main two are transverse and longitudinal (sometimes called compression) waves. These are illustrated in Figure 9.1.2 using a slinky.

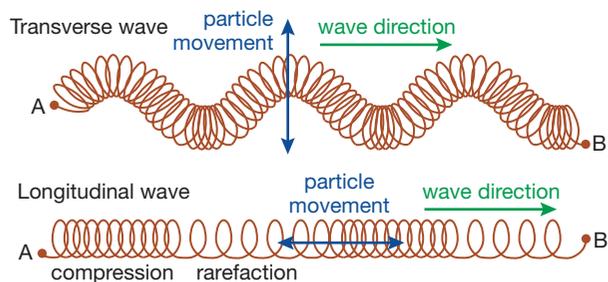


Fig 9.1.2 Two kinds of waves

Activity 2

Polarised

Aim

To investigate the interaction of two polarising filters

Equipment

Two polarising filters, window or other light source

Method

- 1 Look through one of the filters at a nearby window or other light source.
- 2 Hold a second filter in front of the first, and rotate it while keeping the first filter still.

Questions

- 1 Describe what you saw in each case.
- 2 Explain your observations.

One of the special characteristics of waves is their ability to transfer energy from A to B without particles actually moving along the full route. When a transverse wave travels from A to B, the actual particles in the wave merely vibrate up and down. In a longitudinal wave the particles vibrate back and forth.

Think of a surfer on a board or a boat floating in the ocean. Rather than moving along with the waves, both simply bob up and down on the spot.

If the coils of a slinky or the particles of water did move the full distance from A to B, they would all end up at B, leaving nothing at A—this clearly does not happen!

Properties of waves

Imagine you are shaking a slinky back and forth to generate transverse waves at a steady rate. This rate has another name: frequency. If you are producing

two waves every second, the wave frequency is two waves per second, or 2 hertz (2 Hz for short). The unit 'hertz' is used to describe anything that has regular repetitive behaviour, and can be taken to mean 'per second'. For example, a wheel that rotates ten times per second has a frequency of 10 hertz. Likewise, a sound wave that hits your eardrum with 200 compressions per second has a frequency of 200 hertz.

The distance between successive crests or successive troughs in a series of transverse waves is called the wavelength. The height of crests above their normal, middle position is called the amplitude of the wave. In a longitudinal wave, the wavelength is the distance between compressions or rarefactions, and the amplitude is the distance that particles vibrate from their normal, middle position.

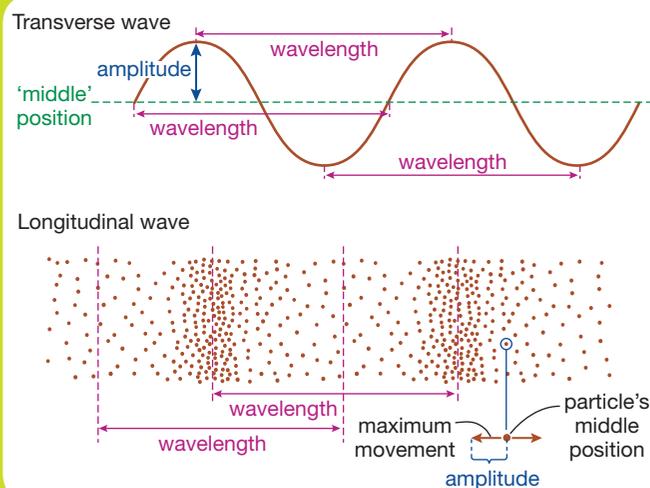


Fig 9.1.3 Amplitude and wavelength for two kinds of waves

Light waves

When sound or light travels from A to B, energy is transferred but no particles actually move from A to B. This suggests that sound and light behave just like the water and slinky waves described above.

Sound waves are longitudinal waves requiring particles to pass vibrations from one layer to the next. Hence sound can travel through gases, liquids and solids but cannot travel through a vacuum. But how can light be a wave? Nothing seems to be vibrating back and forth when we shine a torch, though we can see where its beam strikes an object. Also, light can travel through the vacuum of space.

You know that an electric current causes a magnetic field and that a changing magnetic field causes a current. A mass will only fall if there is a gravitational field, and likewise an electric current only flows when there is an electric field. What all this means is that a magnetic field can cause an electric field and vice versa. Both magnetic fields and electric fields are invisible, but can be detected by the effect they have—for example, the electric field around a Van de Graaf generator can make your hair stand on end and the magnetic field of a magnet will move iron filings around.

Light can be considered a series of changing magnetic and electric fields where the changes in a magnetic field cause a changing electric field, which causes another magnetic field, which causes another electric field and so on and so on. For this reason, we say that light consists of electromagnetic waves that travel at an incredible speed of 300 000 kilometres per second.

The range of colours we are able to see is called the visible spectrum. White light is really a mixture of all the colours of the visible spectrum, and consists of waves of different wavelengths and frequencies all travelling at the same speed.

Other types of electromagnetic waves

The visible spectrum is only a small part of a wide group of electromagnetic waves. In order from smallest to largest wavelength, these are: gamma rays, X-rays, ultraviolet rays, visible light, infrared rays, microwaves, radio waves.

These make up the electromagnetic spectrum. Though we cannot see these other types of waves, they can be detected and are used in a variety of applications.

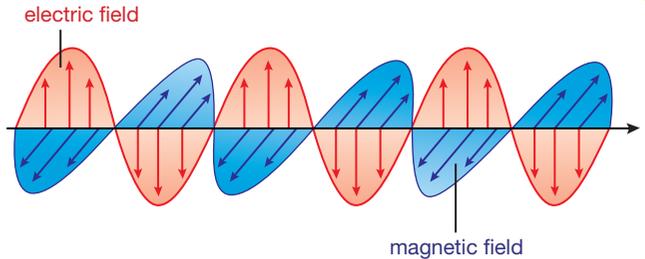
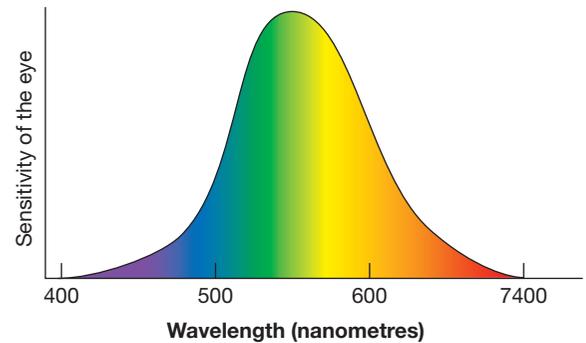


Fig 9.1.4 The magnetic and electric fields of light waves are perpendicular to each other.



$$1 \text{ nanometre} = \frac{1}{1\,000\,000\,000} \text{ of a metre}$$

Fig 9.1.5 The human eye is more sensitive to some colours than to others.

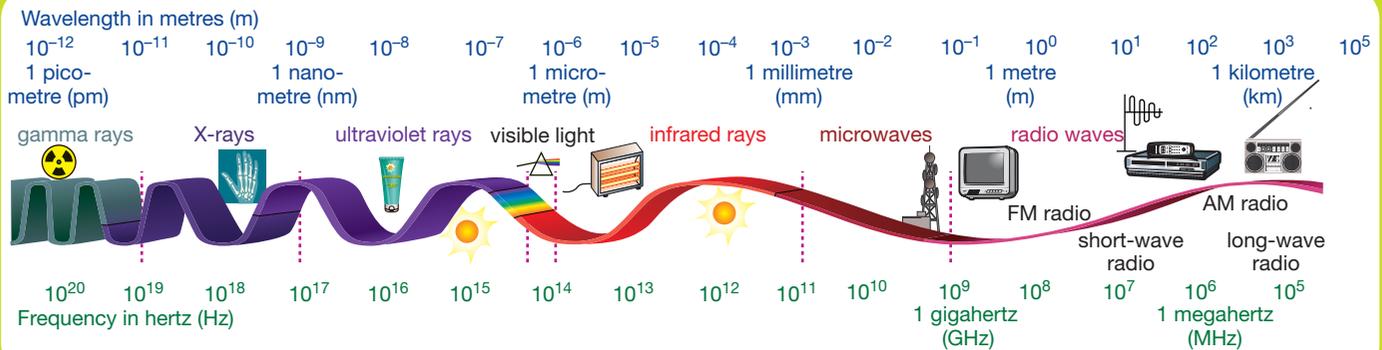


Fig 9.1.6 The electromagnetic spectrum. Although wavelengths and frequency vary, speed is the same (300 000 kilometres per second) for all types of electromagnetic waves.

Gamma rays

Gamma rays are extremely high-energy waves released in bursts from the nucleus of certain atoms, including uranium and plutonium—hence they are a form of nuclear energy. Substances that release nuclear energy such as gamma rays are said to be radioactive. Gamma rays can be detected using photographic film or a Geiger counter, and can be used to destroy cancer cells, which are more sensitive to radiation than normal cells. Some normal cells are still killed, however, resulting in the unpleasant side effects of radiotherapy.

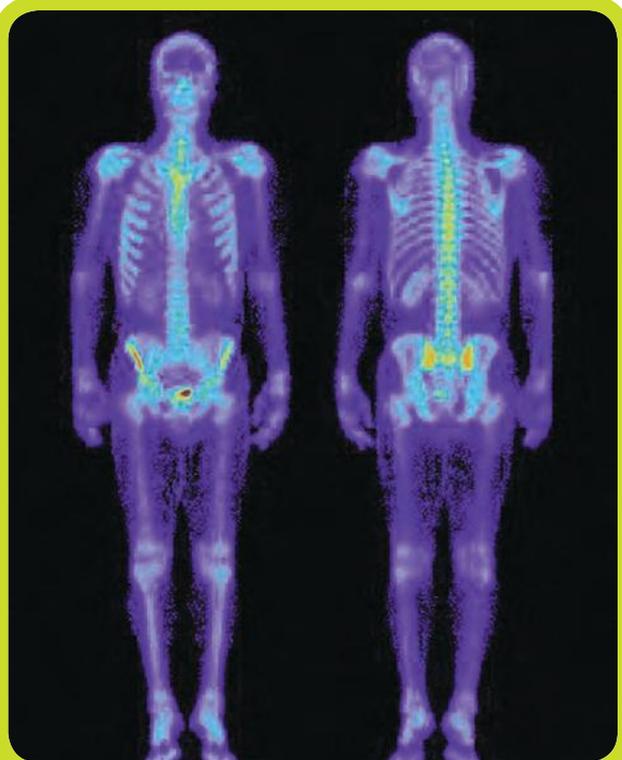


Fig 9.1.7

Gamma rays are used to produce scans like this one of a human skeleton. A radioactive isotope is injected into the blood vessels supplying the region, and tends to concentrate in tumours and cancerous bone. Variations in emitted gamma ray intensity result in different areas showing up in the image.

X-rays

X-rays are produced when fast-moving electrons lose energy suddenly, for example when smashing into a metal target. Short-wavelength X-rays can penetrate dense metals such as lead, while long-wavelength X-rays penetrate flesh but not bone, and so may be used to ‘photograph’ inside the body. The term ‘X-ray’ is also used to refer to the actual photograph produced.

Ultraviolet radiation

Whenever the Sun shines on us, we receive both visible light and invisible ultraviolet (‘ultra’ means ‘beyond’) or UV radiation. A small amount of UV radiation is vital as it helps us produce vitamin D. Too much, however, causes damage to the skin in the form of a suntan, sunburn or various skin cancers. Some washing powders contain special chemicals which absorb ultraviolet light and then re-emit it as visible light to give the impression of ‘whiter-than-white’ clothes. Ultraviolet light can be used to kill bacteria, and is used in hairdressing salons and air-conditioning systems.

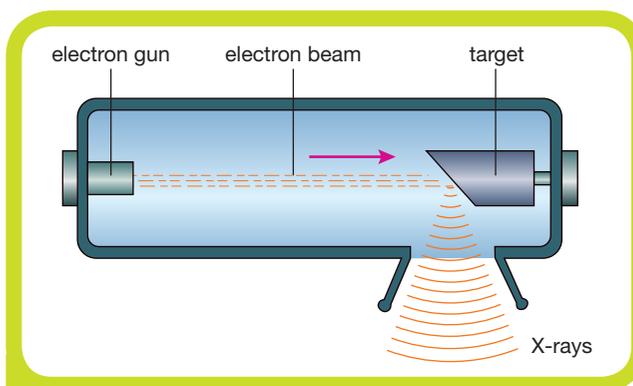


Fig 9.1.8

An X-ray machine



Fig 9.1.9

An X-ray of a woman’s finger. The woman is wearing a ring on her middle finger.

Visible light

Visible light includes the colours of the rainbow (red, orange, yellow, green, blue, indigo and violet) and various combinations, including white. Though we can see an amazing range of colours, these colours are a very small part of the electromagnetic spectrum.

Infrared rays

‘Infra’ is Latin for ‘below’ and infrared (or IR) rays have a frequency below that of red light. They are often associated with heat and are released from vibrating atoms or molecules. All objects contain vibrating atoms and molecules, so all objects emit infrared radiation. The hotter the object, the more the vibration, and so the more the energy released as infrared radiation.



Fig 9.1.10 Radiation from the sun

When high-energy waves are emitted they become visible as red light—hence the expression ‘red hot’. Remote control devices emit infrared waves, which are detected by special components within televisions and sound systems. They are then converted to electrical energy to control functions such as volume and channels.

Microwaves

Sometimes called short-wave radio waves, microwaves are generated by vibrating electrons in electrical devices, and typically have a wavelength of a few centimetres. They are easy to direct, can pass through the Earth’s ionosphere and are used in satellite communication, radar and mobile phones. Water molecules in food vibrate at the same frequency as microwaves. Hence food strongly

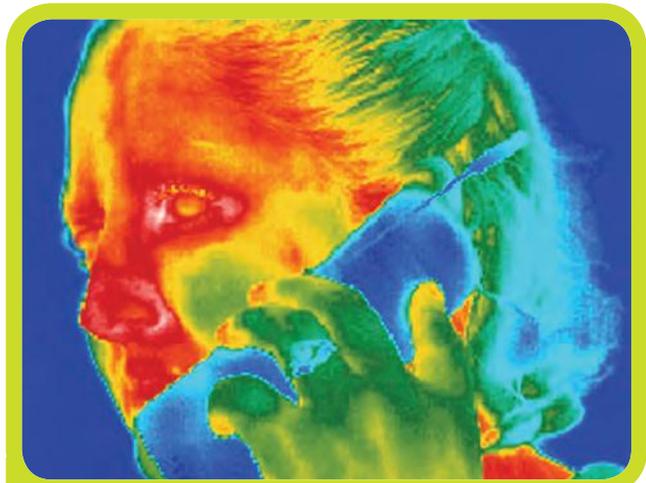


Fig 9.1.11 An infrared image of a person using a mobile phone

absorbs microwaves, converting their energy into heat energy in a microwave oven.

Radio waves

Radio waves are also generated by vibrating or oscillating electrons (eg in a transmitting aerial), and are used in radio and television broadcasting. Radio waves have wavelengths of hundreds of metres to tens of centimetres and are classified into several categories. Long radio waves are useful for communicating around the Earth, as they bend to follow the Earth’s surface (bending around objects like this is called diffraction). Short waves may also travel around the Earth, by reflecting from the ionosphere.



Fig 9.1.12 This dish receives microwave and satellite signals and relays them to Earth-based parts of the communications network.

AM and FM

When listening to your local radio stations, you might come across the terms AM and FM. What do these terms mean?

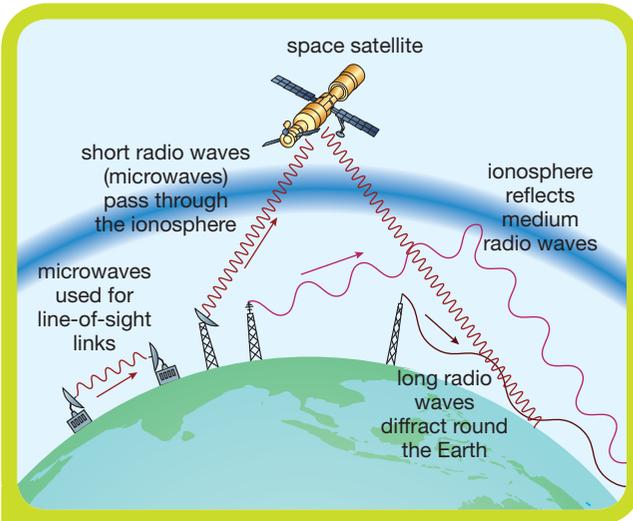


Fig 9.1.13 The behaviour of different types of radio waves

Electromagnetic waves such as radio waves can carry information (eg sound or vision) as changes or fluctuations in either frequency or amplitude. Receivers detect these changes and convert them back to sound or vision or some other form.

This information first must be converted into a wave, in a process called modulation.

Amplitude modulation, or AM, is the process in which information is carried as changes in wave amplitude. Similarly, frequency modulation, or FM, is the process by which information is carried as changes in wave frequency.

Radio stations transmit sound using both AM and FM, while television stations transmit sound using FM, and vision using AM. Solomon Islands Broadcasting corporation (SIBC) transmits AM carrier waves of frequency 1000 kilohertz (1 kilohertz = 1000 hertz), which are detected by a radio tuned to this frequency.

The higher frequencies of FM stations are less affected by interference, and provide a better quality sound than AM, though they have less range.

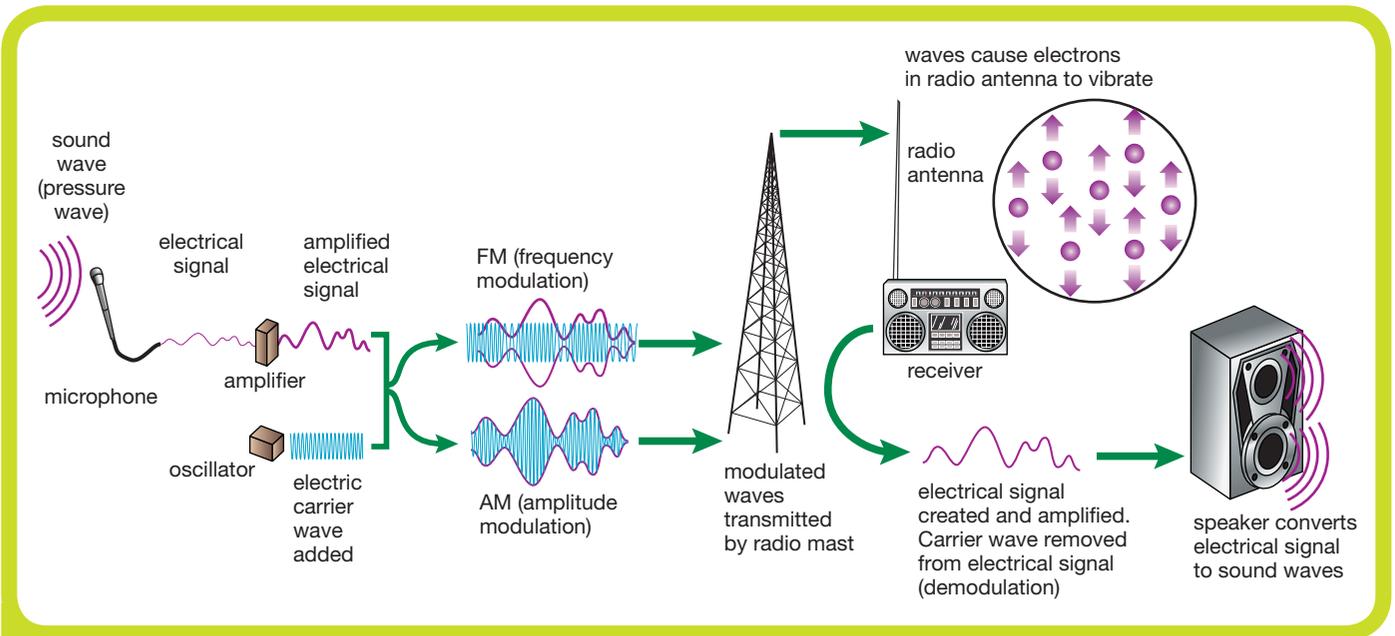


Fig 9.1.14 Modulation is one of many steps in the transmission of sound via radio waves.



9.1

UNIT

[Questions]

Checkpoint

Two kinds of waves

- 1 State the names of the two kinds of waves.
- 2 Outline the main differences between them.

Properties of waves

- 3 Explain the terms 'frequency', 'wavelength' and 'amplitude'.
- 4 What does Hz stand for?

Light waves

- 5 Copy and complete the following statement:
A light wave is made up of changing _____ and _____ fields that are _____ to each other, and moves at _____ kilometres per second.
- 6 State whether the following statements are true or false.
 - a All electromagnetic waves move at the same speed.
 - b Each different colour of light has a different wavelength.
 - c Waves transfer energy by moving particles along with them.

Other types of electromagnetic waves

- 7 State one similarity and one difference between the waves of the electromagnetic spectrum.
- 8 State the speed of light.
- 9 List the main types of waves in the electromagnetic spectrum in order from smallest to largest wavelength.

AM and FM

- 10 AM and FM radio have modulated wavelengths. State the full name for 'AM' and 'FM'.
- 11 State an advantage of each type of carrier wave.

Think

- 12 Explain why it does not make sense to talk about the wavelength of white light.
- 13 Identify which colour of light has the:
 - a greatest wavelength
 - b highest frequency.
- 14 State which colours the human eye is most sensitive to.
- 15 Identify the wave that can penetrate the Earth's atmosphere.
- 16 State the name of the harmful rays that are released in a nuclear explosion.
- 17 Is UV radiation good, bad or both? Justify your answer.

Analyse

- 18 A student shakes out 20 waves on a slinky in 10 seconds. Calculate the frequency of the waves.
- 19 The time between each wave passing is called the period.
 - a Identify the period for the waves in Question 18.
 - b If the wave frequency increases, predict what effect this will have on the period:
 - A The period will increase.
 - B The period will stay the same.
 - C The period will decrease.
 - D There is not enough information to answer the question.

Skills

- 20 Construct a diagram of a transverse wave that has:
 - a a wavelength of 3 cm and amplitude of 2 cm
 - b a wavelength of 10 cm and amplitude of 1 cm.

[Extension]

Investigate

Choose one of the topics listed below and briefly outline the contribution to science.

- a Scottish physicist James Clerk Maxwell and his work on electromagnetic wave theory
- b the development of radio communications by the American engineer Edwin Armstrong
- c the first transmission of radio waves by Guglielmo Marconi
- d John Logie Baird's contribution to the development of television

UNIT 9.2

The communications network

Introduction

Communication methods have changed dramatically in the last hundred years, and will continue to develop in the future in ways that might seem like science fiction right now—but remember, email and the internet were hardly known ten years ago! There are many possibilities for how we will communicate that we do not even know about yet.

In 1844, American Samuel Morse used a code involving dots and dashes to send a message 60 kilometres by telegraph. By opening and closing a simple switch (telegraph key), dots or dashes were sent along the telegraph and transferred to a paper tape printout or converted to sounds for translation by a telegraph operator.

Communications history

The telegraph

Communication was once based on drums, smoke signals, mirrors and flags. Then the invention of the telegraph ('tele' means 'at a distance') changed communication forever. It was a system that sent electrical pulses along a wire. The first telegraph was demonstrated in 1835 by Professor Moncke of Heidelberg, Germany. In 1837, Englishman William Cooke demonstrated his own system (developed with Charles Wheatstone), transmitting a signal a distance of 1.6 kilometres. These early telegraphs used the magnetic effect of a current to move small pointers.



Fig 9.2.2 A telegraph receiver used to print Morse code messages

A	•—	J	•—•—•—	S	•••	1	•—•—•—•—
B	••••	K	—••—	T	—	2	••—•—•—
C	•—•••	L	—••••	U	••—•—	3	•••—•—•—
D	•—••	M	—•—	V	•••—•—	4	•••••—
E	•	N	—••	W	•—•—•—	5	•••••
F	••—•—	O	—•—•—	X	•—•••—	6	••••••
G	—•—•	P	•—•••	Y	—•—•—•—	7	—•—•••
H	••••	Q	—•—•—•—	Z	—•—••	8	—•—•••
I	••	R	—•••			9	—•—••••
FULL STOP	•••••					0	—•—•—•—
COMMA	•—••••					(zero)	

Fig 9.2.1 In Morse code, the most commonly used letters have the shortest codes.

The first telegraph cable was laid across the English Channel in 1851, and in 1858 the first cable across the Atlantic Ocean was laid, although it failed after a month—the tiniest hole in a cable's insulation was enough to provide an alternative path for the current and so destroy the signal. In 1866, the trans-Atlantic cable was successfully relaid. During 1872, the Overland telegraph line was completed in Australia, from Adelaide to Darwin, where it was joined to an undersea cable to Java. From Java, the line connected to Europe and England, allowing overseas communication within hours instead of the customary two months by ship. The telegraph was the main form of telecommunication until the emergence of the telephone.

The telephone

In 1874, Scottish inventor Alexander Graham Bell came up with the idea of converting sound (eg speech) into varying electrical impulses for transmission along a wire and then converting the impulses back to sound at the other end. On 10 March 1876, in Boston USA, Bell spoke to his assistant, Thomas Watson, in Cambridgeport, 3.2 kilometres away. This was the first ever telephone call. Bell's words were: 'Mr Watson, please come here. I want to see you'.

A telephone system requires the following main features: transmitters, receivers, exchanges and a network connecting users.

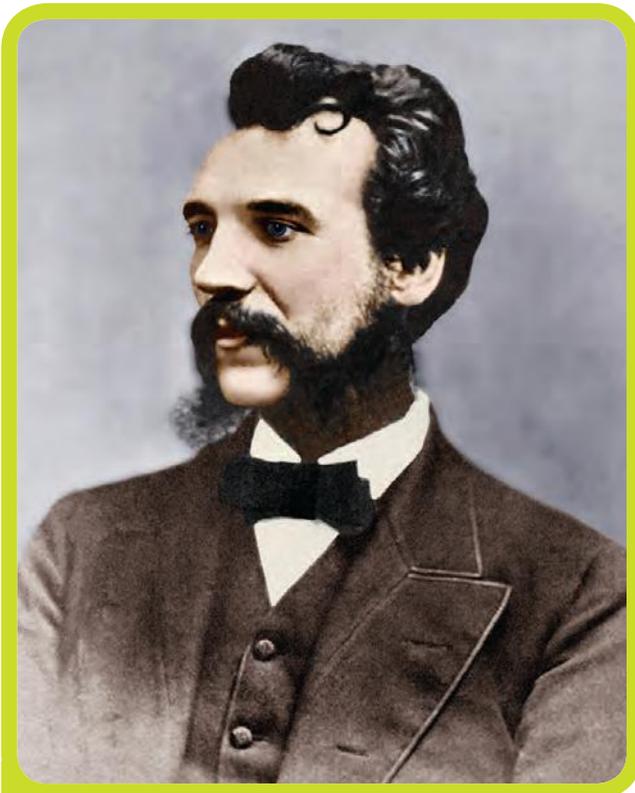


Fig 9.2.3 Alexander Graham Bell, inventor of the telephone

Early manual exchanges required an operator to use a switchboard to physically connect a wire from the caller's telephone to one going to the telephone of the person being called. This was called a line. As the number of calls on a system increased, mechanical exchanges were developed that were able to find free lines and connect callers automatically.

In the Solomon Islands and many other countries today, telephone exchanges are fully automatic and computerised, providing quick and reliable service.

Today's communications network—analogue and digital

Our current global communication network must handle a huge amount of 'traffic', including voice, image and computer data. It copes by transmitting several signals at once in each line. When you talk into a telephone, the initial input is in the form of smoothly varying sound waves. These are converted into smoothly varying electrical signals, otherwise known as an analogue signal. Most homes today are connected to the network via copper wires designed for use with analogue signals.

Digital signal is particularly suited to transmission by optical fibres. Each call is sampled 8000 times per second and is converted into a signal comprising bits (a bit may be considered as a 1 or a 0, or a pulse or no pulse, or 'on' and 'off'). Several different calls may be cut into chunks, interspersed, and sent in the one 'data stream' at a single frequency, and sorted out again at the end of the transmission. This is called time division multiplexing (TDM).

While small-scale links in the network are through copper wire, major links are provided by coaxial cable, fibre-optic cable and radio waves (including microwaves), sometimes via satellites. Signals are converted from analogue to digital as required, depending on the section of the network.

Coaxial cable

Most coaxial cables contain several tubes, each consisting of an inner copper core and an outer cylindrical copper mesh layer separated by an insulating material. A tough outer sheath surrounds these and protects the cable from damage. The inner core carries analogue or digital signals, while the outer copper layer protects the signal from interference between tubes in the same cable or from outside sources. The outer layer also reduces attenuation, or loss of signal strength.

Optical fibres

In the 1930s, the inventor of the optical fibre patented a method for manufacturing it ‘just in case anyone ever finds a use for it’. Today, optical fibre forms the backbone of the global communications network. An optical fibre is a hair-thin tube or strand of glass surrounded by a protective cladding that traps and conducts light, thanks to a phenomenon known as total internal reflection. To use optical fibres for communication of voice, fax or computer data, the original signal first must be converted into an electrical signal, which is in turn converted into pulses of light, the light being provided by a laser. Laser light is coherent—that is, all its waves are of the same frequency and wavelength and are ‘in step’, resulting in a powerful beam that can carry vast amounts of information with little dispersion or spreading out. Lasers can be switched on/off many millions of times every second, making them ideal for transmitting digital data.

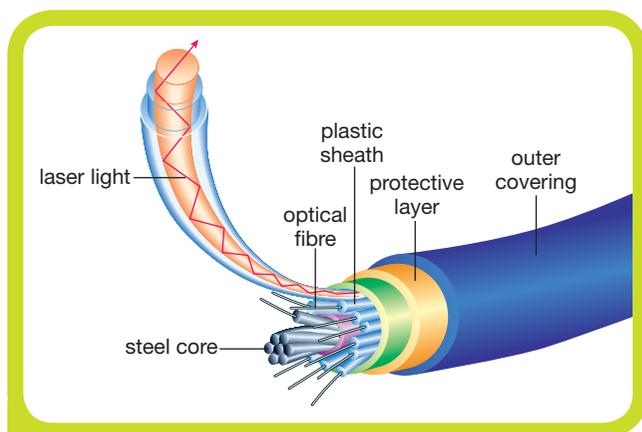


Fig 9.2.4 Many optical fibres can fit in a single cable.

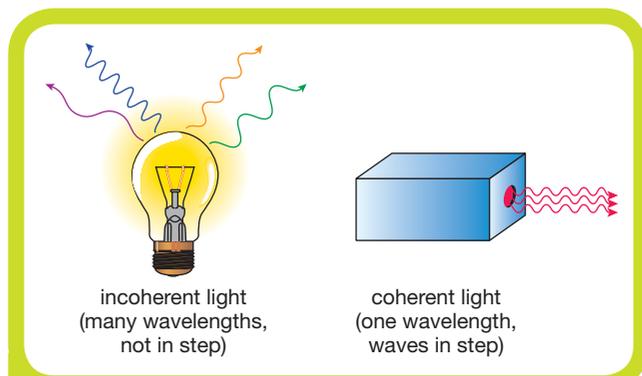


Fig 9.2.5 A light bulb produces a mixture of light of various wavelengths which we perceive as white light. A laser produces coherent light of only one wavelength.

Microwaves

Microwave links can be used to transmit digital signals through the air from repeater station to repeater station. These stations transfer signals from one area to another, and boost signals as required. Microwaves travel in straight lines, so each repeater station must be in sight of the next one in the network. Signals may be modulated to carry pulses of two different frequencies within the wave—one representing 1 or ‘on’, the other representing 0 or ‘off’.

Microwaves are used to link satellites for long-distance communication, as well as within the mobile phone network. Microwave links have been established in many places in Solomon Islands.



Fig 9.2.6 A microwave repeater station

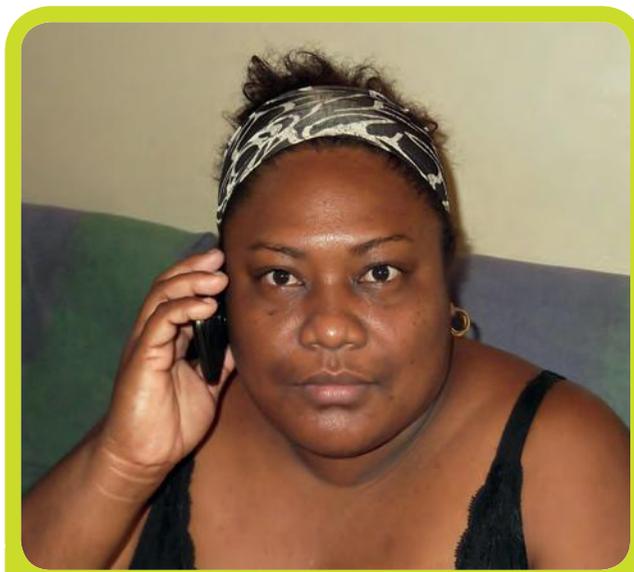


Fig 9.2.7 A modern, and some would say essential, communication device—the mobile phone

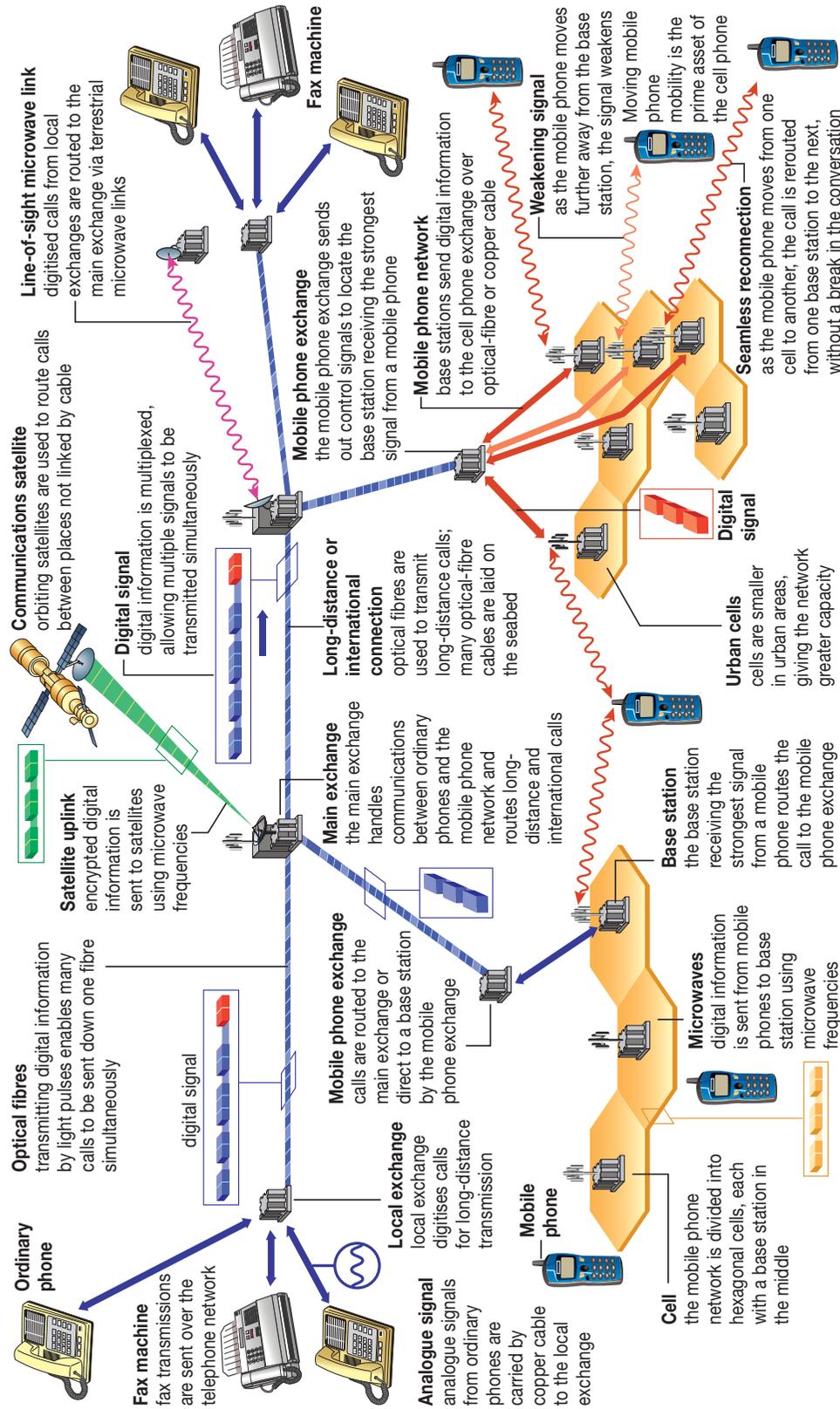


Fig 9.2.8 The global communications network

Mobile phones

Mobile phones use microwaves to transmit digital signals within a network of regions called cells. Each cell uses a different set of frequencies, with no adjacent cells using the same frequency. When you turn on a mobile phone, it sends a signal to the network, which registers your location. As you move from place to place, base stations within the network detect signals from your mobile phone, and the base station receiving the strongest signal sends it to the exchange. When a call is made to your mobile phone, the exchange detects where you are and sends the call to the base stations in the cell you are in.

All the above methods of transmission require repeater stations every 50 kilometres or so to boost weakened signals. The following table shows the different capacities of each type.

Transmission method	Maximum number of two-way conversations
Copper	600
Coaxial cable	2700
Optical fibre	28720
Microwaves	1920

The future

It is likely that in the future our homes will be connected to one cable which provides a broad range of services, including telephone, fax, internet connection, video on demand, video conferencing, pay TV, interactive video and games, and online shopping, news and medical diagnosis. Known as B-ISDN—short for Broadband Integrated Services Digital Network—such a system is the ‘next step’ in our ever-expanding global communications network.

9.2 [Questions]

Checkpoint

Communications history

- 1 List some older forms of communication.
- 2 State the distance over which the first telephone call was made.

Today's communications network—analogue and digital

- 3 How are digital signals transmitted?
- 4 Explain how coaxial cables work.
- 5 What is an optical fibre?
- 6 Explain how microwaves are used in long-distance communication.
- 7 Describe how mobile phones transmit messages.

The future

- 8 State the name of the network predicted for future use.

Think

- 9 List some of the communication services/devices available today in Solomon Islands.
- 10 State two advantages of digital signals over analogue ones.
- 11 Mobile phones are sometimes called cell phones. Explain why.

- 12 The world is sometimes referred to as a global village. Explain why.
- 13 Your behaviour would probably change if you were having a video-phone conversation. Contrast your behaviour on a video-phone with that on a normal phone.

Analyse

- 14 Explain why repeater towers in the mobile phone network are arranged in a zigzag pattern, as shown in Figure 9.2.9.

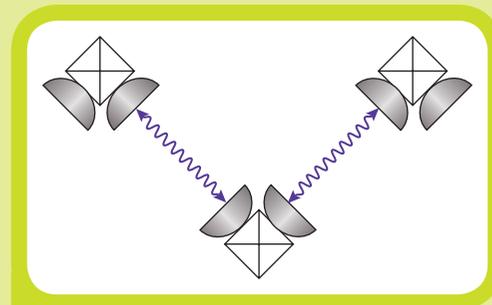


Fig 9.2.9



Solomon Islands Science Year 9

Learner's Book

Solomon Islands Science Year 9 Learner's Book is part of an exciting new series of textbooks for learners in Years 7, 8 and 9. The aim of this series is to show learners they do not have to leave Solomon Islands to learn about science, because science is all around them. These textbooks allow learners to see how science creates and sustains life in a Solomon Islands village and community. They also pave the way for those learners who have an interest in completing further science studies.

These textbooks are designed to help the teacher work as a facilitator, by giving learners a better understanding of science both in the classroom and out in the field and community. The books explore advances in science and technology as well as the interrelationship between science and society.

The major advantage of this series is that it does not depend on a particular teaching method. Teachers are encouraged to enable learners to do the hands-on activities first, before covering the topic in more detail. Each book offers a vast range of experiments and subject matter – much more than would normally be covered in one year. This allows greater flexibility in the selection of material appropriate to the needs of learners.

Solomon Islands Year 9 Learner's Book is the third book in the series and is most suitable for Year 9 learners. This book is also suitable for advanced Year 8 learners, in preparation for their next year of study.

ISBN: 978-1-4425-1359-4



9 781442 513594